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AUTOMATIC MIX-MELT PRODUCTION PROCESS DEVELOPMENT FOR TRITONAL,--ETC(U)
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AUTOMATIC MIX-MELT PRODUCTION PROCESS DEVELOPMENT FOR TRITONAL, H-6, AND MINOL II

A PROJECT OF THE MANUFACTURING TECHNOLOGY PROGRAM NAVAL SEA SYSTEMS COMMAND PROJECT NAPEC 73-20

FINAL REPORT

NAVAL AMMUNITION PRODUCTION ENGINEERING CENTER
NAVAL SEA SYSTEMS COMMAND
NAPEC

BY
NAVAL SEA SYSTEMS COMMAND (NAVAMPROENGCEN)
NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA 47522

18 MAY 1978

AUTOMATIC MIX-MELT PRODUCTION PROCESS DEVELOPMENT FOR TRITONAL, H-6, AND MINOL II,

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ABSTRACT

The results of a successfully completed NAVSEA sponsored Manufacturing Technology project are reported. The project was carried out by the Naval Ammunition Production Engineering Center (NAPEC), NAVAMPROENGCEN Crane, Indiana in connection with the modernization of the bomb loading production facility at McAlester AAP (formerly NAD McAlester). The program objectives including identificationof the parameters governing the mixing process for explosive loads and the develooment of a full-scale automated eauioment svstem necessarv to demonstrate the new technologv in the mixing of tritonal were accomplished. The new process provides a more uniform product, increased safety and economic benefits.

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I. INTRODUCTION

Tritnitrotoluene (TNT) based cast explosives have been used for filling general purpose bombs since World War II. Recently, millions of bombs were produced for the Vietnam War. Three types of fills were used: (1) Tritonal - a mixture of TNT and powdered aluminum, (2) H-6 - a mixture of Composition B, D-2 wax, calcium chloride, and a powdered aluminum, and (3) Minol II - a mixture of ammonium nitrate, TNT, and powdered aluminum. The preponderance of bombs was loaded with tritonal.

The technology for mix-melting TNT based explosives has changed little since World War II. Larger melt kettles and reduced batch times through elimination of pelleting and incremental filling have accounted for the bulk fo the improvements. Material handling, including charging the kettle, is still performed with manual labor. Control of melting, with steam at a maximum of 15 psi (10 psi for tritonal), is also in the hands of the operator.

The moderniztion of Plant "A" at McAlester AAP and the desire to provide a historical record of batch quality have made it essential that improvements be made in the process control of mix-melting. Plant "A", when completed, will have an entirely automatic material handling system for moving explosive ingredients to and into the mix-melt system. The control of mix-melting, however would have to remain with an on-site operator if the equipment and process are not developed to permit his removal. In addition, existing casting plants require a means of controlling and recording the quality of an explosive batch for later use.

The purpose of this Manufacturing Technology Program is to develop the full scale equipment and the process by which both the Plant "A" and existing plant requirements can be met. Tritonal is the primary explosive material for which the system will be designed because it represents the largest mobilization requirement and because it is the most difficult to manufacture.

II. THE TRITONAL PROBLEM

TNT composes at least 50% of any of the explosive fills currently put in conventional bombs. TNT becomes molten at 81 degrees C. (176 degrees F.). This temperature is within safe limits of plant operation and far below its decomposition temperature of 470 degrees C. (878 degrees F.). Tritonal is a mixture of 80% TNT and 20% finely powdered aluminum (100% passes 40 mesh screen). The density of aluminum powder is 1.8 times the density of TNT in its liquid state. The aluminum powder will separate and settle out of the mix if a large portion of the TNT becomes liquid. This stratification, if it occurs in the kettle, can cause the discharge valve to clog. If the stratification occurs within the bomb, the nose fuze can become ineffective and a high dud rate may result. The experienced mix-melt kettle operator has traditionally been the only control available for mixing tritonal. His knowledge of steam energy addition versus material addition versus the visible properties of the mix, gained by experience, has been relied upon to produce acceptable tritonal. In order to replace the operator in a modernized plant, the physical properties of TNT and their measurements must be understood.

A. THERMODYNAMICS

TNT has a variable specific heat from .328 cal/gm/degree C. to .374 cal/gm/degree C. between ambient (20 degrees C.) and its melting temperature (80 degrees C.)*. For test purposes, Table 1 shows the specific heats in BTUs per pound per degree C.

*AMCP 706-177

Table 1

Degrees Centigrade	BTUs/pound/degrees C.
20 (ambient)	.590
50	.635
80	.673

The heat of fusion for TNT is 22.34 cal/gm or 40.21 BTU/pound.*

Figure 1 shows a plot of the thermal energy required to raise one pound of TNT from ambient to 80 degrees C., allowing for complete melting. The change of state of 100% of the TNT from solid to liquid consumes approximately the same energy as is required to raise the TNT from ambient to the melting point.

During the change of state, the temperature of the TNT remains constant at approximately 79 degrees C. Temperature, therefore, cannot be used effectively to batch tritonal since the percentage of TNT to be allowed to melt must remain small. This limited melting occurs at the same temperature as 100% melt. Table 2 shows the calculated thermal energy required to raise 2,400 pounds of TNT flake from 20 degrees C. to 79 degrees C. and to melt various percentages up to 100%

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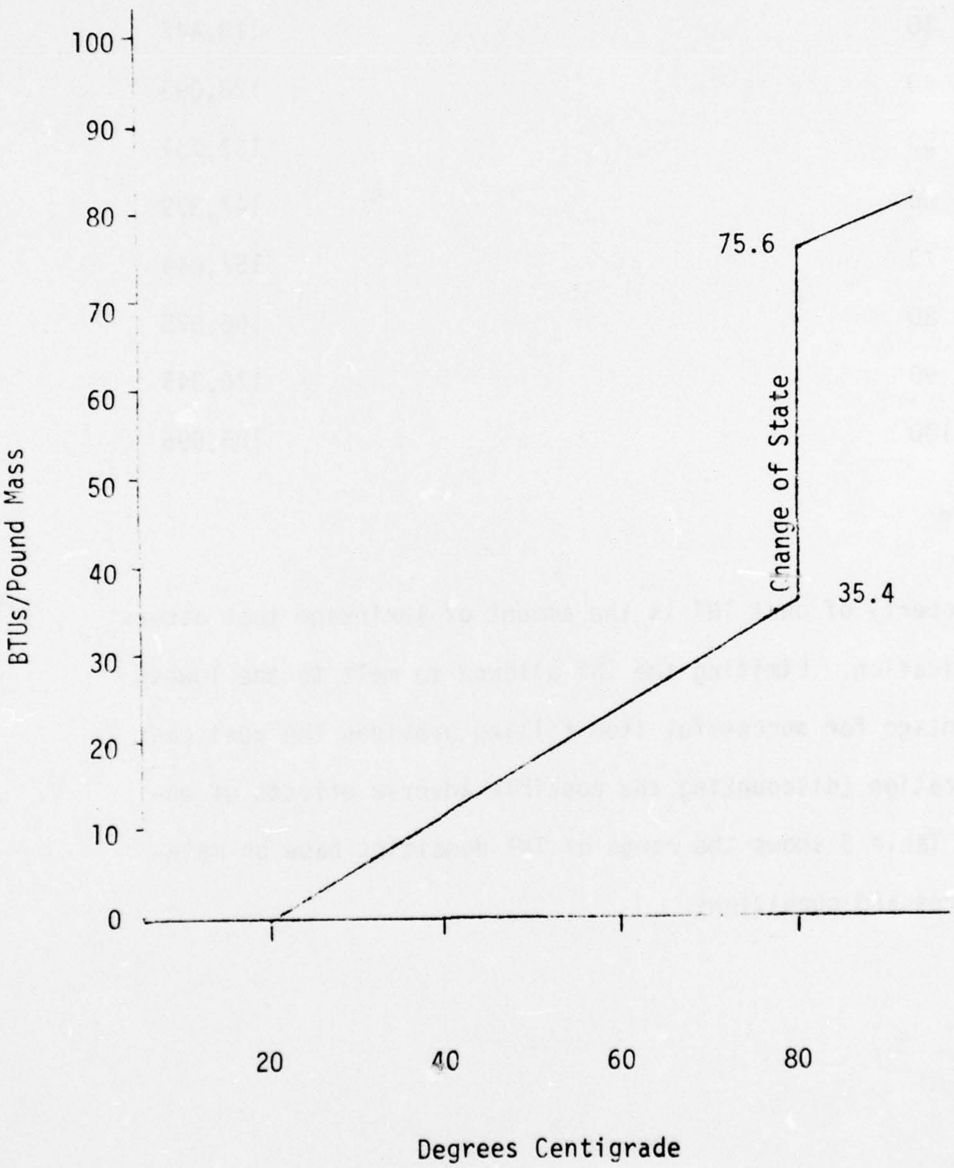

BTUs/Pound Mass
100
90
80
70
60
50
40
30
20
10
0
75.6
35.4
Change of State
20
40
60
80
Degrees Centigrade

Figure 1

Table 2

Percent of material melted @ 79 degrees C.	Total BTUs
0	89,491
10	99,141
20	108,792
30	118,442
40	128,093
50	137,731
60	147,379
70	157,044
80	166,675
90	176,345
100	185,995

B. TNT DENSITY

One adverse property of cast TNT is the amount of shrinkage that occurs during solidification. Limiting the TNT allowed to melt to the lowest possible percentage for successful item filling provides the best cast after solidification (discounting the possible adverse effects of entrapped air). Table 3 shows the range of TNT densities base on material temperatures and conditions.

Table 3

Degrees Centigrade	State	Gm/CC*
27-70	Flaked*	1.65
80	Flaked*	1.64
82	Liquid	1.48
87	Liquid	1.48
95	Liquid	1.47
20	Solid Cast	1.59

*When pressed into a charge.

TNT is normally supplied by the manufacturer as a flake similar in size to uncooked rice. The bulk density has been approximated at 50#/ft^3. The mix-melt process first converts the flake into a thick slurry and eventually into a thin liquid when 100% of the flake is melted. Based on the volume of the existing kettle and the volume of material in the kettle when fully charged, about 5% of the total volume can be air voids between the flake and the liquid TNT. For comparative purposes, the maximum available volume in the current 3,000# capacity kettle is calculated as 36.05 cubic feet. The 600# of powdered aluminum in tritonal will be considered to have a constant volume and be fine enough to preclude generation of air voids when mixed with TNT flake. The volume of powdered aluminum is estimated as 3.58 cubic feet. Figure 2 shows the density changes of the batch as the percentage of melted TNT increased to 100%. The density of cast tritonal is approximately 1.73.**

Considerable change in density occurs with the percentage of TNT melted and with the percentage of air voids in the mix. The air voids must be filled

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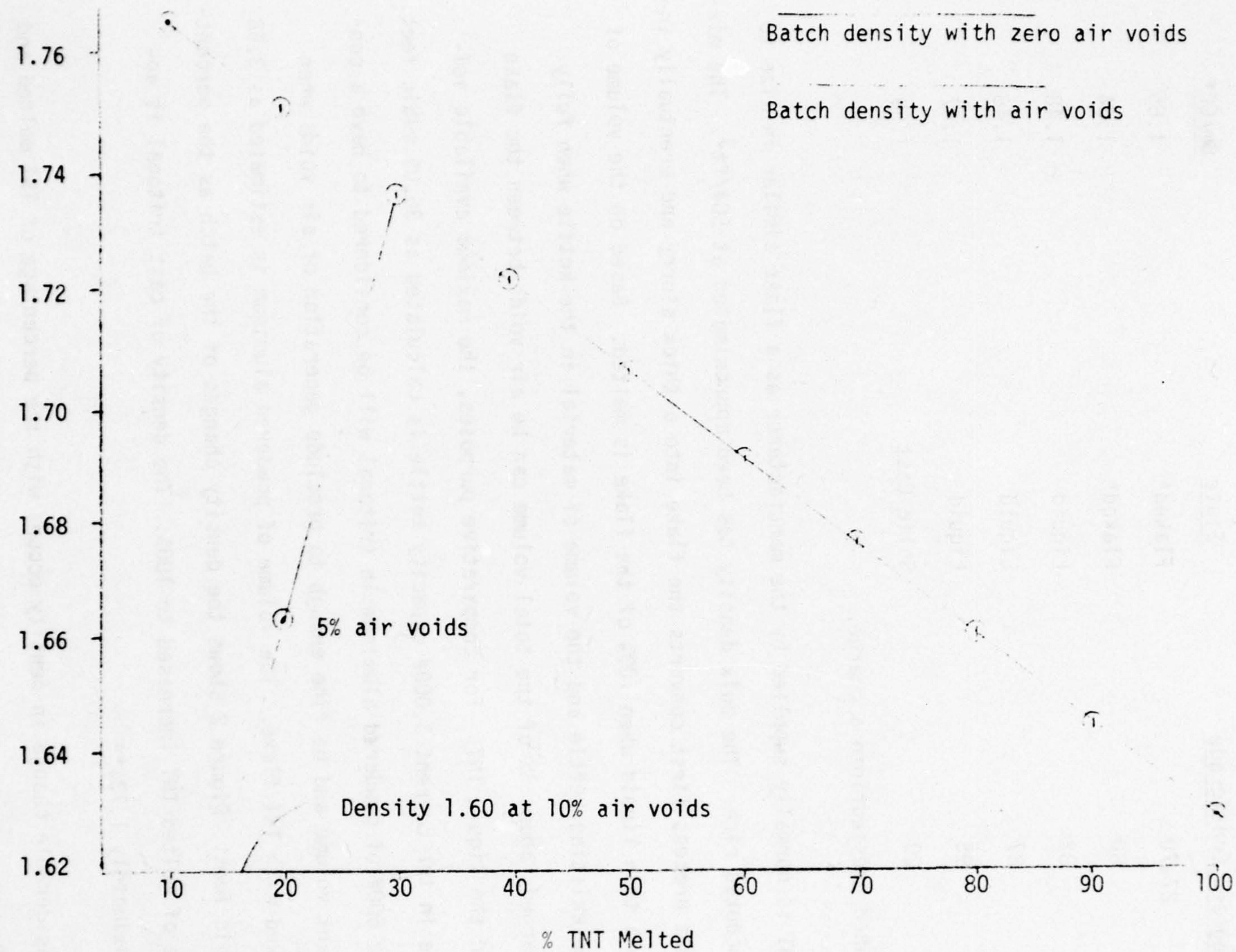


Batch density with zero air voids
Batch density with air voids
5% air voids
Density 1.60 at 10% air voids
1.76
1.74
1.72
1.70
1.68
1.66
1.64
1.62
10
20
30
40
50
60
70
80
90
100
% TNT Melted

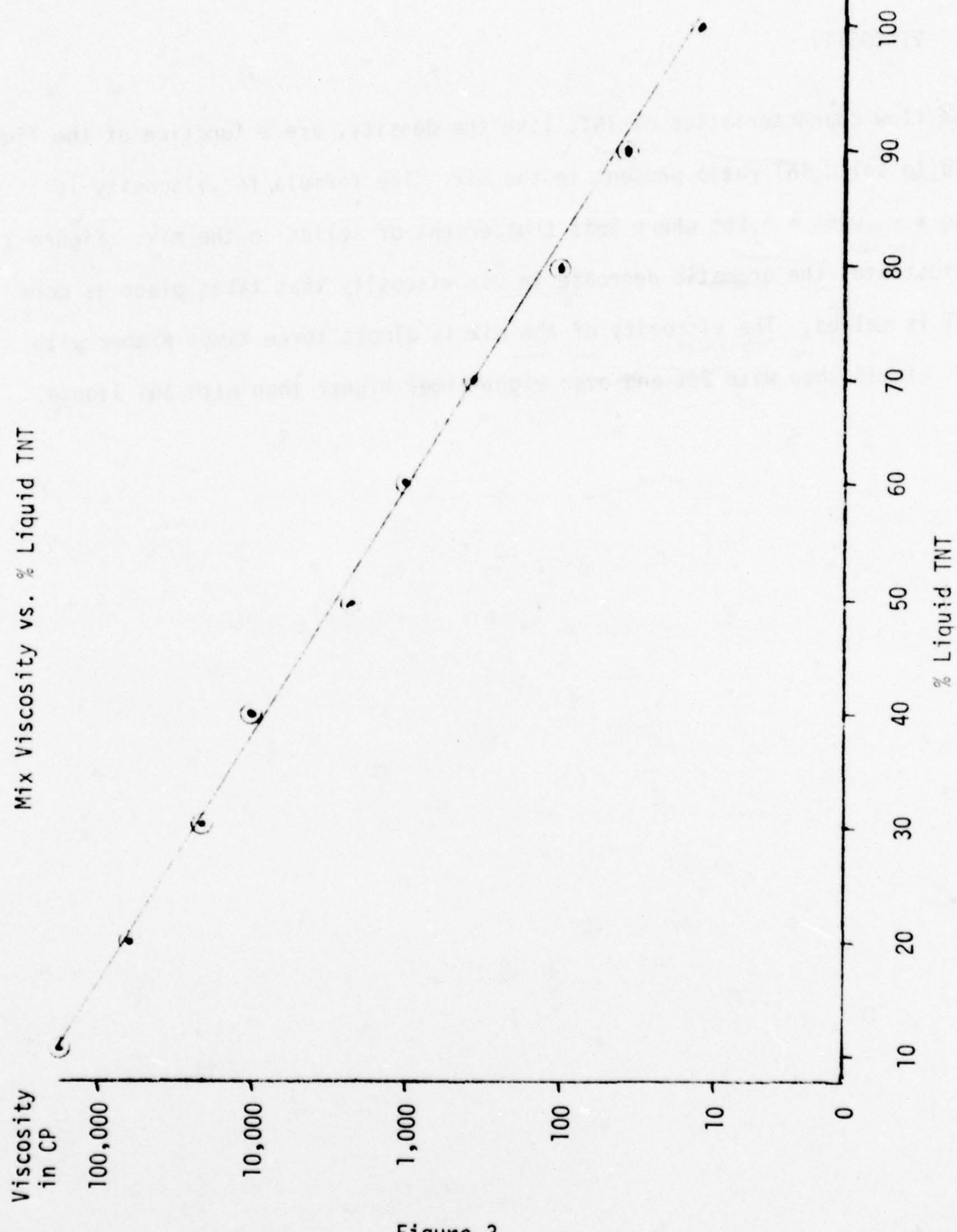
Figure 2

by liquid TNT in order for the density to rise to its final cast value. This property is greatly influenced by the efficiency of agitation.

C. VISCOSITY

The flow characteristics of TNT, like the density, are a function of the liquid to solid TNT ratio present in the mix. The formula for viscosity is $\text{Log } x = .046S + 1.26$* where S is the percent of solids in the mix. Figure 3 illustrates the dramatic decrease in mix viscosity that takes place as more TNT is melted. The viscosity of the mix is almost three times higher with 10% liquid than with 20% and over eight times higher than with 30% liquid.

*IBID



Mix Viscosity vs. % Liquid TNT
Viscosity in CP
100,000
10,000
1,000
100
10
0
10
20
30
40
50
60
70
80
90
100
% Liquid TNT

Figure 3

III. METHODOLOGY

A. GENERAL

The development of equipment for the processing of explosives has traditionally been a slow procedure with each new improvement being a small step built upon many hours of experience. The existing structure of the explosive safety organization and the lack of explosives technology in private industry require most work to be performed "in-house" with commercial equipment modified to meet hazardous conditions. For these reasons, the testing program was broken into three phases to satisfy specific requirements.

B. PHASE I

This phase involved the procurement and installation of equipment systems at the Naval Explosives Development Engineering Department, Naval Weapons Station, Yorktown, Virginia. These systems include proven equipment already in use at existing Navy casting plants, equipment designed for installation in Plant "A", equipment presently being tested by another service for other purposes, and equipment used only in private industry for other purposes. The following systems were purchased and installed:

1. A 3,000# capacity steam heated melt kettle of the latest Navy design and identical to those designated for Plant "A".

2. A bulk explosive handling hopper and conveyor system similar to that designed for Plant "A".

3. An agitator mounted temperature sensing system using thermocouples and a radio transmitter.

4. An agitator shaft mounted torque measuring system using strain gages and a radio transmitter.

5. A gamma ray density measuring device used in industry to measure material such as paper on a continuous basis. A similar system was installed at Louisiana Army Ammunition Plant for tests.

6. A thermal energy measuring device to acquire and record steam generated energy input to the 3,000# kettle for the purpose of melting the TNT.

7. A mini-computer and teleprinter system to scan and record all data for later transcribing. The mini-computer has the capability of being programed to select data considered most useful by the testing personnel. The mini-computer system can also be programed to control batching operations when coupled to one or more of the batch monitoring systems.

The testing portion of Phase I was to evaluate the material handling system and determine a parameter measuring system, or number of systems, that could be used for automatic batch control. Consistency of equipment response and durability in a production environment were two major guidelines for evaluating new equipment.

C. PHASE II

This phase involved the scrutiny of Phase I data and an evaluation of the capability of the measuring equipment to perform in a production environment and provide an operator in existing plants with batching assistance and a permanent record of batch results. Additional explosive testing beyond Phase I was to be conducted only if results from

Phase I supported it. Phase II also included procurement of equipment to provide an automatic equipment base for Phase III testing.

D. PHASE III

This phase involved full scale testing using the min-computer to control material addition to the kettle, to control heat energy addition and to signify batch completion when the material had reached the desired condition. Phase III was considered a proving ground for determining equipment performance and reliability.

IV. SYSTEMS DESCRIPTION

A. 3000# MIX-MELT KETTLE AND MATERIAL FEED SYSTEM

The material handling system for the automatic mix-melt technology development program consists of equipment similar in nature to that being designed for "A" Plant. This provides a smooth regulated material flow which is essential for test repeatability. The feed/melt system consists of the following components:

1. A 3000# capacity steam (hot water capable) jacketed stainless steel melt kettle with heated calandria, agitator, and lid.

2. A 30 HP, two speed electric motor equipped with reduction gears supplying 59 or 39 RPM and 2000 ft-lbs of torque.

3. A 12" wide totally enclosed conveyor belt.

4. A 15 cubic foot capacity bulk TNT feed hopper with vibrated output and automatic operation controls.

The melt kettle selected is 1 of 28 purchased in 1969-1970 to upgrade the melt capabilities of Navy casting plants. Equipped with the 30 HP, two speed motor, the new kettle will provide the melt capability for the McAlester "A" Plant. Figure 4 displays the general arrangement of the drive train and kettle as installed in a typical three story production building. Figure 5 shows the test installation at WPNSTA Yorktown, Building 456. It differs from a production installation in that the kettle is positioned above the second floor level to allow access to test equipment.

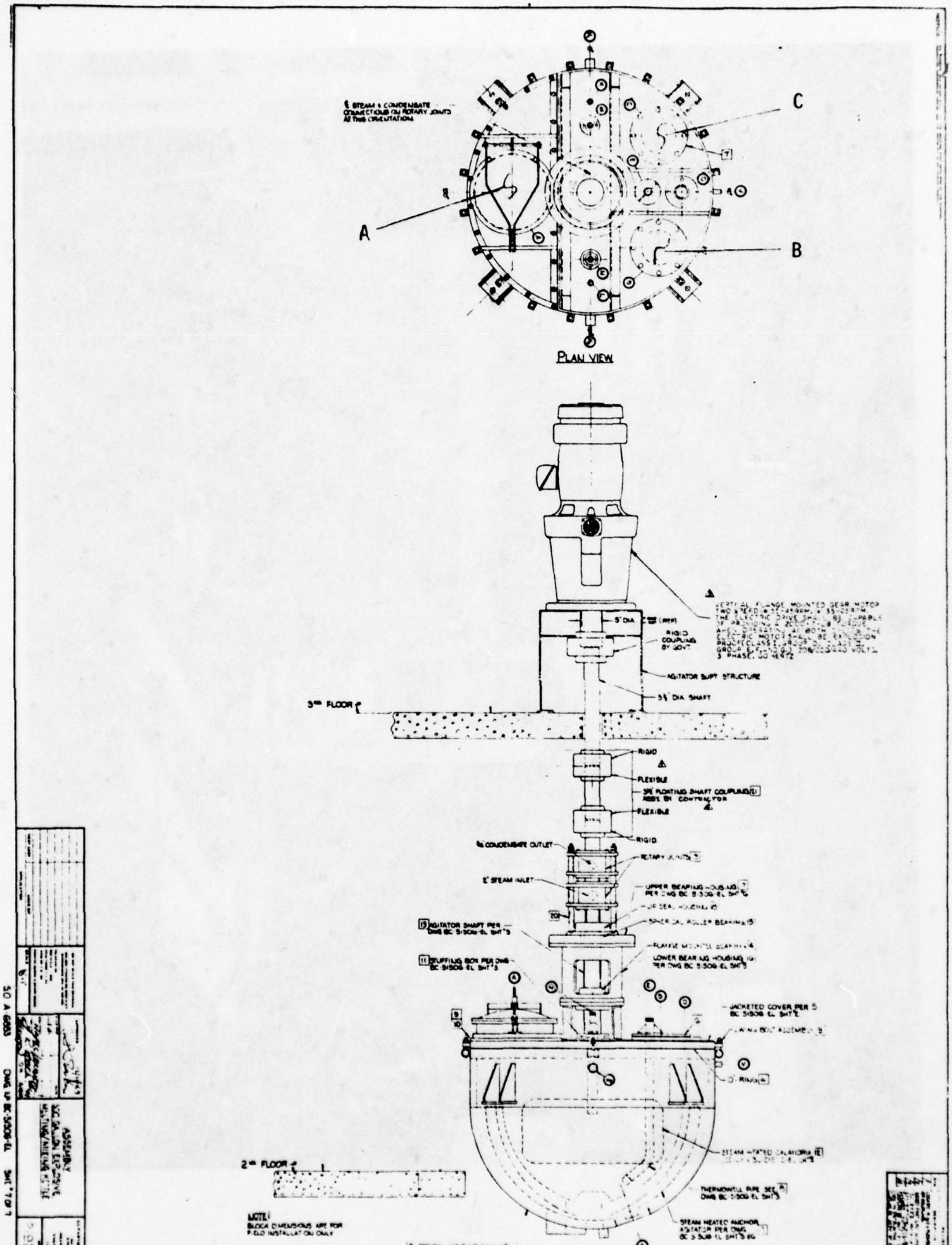


Figure 4

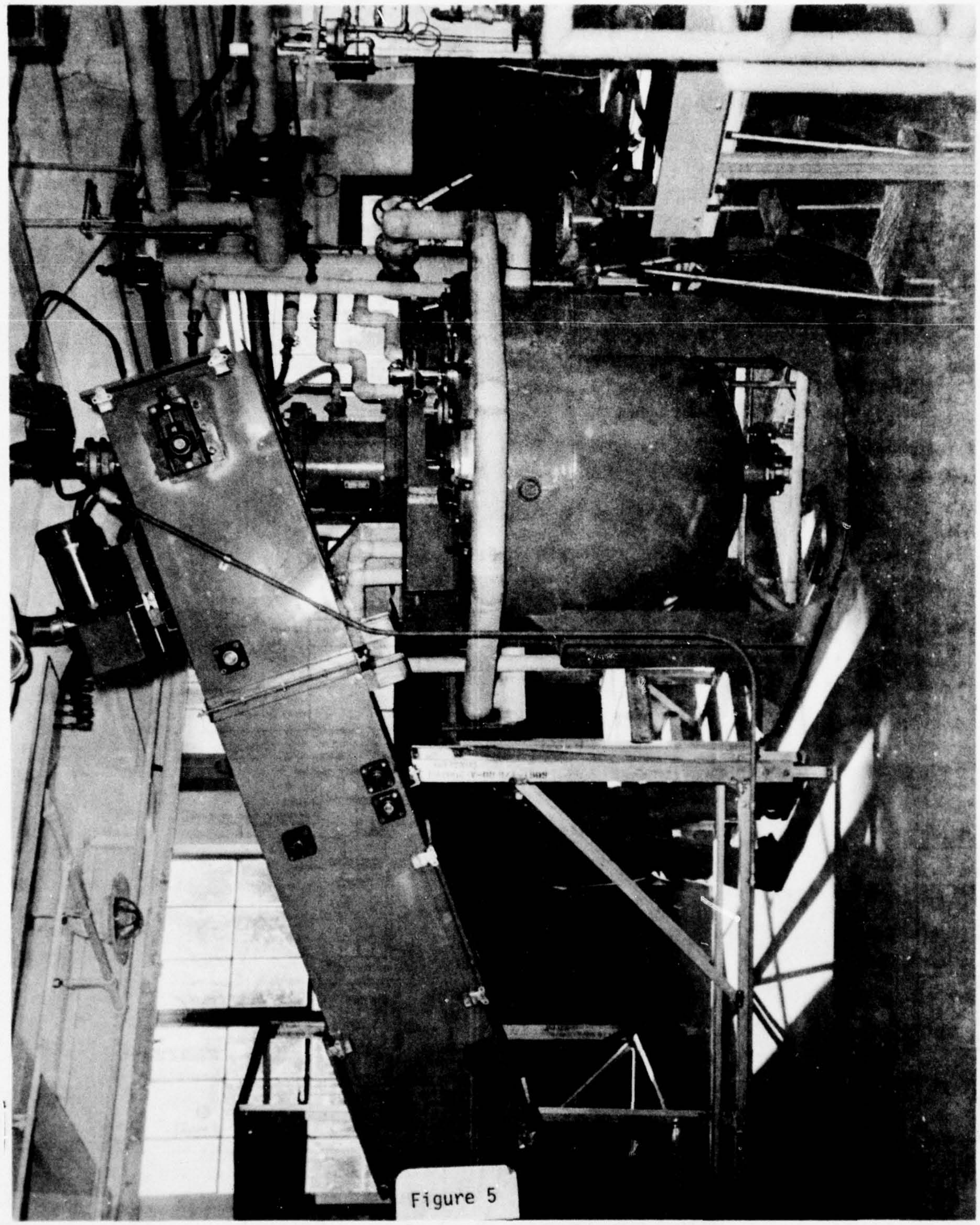


Figure 5

Heat is supplied by steam at a maximum pressure of 15 psig (10 psig for tritonal). The maximum temperature is therefore limited to approximately 121 degrees C. or 250 degrees F. Steam flow to the kettle jacket is regulated by a pneumatic valve operated manually in Phases I and II and by an automatic proportioning valve in Phase III. Steam to the calandria, kettle lid, and agitator is supplied separately since these parts are heated primarily to prevent explosive build-up. Controls for these are manual as shown in Figure 6. TNT, during all phases of the tests, was loaded through the 8" diameter Port B (shown on Figure 4). Aluminum powder was added manually through Port A during all Phases. TNT was conveyed to the kettle by a troughed belt which is totally enclosed within a fabricated housing. All bearings are mounted outboard for safety and simplified maintenance. This conveying technique duplicates, in a large part, the system to be employed at "A" Plant. The angle of carry is, however, considerably greater than planned for "A" Plant. Also, material is not deposited evenly across the belt as will be necessary at "A" Plant to insure compliance with nonpropagation regulations. Material feed is still considered sufficient regardless of limited drawbacks to provide the desired test parameters. Figures 7 and 8 show the conveyor as installed in Building 456 including a view of the belt as seen through an inspection port.

TNT in flake form was fed from a 15 cubic foot capacity hopper onto the conveyor belt. A pneumatically operated valve dispensed the flake in the desired intervals. Pneumatic timers and increment counters allowed for any combination of increments, increment lengths, and spacing between increments to be imputed. Figure 9 shows the TNT hopper and platform for

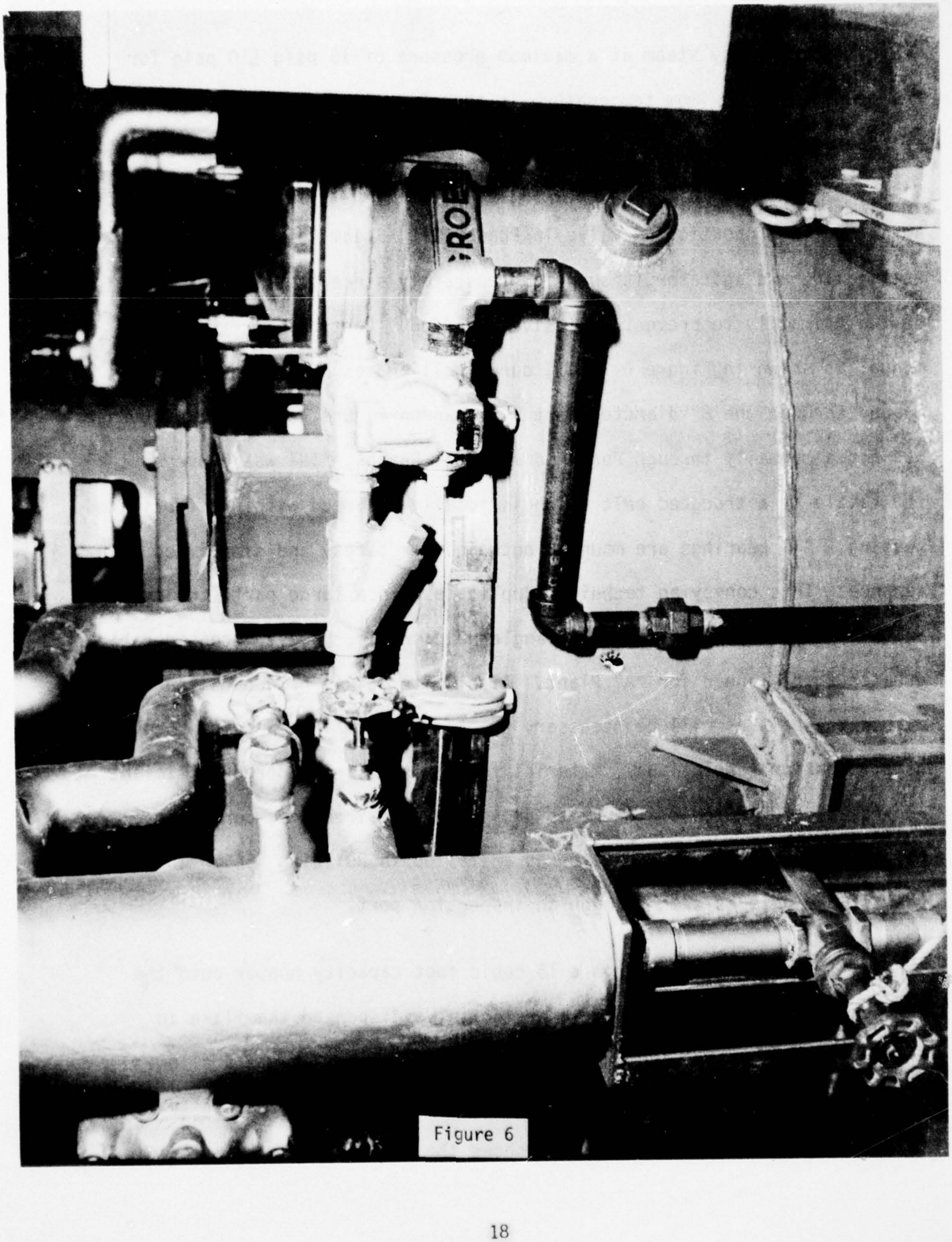


Figure 6

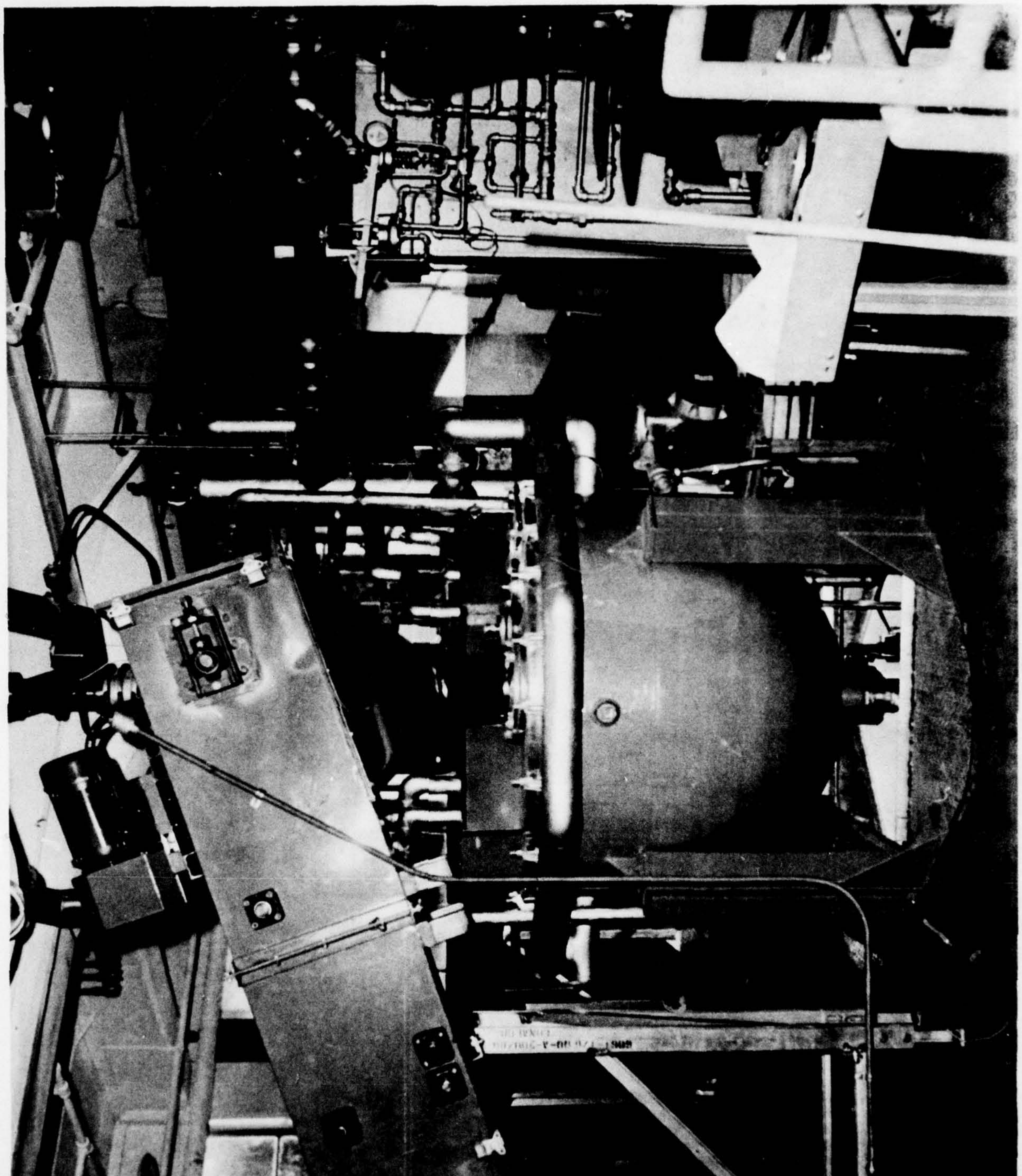


Figure 7

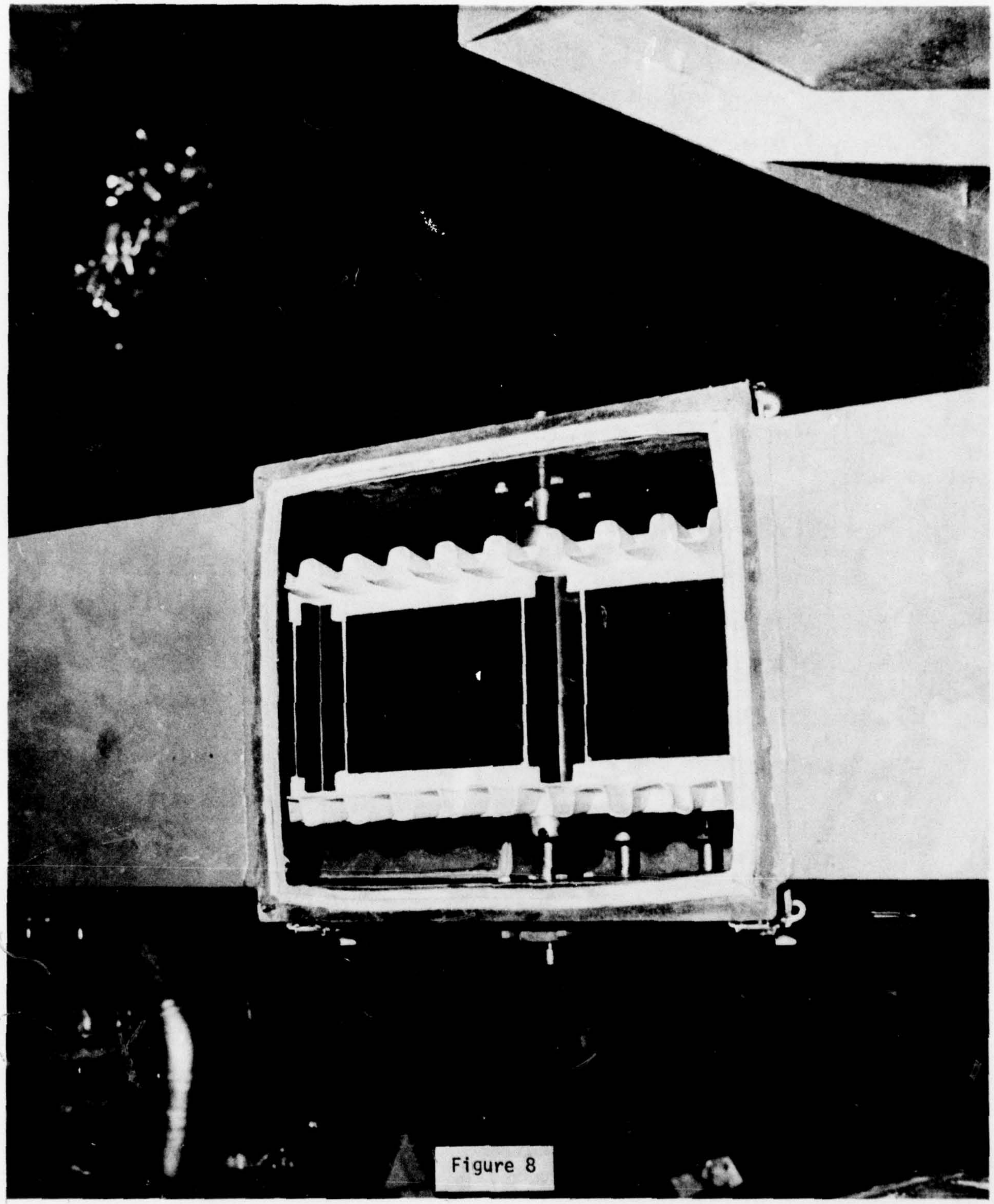


Figure 8

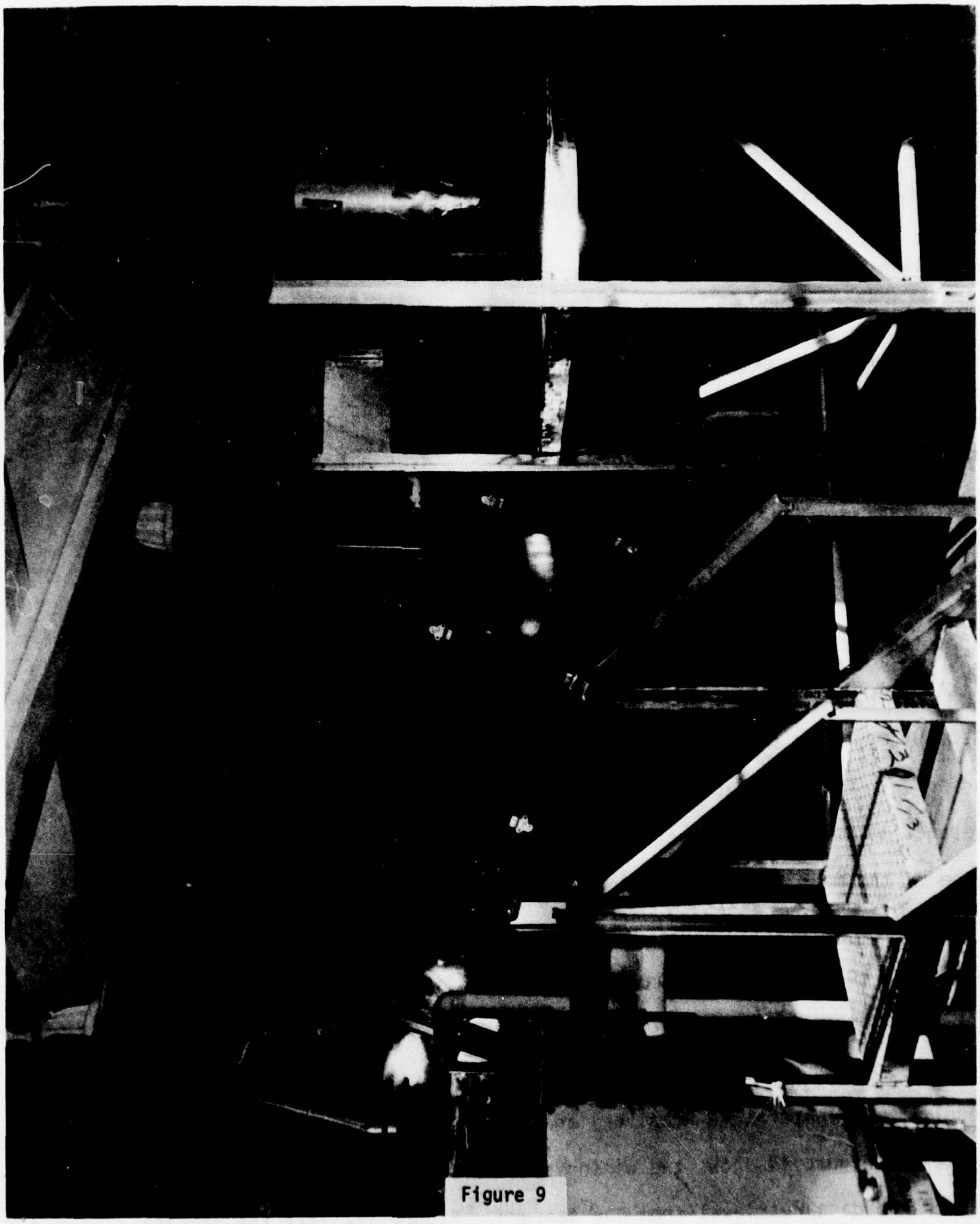


Figure 9

servicing. Figure 10 shows the interior of the hopper including the anti-bridge plate designed to prevent TNT from clogging the discharge port. Figure 11 shows the conveyor discharge chute into the kettle.

B. AGITATOR MOUNTED TEMPERATURE SENSING SYSTEMS

Existing melt operations have always been hampered by lack of immediate knowledge of the material temperature during the batch cycle. The use of hand held thermometers has sufficed when temperature was a necessary parameter for material acceptance. Accurate temperature sensing on a continued basis is an elusive entity. Permanent probes have suffered two major problems. If the probe is left unheated, a crust of explosive builds up on it insulating the sensor from the material. If the probe is provided with some limited heat to prevent the crust buildup, then the sensor is confused and reports false readings. The temperature sensing system installed in the test kettle was an attempt to overcome the two basic problems by mounting the probes on moving surfaces provided by the rotating agitator. Figure 12 shows the general location of the six probes with respect to the kettle geometry. Two probes are mounted on the leading edge of the main blade tips, one on the agitator hup, and three are mounted on the small blades fastened to the center shaft. Figure 13 shows the actual installation prior to explosive material tests. Power for the theromocouples is provided by an FM transmitter/receiver. Accurex Corporation, Mountain View, California, provided all equipment including Model 155 S (Temperature Receiver) and Model 188 (Temperature Demultiplexer). Figure 14 shows the wiring system for signal input to the agitator and data retrieval from the sensors. Figure 15 lists the specifications for equipment used and a diagram of the antenna installation.

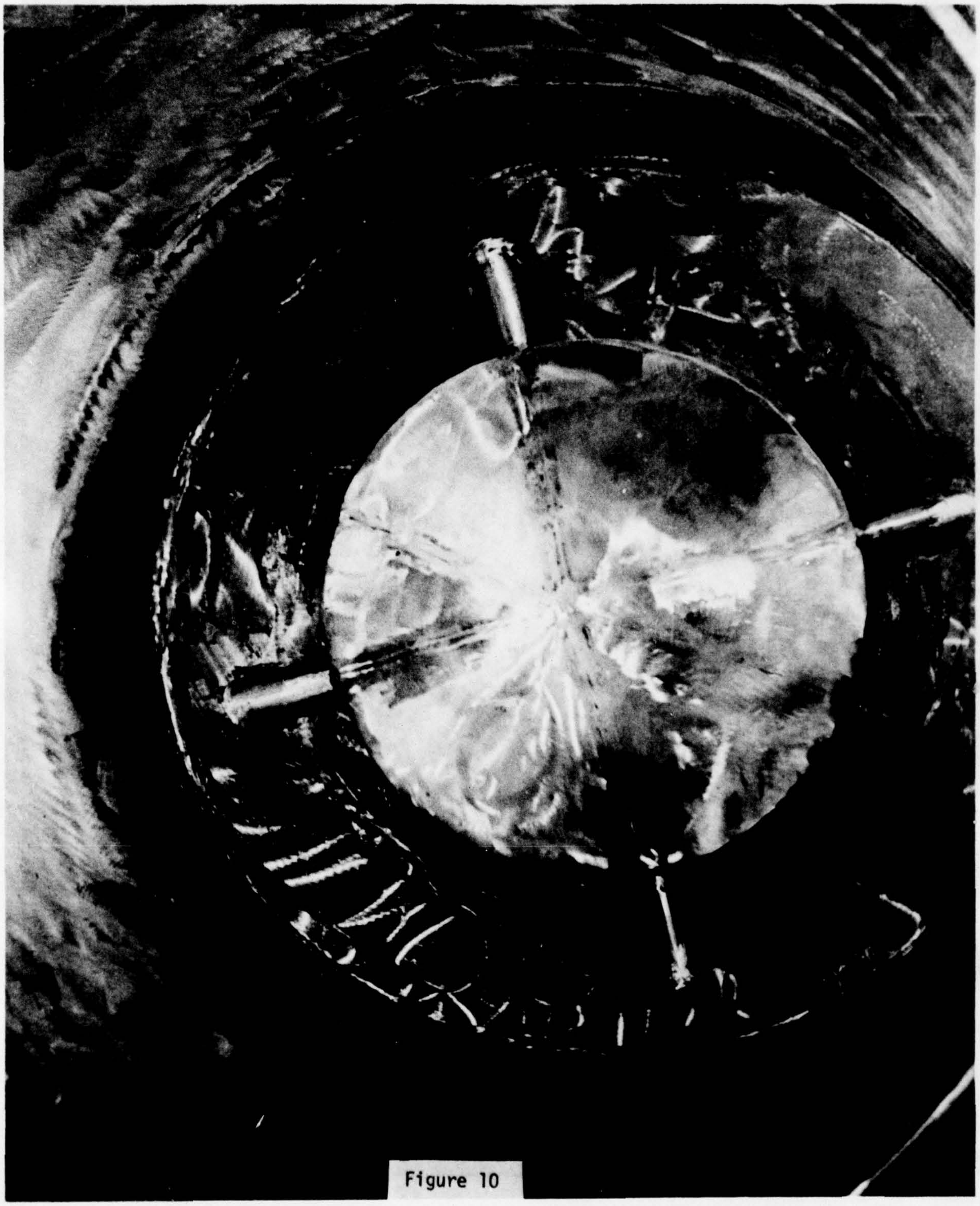


Figure 10

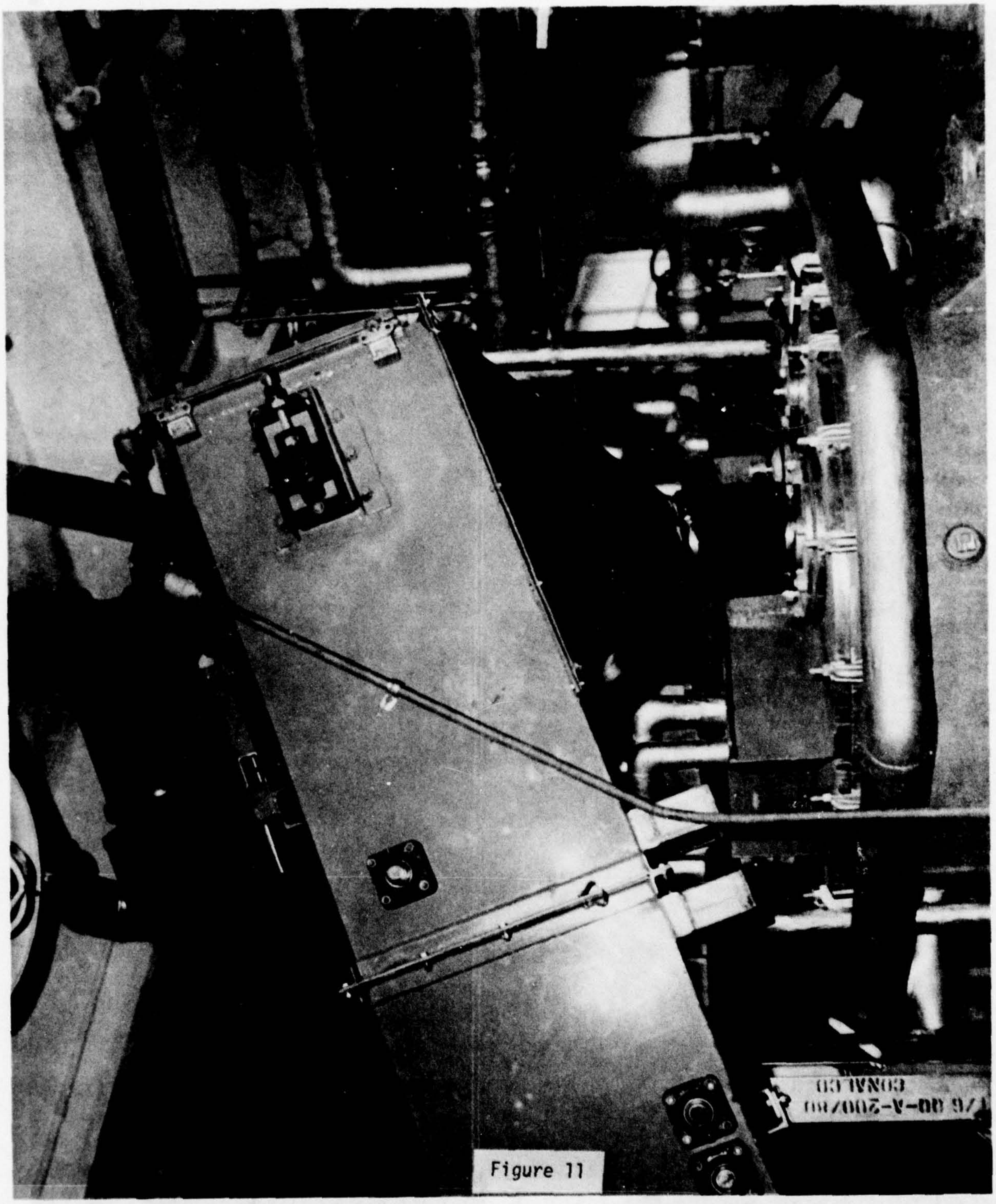
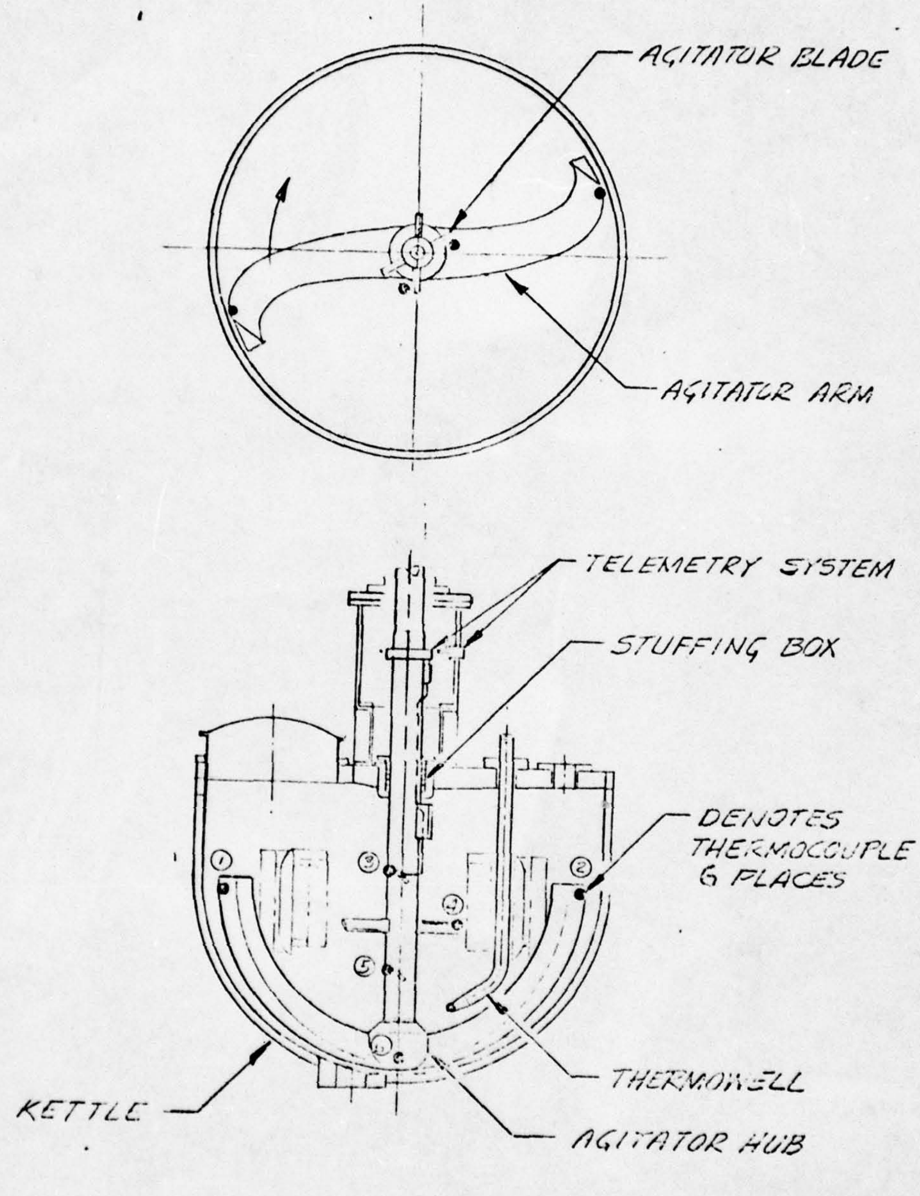


Figure 11



THERMOCOUPLE LOCATIONS

Figure 12

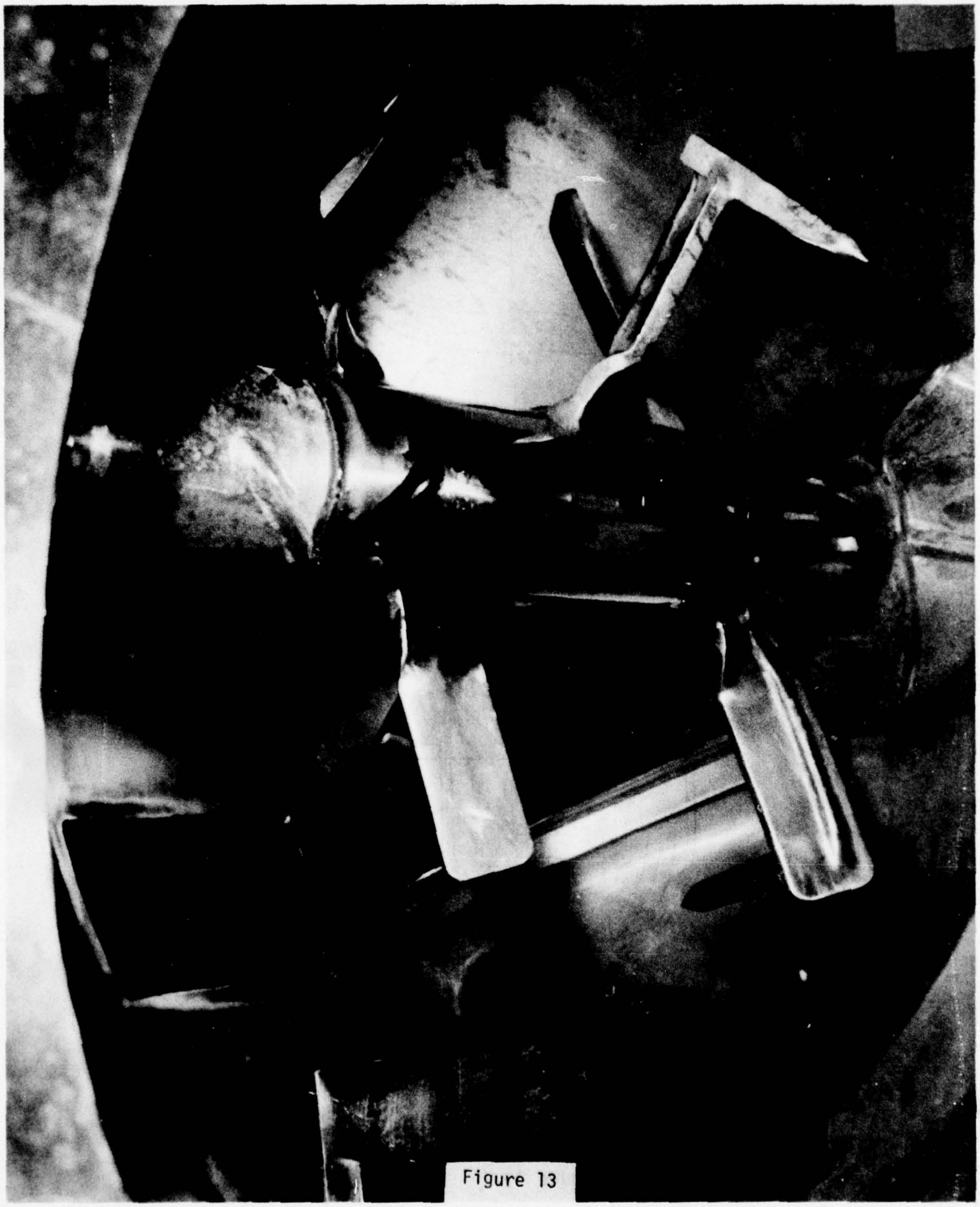


Figure 13

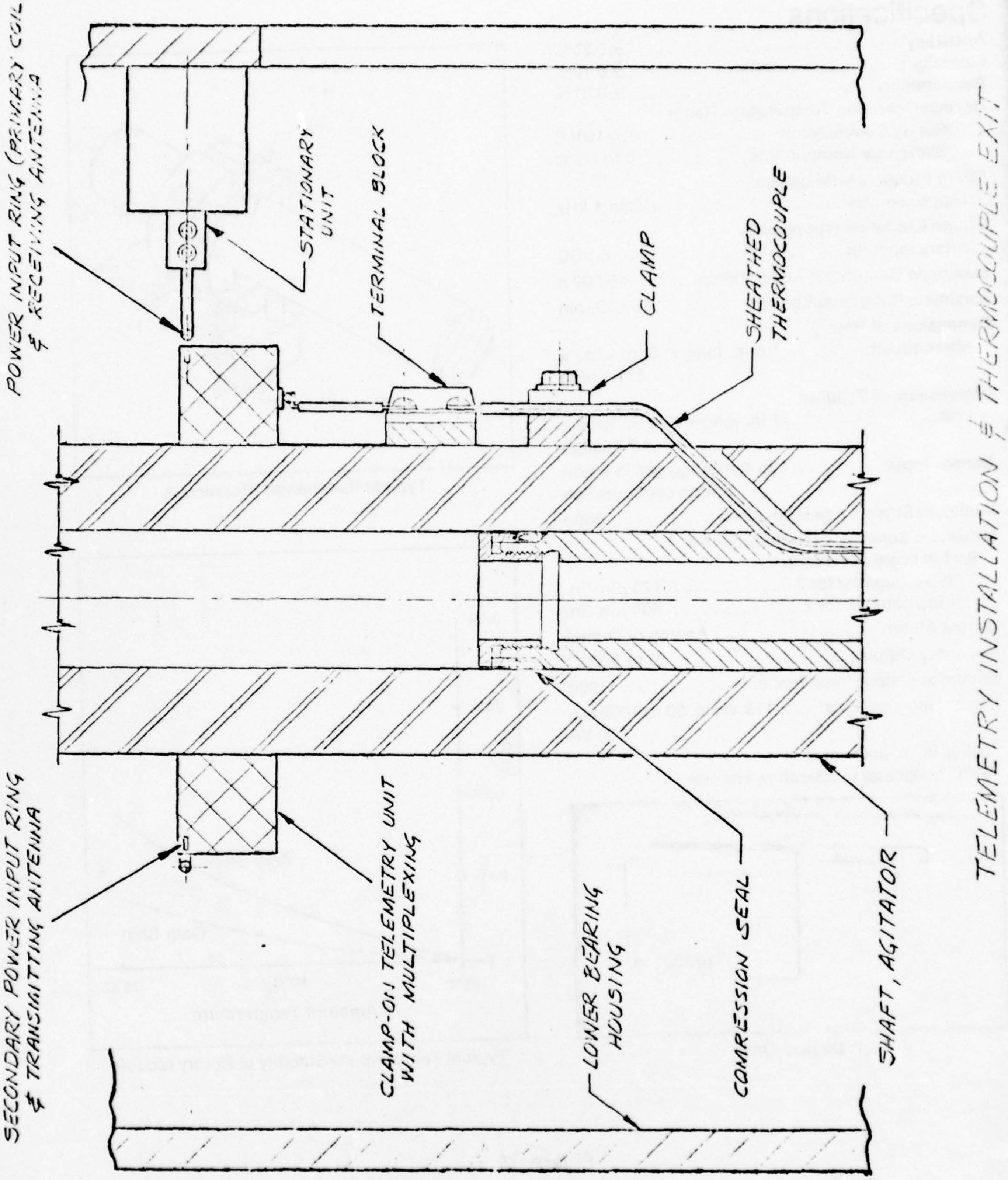
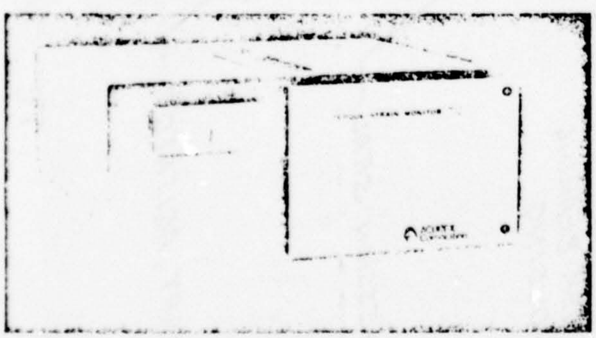

TELEMETRY INSTALLATION & THERMOCOUPLE EXIT
POWER INPUT RING (PRIMARY COIL) & RECEIVING ANTENNA
STATIONARY UNIT
TERMINAL BLOCK
CLAMP
SHEATHED THERMOCOUPLE
SECONDARY POWER INPUT RING & TRANSMITTING ANTENNA
CLAMP-ON TELEMETRY UNIT WITH MULTIPLEXING
LOWER BEARING HOUSING
COMRESSION SEAL
SHAFT, AGITATOR

Figure 14

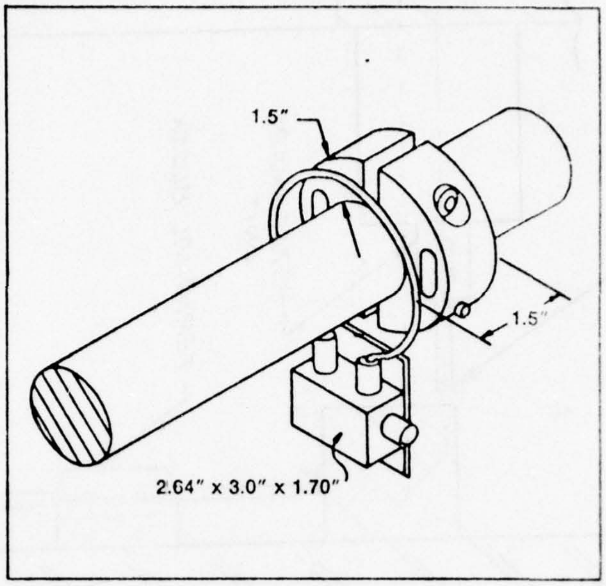
Specifications

Accuracy[1]: .... ±0.25%
Linearity[1]: .... ±0.10%
Repeatability: .... ±0.01%
Normal Operating Temperature Range:
Rotary Components .... 0 to 100°C
Stationary Components .... 0 to 50°C
Strain Frequency Response
(Approximate) .... DC to 1 kHz
Bridge Excitation (supplied by
rotary module): .... 6 VDC
Maximum Centrifugal Acceleration: ...... 15,000 g
Maximum Rotational Speed: .... 15,000 rpm
Dimensions of Rotary
Microcircuit: .... 1.5 in. long x .5 in. wide x .85 in. high
Dimensions of Readout
Unit: .... 11 in. long x 11.1 in. wide x 4.7 in. high
Sensor Input: .... 1 to 4 strain gages in 4-arm bridge configuration
Minimum Strain Gage Resistance 350Ω
Maximum Sensitivity (strain required
for full scale deviation):
350Ω, gage factor 2 .... 175 μin./in.
1 kΩ, gage factor 2 .... 500 μin./in.
Output Meter: .... Analog or Digital
Recorder Output: .... 0 to 5 VDC
Recorder Output Impedance: 100Ω
Power Requirements: .... 115 Vrms, 50 to 1000 Hz, 100 VA

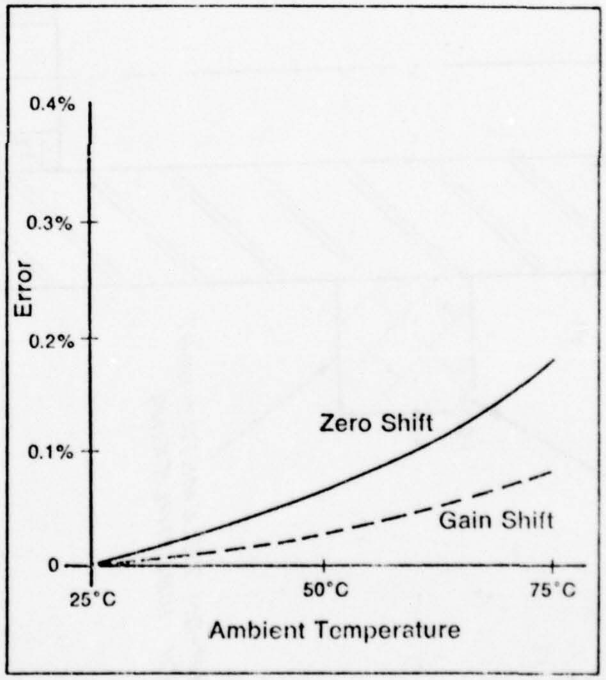
[1] 500 μ-in/in. full scale,
50°C maximum temperature change



Display Unit



Typical Installation Clearances



Typical Temperature Stability of Rotary Module

Figure 15

Figures 16 and 17 show the actual antenna installation. Though temperature is considered the least desirable means to control tritonal batch conditions, knowledge of temperature gradients existing in the existing melt kettle was considered highly desirable. Unfortunately, the sersing system was damaged during the change out of calandrias and it played no part in the mix/melt tests. The contributions of the sensing system were considered insufficient to hold up the program.

C. DRIVE SHAFT TORQUE MEASURING SYSTEM

Many attempts have been made to develop a means of measuring explosive material viscosity on a continuous basis. As shown in Section II, viscosity varies logarithmically with the ratio of TNT melted to unmelted. It is, therefore, a desirable entity for measuring the condition of the batch. A radio telemetry system similar in hardware to that planned for obtaining batch temperatures was mounted on the test kettle. Figure 18 shows the installation of the antenna on the agitator shaft above the rotary steam couplings. Two strain gages were affixed to the shaft 180 degrees apart. A cam actuated electrical limit switch was used to reduce the signal output to that representing shaft strain at one (and only one) point in the rotation cycle. The opening and closing of the switch triggered the data compiler. This was done to remove cyclic strain caused by eccentric movement of the driveline. Forces on the agitator blades created by their passage through the explosive material creates a shaft torque opposite to that created by the drive motor. This counter-rotational force was measured by the strain gages and recorded as a function of the material viscosity.

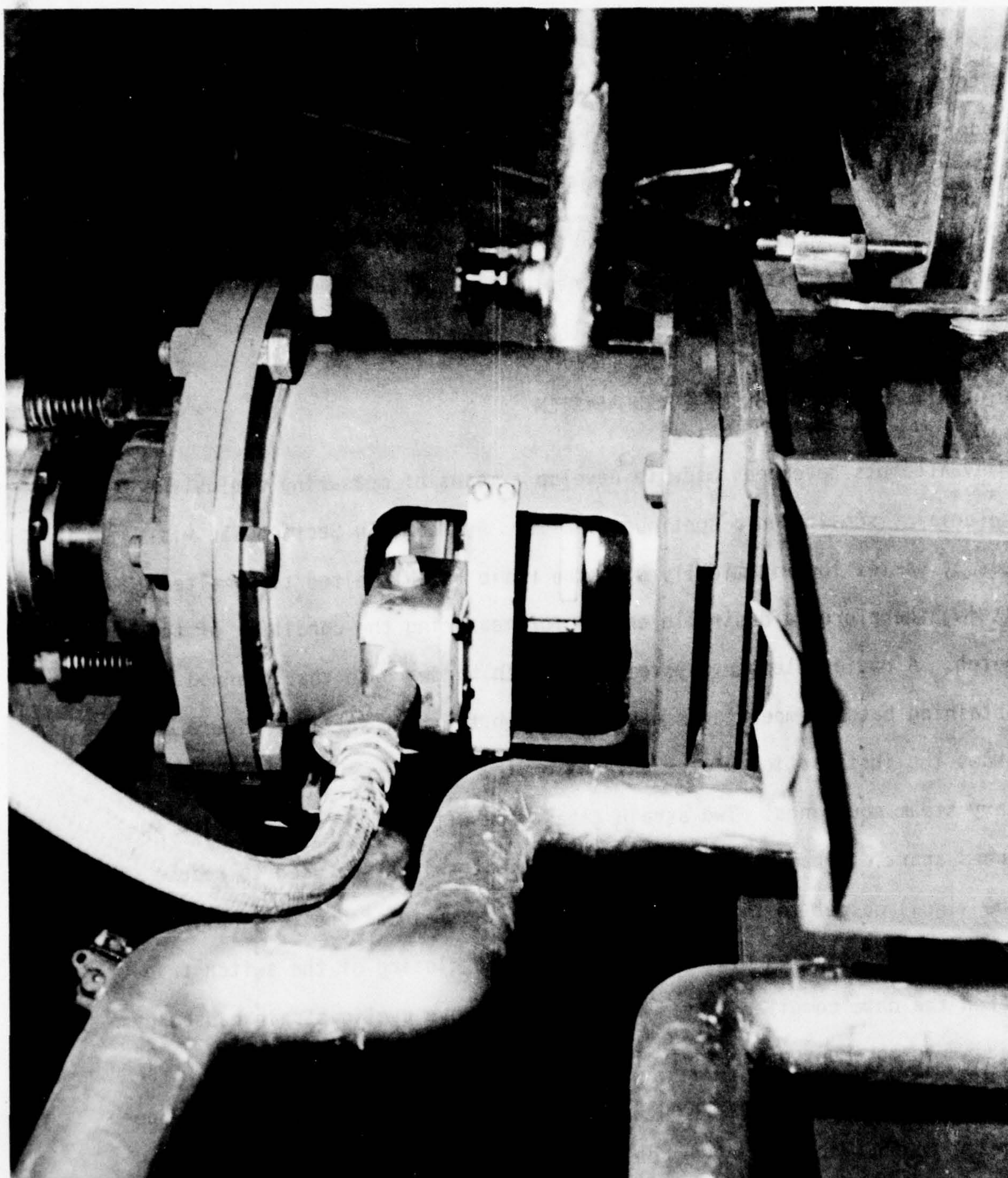


Figure 16

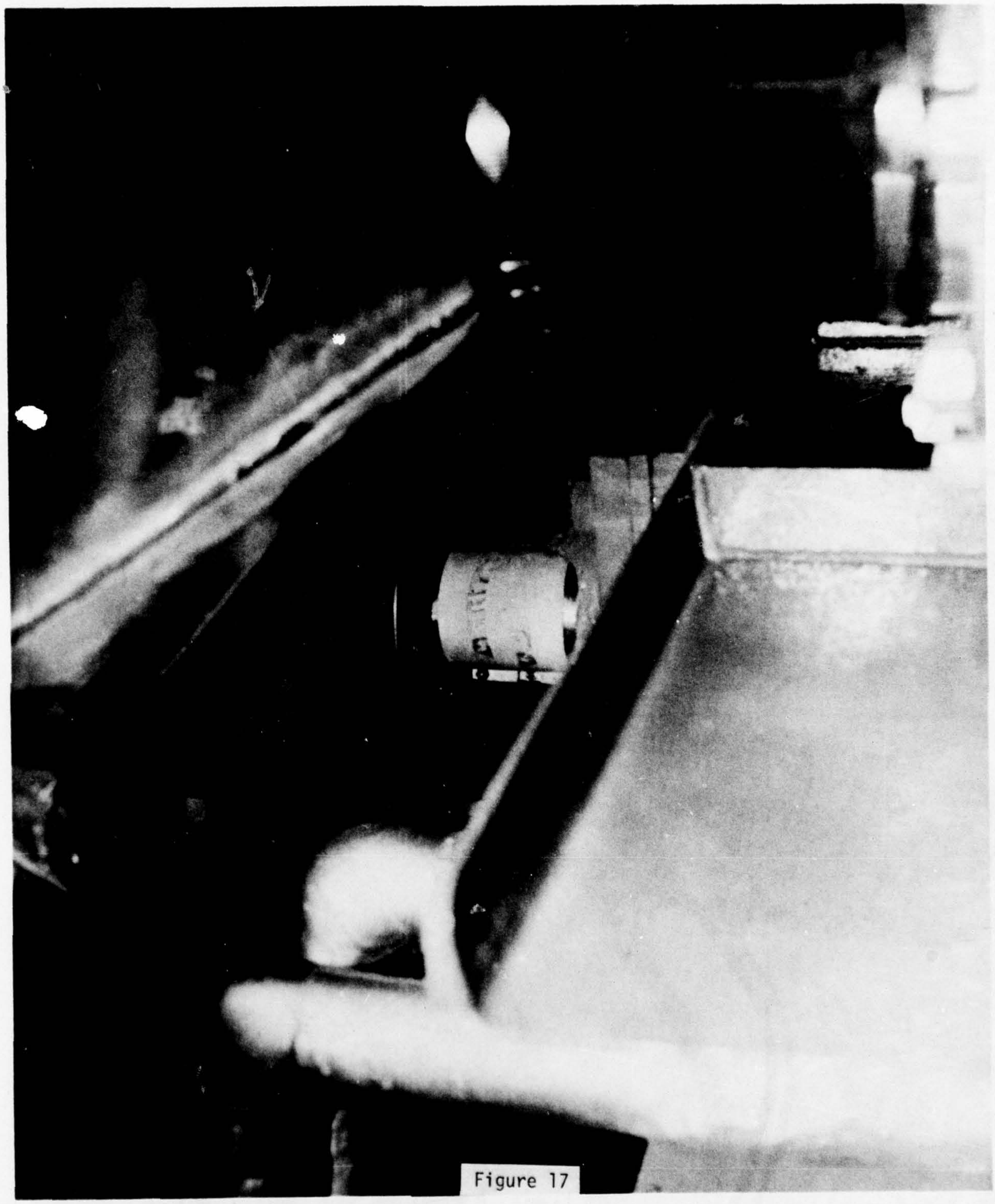


Figure 17

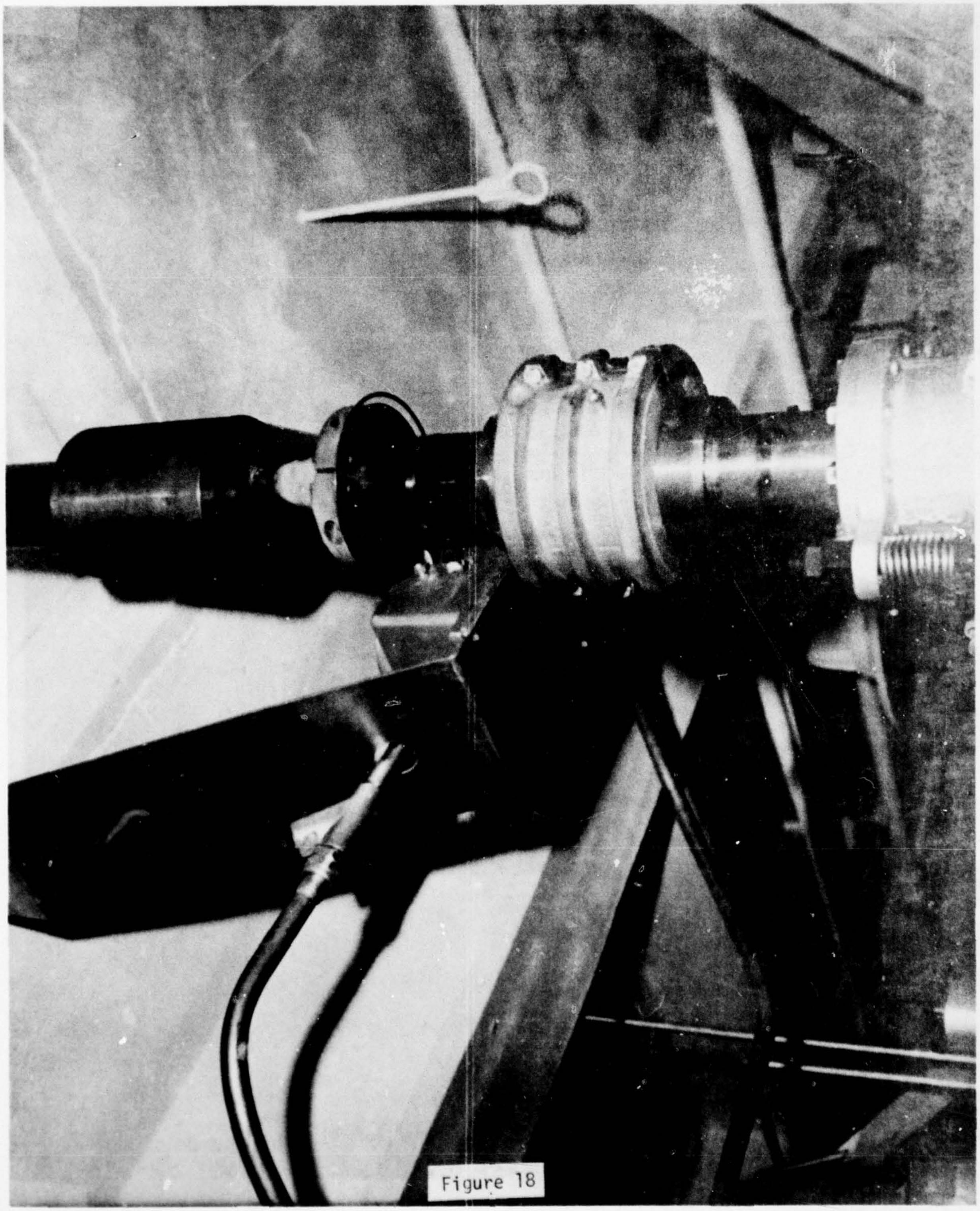


Figure 18

D. GAMMA RAY DENSITY MEASURING SYSTEM

As shown in Section II, the density of TNT based explosives at any point in the molten state is a function of the melted to unmelted TNT ratio and the amount of entrapped air. The higher the percentage of entrapped air, the lower the density of the melted TNT. Likewise, the higher the percentage of melted TNT, the lower the density. A means of measuring these density changes in the test kettle was the intended function of the gamma ray densitometer purchased from Industrial Nucleonics Corporation of Columbus, Ohio. The heart of the system is a 4 curie, cesium-137 source which emits gamma rays through the material whose density is to be measured. As long as the thickness of the material being measured is known and kept constant, its density will be inversely proportional to the amount of radiation reaching a sensitive receiver located on the opposite side of the sample from the source. Figure 19 shows the source and its controls as mounted on the test kettle. Figure 20 shows the detector head in place on the opposite side. Figure 21 shows the total installation. Two 4" diameter tubes were welded onto the kettle to shield the radiation beam. The tubes were cut into the outer jacket of the kettle, welded to the inner bowl, and then welded to the outer jacket to prevent leakage of steam. Limiting the ferrous metal in the beam path improves the efficiency of the density measurements. The source is equipped with a sample plate, equal in density to 20 inches of TNT, which can be pneumatically inserted into the beam path for calibration and to provide a radiation absorbent until the batch material rises above the beam path. Signal output is pneumatic from 0 to 15 psi and is converted to an electrical signal for analysis and recording.

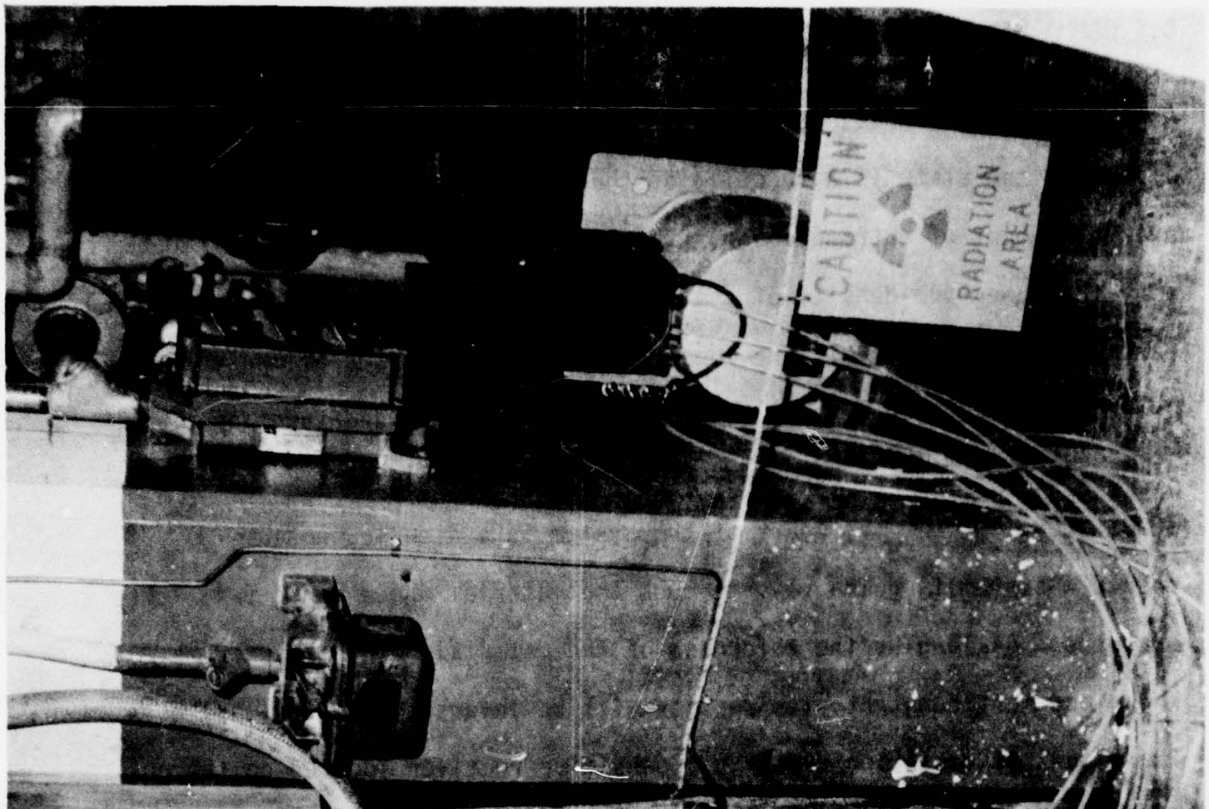


Figure 19

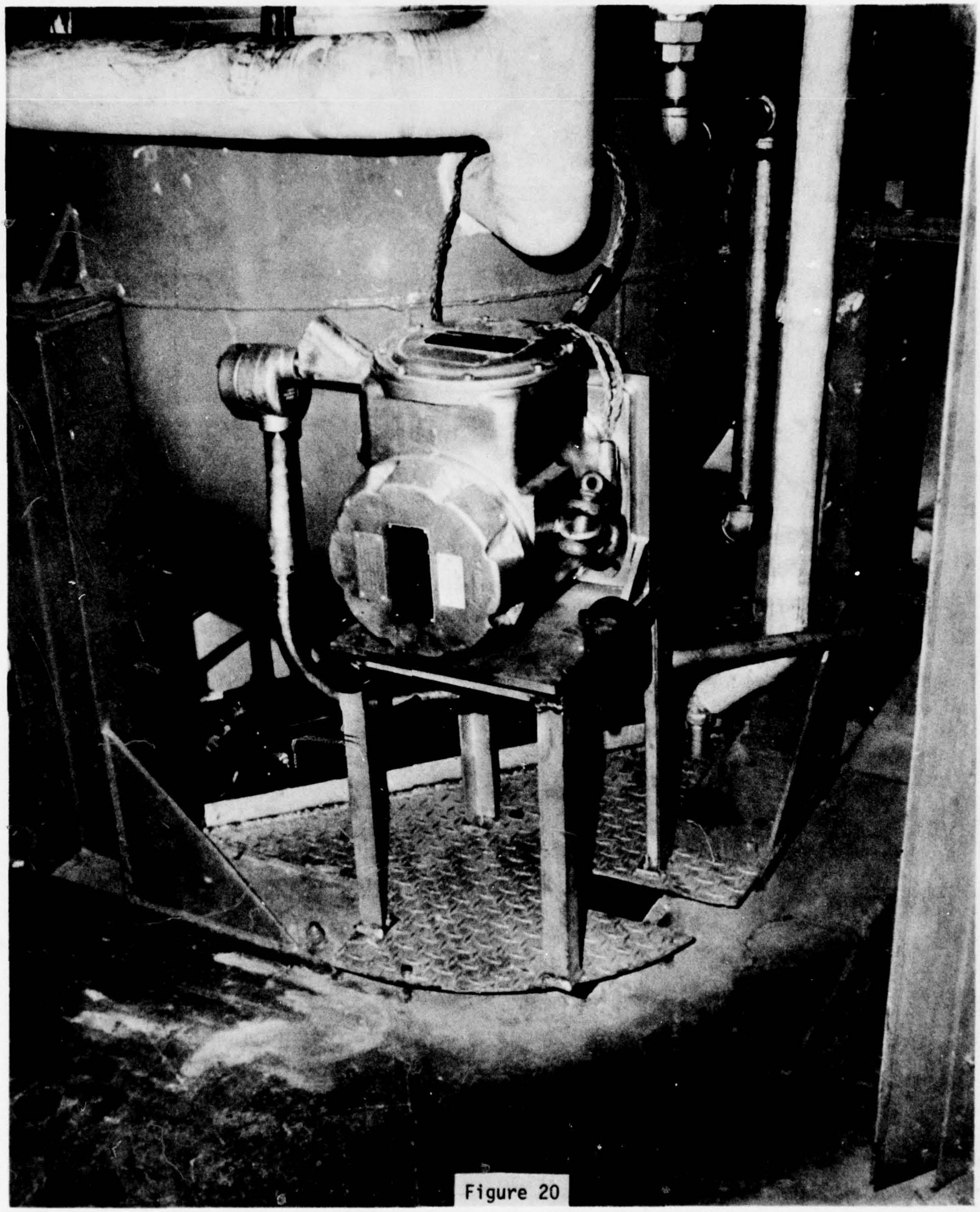


Figure 20

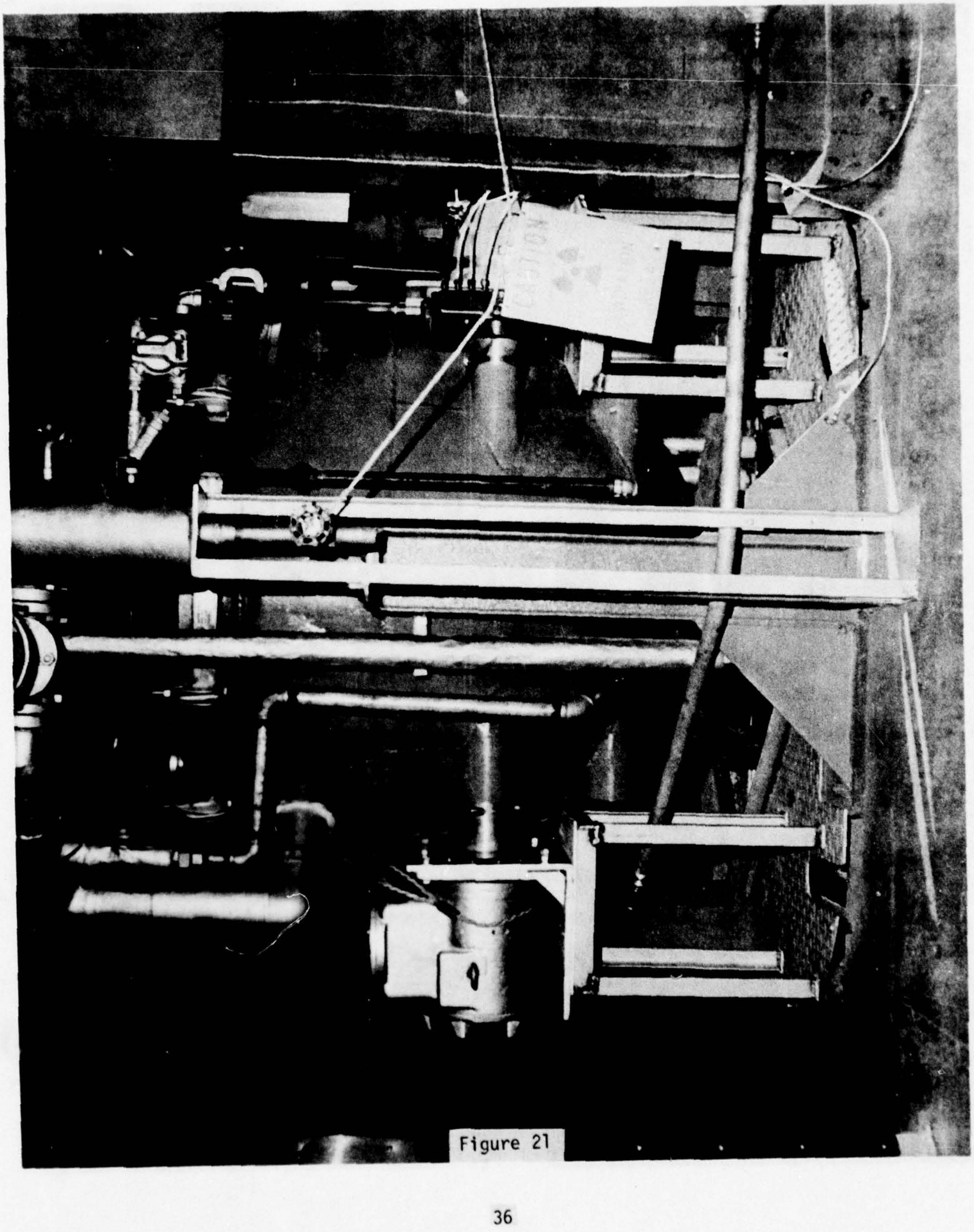


Figure 21

E. THERMAL ENERGY INPUT MEASURING SYSTEM

As shown in Section II, the quantity of TNT that is melted in a batch is a function of the thermal energy provided by the steam. Knowledge of the incoming material temperature, the amount of material, the percent to be melted, and the heat losses through radiation and convection can be used to determine the thermal energy required for a desired batch condition. Measurement and control of the BTUs used can also be a means to produce a desired batch condition. The test kettle was equipped with a Westinghouse BTU calculator designed for steam flow. The calculator is based on the determination of steam flow by measuring the differential pressure across a restriction such as an orfice plate. Flow rate is proportional to the square root of the differential pressure across the orfice. The Westinghouse-Hagen ring balance meter measures the differential pressure and produces an indication of flow rate that is linear over wide ranges with high accuracy. Figure 22 shows the meter case installation with pressure equalizing piping, valves, and blow down lines. The basic meter assembly (shown by the cut-away on Figure 23) consists of (1) a hollow ring sensing element balanced on a knife-edge fulcrum and (2) a precision torque resistant assembly consisting of a push rod and a calibration spring. The ring contains a sealing liquid, the volume and density of which are not critical, and a partition at the top separating the high and low pressure connections. A differential pressure across the partition will produce a torque on the ring causing it to rotate on its fulcrum. As the ring rotates, it moves the push rod against the cantilever type calibration spring until a balance is achieved between the torque produced by the differential pressure measurement and the resisting

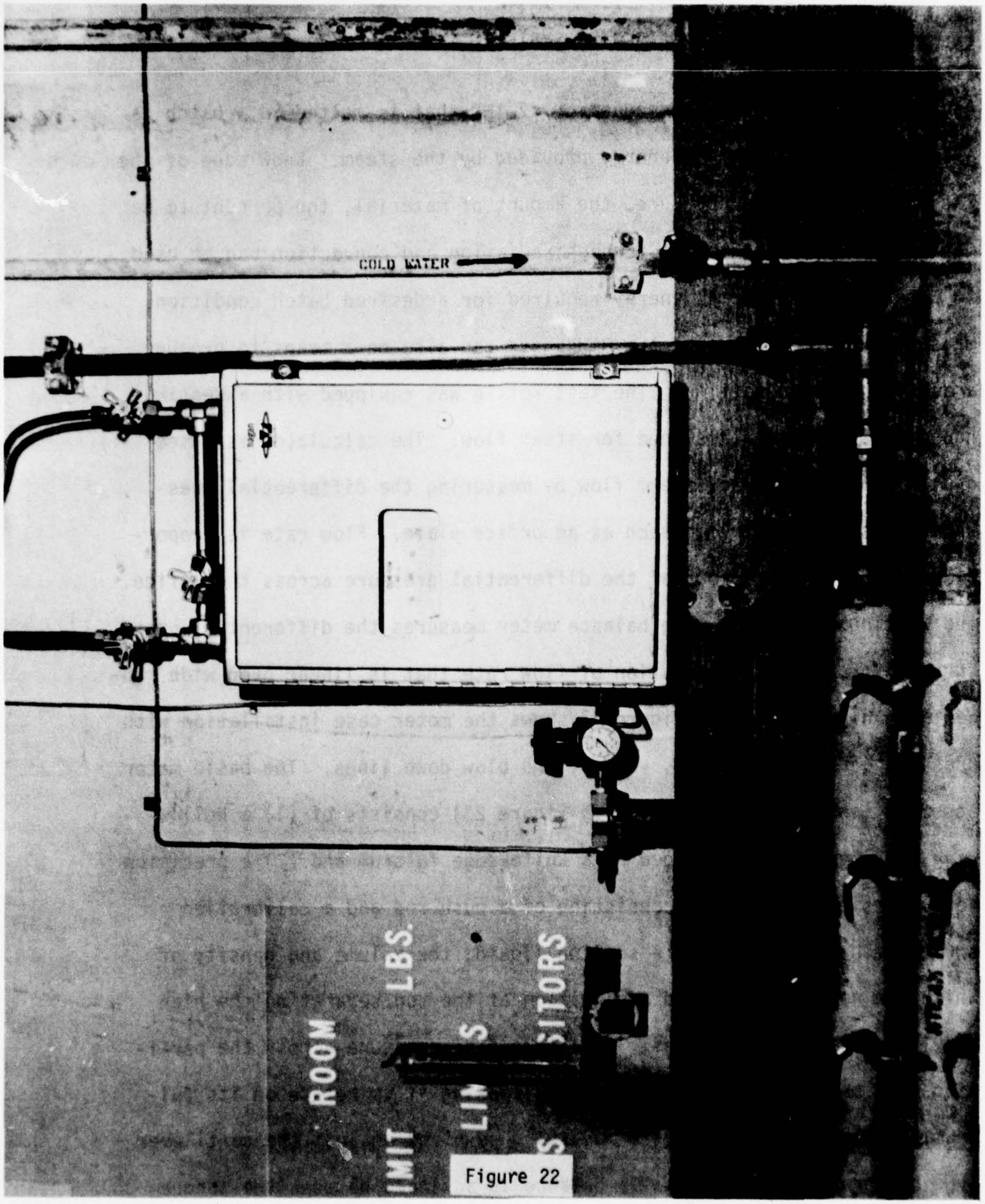


Figure 22

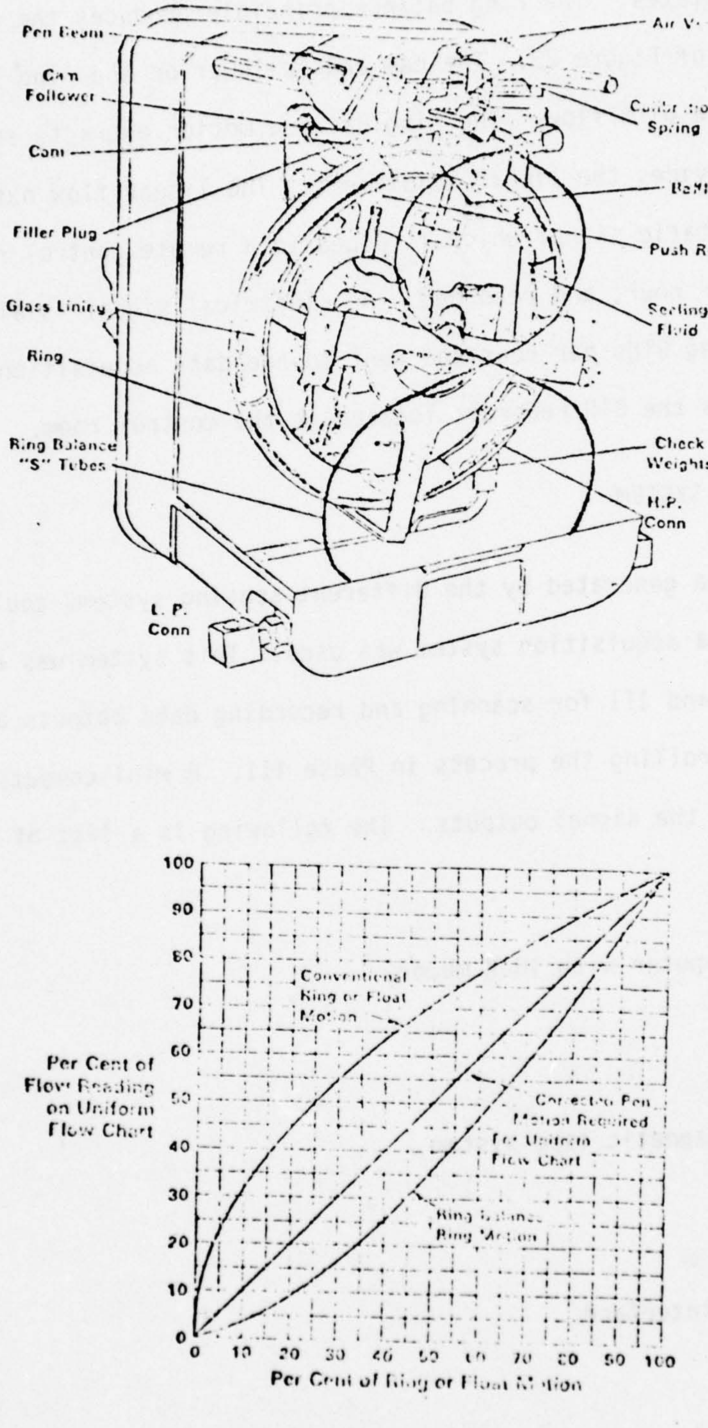

Pen Beam
Cam Follower
Cam
Filler Plug
Glass Lining
Ring
Ring Balance "S" Tubes
L. P. Conn
Air Vents
Calibration Spring
Baffle
Push Rod
Sealing Fluid
Check Weights
H.P. Conn
Conventional Ring or Float Motion
Corrected Pen Motion Required For Uniform Flow Chart
Ring Balance Ring Motion
Per Cent of Flow Reading on Uniform Flow Chart
Per Cent of Ring or Float Motion
0
10
20
30
40
50
60
70
80
90
100

Figure 23

torque produced by the calibration spring on the push rod. The "S" shaped pressure connections to the ring eliminate any effect of these connections on the ring as it rotates. The ring balance principle produces the curve shown at the bottom of Figure 23. The cam and follower on the ring linearize the pen motion with flow. The ring balance motion extracts square root and the cam provides the linear adjustment. The linear flow output is changed to a pneumatic signal which is piped to a remote control room, converted to BTUs per hour, and recorded. An electrical signal is also generated representing BTUs per hour and sent to the data acquisition system. Figure 24 shows the BTU recorder located in the control room.

F. DATA ACQUISITION SYSTEM

In order that the data generated by the different sensing systems couls be made useful, a data acquisition system was used. This system was available in Phases I, II and III for scanning and recording data outputs and additionally for controlling the process in Phase III. A mini-computer was used to condition the signal outputs. The following is a list of the major equipment used:

1. Nova 1220 mini-computer with 16 K memory

2. ASR 33 teletype

3. 2-drive cassette magnetic tape system

4. Real time clock

5. Analog to digital interface

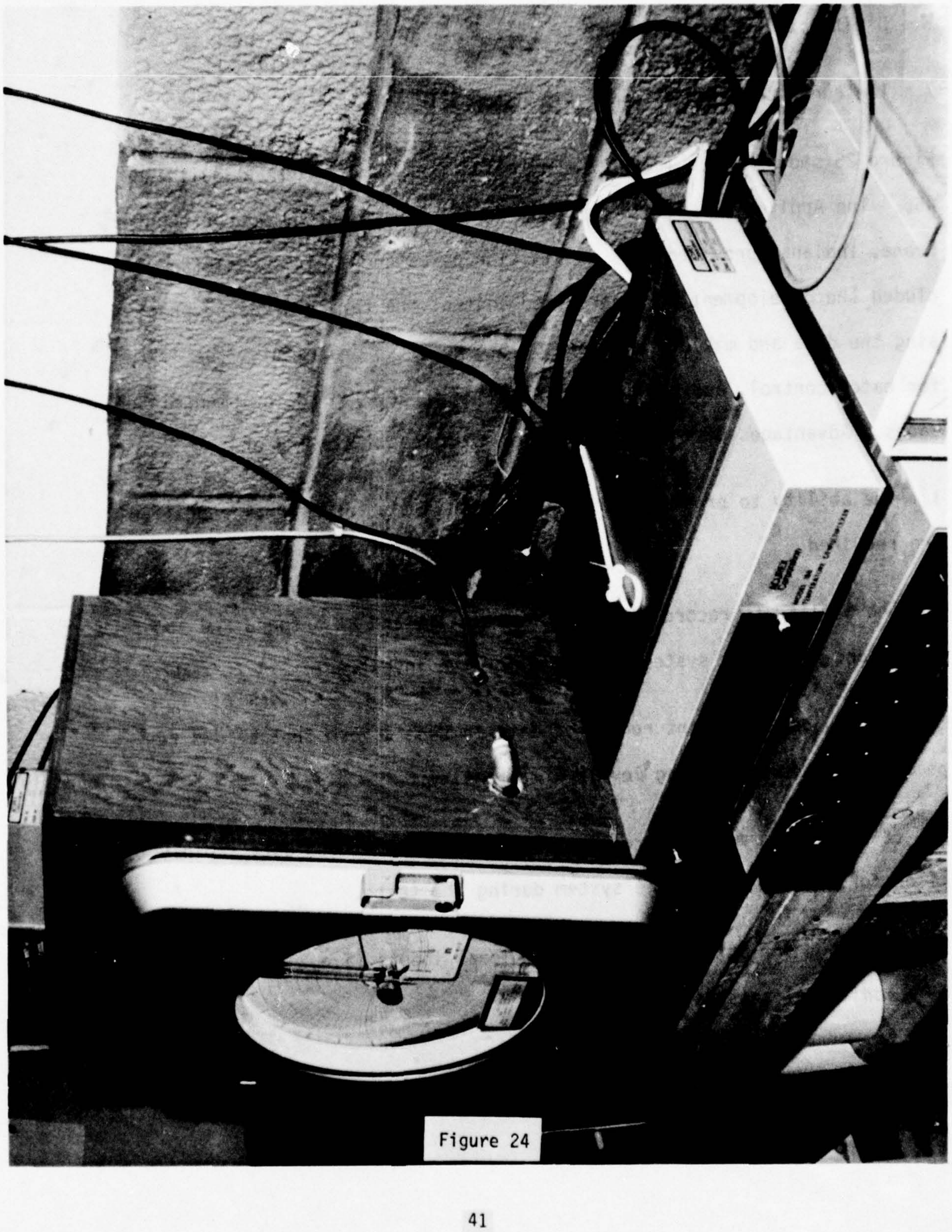


Figure 24

6. Digital to analog interface

7. Tektronix computer display terminal

Figure 25 shows the equipment as installed in a remote room in Building 456. The Applied Sciences Department of the Naval Weapons Support Center, Crane, Indiana, provided data acquisition assistance. This assistance included the development of programs to control the taking of data, processing the data and making hard copy of the results, programming the system for batch control, and providing assistance in developing equipment interfaces. Advantages of the mini-computer system as installed are:

1. The ability to program into the data collection any signal conditioning required.

2. The ability to record all data in real time and at a speed and accuracy far beyond any other system available for the investment.

3. It provides permanant record of data in such a form that allows repeated analyses at varying levels of intensity.

4. It provides a means to reduce, analyze, and print out data rapidly to allow for adjustments in the system during the tests.

5. It allows for introduction of additional inputs (i.e., kettle operator, additional sensors) as required.

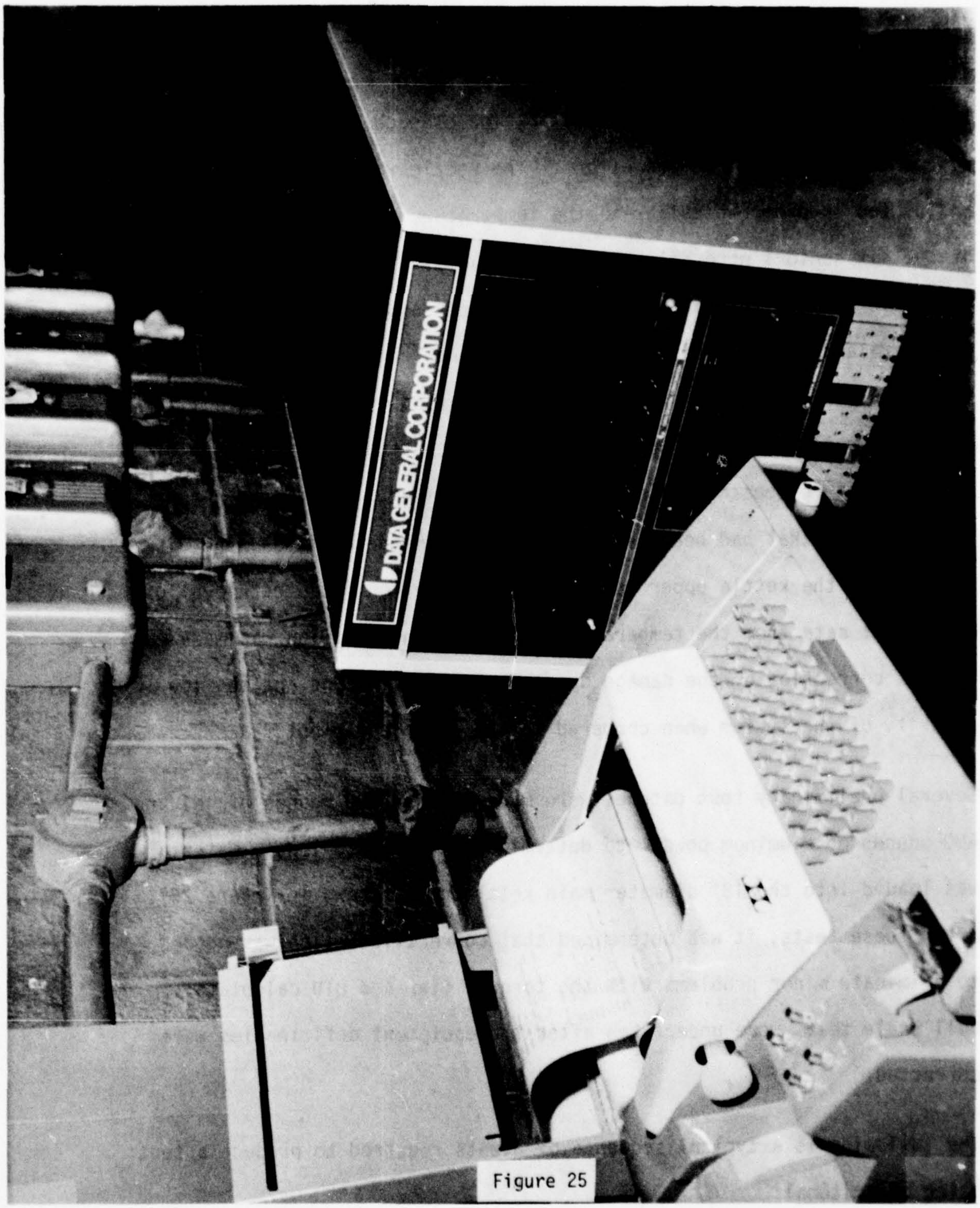


Figure 25

V. PHASE I TESTS

The installation, checkout, and calibration of each sensing system required considerable time and effort. The kettle was filled with water and heated in order to calibrate the temperature sensing system. Five of the six sensors were calibrated effectively. One sensor would not calibrate and was turned off. In order to correct problems with the kettle calandria which had been installed incorrectly when purchased in 1970, the kettle lid, drive shaft, and bearings were temporarily removed and replaced. This unforseen maintenance required disruption of the temperature sensing radio transmitter/receiver. Due to the nature of the wiring that had been factory installed in the agitator, the dismantling of the kettle upper works disrupted the continued retrieval of consistent data from the temperature sensors. The decision was made not to seek correction of the damage due to time restrictions and the low priority of the system when compared to the other equipment.

Several preliminary test batches were made using 2,400 pounds of TNT and 600 pounds of aluminum powder to determine any short comings. Material was loaded into the 18" diameter main kettle port (shown in Figure 26). After these tests, it was determined that corrective action was needed to eliminate minor problems with the torque meter and BTU calculator. Full scale tests were undertaken after the equipment deficiencies were corrected.

The following is a typical sequence of events required to produce a test batch of tritonal:

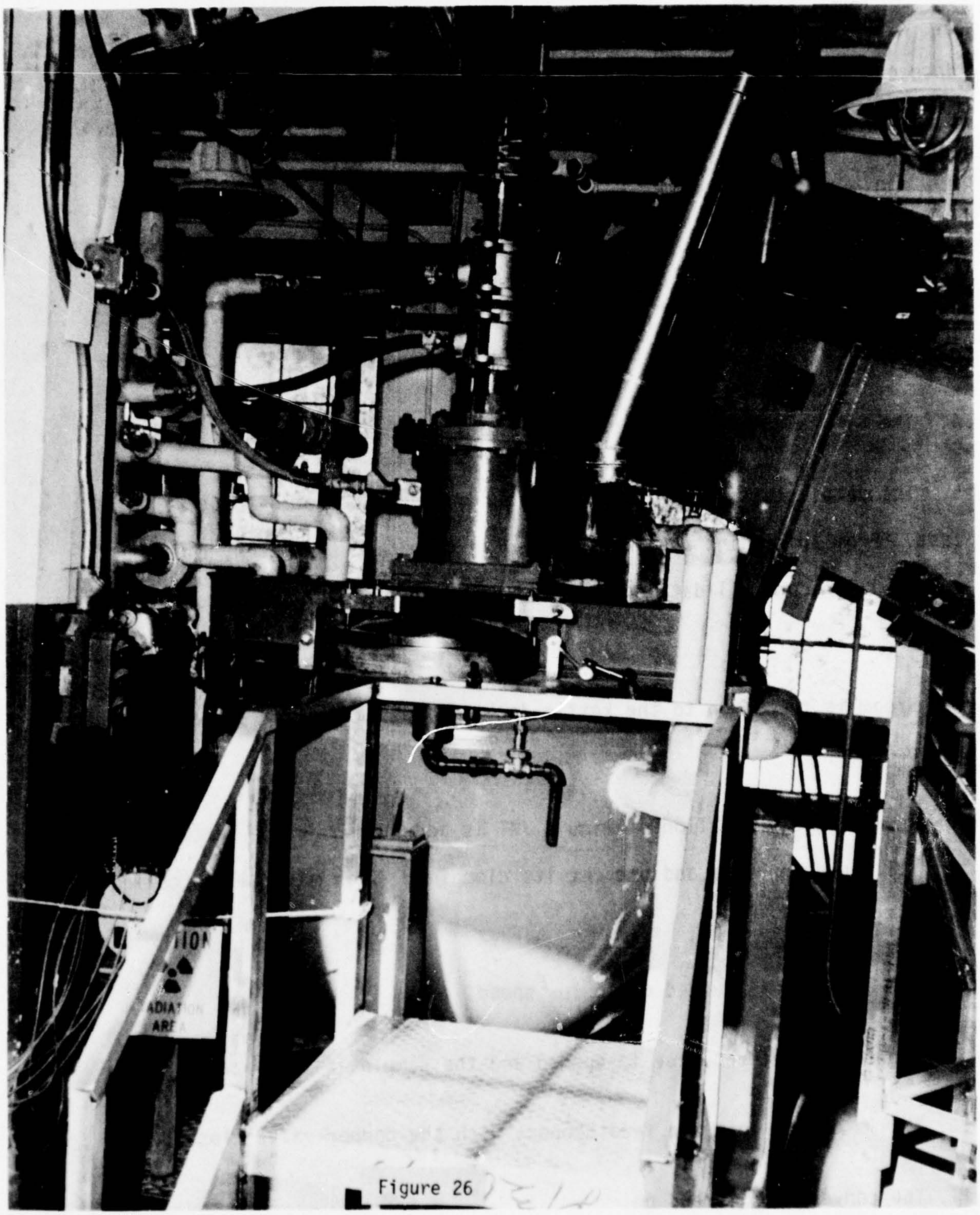


Figure 26

1. 2,400 pounds of TNT flake must be unboxed and screened by hand to reduce or remove lumps which could clog the material handling system. The screened flake is placed in 50 pound capacity aluminum boxes.

2. 600 pounds of aluminum powder are emptied into 50 pound capacity aluminum boxes.

3. All materials are stored in Building 456 overnight to normalize temperature.

4. The BTU calculator is zeroed prior to steam being turned on.

5. The data acquisition system is turned on and instructed to start the test. From this point until instructed to terminate the batch, the computer will record all data on tape and print all channel outputs each minute.

6. Steam is turned on to the kettle jacket, lid, calandria, and agitator for preheat.

7. Approximately a gallon of liquid TNT is added through the kettle port to fill the dump valve and prevent its clogging. This material is called a "heel."

8. The agitator is turned on to low speed.

9. The densitometer source is opened and the sample is in place.

10. TNT is dumped into the feed hoppers with the hopper valve closed.

11. The conveyor is turned on.

12. The TNT metering system is set and actuated.

13. TNT enters the kettle.

14. AL powder is added through main kettle port.

15. Steam is turned off kettle jacket, lid, calandria, and agitator at operator's discretion.

16. Steam is turned on and off to jacket as required.

17. When material in kettle rises above densitometer beam, sample is removed.

18. When all material is in the kettle, the operator indicates for the record when batch appears acceptable.

19. The batch is held in the kettle for an extended period of time at the discretion of the test officer.

20. Explosive material is emptied from kettle and disposed of by burning.

21. The data acquisition system is instructed to terminate the test batch.

The limited availability of TNT for testing, the large quantity required for each test, and the need to dispose of the batch by burning required intensive information gathering from as few tests as practical. Three full scale tests were thus run and the results analyzed.

Tritonal Test Batch 1

The batch was comprised of 2,400 pounds of TNT and 600 pounds of AL powder. The TNT was not screened for lumps prior to introduction into the material handling system. Major events during the batch were recorded and this sequence is shown on Figure 27. Sensing equipment in operation for the test

Batch 1 Event Sequence

15 November 1976

(In Minutes) Batch Time	Real Time	Event
0	1312.00	TNT addition begins. Agitator on high speed
9.00	1321.00	Steam turned off to jacket
33.00	1345.00	TNT added through kettle port as hopper has clogged. Steam on.
42.00	1354.00	Steam off to jacket
44.00	1356.00	Steam on to jacket for 20 seconds
50.00	1402.00	Steam to calandria turned off
54.00	1406.00	Batch ready for use
58.00	1410.00	Steam on to jacket
60.00	1412.00	Steam off
65.00	1417.00	Steam on
66.00	1418.00	Steam off
73.00	1425.00	Steam on
74.00	1426.00	Steam off
78.00	1430.00	Material dropped from kettle

Figure 27

included the torque meter, densitometer, and the BTU calculator. Output of the torque meter is shown on Figure 28. Material began entering the kettle at time zero causing the torque to rise accordingly through the period marked (a). The low point marked (b) occurred because the melting rate of the TNT exceeded the entry of new material into the batch. The sharp rise from point (b) to (c) was the result of aluminum powder being added which reduced the liquid TNT quantity. The same condition occurs between points (c) and (d) as from (a) to (b). Aluminum powder was added at point (d). TNT clogged the hopper outlet prior to point (d) and filling was then shifted to the main kettle using 50 pound increments. The torque experienced during the period (f) exceeded the limits of the data recording system without a change in "gain." Data was retrieved directly from the torque meter amplifier (no tape record available) which has shown torque outputs exceeding seven volts. The same peaks and valleys as found earlier exist during the period (f). The batch was certified by the operator as being acceptable at point (g). The torque from this point onward to the point (j) where the material was dropped from the kettle moves steadily downward. The drop in torque at points (h) and (i) was caused by the addition of steam to the jacket. The downward movement of torque readings after point (j) is caused by the draining of material from the kettle.

The densitometer plot for Test 1 is shown on Figure 29. During the period (2a), the density increased as the material in the kettle rose above the beam path. The attenuation sample was also in the beam path. At point (2b), the sample was removed because the density created output signal was nearing five volts which exceeds equipment capabilities. The sample withdrawal caused the densitometer to give readings of zero for the next 40 minutes

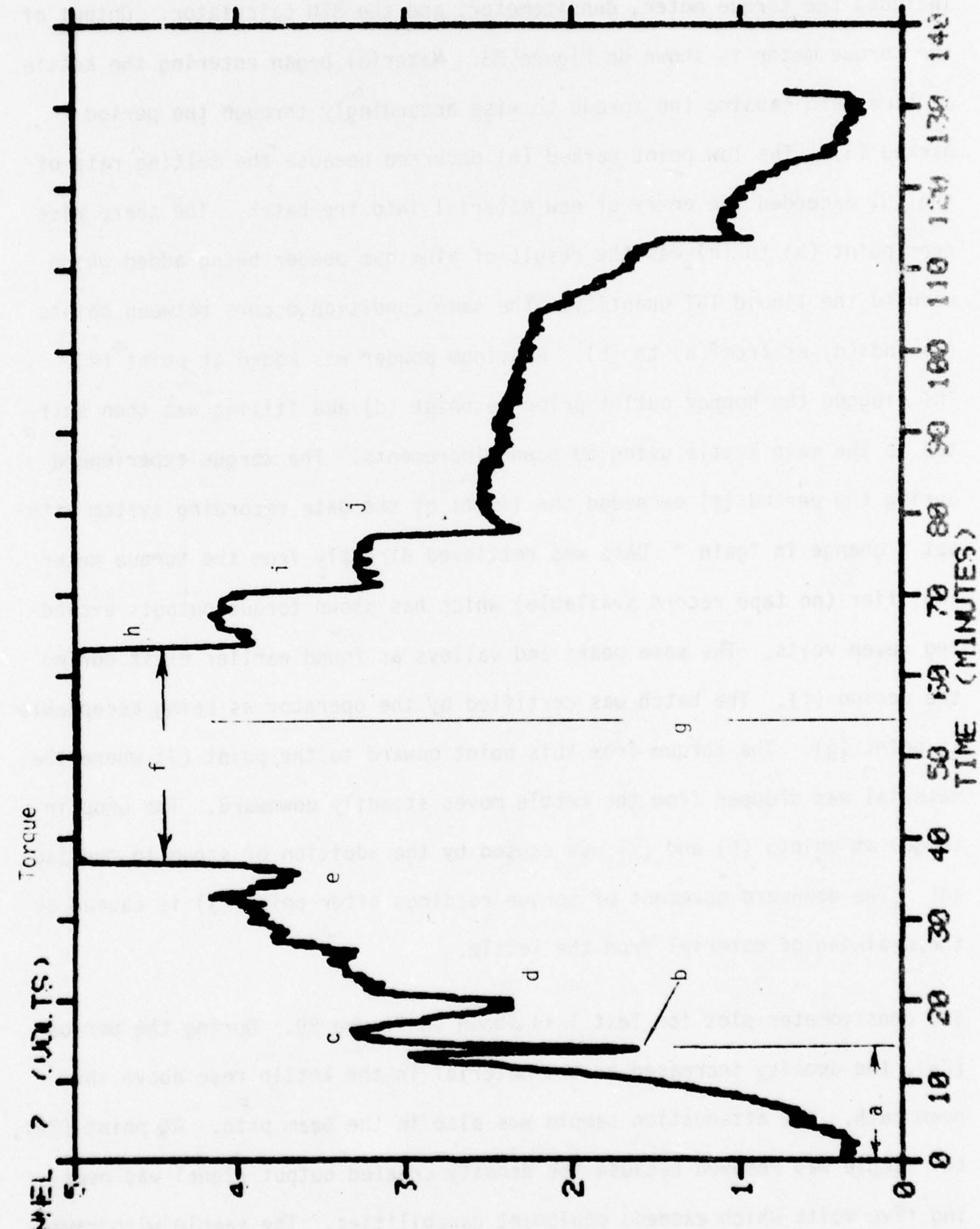

Batch #1
Torque
CHANNEL 7 (VOLTS)
TIME (MINUTES)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
0
1
2
3
4
5
a
b
c
d
e
f
g
h
i
j

Figure 28

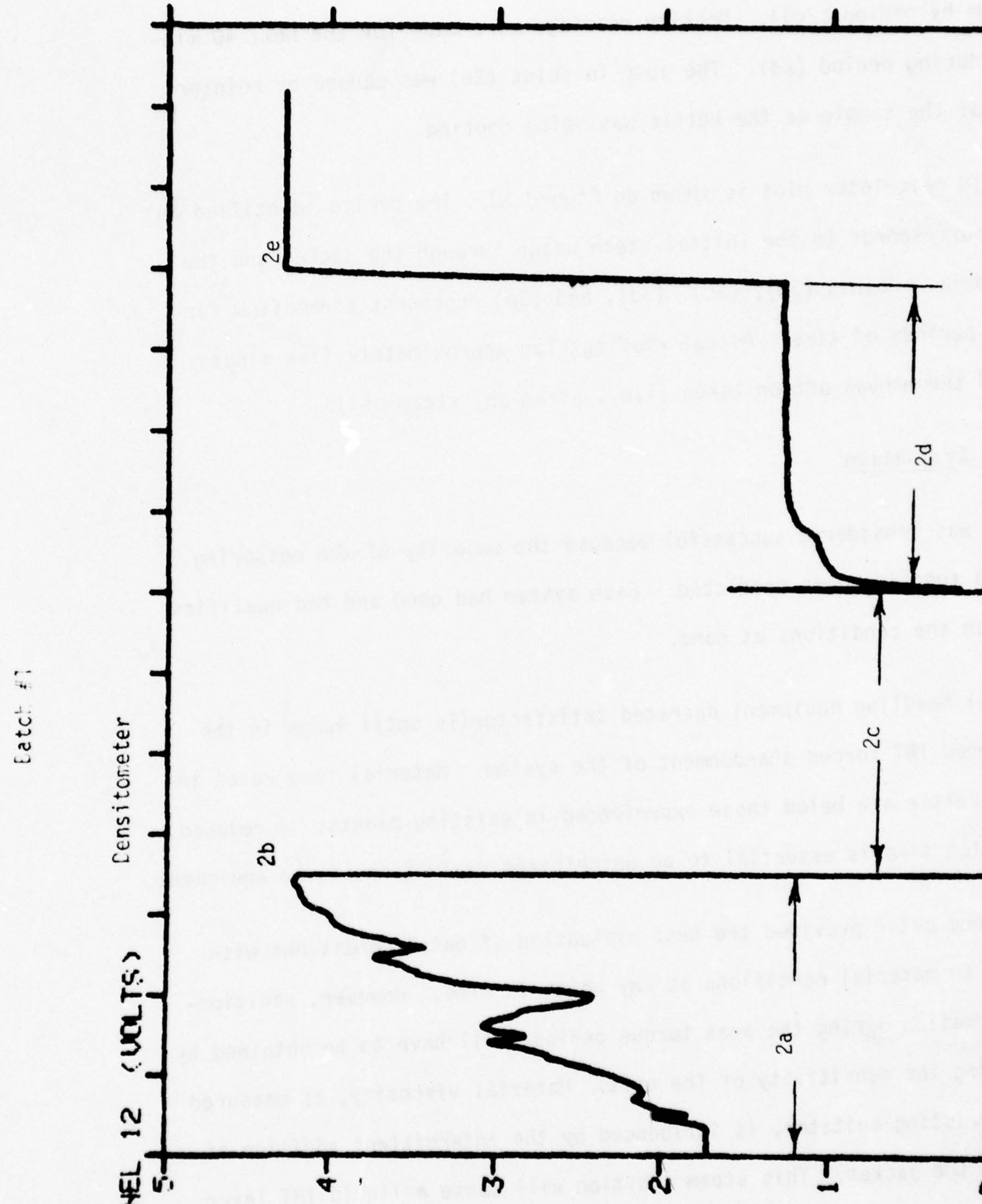

Batch #1
Densitometer
CHANNEL 12 (VOLTS)
TIME (MINUTES)
2a
2b
2c
2d
2e
0
1
2
3
4
5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

Figure 29

(shown by period (2c)). Density readings were made for the next 40 minutes during period (2d). The jump to point (2e) was caused by reinsertion of the sample as the kettle was being emptied.

The BTU calculator plot is shown on Figure 30. The period identified as (3a) corresponds to the initial steam usage through the jacket and the calandria. Points (3b), (3c), (3d), and (3e) represent steam flow for short periods of time. Actual readings lag approximately five minutes behind the manual action taken (i.e., steam on, steam off).

Test 1 Evaluation

Test 1 was considered successful because the majority of the measuring systems functioned as predicted. Each system had good and bad qualities based on the conditions at hand.

Material handling equipment operated satisfactorily until lumps in the unscreened TNT forced abandonment of the system. Material feed rates into the kettle are below those experienced in existing plants. A reduced test batch time is essential to an uninhibited evaluation of the equipment.

The torque meter provided the best evaluation of batch conditions with regards to material conditions at any point in time. However, additional information during the peak torque periods will have to be obtained by decreasing the sensitivity of the unit. Material viscosity, as measured by the existing agitator, is influenced by the intermittent addition of steam to the jacket. This steam addition will cause a liquid TNT layer to be created between the agitator blade and the kettle wall. Torque decreases rapidly for a short period of time until unmelted TNT can be mixed

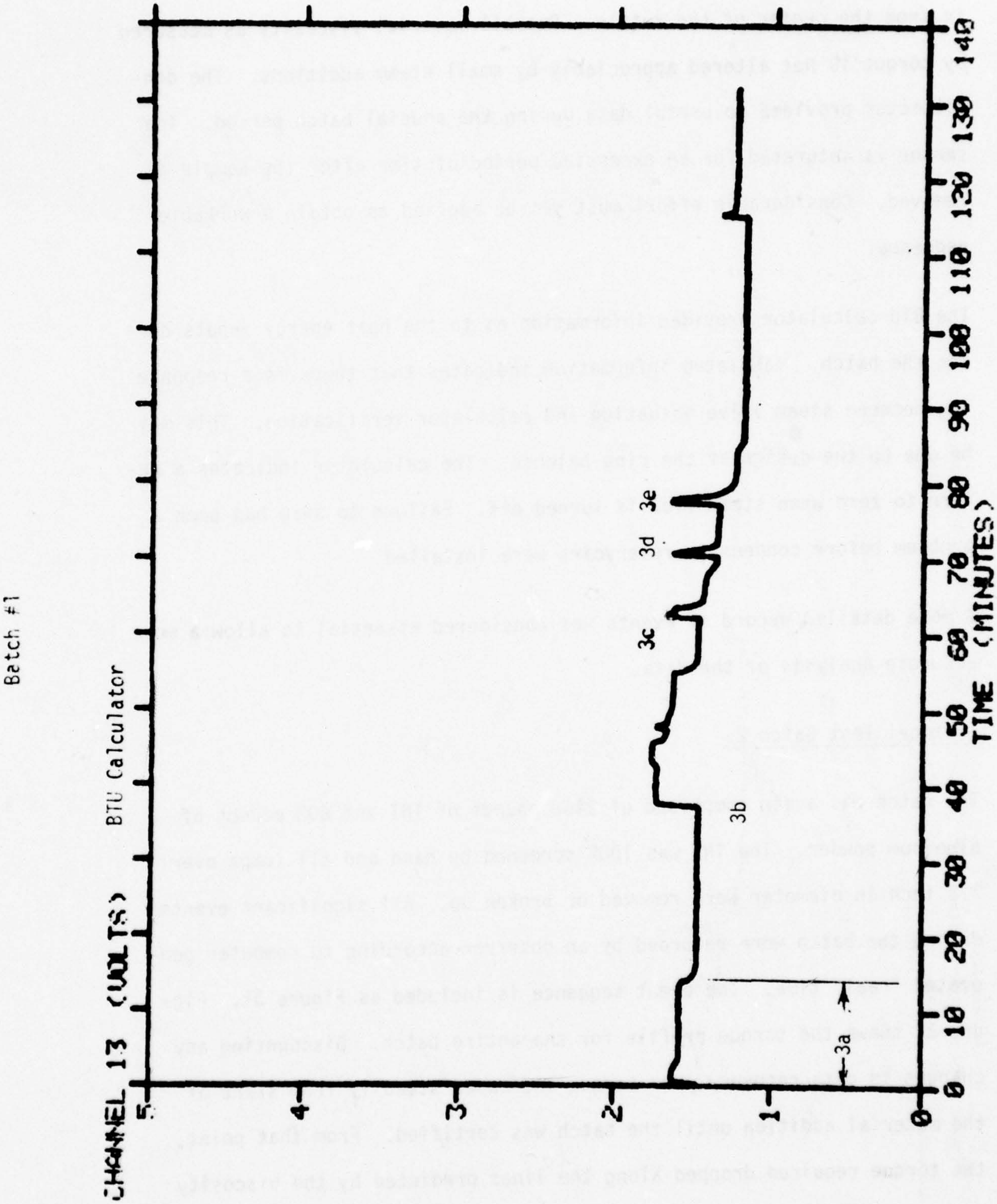

Batch #1
BTU Calculator
CHANNEL 13 (VOLTS)
TIME (MINUTES)
0
1
2
3
4
5
10
20
30
40
50
60
70
80
90
100
110
120
130
140
3a
3b
3c
3d
3e

Figure 30

in from the center of the kettle. Overall material viscosity as measured by torque is not altered appreciably by small steam additions. The densitometer provided no useful data during the crucial batch period. The sensor is saturated for an excessive period of time after the sample is removed. Considerable effort must yet be applied to obtain a workable sequence.

The BTU calculator provided information as to the heat energy inputs during the batch. Tabulated information indicates that there is a response lag between steam valve actuation and calculator verification. This may be due to the design of the ring balance. The calculator indicates a return to zero when steam flow is turned off. Failure to zero had been a problem before condensate reservoirs were installed.

A more detailed record of events was considered essential to allow a more accurate analysis of the data.

Tritonal Test Batch 2

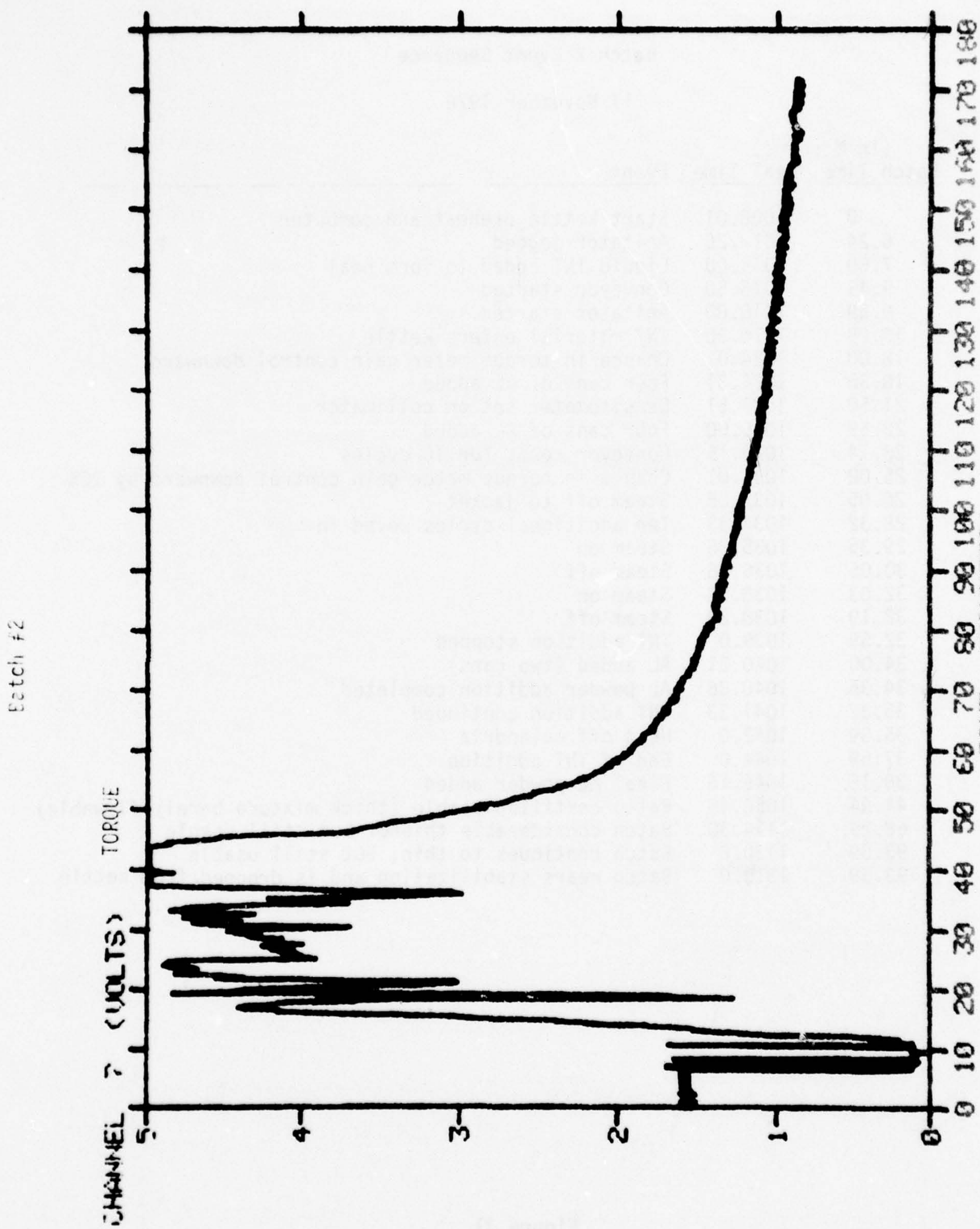
The batch was again comprised of 2400 pounds of TNT and 600 pounds of aluminum powder. The TNT was 100% screened by hand and all lumps over 1/2 inch in diameter were removed or broken up. All significant events during the batch were recorded by an observer according to computer generated "real" time. The event sequence is included as Figure 31. Figure 32 shows the torque profile for the entire batch. Discounting any changes in data recovery, the torque increased steadily from start of the material addition until the batch was certified. From that point, the torque required dropped along the lines predicted by the viscosity

Batch 2 Event Sequence

17 November 1976

Batch Time (In Minutes)	Real Time	Event
0	1006.01	Start kettle preheat and computer
6.24	1012.25	Agitator jogged
7.59	1014.00	Liquid TNT added to form heal
9.49	1015.50	Conveyor started
9.59	1016.00	Agitator started
10.29	1016.30	TNT material enters kettle
18.00	1024.01	Change in torque meter gain control downward
18.30	1024.31	Four cans of AL added
21.50	1027.51	Densitometer set on collimator
22.59	1029.00	Four cans of AL added
23.14	1029.15	Conveyor reset for 10 cycles
25.00	1031.01	Change in torque meter gain control downward by 20%
26.05	1032.06	Steam off to jacket
28.32	1034.33	Ten additional cycles keyed in
29.35	1035.36	Steam on
30.05	1036.06	Steam off
32.03	1038.04	Steam on
32.19	1038.20	Steam off
32.59	1039.0	TNT addition stopped
34.00	1040.01	AL added (two cans)
34.35	1040.36	AL powder addition completed
35.32	1041.33	TNT addition continued
35.59	1042.0	Heat off calandria
37.59	1044.0	End of TNT addition
38.15	1045.16	Final AL powder added
44.44	1050.45	Batch certified usable (thick mixture barely flowable)
68.29	1114.30	Batch considerable thinner but still usable
93.59	1130.0	Batch continues to thin, but still usable
193.59	1310.0	Batch nears stabilization and is dropped from kettle

Figure 31



Batch #2
TORQUE
CHANNEL 7 (VOLTS)
TIME (MINUTES)
0
1
2
3
4
5
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

Figure 32

equation of Section II. Figure 33 displays the torque changes through the critical first 50 minutes of the test. TNT enters the kettle from the conveyor commencing at point (a). The gain control was turned down at point (b) to prevent the readings from going off scale. The sharp rise following point (b) is due to the addition of aluminum powder. The peak at (c) and the fall to (d) was caused by the melting of TNT exceeding the feed rate of unmelted to maintain the high viscosity. The area from point (e) to point (g) was a steady rise in torque due to a constant feed rate of TNT. The drop at (f) was a second change in the gain control. The drop at points (g) and (h) was due to momentary additions of steam to the kettle jacket. The drop marked (i) was due to the stoppage of TNT addition. One hundred pounds of aluminum powder were added at point (j). Melting took over during the drop at (k). TNT addition began again at point (l) causing the torque to exceed instrument capacity at (m). Steam was also turned off calandria, lid, and agitator. Point (n) corresponds to the completion of TNT addition and the loading of the last 100 pounds of aluminum powder. The batch was certified usable by the operator at point (o). The torque dropped rapidly after point (o) until the material was dropped from the kettle 194 minutes after the test began. The densitometer plot is shown on Figure 34. TNT is shown entering the beam path at point (2a). The sample was removed at point (2b) and all readings are zero until point (2c). Unfortunately, the critical batch conditions occurred between points (2b) and 2c).

The BTU calculator plot for Test 2 is shown on Figure 35. Area (3a) corresponds with the kettle preheat period. Area (3b) is a natural taper

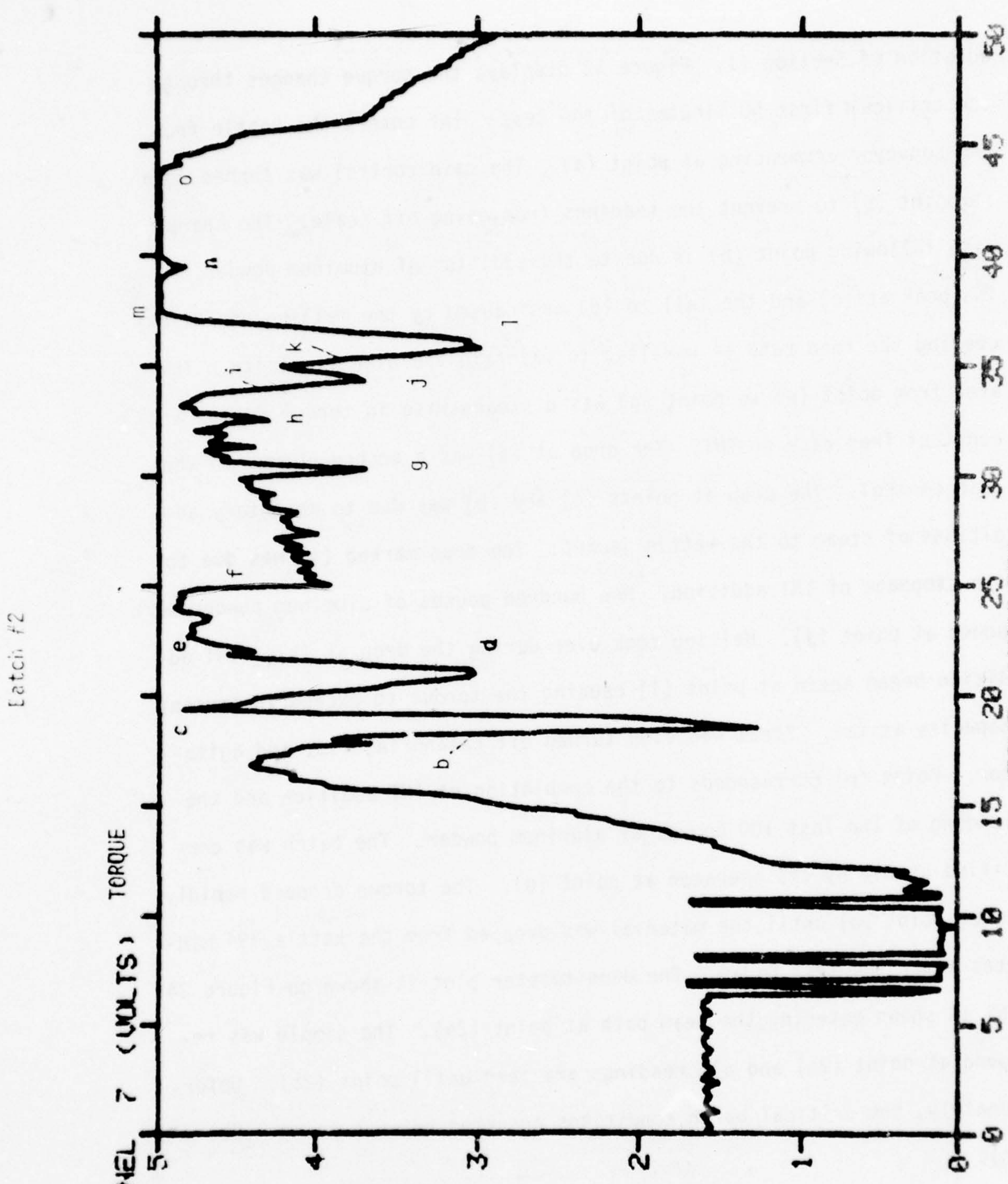
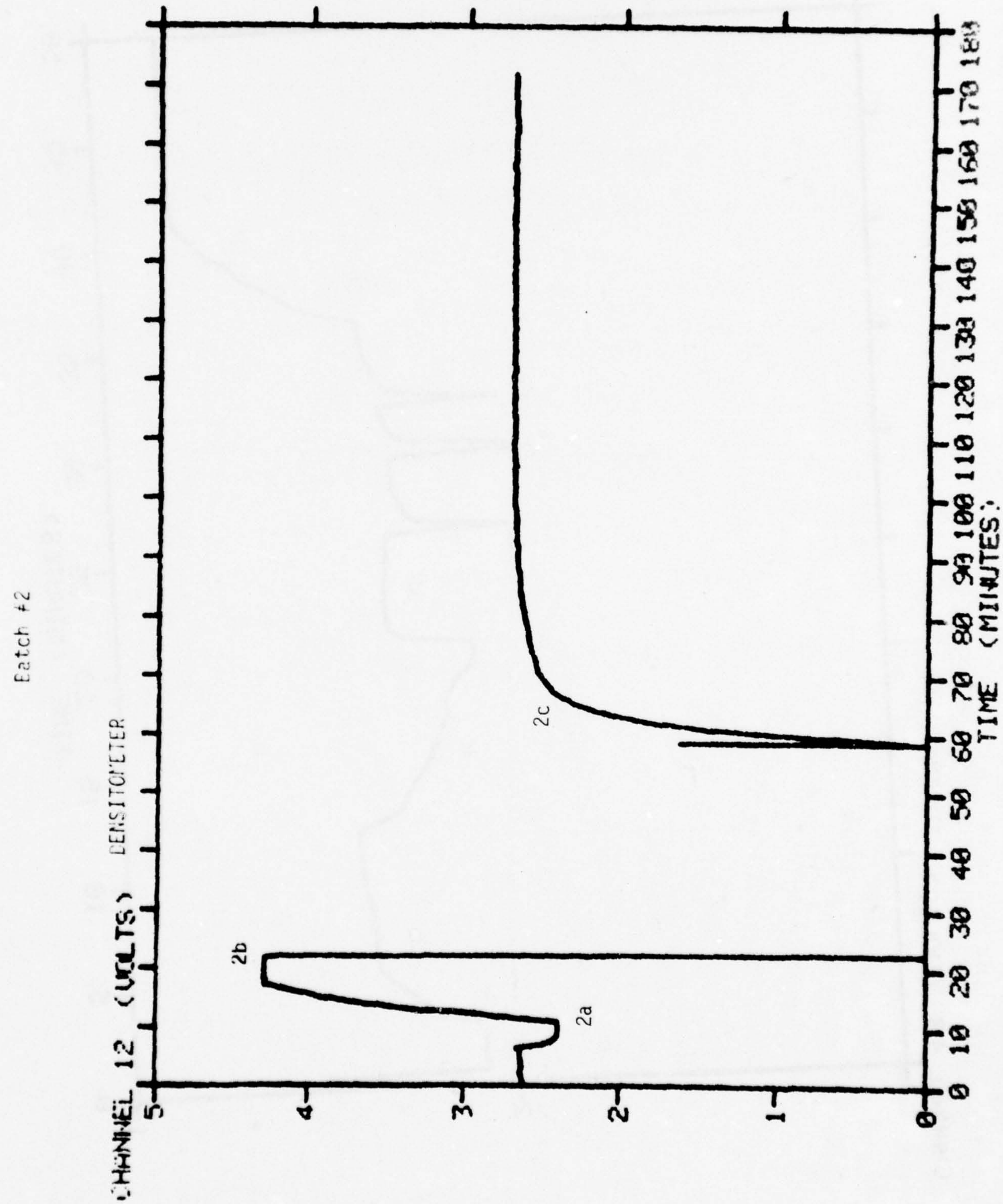

Batch #2
CHANNEL 7 (VOLTS) TORQUE
0
1
2
3
4
5
0
5
10
15
20
25
30
35
40
45
50
TIME (MINUTES)
b
c
d
e
f
g
h
i
j
k
l
m
n
o

Figure 33



Batch #2
CHANNEL 12 (VOLTS) DENSITOMETER
5
4
3
2
1
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
TIME (MINUTES)
2a
2b
2c

Figure 34

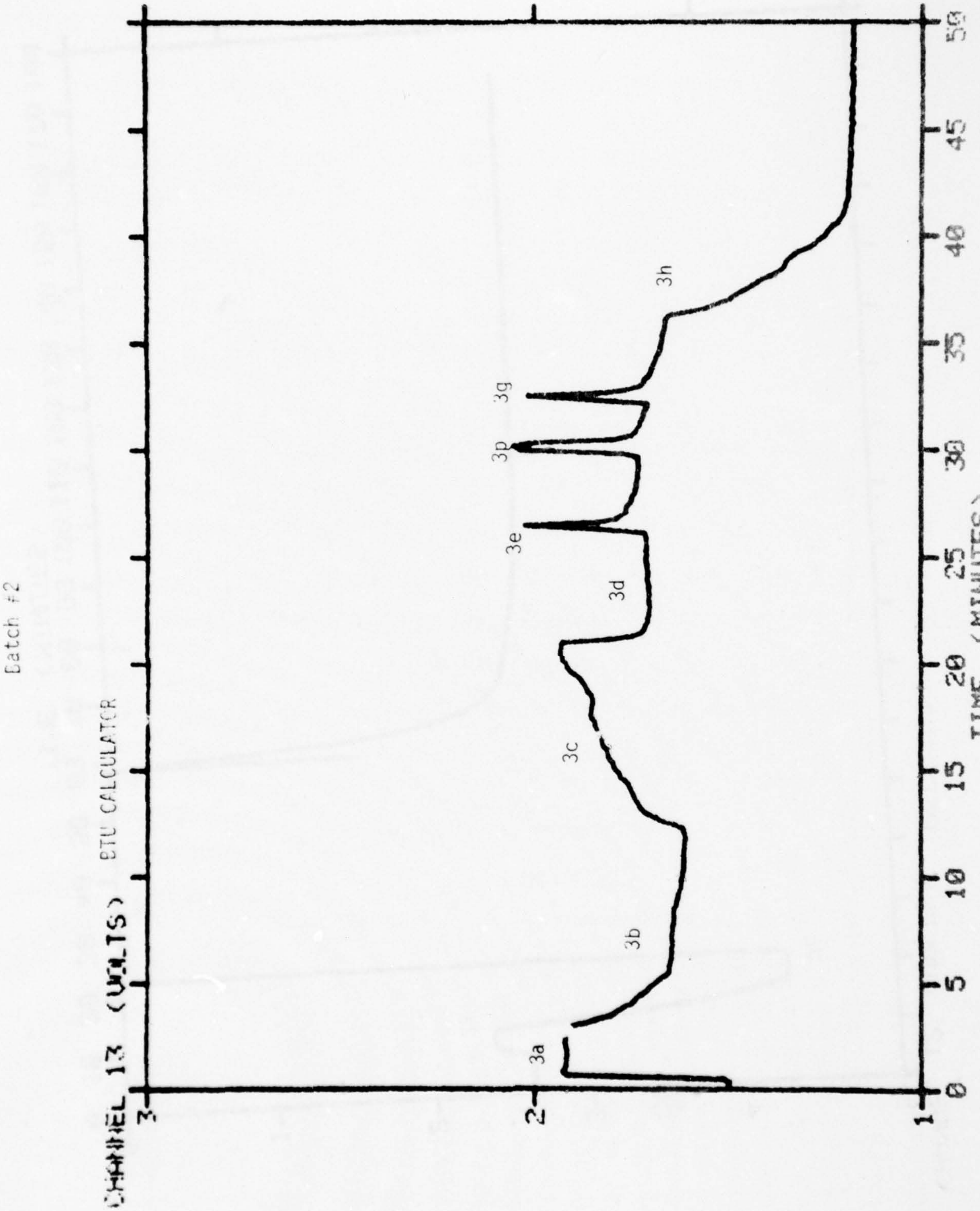

Batch #2
BTU CALCULATOR
CHANNEL 13 (VOLTS)
3
2
1
3a
3b
3c
3d
3e
3p
3g
3h
0
5
10
15
20
25
30
35
40
45
50
TIME (MINUTES)

Figure 35

off of steam usage once the kettle was preheated. Area (3c) indicates steam usage for melting as TNT enters the kettle. Points (3e), (3f), and (3g) indiciate intermittent steam addition to the kettle jacket. Observer notes confirm points (3f) and (3g). It must be concluded that steam was turned off to the jacket prior to (3d) and turned on momentarily at point (3e). The steam to the calandria, lid, and agitator was turned off at point (3h) causing the calculator to return to its zero point.

Test 2 Evaluation

Test 2 was considered supportive of the information gained in Test 1. The test batch was carried out in a smooth concise manner with no surprises or unforeseen events to mar the test results.

Material handling equipment operated successfully throughout the batch. The hand screening of the TNT proved to be the solution to the clogging problem. Feed rates are still below those required of "A" Plant equipment and below that found in existing plants with manual feeding.

The torque meter continued to provide clear, concise information as to the minute by minute conditions in the kettle--response is excellent. Changes in equipment sensitivity or "gain" were required but were well documented and made little influence on the results.

The densitometer continued to provide no data during the crucial part of the batch.

The BTU calculator provided information in a concise manner with rapid response considering its design. The only apparent flaws in output can be explained as observer error in the taking of event sequence data. The intensity of activity during a test makes observations susceptible to error.

The data recovery system operated flawlessly providing detailed record of all data for future analysis and minute by minute print out which pin-pointed probable trouble spots in the batch before they occurred.

Tritonal Test Batch 3

TNT and aluminum powder quantities for batch 3 were screened and weighed identically to those for batch 2. The intention for batch 3 was to test the response of the torque meter and BTU calculator to intermittent applications of steam to the jacket. Some concern had been expressed after Tests 1 and 2 that steam additions could cause false indications of total batch quality. Considerable effort was expended to bring the densitometer on-line. Figure 36 contains the sequence of events during the test batch.

The plot of the torque meter output for the entire batch is shown on Figure 37. The torque increase and decrease proceeded along the same lines as in Tests 1 and 2. The two vertical lines at point (a) were due to the stopping and starting of the agitator. The change at point (b) was due to a change in "gain". A plot of the first 102 minutes is shown on Figure 38. Steam was turned on and off to the jacket several times in the period from minute 54 to minute 72. Batch certification was not conclusive since a crust of unmelted TNT developed above the agitator requiring agitator shut-down and manual crust breakup. The two spikes at (a) and (b) of Figure 38 show the agitator start-stop. The change in instrument gain is shown by

Batch 3 Event Sequence

19 November 1976

(In Minutes) Batch Time	Real Time	Event
0.00	757.02	Computer starts test
22.13	819.15	Steam on to jacket, calandria, and agitator
30.00	827.02	Closed densitometer source, turned to collimator
34.48	831.50	Liquid TNT added for heal
35.58	833.0	Conveyor on
36.18	833.20	TNT addition commences
38.48	835.50	Two cans AL powder added
44.28	841.30	Two cans AL powder added
47.03	844.05	Densitometer source opened
49.58	847.0	Two cans AL powder added
50.33	847.35	Source closed
51.08	848.10	Steam off to jacket
52.18	849.20	Steam off calandria and agitator
53.38	850.40	Source opened partially
54.48	851.50	Two cans AL powder added
55.48	852.50	Conveyor stopped with 400 pounds TNT remaining
57.53	854.55	Steam off to jacket
58.18	855.20	Steam off to jacket, agitator to high
59.13	856.15	TNT feed started again
59.48	856.50	Source closed
60.08	857.10	Two cans AL powder added
60.38	857.40	Steam on to jacket
61.43	858.45	Steam off to jacket
62.48	859.50	TNT flow stopped
64.33	901.35	Source opened with lead in
65.23	902.25	Steam on to jacket
65.43	902.45	Steam off to jacket
65.58	903.00	Final AL powder addition
66.13	903.15	TNT flow restarted
69.33	906.35	Steam on jacket, shutter full open
69.38	906.40	Steam off jacket
69.43	906.45	TNT fill completed
76.28	913.30	Source closed
77.38	914.40	Tritonal sample taken
78.33	915.35	Source partially open
79.18	916.20	Agitator turned off and then on
79.38	916.40	Agitator turned to low
79.53	916.55	Agitator off
80.23	917.25	Agitator turned on high
82.08	919.10	Agitator off
82.48	919.50	Agitator on high
86.38	923.40	Sample taken
92.26	929.28	Steam on jacket
92.46	929.48	Steam off jacket

Figure 36

Batch 3 Event Sequence (Continued)

19 November 1976

(In Minutes) Batch Time	Real Time	Event
102.28	939.30	Steam on
102.48	939.50	Steam off
112.28	949.30	Steam on
112.48	949.50	Steam off
122.28	959.30	Steam on
122.48	959.50	Steam off
142.28	1019.30	Steam on
142.48	1019.50	Steam off
152.28	1029.30	Steam on
152.48	1029.50	Steam off, sample taken
162.28	1039.30	Steam on
162.48	1039.50	Steam off
172.28	1049.30	Steam on
172.48	1049.50	Steam off
183.28	1100.30	Drop starts
204.58	1122.0	Kettle empty

Figure 36 (Continued)

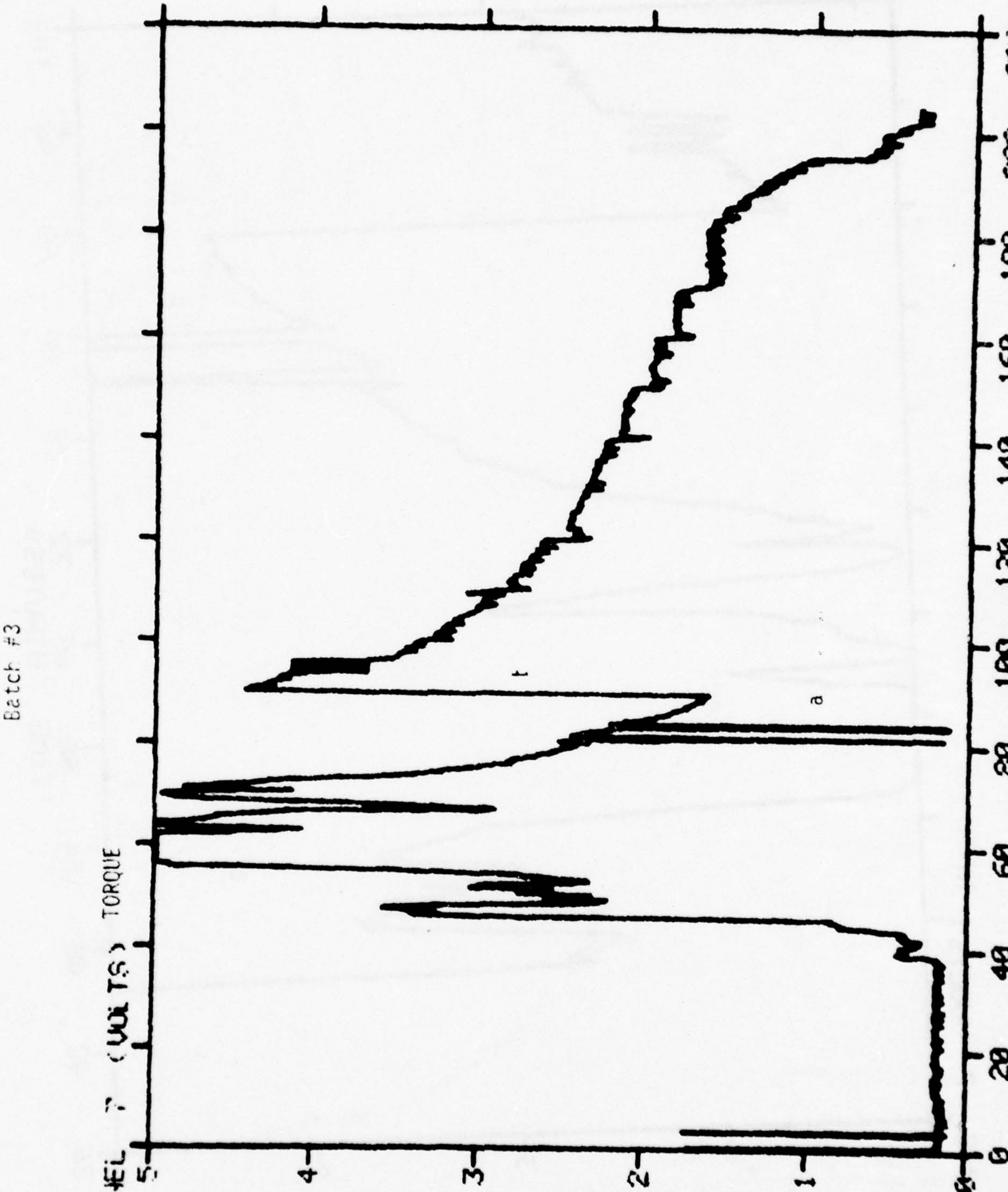
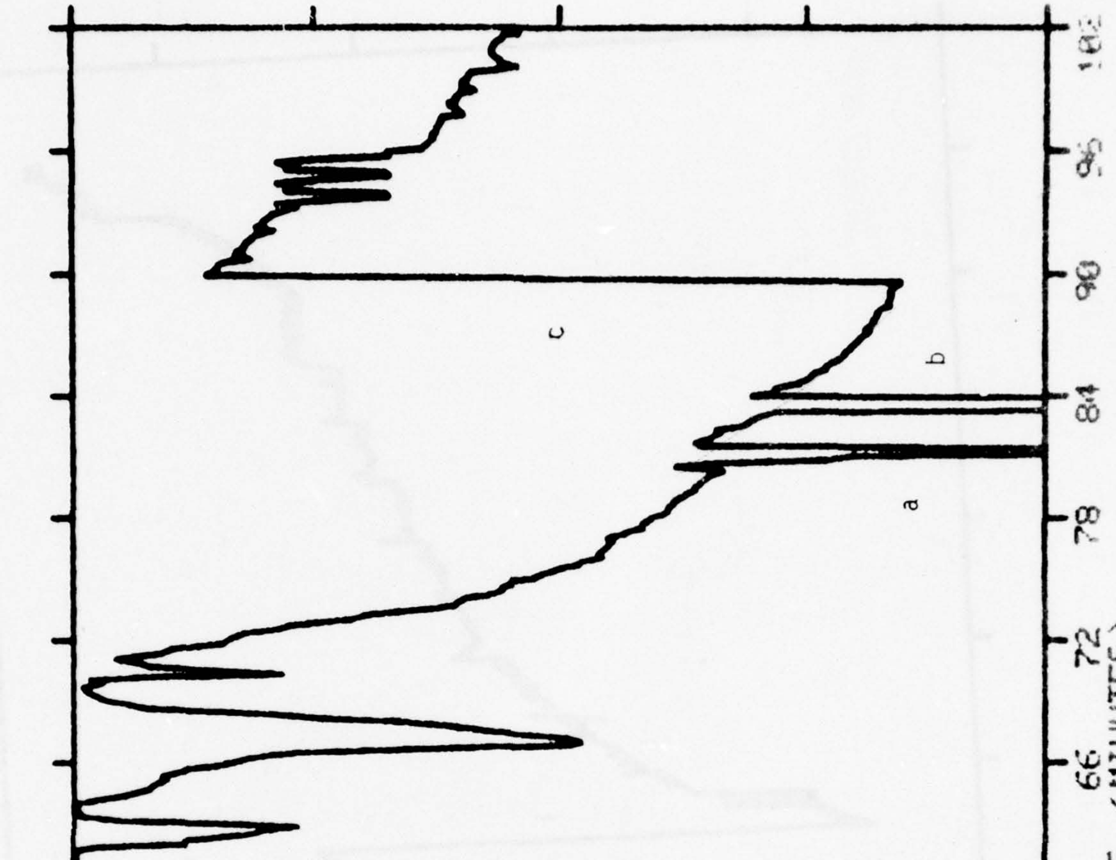

Batch #3
CHANNEL 7 (VOLTS) TORQUE
0
1
2
3
4
5
0 20 40 60 80 100 120 140 160 180 200 220
TIME (MINUTES)
a

Figure 37



Batch #3
CHANNEL 7 (VOLTS) TORQUE
5
4
3
2
1
36
42
48
54
60
66
72
78
84
90
96
102
TIME (MINUTES)
a
b
c

Figure 38

point (c). Addition of steam to the kettle jacket on a regular basis is shown by points (a) through (g) on Figure 39. The plot of the densitometer is shown on Figure 40. Considerable efforts were expended in an attempt to prevent the unit from giving a zero reading. None were successful and the plot only indicates the relative response of the unit to different materials being placed in its beam path. All materials were placed in the beam path outside of the kettle. The plot of the BTU calculator output is shown on Figure 41. The information presented does not resemble that of Tests 1 and 2. Failure to zero the calculator with the steam flow at zero may have caused malfunction of the instrument. Steam flow was in progress for kettle preheat when the unit was being zeroed. All data was considered void.

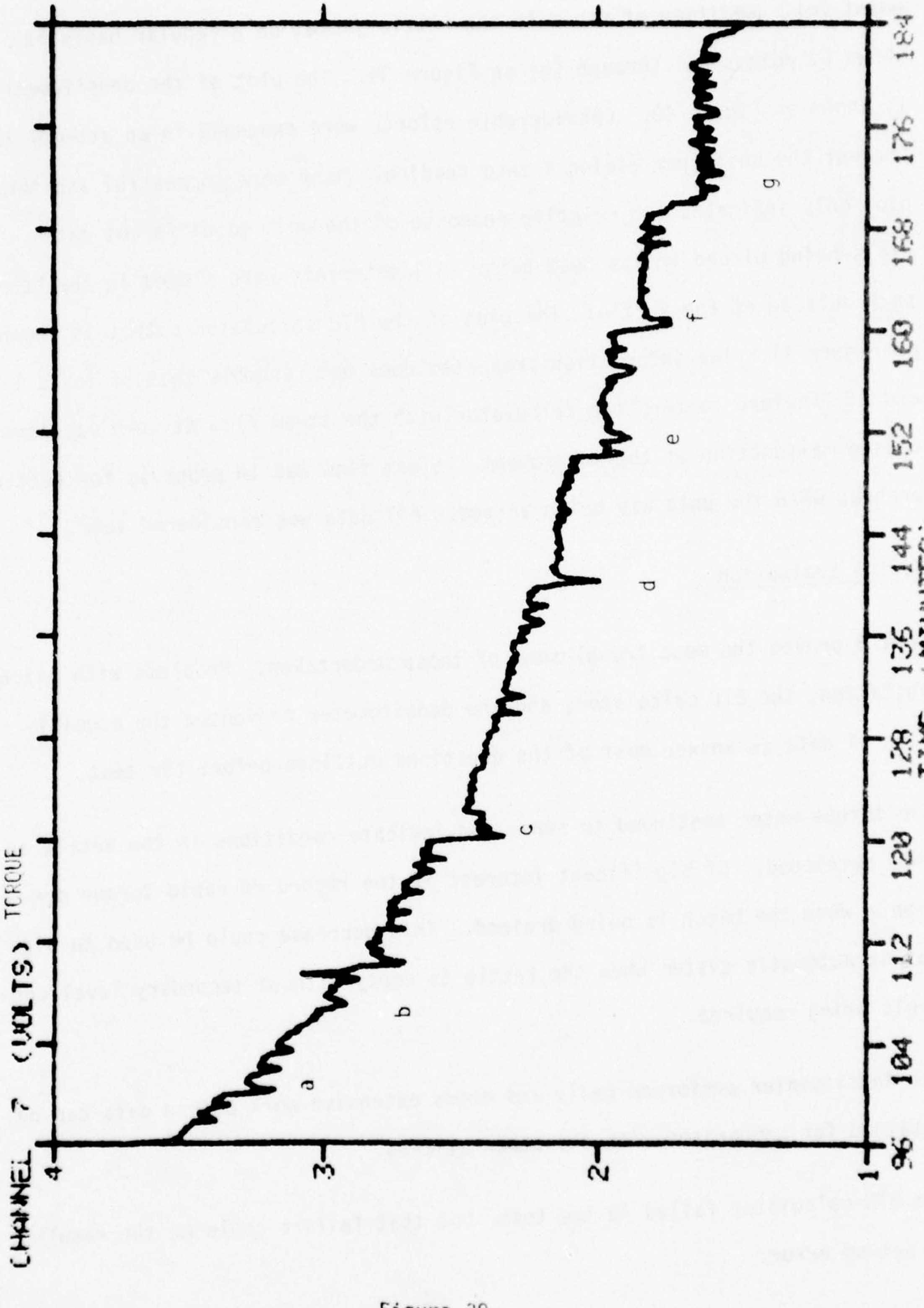
Test 3 Evaluation

Test 3 proved the most troublesome of those undertaken. Problems with batch agitation, the BTU calculator, and the densitometer prevented the acquisition of data to answer most of the questions outlined before the test.

The torque meter continued to sense and indicate conditions in the kettle as they developed. Of significant interest is the record of rapid torque decrease when the batch is being drained. This decrease could be used to signal an automatic system when the kettle is empty without secondary level controls being required.

The densitomater performed badly and needs extensive work before data can be obtained for comparison with the other systems.

The BTU calculator failed in the test, but that failure could be the result of set-up error.



Batch #3
CHANNEL 7 (VOLTS) TORQUE
4
3
2
1
96
104
112
120
128
136
144
152
160
168
176
184
TIME (MINUTES)
a
b
c
d
e
f
g

Figure 39

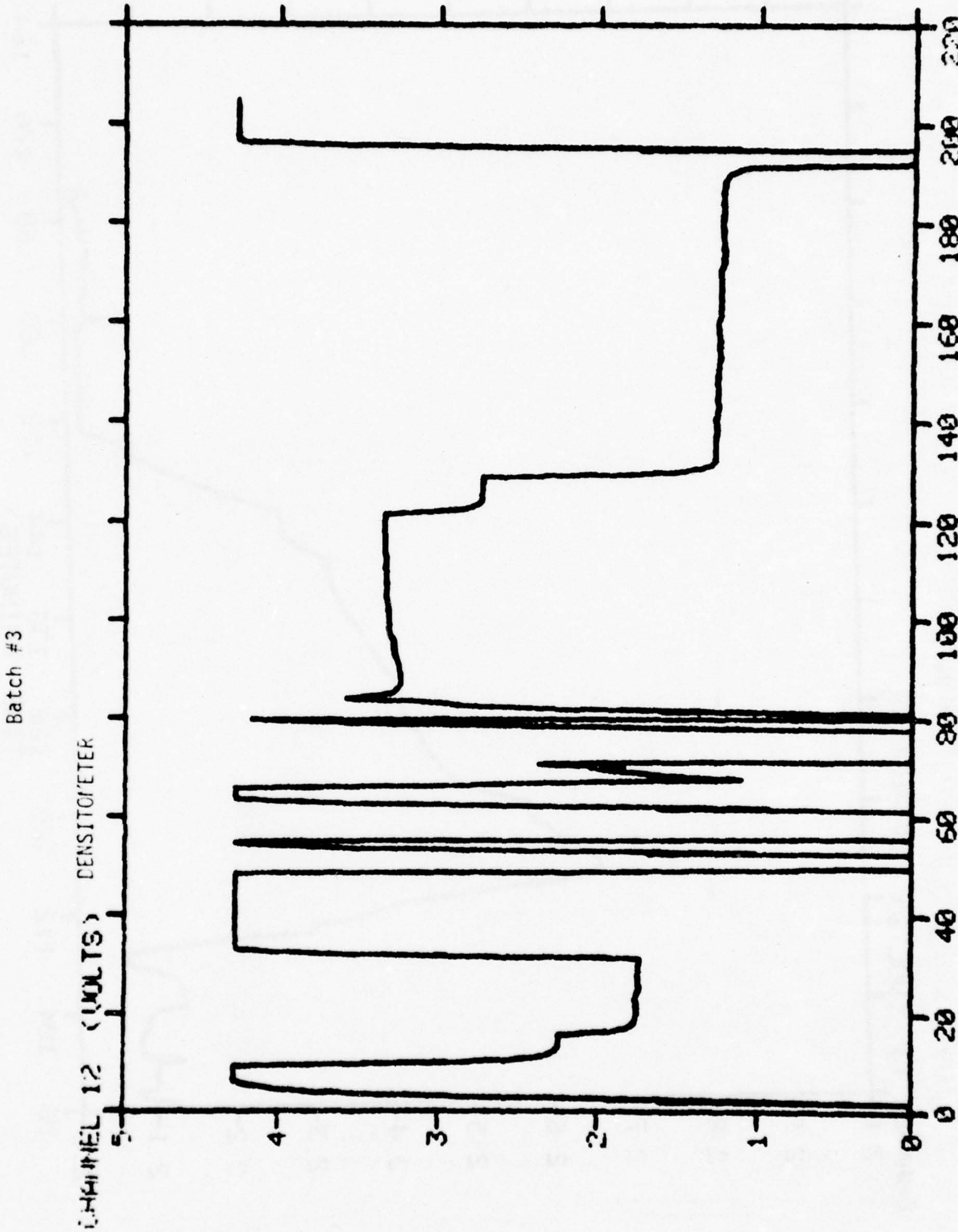

Batch #3
CHANNEL 12 (VOLTS) DENSITOMETER
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
220
TIME (MINUTES)

Figure 40

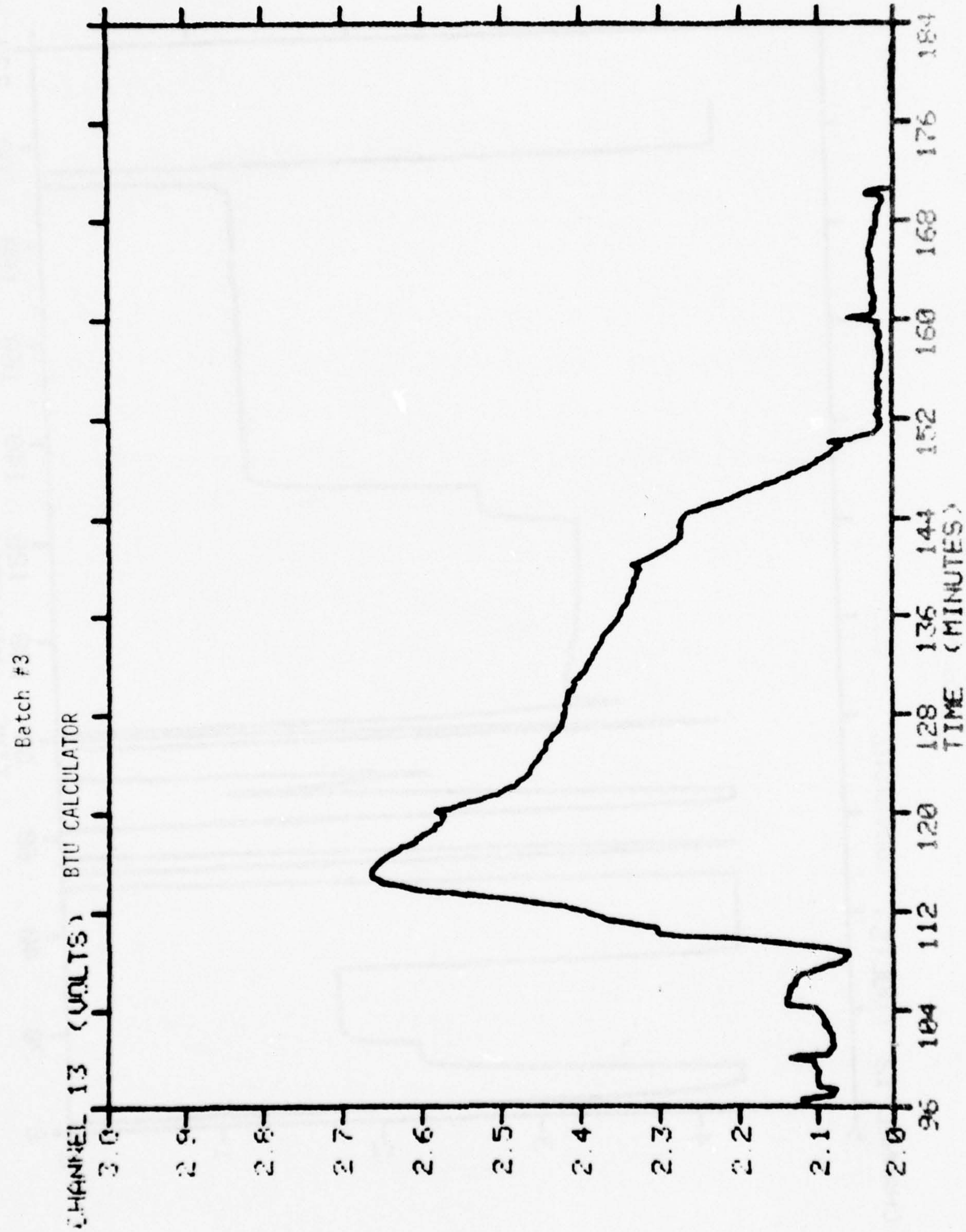

Batch #3
CHANNEL 13 (VOLTS) BTU CALCULATOR
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
96
104
112
120
128
136
144
152
160
168
176
184
TIME (MINUTES)

Figure 41

VI. SYNOPSIS OF PHASE I RESULTS

The following conclusions were drawn after analysis of Phase I test data and comparison with the requirements outlined for the program:

A. Equipment systems installed in Building 456 at NWS Yorktown are equal to, or better than, any now installed at existing production plants. Further, they duplicate, as close as practicable, conditions experienced in existing plants.

B. The temperature sensing system, as installed on the kettle agitator, is not practical in a production environment. With extensive modification, it could be used to analyze batch stratification under experimental conditions.

C. The agitator mounted torque measuring system is an inexpensive, reliable, and responsive sensing system for determining batch conditions and is considered the best candidate for controlling an automatic system.

D. The gamma ray densitometer will require further modification and testing before any conclusions can be made.

E. The BTU calculator is a relatively inexpensive means of determining energy usage. The system, as installed and used in Phase I, provided only usage rate. With the addition of a rate integration program in the mini-computer, the BTU calculator is considered the second candidate for controlling an automatic process.

F. A minimum of two systems in addition to a computer will be required to control an automatic mix-melt system.

G. The TNT material feed rate of the test equipment will have to be increased in order to evaluate conditions expected at McAlester Plant "A".

H. A second hopper, previously purchased, should be mounted to feed aluminum powder into the kettle at a controlled rate and sequence. The batch reaction to aluminum powder addition is a significant input to the torque meter.

The following conclusions have been drawn concerning the application of systems as tested to existing plants:

A. The agitator mounted torque meter used in conjunction with an established pattern of steam application and elapsed batch time, could aid plant operators in preparing tritonal. In addition, a software output could provide a permanent record of batch quality.

B. The BTU calculator used in conjunction with the torque meter could provide the best aid to batching by allowing the kettle operator to work within a specified envelope of total thermal energy input to the kettle. The torque meter would confirm the batch to batch validity of the envelope by measuring the batch viscosity. A permanent record of both outputs would be available.

VII. PHASE II TESTS

It was the original intention of the mix-melt program to schedule a number of tests for the certification of a piece of equipment for use in existing casting plants. Because of the high cost of test material, both for its procurement and for its disposal, Phase II tests were not carried out separately from Phase I. The data generated in Phase I was analyzed and conclusions were made regarding Phase II suitability.

VIII. PHASE III

A. INTERMEDIATE TESTS

The data from Phase I tests was analyzed in order to determine what additional elements would be required to allow the mini-computer system to be programmed for automatic control. Much of the data acquisition to date had been by manual means. It was determined that, in order to control a batch, information such as steam pressure and material feed status would have to be made known to the computer for it to make meaningful decisions. Three tests were scheduled for the express purpose of gaining the specific knowledge to permit automatic control programming. Acquisition of interface equipment to be used in the automatic control tests proceeded independently. The only major change in equipment prior to the second test series was the elimination of the torque sensing limit switch. The switch was the source of some electrical noise which interferred with the collection of data. The mini-computer was therefore reprogrammed to scan and average the torque readings over precise five-second intervals. The average, which is stabilized like a single-point reading, was then used by the computer for control purposes.

Each of the three tests was performed under conditions expected in a production situation. Material was added to the kettle within the time frames necessary to achieve an acceptable production rate. The performances of the BTU calculator and the torque meter were the same as achieved in earlier tests. The densitometer was still plagued with periods of zero readings which could have been attributed to densities below the scanning low-limit.

B. EQUIPMENT ALTERATIONS

Following the intermediate tests, changes were made to the equipment to allow computer control of the mix-melt cycle. These changes, by equipment systems, were as follows:

1. Two air-operated steam control valves were placed in the main steam lines to the kettle. One valve was used to control steam to the kettle jacket and the other was used to control steam to the calandria. The agitator and lid were left under manual control since their heat (used only for the purpose of preventing explosive buildup) was small in comparison with the heat of the jacket and calandria. Both valves are of the air-operated, spring return type. The operating air is controlled by an electric solenoid valve deriving its signal from the mini-computer. A pressure transducer was installed in the main steam line (downstream of the jacket control valve) to measure steam pressure. The signal is picked up by the mini-computer for processing.

2. A pressure transducer was installed in the pneumatic control line actuating the TNT feed hopper. The output signal is picked up and processed by the mini-computer to allow recording of the material increments being fed to the kettle. The signal is also used to trigger portions of the automatic program.

3. The mini-computer was reprogrammed to operate the mix-melting equipment using information from all of the previously identified systems. In addition, the data retrieval system was simplified by removing unused channels to allow the computer to print operating commands as necessary and

also print the batch parameters every minute without a significant discrepancy caused by the time delay between data retrieval and printout. A detailed description of the finalized software program is included in Section IX.

C. BATCH SIMULATION

The program as developed by NAVWPNSUPPCEN Crane Applied Sciences Department (ASD) was checked for errors by coupling the mini-computer to a master computer. The master computer provided the data element inputs derived from previous batch tests. The mini-computer was then reinstalled into the equipment system at WPNSTA Yorktown, Building 456, for the final live tests.

D. FINAL TEST SERIES

The final-proof tests consisted of three test batches with explosives and one simulated test using computer control. The batches consisted of 10 increments and the same total explosive weights used in all the previous tests. The TNT and aluminum powder feed procedures were established to achieve total material input within 10 minutes of the first material introduction. The computer program controlled the thermal energy input and generated messages for the manual control of material feed. The program also was designed to assess the condition of the batch using torque or density conditions and indicate "Batch Ready" by the appropriate system. The computer program was designed to record all batch condition data even if batch control was relinquished to the kettle operator because of a control system malfunction. A review of the batch and computer control results is as follows:

1. Test 1 data is shown on Figure 42. The first spike on the thermal energy plot is indicative of the heat required to bring the kettle to maximum allowable temperature. An inadvertent delay in the start of the batch occurred between the Minute 7 and Minute 35 mark. This delay was responsible for the steady use of thermal energy even though no material had been added until 36 minutes into the test. A sharp increase in energy usage can be noted after the introduction of the first material. This usage continued until Minute 53 when the steam was turned off. The plot of torque shows an initial spike when the agitator was started around Minute 6. The torque increased sharply with the incremental addition of TNT and aluminum powder. Operator's certification of the batch as ready for use occurred around Minute 54.

The computer program performed all intended operations up to Minute 36. Shortly after initiating the material feed cycle, the computer turned control over to the kettle operator and indicated it would only continue recording data. The batch was successfully completed manually as shown by Figure 42. Later examinations of the data and event sequence (also recorded by the computer) resulted in the conclusion that a negative value produced by the densitometer at Minute 36 caused the program to shift to an incorrect address and subsequently relinquish the control as planned if an emergency should occur. The negative value, not occurring in previous tests, resulted from removing the lead sample from the source path.

2. Program corrections were made in order to perform another test. In addition to the negative value correction, the program was altered to correct any problems made possible by an extended preheat time as experienced in Test 1. The original program was designed to accumulate thermal energy continually

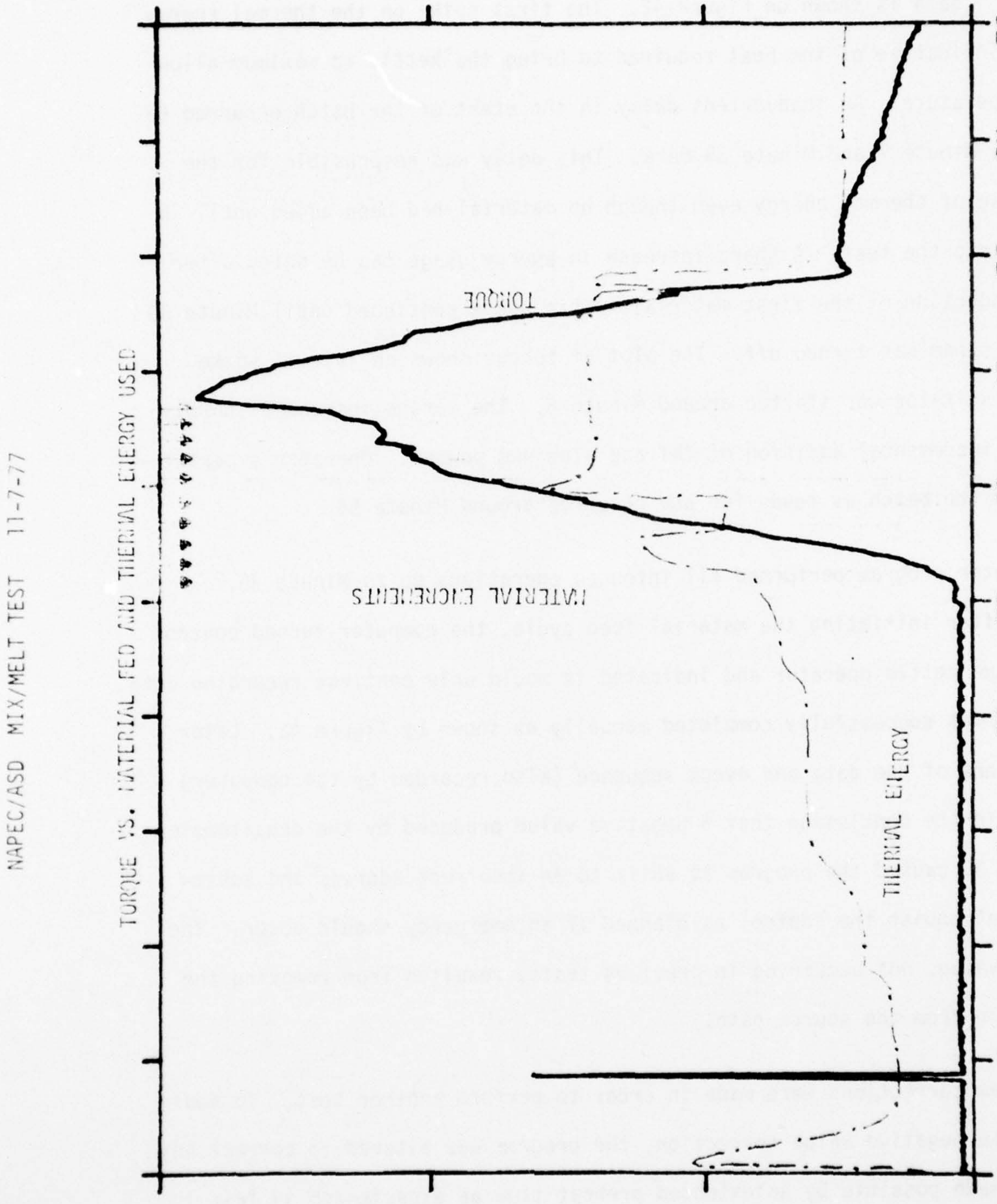

NAPEC/ASD MIX/MELT TEST 11-7-77
TORQUE VS. MATERIAL FED AND THERMAL ENERGY USED
TORQUE
MATERIAL INCREMENTS
THERMAL ENERGY
0
7
14
21
28
35
42
49
56
63
70
TIME (MINUTES)

Figure 42

from the start of the preheat. Because of the decision points built into the program based on energy usage, the program was altered to include a BTU calculator value reset to zero when the agitator is started.

Test 2 data is shown by Figure 43. The test batch was again completed but without computer control. The computer relinquished control 22 minutes into the batch when the torque reading became too high for a no-load condition. From later examination of the data, it was determined that the approval for the start of material addition was erroneous. The computer program had not been satisfied that the torque reading had stabilized after the start of the agitator and the command signal from the computer had not been given to start material feed. Consequently, the automatic control system aborted and only recorded data.

3. A simulated test was scheduled to check the changes in the program. Thermal energy and torque values were simulated with a signal generator; all other signals were reproduced by operating the equipment in "dry cycle." Figure 44 shows a printout of the results of the simulated test. All parts of the program functioned as originally intended and the third mix-melt test was then scheduled.

4. Test 3 data is shown by Figure 45. All operations were successfully performed under computer control up to a point 22 minutes into the batch cycle. At that point, the total energy used exceeded the BTU limit for continuous steam application and the program shifted to a steam on/steam off cycle. This portion of the program did not have an overload torque check and the thermal energy input could not keep up with the material being dumped into the kettle. The drive motor overloaded and stopped agitation

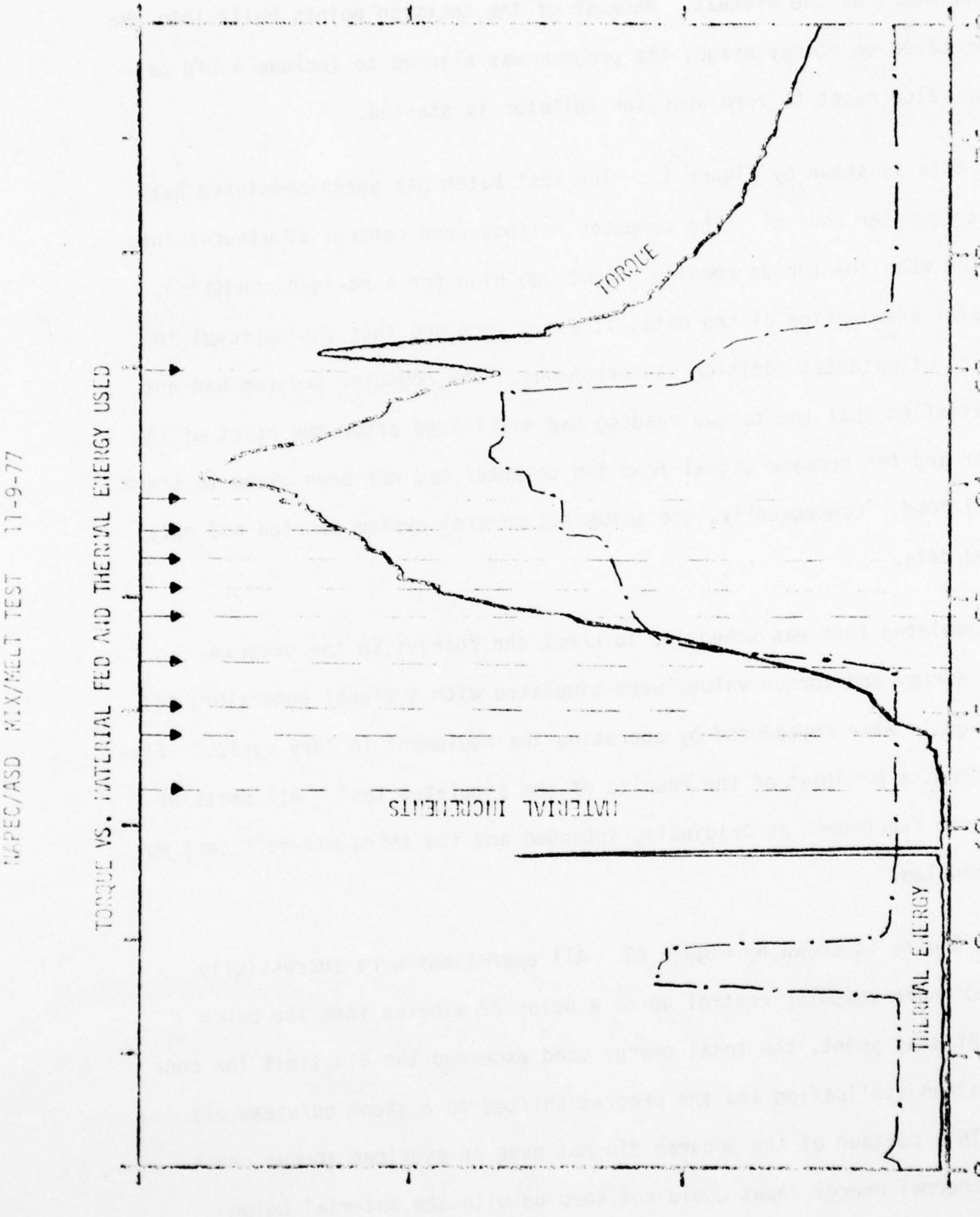

NAPEC/ASD MIX/MELT TEST 11-9-77
TORQUE VS. MATERIAL FED AND THERMAL ENERGY USED
TORQUE
MATERIAL INCREMENTS
THERMAL ENERGY
0
4
8
12
15
20
24
28
32
36
40
TIME (MINUTES)

Figure 43

```
KEYBOARD CONTROL
AUTO
PUT BLANK CASSETTES IN UNIT 0 & 1
STRIKE ANY KEY WHEN LOADED
ENTER ID RECORD FOR THIS TEST
SIMULATED TEST  11/10/1977
STRIKE ANY KEY TO START TEST
TEST STARTED

KEYBOARD CONTROL
14:39:25  KETTLE PREHEAT STARTED
CHECK
14:39:31
  +.00     -.04    +3.32    +1.34    +4.68     +.56     +.00     +.00

KEYBOARD CONTROL
PRINT
PRINT DATA EACH MINUTE DURING TEST
14:39:20
  +.00    +1.59    +3.32    +1.16     +.90     +.53     +.00     +.00

14:40:20
  +.00    +1.59    +3.31    +1.91    +3.81     +.57    +5.00    +5.00

14:41:20
  +.00    +1.60    +3.62    +1.88    +3.61    +2.64    +5.00    +5.00

14:42:55  PREHEAT COMPLETE
14:42:58  START AGITATOR
14:43:00  START AGITATOR
14:42:20
  +.00    +1.65    +3.47    +1.79    +4.25    +2.85    +5.00    +5.00

KEYBOARD CONTROL
14:45:35  START ADDING MATERIAL TO KETTLE
CHECK
14:46:21
  +.00     +.05    +3.62    +1.13     +.90    +4.99     +.00     +.00

KEYBOARD CONTROL
CHECK
14:48:36
 +4.99     +.06    +3.64    +1.32    +1.50    +1.66     +.00     +.00

KEYBOARD CONTROL
CHECK
14:49:51
 +4.99     +.58    +3.64    +1.29    +1.60    +4.99     +.00     +.00

KEYBOARD CONTROL
14:51:05  STEAM OFF BY LOW TORQUE
14:52:05  STEAM ON AFTER LOW TORQUE
14:52:30  STEAM OFF BY LOW TORQUE
14:52:50  STEAM ON AFTER LOW TORQUE
14:52:55  STEAM OFF BY LOW TORQUE
14:53:05  STEAM ON AFTER LOW TORQUE
14:53:10  STOP MATERIAL, TORQUE TOO HIGH
14:54:03  START ADDING MATERIAL TO KETTLE
CHECK
14:54:50
 +4.99    +2.54    +3.64    +1.86    +3.76    +4.87     +.00     +.00
```

Figure 44

```
KEYBOARD CONTROL
14:56:10   STEAM OFF BY MAX BTU SUM
14:56:15   STEAM ON 5 SEC
14:56:20   STEAM OFF
14:56:25   STEAM ON 5 SEC
14:56:30   STEAM OFF
14:56:35   STEAM ON 5 SEC
14:56:40   STEAM OFF
14:56:45   STEAM ON 5 SEC
14:56:50   STEAM OFF
14:56:55   STEAM ON 5 SEC
14:57:00   STEAM OFF
14:57:25   STEAM ON 5 SEC
14:57:30   STEAM OFF
14:57:35   STEAM ON 5 SEC
14:57:40   STEAM OFF
14:57:55   STEAM ON 5 SEC
14:58:00   STEAM OFF
14:58:05   STEAM ON 5 SEC
14:58:10   STEAM OFF
14:58:15   STEAM ON 5 SEC
14:58:20   STEAM OFF
14:58:25   STEAM ON 5 SEC
14:58:30   STEAM OFF
14:58:45   STEAM ON BECAUSE OF RISING TORQUE
14:58:50   STEAM OFF
14:58:55   STEAM ON BECAUSE OF RISING TORQUE
CHECK
15:02:22
  +.00     +.95    +4.31    +1.73    +3.04    +4.82     +.00     +.00
15:12:13   BATCH READY BY TORQUE
CHECK
15:12:44
  +.00     +.41    +4.30    +1.28     +.95    +4.99     +.00     +.00

KEYBOARD CONTROL
CHECK
15:17:32
  +.00     +.35    +4.30    +1.13     +.95    +4.99     +.00     +.00

KEYBOARD CONTROL
MANUAL
15:17:47  AUTO TERMINATED FROM KEYBOARD

KEYBOARD CONTROL
STOP
TEST WILL BE STOPPED AT THE END OF THE ONE MINUTE SAMPLE INTERVAL.
TEST COMPLETED.
```

Figure 44 (Continued)

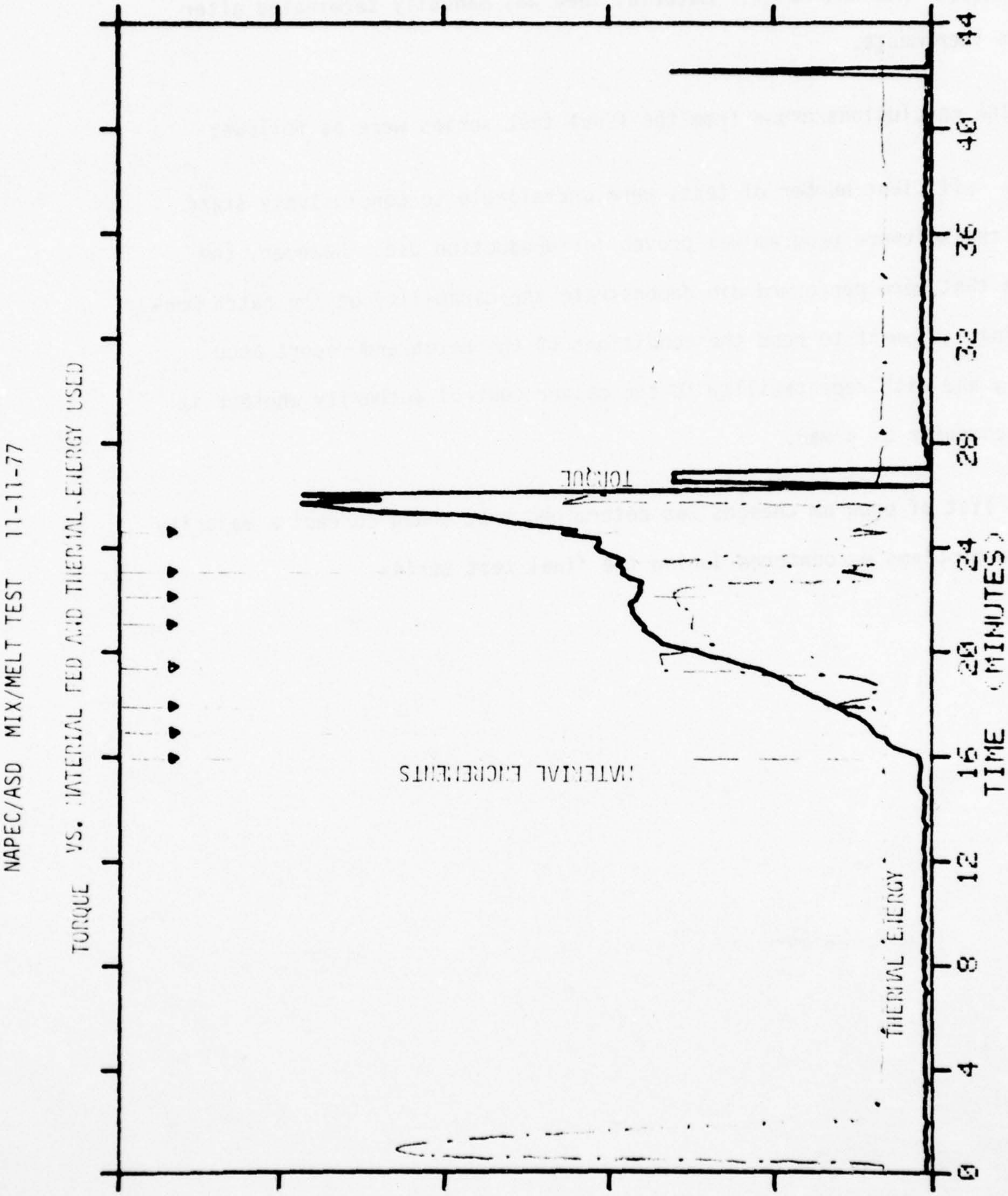

NAPEC/ASD MIX/MELT TEST 11-11-77
TORQUE VS. MATERIAL FED AND THERMAL ENERGY USED
TORQUE
MATERIAL INCREMENTS
THERMAL ENERGY
0
4
8
12
16
20
24
28
32
36
40
44
TIME (MINUTES)

Figure 45

26 minutes into the batch. Material feed was manually terminated after eight increments.

5. The conclusions drawn from the final test series were as follows:

a. A sufficient number of tests were unavailable to conclusively state that the software program was proven for production use. However, the tests that were performed did demonstrate the capability of the batch monitoring equipment to read the conditions of the batch and report accurately and with repeatability to the master control authority whether it be a computer or a man.

b. A list of program changes was determined that would correct a majority of the problems encountered during the final test series.

IX. SOFTWARE PROGRAM ANALYSIS

A. METHODOLOGY

The computer program developed is based on empirical data produced by the actual mix-melt tests. In addition to specific values, rates of change of values were used to measure "trends" during the mix-melt process. This "trend" monitoring helps to minimize erratic control behavior caused by fluctuations in data attributable to changing environmental and material conditions. In essence, the "trend" monitoring helps to validate data used by the computer to base its decisions. The final program used the torque meter, material feed equipment and thermal energy measuring equipment to base the control functions. The densitometer has not been included in the control schematic due primarily to its inability to provide data during that part of the program where control of thermal energy input and material input is critical. The results of the final series of tests have shown that the densitometer will provide a valid indication of batch quality near the end of the batch. Figures 46 and 47 show the comparison of density and torque plots and a comparison of the batch ready points built into the computer program for the Phase III tests. Because of comparability and repeatability, either piece of equipment could be used for control purposes. However, because of the tendency of the densitometer to go off scale and its dependence on a radioactive source, the torque meter was chosen for governing control responsibility.

B. COMPUTER PROGRAM DESCRIPTION

The finalized computer program, included as Appendix A, is designed for a digital system and will provide equipment control, equipment monitoring and

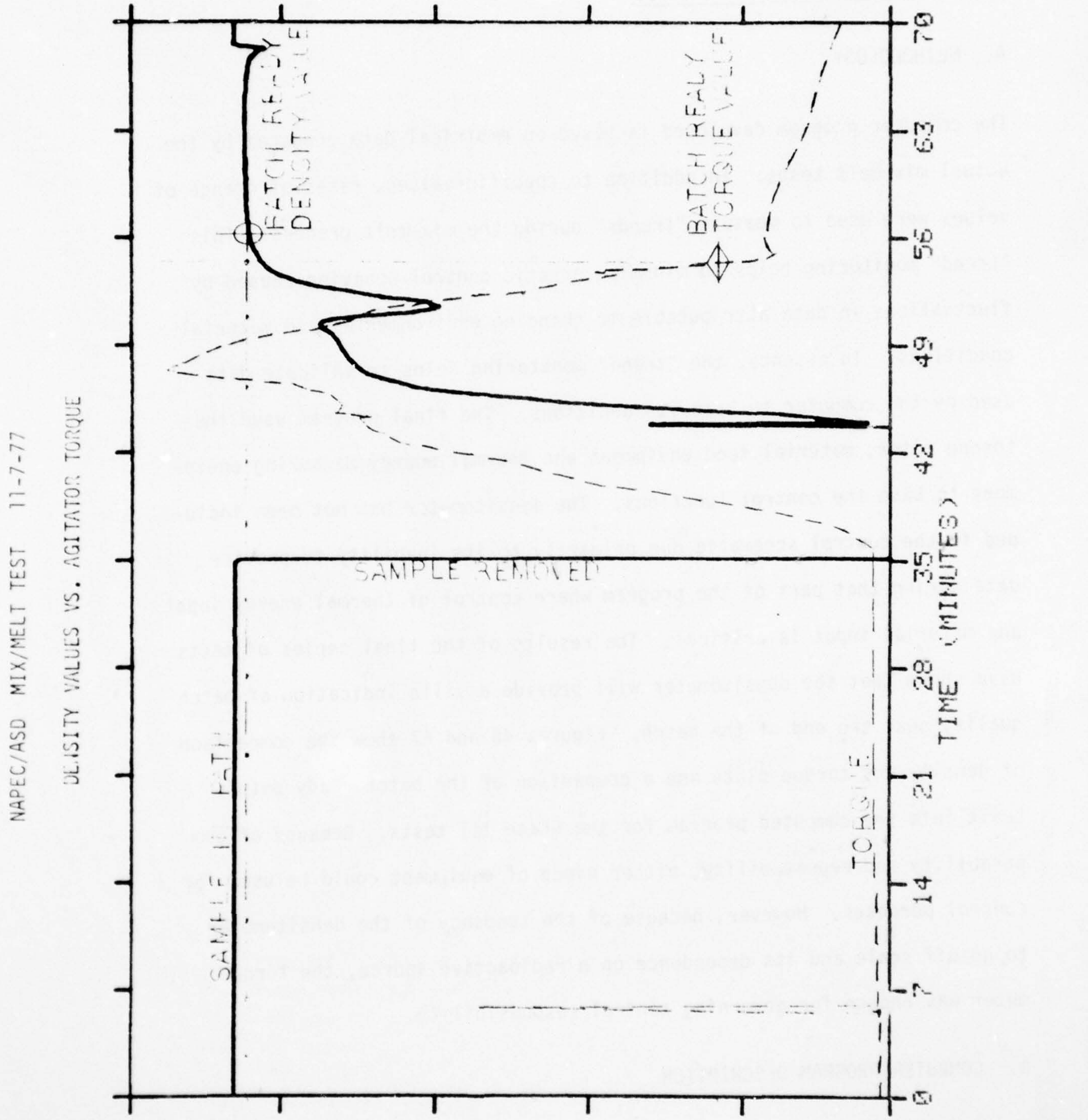

NAPEC/ASD MIX/MELT TEST 11-7-77
DENSITY VALUES VS. AGITATOR TORQUE
SAMPLE IN BATH
SAMPLE REMOVED
TORQUE
BATCH READY DENSITY VALUE
BATCH READY TORQUE VALUE
TIME (MINUTES)
0
7
14
21
28
35
42
49
56
63
70

Figure 46

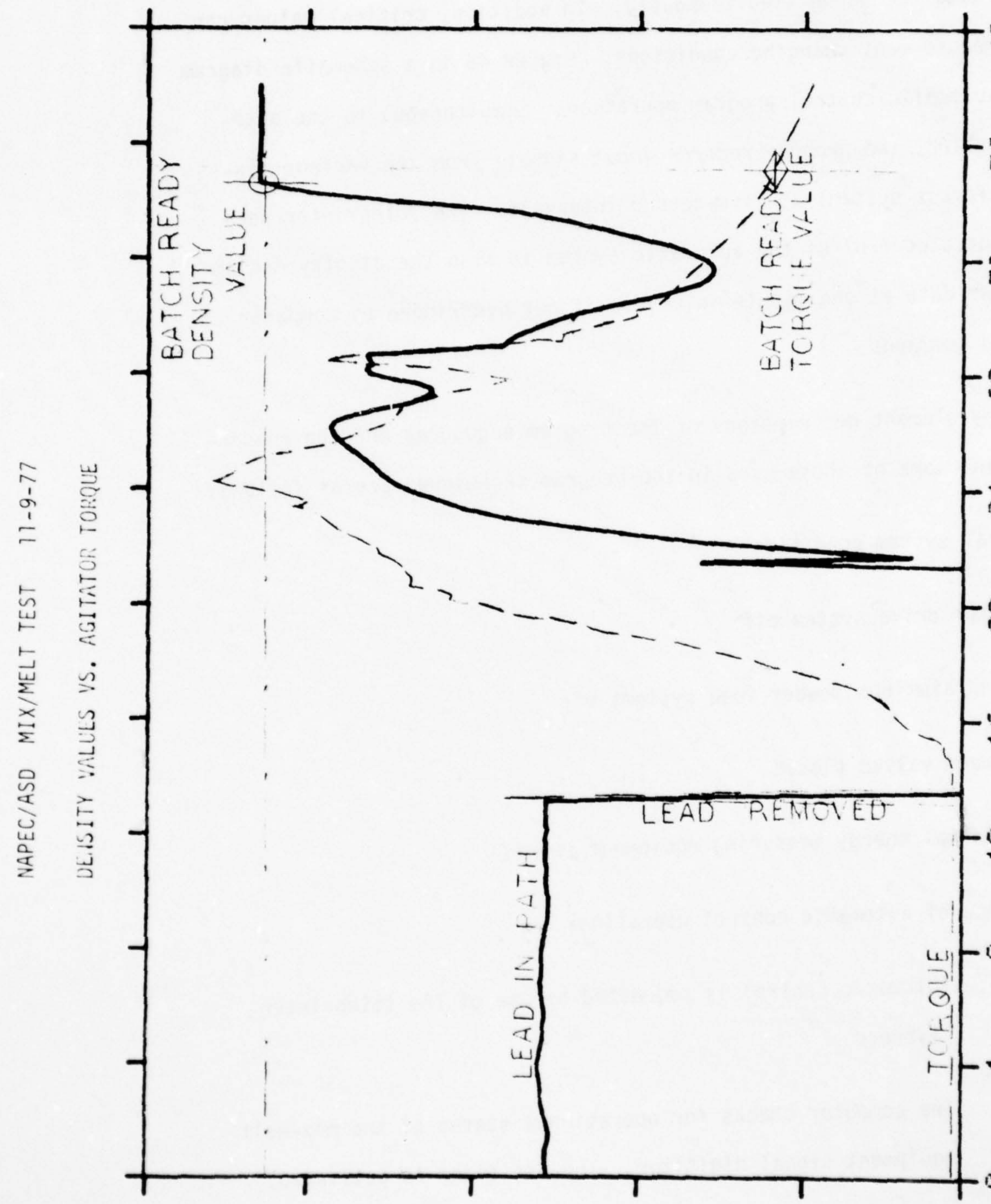

NAPEC/ASD MIX/MELT TEST 11-9-77
DENSITY VALUES VS. AGITATOR TORQUE
BATCH READY DENSITY VALUE
BATCH READY TORQUE VALUE
LEAD IN PATH
LEAD REMOVED
TORQUE
0
4
8
12
16
20
24
28
32
36
40
TIME (MINUTES)

Figure 47

process data recording simultaneously. In addition, critical values can be altered to meet changing conditions. Figure 48 is a schematic diagram of the automatic control program operation. Simultaneous to the automatic portion, the program records input signals from the various mix-melt equipment systems at five-second intervals. The teleprinter used for keyboard control of the automatic system is also the display medium for system data at one minute intervals if not overridden by computer generated commands.

Element-by-element descriptions of the program sequences and the reasonings behind some of those used in the program techniques are as follows:

1. Initial system condition

a. Agitator drive system off

b. TNT and aluminum powder feed systems off

c. All steam valves closed

d. The thermal energy measuring equipment zeroed

2. Sequence of automatic control operations

Step a. Automatic control is requested by use of the teleprinter keyboard.

Step b. The computer checks for operational status of the mix-melt equipment signal digitizer. The digitizer is activated.

Step c. The computer asks for, and records, the current signal value being produced by the thermal energy measuring equipment. This value can vary day-to-day, but can be compensated.

AD-A070 561 NAVAL AMMUNITION PRODUCTION ENGINEERING CENTER CRANE IND F/G 19/1
AUTOMATIC MIX-MELT PRODUCTION PROCESS DEVELOPMENT FOR TRITONAL,--ETC(U)
MAY 78 G A GROH

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2 OF 3
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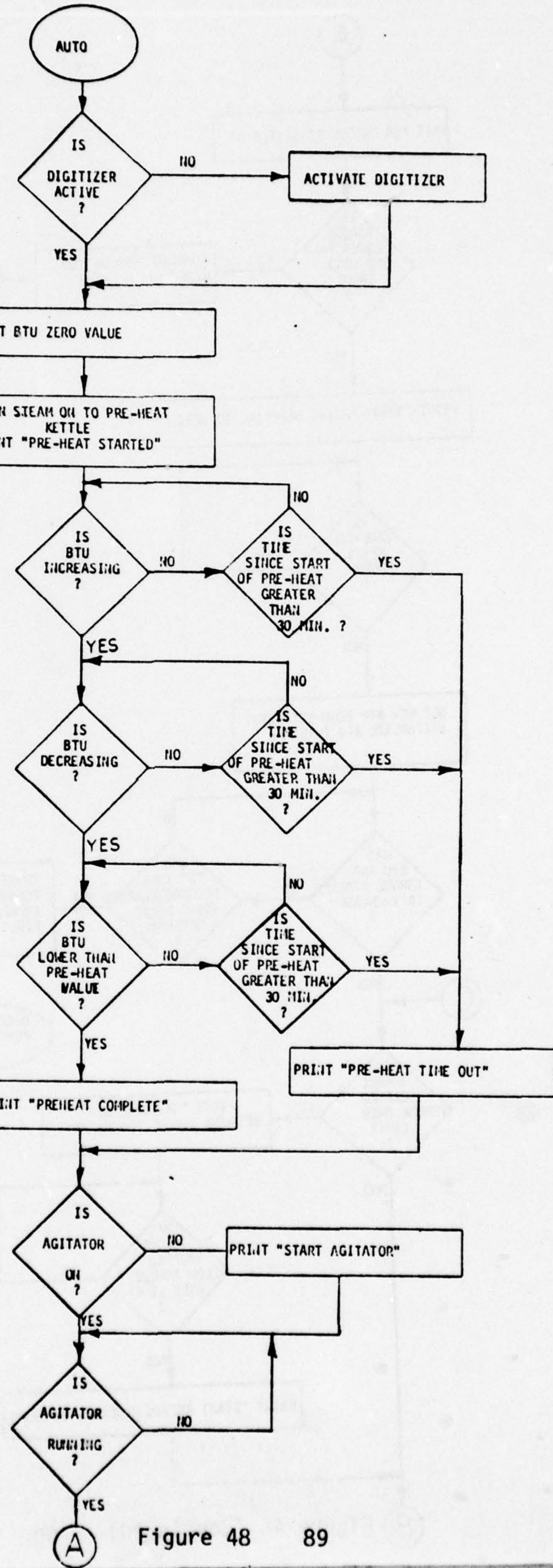
AUTO
IS DIGITIZER ACTIVE ?
NO
ACTIVATE DIGITIZER
YES
GET BTU ZERO VALUE
TURN STEAM ON TO PRE-HEAT KETTLE
PRINT "PRE-HEAT STARTED"
IS BTU INCREASING ?
NO
IS TIME SINCE START OF PRE-HEAT GREATER THAN 30 MIN. ?
YES
NO
YES
IS BTU DECREASING ?
NO
IS TIME SINCE START OF PRE-HEAT GREATER THAN 30 MIN. ?
YES
NO
YES
IS BTU LOWER THAN PRE-HEAT VALUE ?
NO
IS TIME SINCE START OF PRE-HEAT GREATER THAN 30 MIN. ?
YES
NO
YES
PRINT "PREHEAT COMPLETE"
PRINT "PRE-HEAT TIME OUT"
IS AGITATOR ON ?
NO
PRINT "START AGITATOR"
YES
IS AGITATOR RUNNING ?
NO
YES
A

Figure 48

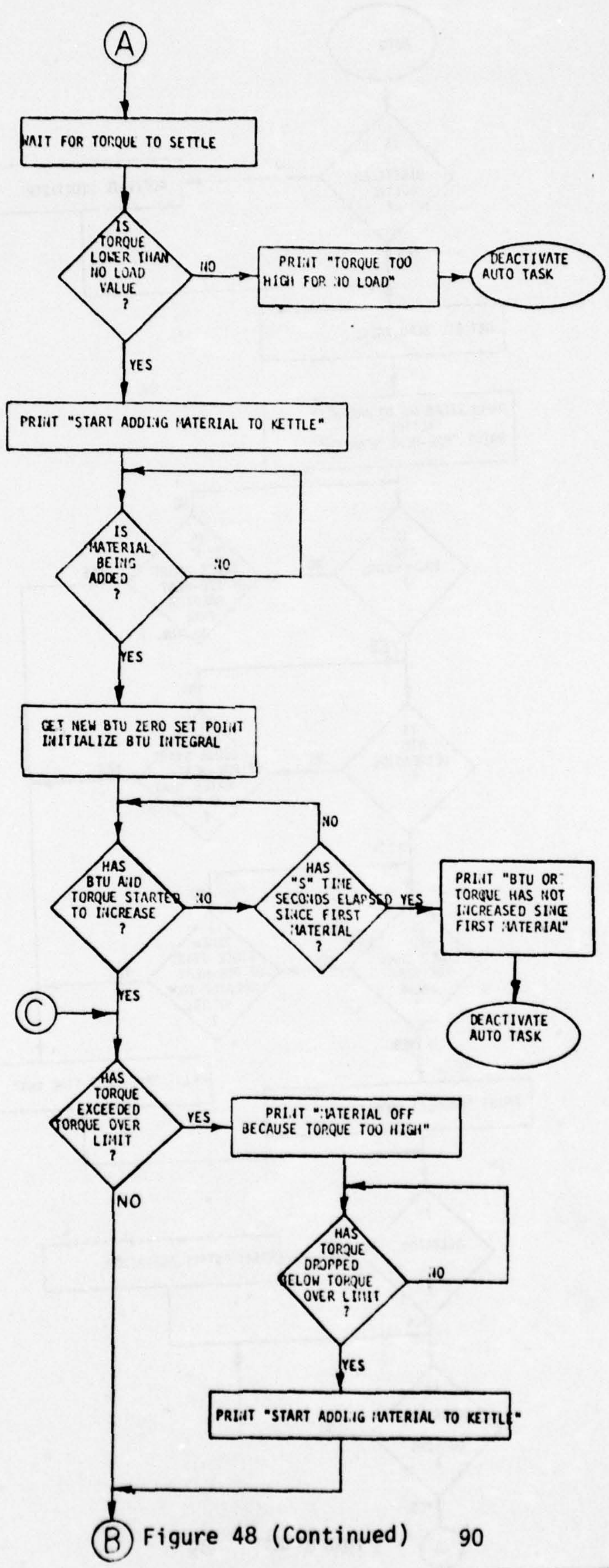

Figure 48 (Continued)

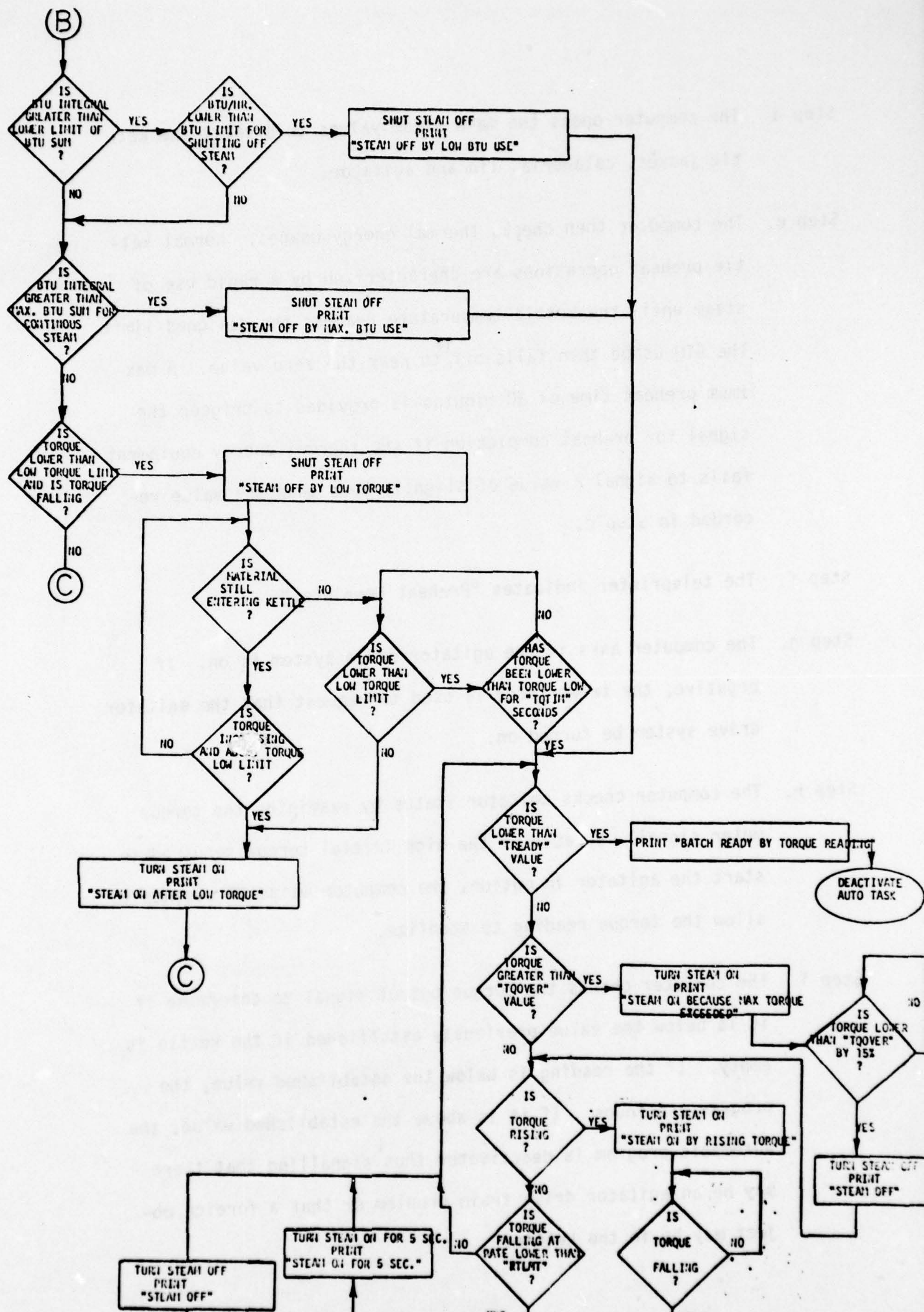

Figure 48 (Continued)

Step d. The computer opens the main steam valves to preheat the kettle jacket, calandria, lid and agitator.

Step e. The computer then checks thermal energy usages. Normal kettle preheat operations are characterized by a rapid use of steam until the kettle temperature reaches the designed limit. The BTU usage then falls off to near the zero value. A maximum preheat time of 30 minutes is provided to trigger the signal for preheat completion if the thermal energy equipment fails to signal a value of slightly less than the value recorded in Step c.

Step f. The teleprinter indicates "Preheat Complete."

Step g. The computer asks if the agitator drive system is on. If negative, the teleprinter is used to request that the agitator drive system be turned on.

Step h. The computer checks agitator status by examining the torque meter signal. Because of the high initial torque required to start the agitator in motion, the computer waits 30 seconds to allow the torque reading to stablize.

Step i. The computer checks the torque output signal to determine if it is below the value previously established if the kettle is empty. If the reading is below the established value, the program continues. If it is above the established value, the automatic program is deactivated thus signalling that there may be an agitator drive train problem or that a foreign object may be in the kettle.

Step j. The computer signals via the teleprinter to start adding explosive ingredients to the kettle.

Step k. The computer initially checks for material addition by checking the operation of the TNT feed hopper value. If the value signals "Open," the program continues to the next element.

Step l. The computer records a new thermal energy, zero set-point figure and begins to integrate all further energy usage. This reset function eliminates calculation of unwanted energy usage produced by varying preheat conditions.

Step m. The computer checks to see if thermal energy usage and torque values have increased to verify that material is entering the kettle. If the values have not increased above the recorded no-load torque or recorded BTU zero set-point within 150 seconds of the hopper opening signal, then the automatic program is deactivated. This feature is used to signal problems with the material feeding system that must be corrected before continuing.

Step n. If the torque and thermal energy tests are satisfied, the computer then checks to see if the torque reading exceeds the over-torque limit value. This value is purposely set higher than any reading that should be experienced during a routine batch. Exceeding this value will cause the computer to signal via the teleprinter to discontinue material addition until the torque reading drops below the high limit. Dropping below the limit will cause the computer to print a message for restarting the material addition. This sequence is used to prevent overloading the drive unit when material addition exceeds the capability of the steam to melt the TNT.

Step o. The computer is now required to closely monitor the material and thermal energy usages to prevent over-torque situations or too much thermal energy addition which would result in more TNT being melted than desired for final batch viscosity. The computer checks the total BTU consumption and compares it with a pre-established empirical value. If the value is exceeded, the computer checks the rate of energy usage and compares it with an empirical value. If the energy usage rate is lower than the check value, the computer shuts off the main steam valves and shifts the program emphasis to the final "Fine Tune" stage. This element of the program is used for batches smaller than the optimum.

Step p. If the total thermal energy does not exceed the lower limit or if it does but the usage rate is above the steam cut-off rate, the computer checks to see if the total thermal energy usage upper limit is exceeded. If this empirical value (based on previous batches) is exceeded, then the main steam valves are closed, the teleprinter so indicates the condition and the program shifts to the "Fine Tune" stage.

Step q. If the total thermal energy usage does not exceed the maximum limit, the computer checks the condition of the torque. If the torque is higher than the lower limit and is not falling, the program shifts back to perform the tasks again (starting with Step n).

Step r. If the torque value and trend indicate a thinner than desired material condition, the computer closes the main steam valves, so indicates by teleprinter message and begins to check the material feed conditions.

Step s. The computer checks the status of the material feed system from the TNT hopper valve. If material is entering the kettle and if the agitator torque is above the low limit, then the computer indicates by teleprinter message and opens the main steam valves. The program then shifts back to perform again the tasks starting with Step n. The low-torque limit is set above the torque value required for batch ready.

Step t. If material is not entering the kettle to indicate that all TNT and aluminum powder intended for this batch is in the kettle, then the computer begins a series of checks to determine batch condition by measuring material viscosity as a function of agitator torque. If the torque is below a pre-established low limit, then the computer checks to see if this is a short-term effect. Torque readings can move up or down because of the mixing taking place between melted and unmelted TNT. If the torque remains below the low limit set point for more than 240 seconds, the program shifts to the "Fine Tune" stage. If the torque exceeds the low limit within the 240 seconds, the computer opens the main steam valves, indicates the action via the teleprinter and the program returns to Step n.

Step u. The "Fine Tune" stage of the automatic mix-melt program involves the control of thermal energy input to bring the batch viscosity, as measured in terms of agitator drive torque, to a value determined empirically from previous batch tests. Steam is applied to the kettle jacket and calandria primarily in five-second bursts since the batch is considered to be in a critical stage where continuous steam would cause too much TNT melting. The first test in the "Fine Tune" stage is for "Batch Ready by Torque." If the torque reading is below the torque ready value, the computer indicates "Batch Ready by Torque Reading" via the teleprinter and then deactivates the autotask.

Step v. If the torque reading is still above the torque ready value, the computer checks for any over-torque situations. A torque reading in excess of the over-torque limit will trigger the computer to open the steam valves, so indicate by teleprinter and leave the valves open until the torque reading drops 15 percent below the torque-over value. The computer then will close the main steam valves and return to the tasks in the "Fine Tune" portion of the program. This series of tasks is designed to prevent excessive torque situations caused by material added after the test for maximum continuous steam energy addition has been made.

Step w. If the torque reading is below the torque over value, the computer checks for rising torque. If the torque is rising, the computer opens the steam valves, indicates (via the teleprinter) "Steam on by Rising Torque" and leaves the steam on until the torque beings to fall. The computer allows a minimum of five seconds steam addition until the falling torque causes the main steam valves to close, indicates "Steam Off" via the teleprinter and returns the program to check for the "Batch Ready by Torque Reading" tasks.

Step x. If the check for rising torque as performed in Step w is negative, the computer checks to see if the rate of torque fall is within the desired range. If it is slower than desired, the computer opens the steam valves for five seconds and then closes them with the appropriate message being made via the teleprinter. The program is then shifted to check for "Batch Ready by Torque Reading" and final deactivation of the autotask.

NOTE: The "Fine Tune" cycle will end only when the agitator torque is below a preset value determined empirically. This value can be changed up or down depending on the desired final batch viscosity. The quantity of material in the kettle could probably vary by 600 pounds of the maximum without appreciably altering this value since the agitator blades are located below the batch surface.

X. CONCLUSIONS

The task which was accomplished within the scope of this manufacturing technology development program has provided a base for a number of significant conclusions. The most pertinent conclusions are outlined in the following statements:

A. WITH REGARD TO EQUIPMENT SYSTEMS:

1. Equipment installed in Building 456, WPNSTA Yorktown, is considered equal to, or better than, any now installed at Navy or Single Manager (SM) ammunition production plants. Furthermore, the conditions at Building 456 duplicated as closely as practicable the conditions experienced in existing plants.

2. The temperature sensing system as installed on the kettle agitator is not practical in a production environment because the wiring system proved too fragile for shock and tear-down requirements of a production system. However, with extensive modification, the system could be used to analyze batch mixing efficiency.

3. The agitator shaft mounted torque measuring system, when coupled with a system for eliminating cyclic torque factors introduced by the shaft, bearings, packing glands, etc., is an inexpensive, reliable and responsive system for determining batch conditions. It is considered an essential element in a system for automatically controlling mix-melting.

4. The BTU calculator, when coupled with a system for determining accumulated thermal energy usage, can be used to control the quantity of TNT melted in a batch and thus control the viscosity of the batch.

5. The torque measuring system and the thermal energy measuring system, used in tandom, can effectively provide "Hands-Off" control of TNT mix-melting when coupled with a mini-computer and automatic or manually controlled material feed system.

B. WITH REGARD TO SOFTWARE:

1. The digital computer program, provided as appendix A, was developed to control the mix-melting of TNT within the limits set forth in this technology development project.

2. The program can effectively operate steam and material feed systems and provide interlocks essential to the safe operation of an explosive plant.

3. The program is flexible in that it can be altered to meet the changing conditions of the production environment.

4. The program can provide continuous data retrieval and recording for later analysis of batch quality or analysis of events leading up to an equipment malfunction (minor or catastrophic).

C. WITH REGARD TO ECONOMIC BENEFITS:

There are economic benefits of an improved TNT mix-melt control system. Appendix B provides discounted savings for peacetime and mobilization production.

XI. RECOMMENDATIONS

Recommendation 1

One or more of the equipment systems developed in this project be considered for use in improving the mix-melting of TNT based explosives.

Recommendation 2

Further testing, to refine the software program and expand its possible use to other formulations of TNT explosives beyond Tritonal, be performed with the equipment systems now located at WPNSTA Yorktown.

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APPENDIX A

COMPUTER PROGRAM

FOR

AUTOMATIC MIX-MELTING

OF

TRITONAL EXPLOSIVE

15 May 1978

```
0001  MELT5
                    .TITL    MELT5
                    .EXTN    DEBUG
                    .ENT     START .GTCH .PTCH
                    .EXTN    .ARDY .AKILL .ASUSP .IXMT .UIEX
                    .EXTN    .TASK .PRI .KILL .REC .XMT .UCEX
                    .EXTN FENT FINT
                    .ENT WSA GETC PUTC
                    .EXTN .TIDR .TIDK .SUSP .TIDS
                    .EXTN .IDST
                    .EXTN    .DIV

      000001        .TXTN    1



             .ZREL
00000-000000 TINPR:  0       ;TEST IN PROGRESS
00001-000001 KEYID:  1       ;KEYBOARD ID
00002-000000 STOPC:  0       ;WILL BE SET TO '1' FOR STOP
00003-001505'ZSTMES: STMES   ;STOP MESSAGE ADDRESS
00004-003376'ZREPORT:        REPORT  ;CASSETTE RECORD COUNT REPORT
00005-006311'GETC:   GTCH
00006-006303'PUTC:   PUTZ
00007-002576'WSA:    WRITA
00010-000000 DOUTC:  0       ;DATA PRINTING REQUIRED
00011-003447'XBNDEC: BNDEC
00012-000000 DIGRQ:  0       ;REQUEST FOR A/D FROM DIG
00013-000000 FSTRQ:  0       ;REQUEST FOR A/D FROM FAST
00014-000000 CHKRQ:  0       ;REQUEST FOR A/D FROM CHECK
00015-000017 FSTCHN: 15.     ;AGITATOR ROTATION INDICATOR CHAN
                                     ;    USED BY CONVRT TASK
00016-000000 INITL:  0       ;SET TO INDICATE CASSETTE INITIALIZED
00017-004602'XMESS:  MESS
00020-004444'XSTOFF: STMOFF
00021-004455'XSTON:  STMON

00022-000000 DA0:    0       ;WORD SENT TO DA0
00023-000000 DA1:    0       ;WORD SENT TO DA1

00024-000000 BTUFST: 0       ;USED TO GET BTUZER


             ;-----------------------------------------------------------------
             ;////////////////////////////////////////////////////////////////


00025-000000 AGRUN:  0       ;AGITATOR NOT RUNNING '0', RUNNING '1'
00026-000000 MTRUN:  0       ;MATERIAL NOT BEING ADDED '0', BEING ADDED '1'
00027-000000 TORQUE: 0       ;PRESENT TORQUE
00030-000000 TQDIR:  0       ;PRESENT TORQUE DIRECTION FALL '-1',
                             ;  RISE '1', NO CHANGE '0'
00031-000000 TORATE: 0       ;PRESENT RATE OF CHANGE IN TORQUE, ALWAYS POS.
00032-000000 BTU:    0       ;PRESENT VALUE OF BTU
00033-000000 BTUSUM: 0       ;BTU INTEGRAL
00034-000000 BTUDIR: 0       ;PRESENT BTU DIRECTION FALL '-1', RISE '1',
                             ;  NO CHANGE '0'
00035-000000 BTUZER: 0       ;VALUE OF BTU CALCULATOR BEFORE STEAM ON
00036-000000 DENSE:  0       ;PRESENT DENSITOMETER READING
```

```
;********     *******     *******

;ALL TIMES WILL BE # OF 5 SEC INTERVALS
;VOLTAGES AR REPRESENTED BY A COUNT OF 410/VOLT.

00037-000051 PREHEAT:        41.     ;BTU SHOULD BE WITHIN THIS VALUE OF
                                     ;    BTUZER FOR PREHEAT TO COMPLETE
00040-000006 TOWAIT: 6               ;TIME WAITED AFTER AGITATOR IS KNOWN TO BE
                                     ;  ON BEFORE NO LOAD TORQUE READING IS TAKEN
00041-000170 TONLD:   120.           ;NO LOAD TORQUE READING SHOULD BE
                                     ;  BELOW THIS VALUE
00042-000133 TOSRT:   91.            ;AFTER MATERIAL IS STARTED, TORQUE SHOULD EXCEED
                                     ;  THIS VALUE WITHIN "STIME"
00043-000074 BTUSRT:  60.            ;AFTER MATERIAL IS STARTED, BTU SHOULD EXCEED
                                     ;  THIS VALUE WITHIN "STIME"
00044-000044 STIME:   36.            ;AFTER MATERIAL IS STARTED, THIS IS MIN TIME
                                     ;  FOR TORQUE AND BTU TO EXCEED
                                     ;  "TOSRT" AND "BTUSRT"
00045-002316 TOOVER: 1230.           ;VOLTAGE FOR WHICH TORQUE IS CONSIDERED
                                     ;  TO BE IN OVERLOAD CONDITION.
00046-002025 TOUMAX: 1045.           ;TORQUE MUST FALL 15% BELOW MAX TORQUE
                                     ; BEFORE STEAM IS SHUT OFF.
00047-014234 SLMT1:   6300.          ;LOWER LIMIT ON BTU SUM, IF BTU
                                     ;  USE IS LOWER THAN "BLMT",
                                     ;THAN THE STEAM WILL BE SHUT OFF.
00050-000007 BLMT:    7.             ;BTU LOWER LIMIT USED IN SHUTTING OFF STEAM.
00051-020464 SLMT2:   8500.          ;MAX BTUSUM FOR CONTINOUS INPUT OF STEAM.
00052-000632 TOLOW:   410.           ;VOLTAGE AT WHICH IF TORQUE GETS LOWER THAN THIS
                                     ;  AND IS FALLING, THE STEAM WILL BE SHUT OFF.
00053-000060 TOTIM:   48.            ;THIS IS MAX TIME ALLOWED IN LOW TORQUE
                                     ;  WITH NO MATERIAL COMING IN,  BEFORE
                                     ;ENTERING BATCH OK CHECK.
00054-003221 DREADY: 1681.           ;BATCH IS READY BY DENSITOMETER WHEN
                                     ;  DENSE IS GT THIS VALUE.
00055-000437 TREADY: 287.            ;BATCH IS READY BY TORQUE WHEN TORQUE
                                     ;  IS LESS THAN THIS VALUE.
00056-000005 NOISE:   5              ;IF VOLTAGE CHANGED BY LESS THAN
                                     ; + OR - "NOISE" THAN NO CHANGE IS CONSIDERED.
00057-000017 RTLMT:   15.            ;LOWEST RATE THAT TORQUE CAN BE
                                     ;  FALLING WITHOUT ADDING 5 SEC. STEAM.
00060-000030 DELAY:   24.            ;# OF 5 SEC INTERVALS USED IN
                                     ;  FIGURING RATE OF FALL FOR TORQUE.
```

```
                .NREL

                ;-----------------------------------
                ;DEFAULT TASK

                START:
00000'077777              FINT
00001'006020-             JSR@    XSTOFF  ;CLEAR DA ' S
00002'102400              SUB     0,0
00003'040002-             STA     0,STOPC ;CLEAR STOPC AND
00004'040000-             STA     0,TINPR ;  TEST IN PROGRESS
00005'040010-             STA     0,DOUTC ;CLEAR PRINT DATA
00006'006066-             JSR@    XCRLF
00007'020440              LDA     0,MBGN  ;PRINT STARTING MESSAGE
00010'006126-             JSR@    XWRLO
00011'020441              LDA     0,PHMASK
00012'062077              MSKC    0
00013'006440              JSR@    ZINTDT  ;ENTER DATE
00014'006440              JSR@    ZINTTM  ;ENTER TIME

00015'020444              LDA     0,INITID          ;IDENTIFY INITIALIZE TASK
00016'024444              LDA     1,INTAD
00017'077777              .TASK
00020'006135-             JSR@    XERR

00021'020427              LDA     0,MBGN+1
00022'006126-             JSR@    XWRLO   ;TYPE "HELP" FOR LIST OF COMMANDS

00023'020440              LDA     0,CNVIP ;IDENTIFY CONVERT TASK
00024'024440              LDA     1,CNVSA
00025'000017'             .TASK
00026'006135-             JSR@    XERR

00027'006061-             JSR@    XIKCT   ;IDENTIFY KEYBOARD TASK

00030'006421              JSR@    ZWAITR  ;IDENTIFY WAIT FOR CHAR TASK

00031'077777              .KILL           ;KILL THIS TASK


                ;LIST KEYBOARD COMMANDS
00032'020423 HELP:        LDA     0,NLINE ;NUMBER OF LINES
00033'040423              STA     0,DNLINE
00034'020423              LDA     0,ZLST  ;LIST ADDRESS
00035'040423              STA     0,PNTS
00036'022422 STLP1:       LDA@    0,PNTS
00037'006126-             JSR@    XWRLO
00040'010420              ISZ     PNTS
00041'014415              DSZ     DNLINE
00042'000774              JMP     STLP1
00043'024001-             LDA     1,KEYID
00044'077777              .TIDR
00045'006135-             JSR@    XERR
```

```
0004  MELTS
 00046'000031'            .KILL



 00047'000222"MBGN:    2*MSTRT
 00050'001326"         2*MS201
 00051'000605'ZWAITR: WAITR
 00052'177730 PHMASK: 177730
 00053'006105'ZINTDT: INTDT
 00054'006126'ZINTTM: INTTM
 00055'000024 NLINE:  KCEND-KCLST
 00056'000000 DNLINE: 0
 00057'000065'ZLST:   KCLST
 00060'000000 PNTS:   0
 00061'002050 INITID: 4B7+50
 00062'005647'INTAD:  INIT
 00063'007415 CNVIP:  17B7+15
 00064'002776'CNVSA:  CNVRT

 00065'000264"KCLST:  2*MKC0
 00066'000266"        2*MKC1
 00067'000264"        2*MKC0
 00070'000312"        2*MKC2
 00071'000354"        2*MKC3
 00072'000400"        2*MKC4
 00073'000436"        2*MKC5
 00074'000476"        2*MKC6
 00075'000540"        2*MKC7
 00076'000600"        2*MKC8
 00077'000640"        2*MKC9
 00100'000714"        2*MKC11
 00101'000750"        2*MKC10
 00102'001034"        2*MKC12
 00103'001160"        2*MKC14
 00104'001114"        2*MKC15
 00105'001222"        2*MKC16
 00106'001264"        2*MKC13
 00107'000264"        2*MKC0
 00110'000264"        2*MKC0
              KCEND:

              MSTRT:  .TXT *MIX MELT DATA COLLECTION PROGRAM<15>*
 00111'046511
 00112'054040
 00113'046505
 00114'046124
 00115'020104
 00116'040524
 00117'040440
 00120'041517
 00121'046114
 00122'042503
 00123'052111
 00124'047516
 00125'020120
 00126'051117
 00127'043522
 00130'040515
```

```
 00131'006400

               MKC0:    .TXT *<15>*
 00132'006400
               MKC1:    .TXT *KEYBOARD COMMANDS<15>*
 00133'045505
 00134'054502
 00135'047501
 00136'051104
 00137'020103
 00140'047515
 00141'046501
 00142'047104
 00143'051415
 00144'000000
               MKC2:    .TXT *TEST     - PREPARE AND START TEST<15>*
 00145'052105
 00146'051524
 00147'020040
 00150'020055
 00151'070120
 00152'051105
 00153'050101
 00154'051105
 00155'020101
 00156'047104
 00157'020123
 00160'052101
 00161'051124
 00162'020124
 00163'042523
 00164'052015
 00165'000000
               MKC3:    .TXT *STOP     - STOP TEST<15>*
 00166'051524
 00167'047520
 00170'020040
 00171'020055
 00172'020123
 00173'052117
 00174'050040
 00175'052105
 00176'051524
 00177'006400
               MKC4:    .TXT *TIME     - PRINT TIME AND DATE<15>*
 00200'052111
 00201'046505
 00202'020040
 00203'020055
 00204'020120
 00205'051111
 00206'047124
 00207'020124
 00210'044515
 00211'042440
 00212'040516
 00213'042040
 00214'042101
 00215'052105
```

```
0006  MELTS
 00216'006400
                        MKC5:    .TXT *CTIME  - CHANGE TIME AND DATE<15>*
 00217'041524
 00220'044515
 00221'042440
 00222'020055
 00223'020103
 00224'044101
 00225'047107
 00226'042440
 00227'052111
 00230'046505
 00231'020101
 00232'047104
 00233'020104
 00234'040524
 00235'042415
 00236'000000
                        MKC6:    .TXT *PRINT  - PRINT DATA DURING TEST<15>*
 00237'050122
 00240'044516
 00241'052040
 00242'020055
 00243'020120
 00244'051111
 00245'047124
 00246'020104
 00247'040524
 00250'040440
 00251'042125
 00252'051111
 00253'047107
 00254'020124
 00255'042523
 00256'052015
 00257'000000
                        MKC7:    .TXT *LIST   - LIST DATA ON CASSETTE<15>*
 00260'046111
 00261'051524
 00262'020040
 00263'020055
 00264'020114
 00265'044523
 00266'052040
 00267'042101
 00270'052101
 00271'020117
 00272'047040
 00273'041501
 00274'051523
 00275'042524
 00276'052105
 00277'006400
                        MKC8:    .TXT *STATUS - PRINT STATUS OF TEST<15>*
 00300'051524
 00301'040524
 00302'052523
 00303'020055
 00304'020120
```

```
0007  MELTS
 00305'051111
 00306'047124
 00307'020123
 00310'052101
 00311'052125
 00312'051440
 00313'047506
 00314'020124
 00315'042523
 00316'052015
 00317'000000
                        MKC9:    .TXT *CHECK   - PRINT READINGS FROM A/D CHANNELS<15>*
 00320'041510
 00321'042503
 00322'045440
 00323'020055
 00324'020120
 00325'051111
 00326'047124
 00327'020122
 00330'042501
 00331'042111
 00332'047107
 00333'051440
 00334'043122
 00335'047515
 00336'020101
 00337'027504
 00340'020103
 00341'044101
 00342'047116
 00343'042514
 00344'051415
 00345'000000
                        MKC11:   .TXT *SCAN    - POSITION CASSETTE<15>*
 00346'051503
 00347'040516
 00350'020040
 00351'020055
 00352'020120
 00353'047523
 00354'044524
 00355'044517
 00356'047040
 00357'041501
 00360'051523
 00361'042524
 00362'052105
 00363'006400
                        MKC10:   .TXT *CTRL A - TERMINATES PRINT, LIST, AND SCAN
 00364'041524
 00365'051114                     COMMANDS<15>
 00366'020101
 00367'020055
 00370'020124
 00371'042522
 00372'046511
 00373'047101
 00374'052105
```

```
0008  NELTS
 00375'051440
 00376'050122
 00377'044516
 00400'052054
 00401'020114
 00402'044523
 00403'052054
 00404'020101
 00405'047104
 00406'020123
 00407'041501
 00410'047040
 00411'041517
 00412'046515
 00413'040516
 00414'042123
 00415'006400
                 MKC12:  .TXT *AUTC   - COMPUTFR CONTROL OF STEAF FOR
 00416'040525
 00417'052117                          KETTLF<15>*
 00420'020040
 00421'020055
 00422'020103
 00423'047515
 00424'050125
 00425'052105
 00426'051040
 00427'041517
 00430'047124
 00431'051117
 00432'046040
 00433'047506
 00434'020123
 00435'052105
 00436'040515
 00437'020106
 00440'047522
 00441'020113
 00442'042524
 00443'052114
 00444'042415
 00445'000000
                 MKC15:  .TXT *MANUAL - RELEASES COMPUTER CONTFCL<15>*
 00446'046501
 00447'047125
 00450'040514
 00451'020055
 00452'020122
 00453'042514
 00454'042501
 00455'051505
 00456'051440
 00457'041517
 00460'046520
 00461'052524
 00462'042522
 00463'020103
 00464'047516
 00465'052122
```

```
0009  MFLT5
 00466'047514
 00467'006400
                MKC14:  .TXT *OFF      - STEAM OFF FROM KEYBOARD<15>*
 00470'047506
 00471'043040
 00472'020040
 00473'020055
 00474'020123
 00475'052105
 00476'040515
 00477'020117
 00500'043106
 00501'020106
 00502'051117
 00503'046440
 00504'045505
 00505'054502
 00506'047501
 00507'051104
 00510'006400
                MKC16:  .TXT *ON       - STEAM ON FROM KEYBOARD<15>*
 00511'047516
 00512'020040
 00513'020040
 00514'020055
 00515'020123
 00516'052105
 00517'040515
 00520'020117
 00521'047040
 00522'043122
 00523'047515
 00524'020113
 00525'042531
 00526'041117
 00527'040522
 00530'042015
 00531'000000
                MKC13:  .TXT *HELP     - PRINTS LIST OF COMMANDS<15>*
 00532'044105
 00533'046120
 00534'020040
 00535'020055
 00536'020120
 00537'051111
 00540'047124
 00541'051440
 00542'046111
 00543'051524
 00544'020117
 00545'043040
 00546'041517
 00547'046515
 00550'040516
 00551'042123
 00552'006400
                MS201:  .TXT     *TYPE "HELP" FOR LIST OF COMMANDS<15>*
 00553'052131
 00554'050105
```

```
0010  MELTS
 00555'020042
 00556'044105
 00557'046120
 00560'021040
 00561'043117
 00562'051040
 00563'046111
 00564'051524
 00565'020117
 00566'043040
 00567'041517
 00570'046515
 00571'040516
 00572'042123
 00573'006400

                         ;IDENTIFY KEYBOARD TASK ROUTINE
                         ;-------------------------------
 00574'054406 IKCT:      STA     3,IKCTO
 00575'020407            LDA     0,KCTIP
 00576'024405            LDA     1,KCTSA
 00577'000025'           .TASK
 00600'006135-           JSR     @XERR
 00601'002401            JMP     @IKCTO

 00602'000000 IKCTO:     0
 00603'000665'KCTSA:     KCT
 00604'000440 KCTIP:     1B7+40

                         .ZREL
 00061-000574'XIKCT:     IKCT
```

```
                  .NREL
                  ;TASK TO WAIT ON A CTRL A
                  ; WHEN CTRL A IS RECEIVED, PRINT AND LIST TASKS ARE KILLED
                  ; KEYBOARD TASK IS MADE READY

                  .NREL
00605'054406 WAITR:    STA     3,WTRO
00606'020407           LDA     0,WTRIP
00607'024405           LDA     1,WTRSA
00610'000577'          .TASK
00611'006135-          JSR@    XERR
00612'002401           JMP@    WTRO
00613'000000 WTRO:     0
00614'000616'WTRSA:    WATT
00615'001007 WTRIP:    2B7+7

00616'020445 WATT:     LDA     0,WATCH
00617'006017           .SYSTM
00620'021023           .WCHAR
00621'006135-          JSR@ XERR

00622'024436           LDA     1,WTT1    ;ID OF PRINT
00623'077777           .IDST
00624'024435           LDA     1,WTT2    ;10
00625'106415           SUB#    0,1,SNR
00626'000406           JMP     WTT3      ;NO TASK AT THIS ID

00627'024431           LDA     1,WTT1
00630'077777           .TIDK
00631'006135-          JSR@    XERR
00632'102400           SUB     0,0
00633'040010-          STA     0,DOUTC ;CLEAR PRINT DATA

00634'024426 WTT3:     LDA     1,WTT4    ;ID OF LIST
00635'000623'          .IDST
00636'024423           LDA     1,WTT2
00637'106415           SUB#    0,1,SNR
00640'000404           JMP     WTT6

00641'024421           LDA     1,WTT4
00642'000630'          .TIDK
00643'006135-          JSR@    XERR

00644'024420 WTT6:     LDA     1,WTT7    ;ID OF SCAN
00645'000635'          .IDST
00646'024413           LDA     1,WTT2
00647'106415           SUB#    0,1,SNR
00650'000404           JMP     WTT5
00651'024413           LDA     1,WTT7
00652'000642'          .TIDK
00653'006135-          JSR@    XERR

00654'024001-WTT5:     LDA     1,KEYID
00655'000044'          .TIDR
00656'006135-          JSR@    XERR

00657'000737           JMP     WATT

00660'000010 WTT1:     10
```

```
0012  MELTS
 00661'000010 WTT2:     10
 00662'000015 WTT4:     15
 00663'000001 WATCH:    1          ;CTRL A
 00664'000016 WTT7:     16
```

```
                          ;KEYBOARD CONTROL TASK
                          ;TASK I.D. NO. - 20
                          ;TASK PRIORITY - 40
                          ;-----------------------------------------------------
00665'006066-KCT:         JSR@      XCRLF      ;CR LF
00666'020532              LDA       0,KCD
00667'006126-             JSR@      XWRLO
00670'020473              LDA       0,XCMD     ;READ COMMAND LINE
00671'006125-             JSR       @XRDLR
00672'020471              LDA       0,XCMD     ;COMMAND MESSAGE START
00673'040454              STA       0,POINT
00674'102400              SUB       0,0        ;ZERO COMMAND WORD
00675'040467              STA       0,CMDW
00676'020467              LDA       0,TRAY     ;NUMBER OF CHAR ALLOWED IN COMMAND
00677'040467              STA       0,DNTRY
00700'006455 KLP0:        JSR@      XGTCH      ;GET CHAR OF COMMAND
00701'034466              LDA       3,KCR      ;IS CHAR CR
00702'116415              SUB#      0,3,SNR
00703'000435              JMP       KLP1       ;YES
00704'034464              LDA       3,KBLK     ;IS CHAR BLANK
00705'116415              SUB#      0,3,SNR
00706'000432              JMP       KLP1       ;YES
00707'024442              LDA       1,K101     ;IS CHAR A LETTER
00710'030442              LDA       2,K132
00711'106033              ADCZ#     0,1,SNC    ;SKIP IF NOT LETTER, 101>CHAR
00712'112433              SUBZ#     0,2,SNC    ;SKIPIF LETTER, 132>=CHAR
00713'000404              JMP       KLP2       ;NOT LETTER
00714'024434              LDA       1,K100     ;LETTER, SUB 100 FROM CHAR
00715'122400              SUB       1,0
00716'000410              JMP       KLP3
00717'024434 KLP2:        LDA       1,K60      ;IS CHAR NUMBER
00720'030441              LDA       2,K71
00721'106033              ADCZ#     0,1,SNC              ;SKIP IF NOT NUM, 60>CHAR
00722'112433              SUBZ#     0,2,SNC    ;SKIP IF NUM, 71>=CHAR
00723'000462              JMP       KLP4       ;NOT NUM, ERROR
00724'024430              LDA       1,K25      ;NUM
00725'122400              SUB       1,0        ;SUB 25 FROM CHAR
00726'040430 KLP3:        STA       0,TCHAR
00727'030435              LDA       2,CMDW
00730'024432              LDA       1,K36D
00731'006426              JSR       @XMPY
00732'030424              LDA       2,TCHAR    ;ADD IN CHAR
00733'147000              ADD       2,1
00734'044430              STA       1,CMDW
00735'014431              DSZ       DNTRY
00736'000742              JMP       KLP0
00737'000433              JMP       KLP5       ;COMMAND WORD FOUND
00740'030424 KLP1:        LDA       2,CMDW
00741'024421              LDA       1,K36D
00742'006415              JSR@      XMPY
00743'044421              STA       1,CMDW
00744'014422              DSZ       DNTRY
00745'000773              JMP       KLP1
00746'000424              JMP       KLP5
00747'000000 POINT:       0
00750'000100 K100:        100
00751'000101 K101:        101
00752'000132 K132:        132
00753'000060 K60:         60
```

```
0014  M.LTS
 00754'000025 K25:      25
 00755'001201'XGTCH:    GETCH
 00756'000000 TCHAR:    0
 00757'001216'XMPY:     MPY
 00760'000000 CMADD:    0
 00761'000071 K71:      71
 00762'000044 K36E:     36.
 00763'002174"XCMD:     CMD*2
 00764'000000 CMDW:     0
 00765'000003 TRAY:     3
 00766'000000 DNTRY:    0
 00767'000015 KCR:      15
 00770'000040 KBLK:     40
 00771'000003 KWRDS:    3           ;NUMBER OF WORDS PER COMMAND IN TABLE

 00772'034430 KLP5:     LDA     3,XTABLE        ;TABLE START ADDRESS
 00773'020430           LDA     0,TLONG ;TABLE LENGTH
 00774'040772           STA     0,DNTRY
 00775'030774           LDA     2,KWRDS ;NUMBER OF WORDS PER COMMAND
 00776'020766           LDA     0,CMDW   ;COMMAND WORD
 00777'025400 KLP7:     LDA     1,0,3    ;TABLE COMMAND
 01000'106415           SUB#    0,1,SNR
 01001'000407           JMP     KLP6     ;COMMAND FOUND
 01002'157000           ADD     2,3
 01003'014763           DSZ     DNTRY
 01004'000773           JMP     KLP7
 01005'020414 KLP4:     LDA     0,KCC    ;ERROR
 01006'006126-          JSR@    XWRLO
 01007'000656           JMP     KCT

 01010'054750 KLP6:     STA     3,CMADD
 01011'034747           LDA     3,CMADD
 01012'025401           LDA     1,1,3     ;TASK ADDRESS
 01013'021402           LDA     0,2,3     ;ID & PRIORITY
 01014'000610'          .TASK             ;IDENTIFY TASK
 01015'006135-          JSR@ XERR
 01016'077777           .SUSP             ;SUSPEND KEY BOARD
 01017'000646           JMP     KCT

 01020'002306"KCD:      2*KKPCT
 01021'002330"KCC:      2*KCUST
 01022'001024'XTABLE:   TABLE
 01023'000016 TLONG:    TBEND-TABLE/3


                ;      COMMAND TABLE

                ;NOTE!!
                ;  SUB 100 FROM LETTERS
                ;  SUB 25 FROM NUMBERS


 01024'063007 TABLE:    "T-100*36.+"E-100*36.+"S-100
 01025'001242'          TEST
 01026'001405           3B7+5
 01027'061417           "S-100*36.+"T-100*36.+"O-100
 01030'001441'          STOP
 01031'003407           7B7+7
```

```
 01032'051621          "P-100*36.+"R-100*36.+"I-100
 01033'001650'         PRINT
 01034'004020          10B7+20
 01035'061401          "S-100*36.+"T-100*36.+"A-100
 01036'002003'         STATUS
 01037'004420          11B7+20
 01040'011011          "C-100*36.+"T-100*36.+"I-100
 01041'002043'         CTIME
 01042'005020          12B7+20
 01043'063221          "T-100*36.+"I-100*36.+"M-100
 01044'001633'         TIME
 01045'005420          13B7+20
 01046'010125          "C-100*36.+"H-100*36.+"E-100
 01047'001701'         CHECK
 01050'006020          14B7+20
 01051'037027          "L-100*36.+"I-100*36.+"S-100
 01052'002062'         LIST
 01053'006420          15B7+20
 01054'060235          "S-100*36.+"C-100*36.+"A-100
 01055'005737'         SCAN
 01056'007020          16B7+20
 01057'024500          "H-100*36.+"E-100*36.+"I-100
 01060'000032'         HELP
 01061'014420          31B7+20
 01062'004030          "A-100*36.+"U-100*36.+"T-100
 01063'004111'         AUTO
 01064'020010          40B7+10
 01065'041002          "M-100*36.+"A-100*36.+"N-100
 01066'005421'         MANUAL
 01067'020407          41B7+7
 01070'046316          "O-100*36.+"F-100*36.+"F-100
 01071'005401'         SOFF
 01072'021004          42B7+4
 01073'046750          "O-100*36.+"N-100*36.
 01074'005410'         SON
 01075'021407          43B7+7
                TBEND:
 01076'000000 CMD:     0
        000043         .BLK 35.
 01142'000000          0

                MKBCT:  .TXT *KEYBOARD CONTROL<15>*
 01143'045505
 01144'054502
 01145'047501
 01146'051104
 01147'020103
 01150'047516
 01151'052122
 01152'047514
 01153'006400
                MQUST:  .TXT *??<7><15>*
 01154'037477
 01155'003415
 01156'000000
                MS109:  .TXT *PRINT DATA EACH MINUTE DURING TEST<15>*
 01157'050122
 01160'044516
```

```
0016  FILT5
 01161'052040
 01162'042101
 01163'052101
 01164'020105
 01165'040503
 01166'044040
 01167'046511
 01170'047125
 01171'052105
 01172'020104
 01173'052522
 01174'044516
 01175'043440
 01176'052105
 01177'051524
 01200'006400

                    ;SUBROUTINE TO GET A CHAR FROM READ LINE BUFFER
                    ;ASSUMES BUFFER POINTER IN POINT
                    ;AC0 CONTAINS CHAR
 01201'054413 GETCH:   STA     3,GGRET
 01202'036413          LDA@    3,GPOINT
 01203'175220          MOVZR   3,3
 01204'021400          LDA     0,0,3
 01205'175003          MOV     3,3,SNC
 01206'101300          MOVS    0,0
 01207'034404          LDA     3,MGK
 01210'163400          AND     3,0
 01211'012404          ISZ@    GPOINT
 01212'002402          JMP@    GGRET
 01213'000177 MGK:     177
 01214'000000 GGRET:   0
 01215'000747'GPOINT:  POINT

 01216'102460 MPY:     SUBC    0,0      ;INTEGERS IN AC1 AND AC2
 01217'054411          STA     3,CB03
 01220'034411          LDA     3,CB20
 01221'125203 CB99:    MOVR    1,1,SNC
 01222'101201          MOVR    0,0,SKP
 01223'143220          ADDZR   2,0
 01224'175404          INC     3,3,SZR
 01225'000774          JMP     CB99
 01226'125260          MOVCR   1,1
 01227'002401          JMP@    CB03     ;RESULT AC0-AC1
 01230'000000 CB03:    0
 01231'177760 CB20:    -20
```

```
                        ;OUTPUT CR AND LF ROUTINE
                        ;-------------------------
01232'054404 CRLF:      STA     3,CLO
01233'020404            LDA     0,.+4
01234'006126-           JSR     @XWRLO
01235'002401            JMP     @CLO

01236'000000 CLO:       0
01237'002500"           2*MCRLF
             MCRLF:     .TXT    "<15><12>"
01240'006412
01241'000000


                        .ZREL
00062-000005 TPRI:      5
00063-000007 TPRI7:     7
00064-000010 TPRI1:     10
00065-000020 TPRI2:     20
00066-001232'XCRLF:     CRLF
```

```
                    ;TASK TO START THE TEST

                    ;----------------------------

                    .NREL
01242'020000-TEST:      LDA     0,TINPR ;IS A TEST IN PROGRESS?
01243'101004            MOV     0,0,SZR
01244'000453            JMP     YLUM    ;TEST IN PROGRESS
01245'102000            ADC     0,0
01246'040000-           STA     0,TINPR ;SHOW THAT A TEST IS IN PROGRESS

01247'024464            LDA     1,WTST  ;SUSPEND WAIT CHAR. TASK
01250'077777            .TIDS
01251'006135-           JSR@    XERR

                    ;MAKE SURE CASSETTES ARE IN PLACE.
01252'020453            LDA     0,TSTCAS        ;PUT CASSETTES IN UNIT 0 & 1
01253'006126-           JSR@    XWRLO
01254'020452            LDA     0,TSTCAS+1      ;STRIKE ANY KEY WHEN LOADED
01255'006126-           JSR@    XWRLO
01256'006103-           JSR@    XGETC   ;WAIT FOR A CHAR

                    ;CHECK TO SEE IF CASSETETES INITIALIZED
01257'020016-           LDA     0,INITL
01260'101004            MOV     0,0,SZR
01261'000410            JMP     TST1
01262'020452            LDA     0,WTPRY ;WAIT PRIORITY
01263'077777            .PRI

01264'020016-TST2:      LDA     0,INITL
01265'101005            MOV     0,0,SNR
01266'000776            JMP     TST2
01267'020446            LDA     0,RUNPRY        ;RUN PRIORITY
01270'001263'           .PRI

01271'020120-TST1:      LDA     0,STCN  ;REWIND SECONDARY
01272'040115-           STA     0,TAPCN
01273'024110-           LDA     1,K1
01274'006124-           JSR@    XTVFE
01275'000776            JMP     .-2

01276'020116-           LDA     0,PTCN  ;REWIND PRIMARY
01277'040115-           STA     0,TAPCN
01300'024110-           LDA     1,K1
01301'006124-           JSR@    XTVFE
01302'000776            JMP     .-2

01303'102400            SUB     0,0
01304'040002-           STA     0,STOPC ;CLEAR STOP CODE
01305'040123-           STA     0,PSTF  ;INDICATE PRIMARY ACTIVE
01306'040117-           STA     0,NPTCN ;0 RECORDS
01307'040121-           STA     0,NSTCN

01310'020420            LDA     0,INE
01311'006126-           JSR@    XWRLO
01312'024417            LDA     1,INE+1
01313'020417            LDA     0,INE+2
01314'001014'           .TASK
01315'006135-           JSR@    XERR
```

```
01316'000046'          .KILL

01317'020410 YDUF:     LDA      0,TSTCAS+2
01320'006126-          JSR@     XWRLO
01321'024001-          LDA      1,KEYID
01322'000655'          .TIDR
01323'006135-          JSR@     XERR
01324'001316'          .KILL

01325'002674"TSTCAS:   2*MTCASS
01326'002740"          2*STRKY
01327'003034"          2*TTRG
01330'002774"INE:      2*MACPT
01331'003476'          ACPT
01332'002010           4B7+10
01333'000002 WTST:     2        ;ID OF WAIT CHAR.
01334'000100 WTPRY:    100      ;WAIT PRIORITY
01335'000005 RUNPRY:   5        ;RUN PRIORITY
             MTCAS:    .TXT *PUT BLANK CASSETTES IN UNIT 0 & 1<15>*
01336'050125
01337'052040
01340'041114
01341'040516
01342'045440
01343'041501
01344'051523
01345'042524
01346'052105
01347'051440
01350'044516
01351'020125
01352'047111
01353'052040
01354'030040
01355'023040
01356'030415
01357'000000
             STRKY:    .TXT     *STRIKE ANY KEY WHEN LOADED<15>*
01360'051524
01361'051111
01362'045505
01363'020101
01364'047131
01365'020113
01366'042531
01367'020127
01370'044105
01371'047040
01372'046117
01373'040504
01374'042504
01375'006400
             MACPT:    .TXT *ENTER ID RECORD FOR THIS TEST<15>*
01376'042516
01377'052105
01400'051040
01401'044504
```

```
0020  FFITS
 01402'020122
 01403'042503
 01404'047522
 01405'042040
 01406'043117
 01407'051040
 01410'052110
 01411'044523
 01412'020124
 01413'042523
 01414'052015
 01415'000000
                    TTRG:    .TXT *THEFE IS A TEST ALREADY IN PROGFESS<15>*
 01416'052110
 01417'042522
 01420'042440
 01421'044523
 01422'020101
 01423'020124
 01424'042523
 01425'052040
 01426'040514
 01427'051105
 01430'040504
 01431'054440
 01432'044516
 01433'020120
 01434'051117
 01435'043522
 01436'042523
 01437'051415
 01440'000000
```

```
                        ;    STOP TASK
                        ;THIS TASK ENDS THE CURRENT TEST AND CLOSES THE DATA FILE

01441'020000-STOP:      LDA     0,TINPR ;IS THERE A TEST IN PROGRESS
01442'101005            MOV     0,0,SNR
01443'000436            JMP     STPER   ;NO TEST IN PROGRESS

01444'024445            LDA     1,SAUTID
01445'000645'           .IDST
01446'024444            LDA     1,STN10
01447'106414            SUB#    0,1,SZR
01450'000427            JMP     STNO

01451'102000            ADC     0,0     ;TELL DIGITIZE TIME TO STOP
01452'040002-           STA     0,STOPC
01453'020431            LDA     0,STPTRY
01454'006126-           JSR@    XWRLO

01455'020003-           LDA     0,ZSTMES            ;WAIT TILL DIGITIZE IS READY
01456'077777            .REC
                                                     TO STOP
                        ;DIGITIZE IS COMPLETED
                        ;PUT EOF ON ACTIVE TAPE DRIVE
                        ;CLOSE ACTIVE CASSETTE CHANNELS
01457'024114-           LDA     1,K6
01460'006124-           JSR@    XTWFE   ;PUT EOF ON TAPE
01461'000401            JMP     .+1
01462'102400            SUB     0,0
01463'040012-           STA     0,DIGRQ ;CLEAR A/D REQUEST
01464'040000-           STA     0,TINPR ;CLEAR TEST IN PROGRESS

                        ;KILL DIGITIZE TASK
01465'024426            LDA     1,STPID
01466'000652'           .TIDK
01467'006135-           JSR@    XERR

01470'020416            LDA     0,STCMP ;STOP COMPLETE
01471'006126-           JSR@    XWRLO

01472'006004-           JSR@    ZREPORT ;REPORT CASSETTE USE

01473'024001-LEAVE:     LDA     1,KEYID
01474'001322'           .TIDR
01475'006135-           JSR@    XERR
01476'001324'           .KILL

01477'020411 STNO:      LDA     0,STPYY
01500'000402            JMP     STCON

01501'020406 STPER:     LDA     0,STPXX
01502'006126-STCON:     JSR@    XWRLO
01503'000770            JMP     LEAVE

01504'003230"STPTRY:    2*MS102
01505'000000 STMES:     0
01506'003334"STCMP:     2*MS103
01507'003356"STPXX:     2*MS104
01510'003404"STPYY:     2*MS401
01511'000040 SAUTID:    40
```

```
 01512'000010 STN10:   10
 01513'000006 STPID:   6          ;ID OF DIG TASK

              MS102:   .TXT *TEST WILL BE STOPPED AT THE END OF THE ONE MINUT
 01514'052105
 01515'051524
 01516'020127
 01517'044514
 01520'046040
 01521'041105
 01522'020123
 01523'052117
 01524'050120
 01525'042504
 01526'020101
 01527'052040
 01530'052110
 01531'042440
 01532'042516
 01533'042040
 01534'047506
 01535'020124
 01536'044105
 01537'020117
 01540'047105
 01541'020115
 01542'044516
 01543'052524
 01544'042440
 01545'051501 SAMPLE INTERVAL.<15>*
 01546'046520
 01547'046105
 01550'020111
 01551'047124
 01552'042522
 01553'053101
 01554'046056
 01555'006400
              MS103:   .TXT *TEST COMPLETED.<15>*
 01556'052105
 01557'051524
 01560'020103
 01561'047515
 01562'050114
 01563'042524
 01564'042504
 01565'027015
 01566'000000
              MS104:   .TXT *NO TEST IN PROGRESS<15>*
 01567'047117
 01570'020124
 01571'042523
 01572'052040
 01573'044516
 01574'020120
 01575'051117
 01576'043522
 01577'042523
 01600'051415
```

```
0023  MEL15
 01601'000000
                   MS401:  .TXT *CAN NOT STOP TEST WHILE AUTO CONTROL
 01602'041501
 01603'047040
 01604'047117
 01605'052040
 01606'051524
 01607'047520
 01610'020124
 01611'042523
 01612'052040
 01613'053510
 01614'044514
 01615'042440
 01616'040525
 01617'052117
 01620'020103
 01621'047516
 01622'052122
 01623'047514
 01624'020111    IS RUNNING<15>*
 01625'051440
 01626'051125
 01627'047116
 01630'044516
 01631'043415
 01632'000000
```

```
                    ;TASK THAT PRINTS THE TIME

                    TIME:
01633'006411              JSR@    TME1      ;GET DATE
01634'006411              JSR@    TME2      ;PRINT DATE
01635'006411              JSR@    TME3      ;GET TIME
01636'006411              JSR@    TME4      ;PRINT TIME
01637'006066-             JSR@    XCRLF

01640'024001-             LDA     1,KEYID
01641'001474'             .TIDR
01642'006135-             JSR@    XERR

01643'001476'             .KILL

01644'005715'TME1:        GDATE
01645'003335'TME2:        PDATE
01646'005726'TME3:        GTIME
01647'003275'TME4:        PTIME
```

```
                     ;A TASK THATS PRINTS DATA ONCE A MINUTE DURING DIGITIZE

                     PRINT:
01650'020000-               LDA     0,TINPR ;IS TEST IN PROGRESS
01651'101005                MOV     0,0 SNR
01652'000414                JMP     PR6     ;NO TEST IN PROGRESS
01653'020425                LDA     0,PR8
01654'006126-               JSR@    XWRLO
01655'102000                ADC     0,0     ;TELL DIGITIZE THAT DAT
01656'040010-               STA     0,DOUTC ;MUST BE PRINTED

01657'020416 PR5:           LDA     0,YTDMG ;WAIT FOR DATA TO BE READY
01660'001456'               .REC
01661'006415                JSR@    YPTIME  ;PRINT TIME
01662'006066-               JSR@    XCRLF
01663'006411                JSR     @ZADOUT ;PRINT DATA
01664'006066-               JSR@    XCRLF
01665'000772                JMP     PR5
01666'020411 PR6:           LDA     0,PR7
01667'006126-               JSR@    XWRLO
01670'024001-               LDA     1,KEYID
01671'001641'               .TIDR
01672'006135-               JSR@    XERR
01673'001643'               .KILL

01674'002434'ZADOUT:        ADOUT
01675'003274'YTDMG:         TDMG
01676'003275'YPTIME:        PTIME
01677'003356"PR7:           2*MS104
01700'002336"PR8:           2*MS109
```

```
                    ; A TASK THAT READS 16 CHAN OF A/D AND PRINTS VOLTAGES

                    CHECK:

01701'010014-              ISZ      CHKRQ    ;REQUEST A/D DATA
01702'001016'              .SUSP             ;WAIT
01703'102400               SUB      0,0      ;GOT IT, CANCEL REQUEST
01704'040014-              STA      0,CHKRQ

01705'006416               JSR@     ZGTIME
01706'006416               JSR@     ZPTIME   ;PRINT TIME
01707'006066-              JSR@     XCRLF
01710'020420               LDA      0,CHK1
01711'042420               STA      @0,CHK2
01712'006413               JSR@     CMOVE    ;TRANSFER TO PRINT OUT BUFFER

01713'006413               JSR@     CADOUT   ;PRINT A/D OUTPUT

01714'024001-HOME:         LDA      1,KEYID
01715'001671'              .TIDR
01716'006135-              JSR@     XERR

01717'001673'              .KILL

01720'020407 CHKER:        LDA      0,CHMS
01721'006126-              JSR@     XWRLO
01722'000772               JMP      HOME

01723'005726'ZGTIME:       GTIME
01724'003275'ZPTIME:       PTIME
01725'002750'CMOVE:        TRNFR
01726'002434'CADOUT:       ADOUT
01727'003724"CHMS:         2*MS110
01730'001732'CHK1:         CHKBUF
01731'002772'CHK2:         ZSCBC
           000020 CHKBUF:  .BLK 16.
                  MS110:   .TXT *THIS COMMAND CAN NOT BE PERFORMED DURING A
01752'052110
01753'044523                        TEST<15>*
01754'020103
01755'047515
01756'046501
01757'047104
01760'020103
01761'040516
01762'020116
01763'047524
01764'020102
01765'042440
01766'050105
01767'051106
01770'047522
01771'046505
01772'042040
01773'042125
01774'051111
01775'047107
01776'020101
01777'020124
```

```
0027   FFI35
 02000'042523
 02001'052015
 02002'000000
```

```
                   ;A TASK THAT PRINTS CASSETTE USAGE DURING A TEST

                   STATUS:
02003'020000-               LDA     0,TINPR  ;IS TEST IN PROGRESS?
02004'101005                MOV     0,0,SNR
02005'000404                JMP     STT1     ;NO TEST IN PROGRESS
02006'020412                LDA     0,STT2
02007'006126-               JSR@    XWRLO    ;TEST IN PROGRESS
02010'000403                JMP     STT3
02011'020410 STT1:          LDA     0,STT4
02012'006126-               JSR@    XWRLO    ;NO TEST IN PROGRESS

02013'006004-STT3:          JSR@    ZREPORT
02014'024001-               LDA     1,KEYID
02015'001715'               .TIDF
02016'006135-               JSR@    XERR

02017'001717'               .KILL

02020'004044"STT2:          2*MS111
02021'004066"STT4:          2*MS112
             MS111:         .TXT *TEST IN PROGRESS<15>*
02022'052105
02023'051524
02024'020111
02025'047040
02026'050122
02027'047507
02030'051105
02031'051523
02032'006400
             MS112:         .TXT *TEST COMPLETED<15>*
02033'052105
02034'051524
02035'020103
02036'047515
02037'050114
02040'042524
02041'042504
02042'006400
```

```
                        ; A TASK TO CHANGE THE TIME
                        CTIME:
02043'020000-           LDA     0,TINPR ;IS A TEST IN PROGRESS?
02044'101004            MOV     0,0,SZR
02045'000407            JMP     CTM1    ;TEST IN PROGRESS

02046'006412            JSR@    YINTDT  ;INPUT DATE
02047'006412            JSR@    YINTTM  ;INPUT TIME

02050'024001-CTM3:      LDA     1,KEYID
02051'002015'           .TIDR
02052'006135-           JSR@    XERR

02053'002017'           .KILL

02054'020403 CTM1:      LDA     0,CTM2
02055'006126-           JSR@    XWRLD
02056'000772            JMP     CTM3

02057'003724"CTM2:      2*MS110
02060'006105'YINTDT:    INTDT
02061'006126'YINTTM:    INTTM
```

```
                   ; A TASK TO LIST CASSETTE DATA TAPE

02062'020000-LIST:     LDA      0,TINPR ;TEST IN PROGRESS?
02063'101004           MOV      0,0,SZR
02064'000561           JMP      LSTER

02065'020567 LST3:     LDA      0,LST1  ;PRIMARY OR SECONDARY?
02066'006126-          JSR@     XWRLO
02067'006101-          JSR@     .GTCH
02070'040563           STA      0,LSTTP
02071'006066-          JSR@     XCRLF
02072'020561           LDA      0,LSTTP
02073'024562           LDA      1,LST60
02074'106415           SUB#     0,1,SNR
02075'000413           JMP      LST2    ;LIST PRIMARY
02076'024560           LDA      1,LST61
02077'106414           SUB#     0,1,SZR
02100'000765           JMP      LST3
02101'020556           LDA      0,LST4  ;LIST SECONDARY
02102'006126-          JSR@     XWRLO
02103'020120-          LDA      0,STCN
02104'040115-          STA      0,TAPCN
02105'102000           ADC      0,0
02106'040123-          STA      0,PSTF
02107'000407           JMP      LST5

02110'020550 LST2:     LDA      0,LST6  ;LIST PRIMARY
02111'006126-          JSR@     XWRLO
02112'020116-          LDA      0,PTCN
02113'040115-          STA      0,TAPCN
02114'102400           SUB      0,0
02115'040123-          STA      0,PSTF

02116'020543 LST5:     LDA      0,LST7  ;LIST ALL OR PART?
02117'006126-          JSR@     XWRLO
02120'006101-          JSR@     .GTCH
02121'040532           STA      0,LSTTP
02122'006066-          JSR@     XCRLF
02123'020530           LDA      0,LSTTP
02124'024532           LDA      1,LST61
02125'106415           SUB#     0,1,SNR
02126'000411           JMP      LST8
02127'024526           LDA      1,LST60 ;0 LIST PART
02130'152400           SUB      2,2
02131'106414           SUB#     0,1,SZR
02132'000764           JMP      LST5
02133'050527           STA      2,LISTC
02134'020527           LDA      0,LST9  ;LIST PART
02135'006126-          JSR@     XWRLO
02136'000405           JMP      LST10
02137'152000 LST8:     ADC      2,2
02140'050522           STA      2,LISTC
02141'020523           LDA      0,LST11 ;LIST ALL
02142'006126-          JSR@     XWRLO

02143'020522 LST10:    LDA      0,LST12 ;REWIND? 0 - NO  1 - YES
02144'006126-          JSR@     XWRLO
02145'006101-          JSR@     .GTCH
02146'040505           STA      0,LSTTP
```

```
02147'006066-          JSR@     XCRLF
02150'020503           LDA      0,LSTTP
02151'024504           LDA      1,LST60
02152'106415           SUB#     0,1,SNR
02153'000422           JMP      LST13
02154'024502           LDA      1,LST61
02155'106414           SUB#     0,1,SZR
02156'000765           JMP      LST10
02157'024110-          LDA      1,K1
02160'006124-          JSR@     XTVFE
02161'000776           JMP      .-2
02162'020504           LDA      0,LST14 ;REWINDING
02163'006126-          JSR@     XWRLO

               ;DO NOT TYPE ID IF NOT THE PRIMARY UNIT
02164'020115-          LDA      0,TAPCN
02165'024116-          LDA      1,PTCN
02166'106404           SUB      0,1,SZR
02167'000406           JMP      LST13

02170'024107-          LDA      1,K0     ;TYPE ID RECORD
02171'006124-          JSR@     XTVFE
02172'006135-          JSR@     XERR
02173'020067-          LDA      0,X2BUF
02174'006126-          JSR@     XWRLO

02175'024107-LST13:    LDA      1,K0
02176'006124-          JSR@     XTVFE
02177'000450           JMP      LST32    ;EOT OR EOF, RETURN

               ;PRINT DATE
02200'034141-          LDA      3,XYBUF
02201'021400           LDA      0,0,3
02202'042465           STA@     0,LST18 ;ORS0
02203'021401           LDA      0,1,3
02204'042464           STA@     0,LST19 ;ORS1
02205'021402           LDA      0,2,3
02206'042463           STA@     0,LST20 ;ORS2
02207'006463           JSR@     LST21    ;PDATE

02210'020475           LDA      0,STRBUF
02211'040475           STA      0,WRKBUF
02212'020461           LDA      0,LST22 ;1
02213'034447           LDA      3,LISTC ;ALL OR PART?
02214'175004           MOV      3,3,SZR
02215'020457           LDA      0,LST23 ;12
02216'040457           STA      0,LST24 ;DOWN COUNT OF TIMES

02217'034467 LST30:    LDA      3,WRKBUF
02220'021400           LDA      0,0,3
02221'042446           STA@     0,LST18 ;OSR0
02222'021401           LDA      0,1,3
02223'042445           STA@     0,LST19 ;ORS1
02224'021402           LDA      0,2,3
02225'042444           STA@     0,LST20 ;ORS2
02226'006450           JSR@     LST25    ;PTIME
02227'006066-          JSR@     XCRLF

02230'034456           LDA      3,WRKBUF
```

```
0032  MFLTS
 02231'020446           LDA     0,LST26 ;3
 02232'117000           ADD     0,3
 02233'056445           STA@    3,LST27 ;ZSORC
 02234'006445           JSR@    LST28   ;TRNFR
 02235'006445           JSR@    LST29   ;ADOUT
 02236'034450           LDA     3,WRKBUF
 02237'020444           LDA     0,LST33 ;19.
 02240'117000           ADD     0,3
 02241'054445           STA     3,WRKBUF
 02242'014433           DSZ     LST24
 02243'000754           JMP     LST30
 02244'000731           JMP     LST13

 02245'020437 LSTER:    LDA     0,LST31 ;TEST IN PROGRESS
 02246'006126-          JSR@    XWRLO
 02247'024001-LST32:    LDA     1,KEYID ;KEYBOARD CONTROL
 02250'002051'          .TIDR
 02251'006135-          JSR@    XERR
 02252'002053'          .KILL

 02253'000000 LSTTP:    0
 02254'004616"LST1:     2*MS120
 02255'000060 LST60:    60
 02256'000061 LST61:    61
 02257'004666"LST4:     2*MS121
 02260'004704"LST6:     2*MS122
 02261'004722"LST7:     2*MS123
 02262'000000 LISTC:    0
 02263'004764"LST9:     2*MS124
 02264'005000"LST11:    2*MS125
 02265'005012"LST12:    2*MS126
 02266'005054"LST14:    2*MS127
 02267'000075-LST18:    ORSC
 02270'000076-LST19:    ORS1
 02271'000077-LST20:    ORS2
 02272'003335'LST21:    PDATE
 02273'000001 LST22:    1
 02274'000014 LST23:    12.
 02275'000000 LST24:    0
 02276'003275'LST25:    PTIME
 02277'000003 LST26:    3
 02300'002772'LST27:    ZSORC
 02301'002750'LST28:    TRNFR
 02302'002434'LST29:    ADOUT
 02303'000023 LST33:    19.
 02304'003724"LST31:    2*MS110
 02305'007272'STRBUF:   YBUF+3
 02306'000000 WRKBUF:   0

                MS120:  .TXT *WHICH UNIT (0 - UNIT 0 , 1 - UNIT 1)?  *
 02307'053510
 02310'044503
 02311'044040
 02312'052516
 02313'044524
 02314'020050
 02315'030040
 02316'026440
 02317'052516
```

```
0033  MELT5
 02320'044524
 02321'020060
 02322'020054
 02323'020061
 02324'020055
 02325'020125
 02326'047111
 02327'052040
 02330'030451
 02331'037440
 02332'020000
                    MS121:   .TXT *LIST UNIT 1<15>*
 02333'046111
 02334'051524
 02335'020125
 02336'047111
 02337'052040
 02340'030415
 02341'000000
                    MS122:   .TXT *LIST UNIT 0<15>*
 02342'046111
 02343'051524
 02344'020125
 02345'047111
 02346'052040
 02347'030015
 02350'000000
                    MS123:   .TXT *HOW MUCH (0 - PART , 1 - ALL)?  *
 02351'044117
 02352'053440
 02353'046525
 02354'041510
 02355'020050
 02356'030040
 02357'026440
 02360'050101
 02361'051124
 02362'020054
 02363'020061
 02364'020055
 02365'020101
 02366'046114
 02367'024477
 02370'020040
 02371'000000
                    MS124:   .TXT *LIST PART<15>*
 02372'046111
 02373'051524
 02374'020120
 02375'040522
 02376'052015
 02377'000000
                    MS125:   .TXT *LIST ALL<15>*
 02400'046111
 02401'051524
 02402'020101
 02403'046114
 02404'006400
                    MS126:   .TXT *REWIND UNIT (0 - NO , 1 - YES)?  *
```

```
0034  MFL75
 02405'051105
 02406'053511
 02407'047104
 02410'020125
 02411'047111
 02412'052040
 02413'024060
 02414'020055
 02415'020116
 02416'047440
 02417'026040
 02420'030440
 02421'026440
 02422'054505
 02423'051451
 02424'037440
 02425'020000
                 MS127:   .TXT *REWINDING<15>*
 02426'051105
 02427'053511
 02430'047104
 02431'044516
 02432'043415
 02433'000000
```

```
                 ;SUBROUTINE TC OUTPUT 16 A/D READINGS AS A VOLTAGE

02434'054412 ADOUT:   STA     3,ADRTN
02435'034007-         LDA     3,WSA    ;STORE F FORMAT SPEC
02436'020411          LDA     0,WFPF
02437'041521          STA     0,121,3
02440'020410          LDA     0,DFPF
02441'041522          STA     0,122,3

02442'020407          LDA     0,BFLOC  ;STORE ASSRESS OF A/D LIST
02443'040407          STA     0,BFPNT

02444'004407          JSR     BFRUN    ;PRINT ONE LINE

02445'002401          JMP@    ADRTN

02446'000000 ADRTN:   0
02447'000006 WFPF:    6
02450'000002 DFPF:    2
02451'002523'BFLOC:   ADLIST
02452'000000 BFPNT:   0

02453'054437 BFRUN:   STA     3,BXRTN
02454'020437          LDA     0,BFTMS  ;STORE NUMBER OF TIMES
02455'040437          STA     0,BFDNS

02456'036774 BFRD1:   LDA@    3,BFPNT
02457'020437          LDA     0,BFN16
02460'162433          SUBZ#   3,0,SNC  ;SKIP IF AC0 GE AC3
02461'000424          JMP     BFRD2
02462'175120          MOVZL   3,3
02463'020426          LDA     0,ZBFADD
02464'117000          ADD     0,3
02465'054430          STA     3,BFPLC

02466'077777          FENT
02467'020430          FLDA    0,F409P6
02470'062425          FFLO@   BFPLC
02471'026424          FLDA@   1,BFPLC
02472'104200          FDIV    0,1
02473'144001          FFDCF   1
02474'100000          FEXT
02475'010755          ISZ     BFPNT
02476'020423          LDA     0,BFMSG
02477'006126-         JSR@    XWRLO
02500'014414 BFRD3:   DSZ     BFDNS
02501'000755          JMP     BFRD1

02502'020420          LDA     0,BFMSX
02503'006126-         JSR@    XWRLO
02504'002406          JMP@    BXRTN

02505'020403 BFRD2:   LDA     0,BFMBK
02506'006126-         JSR@    XWRLO
02507'000771          JMP     BFRD3

02510'005706"BFMBK:   MZBX2*2
02511'002535'ZBFADD:  BFADD
```

```
0036  MELTS

02512'000000 BXRTN:  0
02513'000010 BFTNS:  8.
02514'000000 BFDNS:  0
02515'000000 BFFLC:  0
02516'000020 BFN16:  16.
02517'041431 F409P6: 409.6
02520'114631
02521'005266"BFMSG:  2*MS108
02522'000264"BFMSX:  2*MFCO
02523'000000 ADLIST: 0
02524'000007         7
02525'000014         12.
02526'000015         13.
02527'000016         14.
02530'000017         15.
02531'000010         8.
02532'000011         9.

             MS108:  .TXT *  *
02533'020040
02534'000000
      000040 BFADD:  .BLK 32.
02575'000000         0
      000144 WRITA:  .BLK 100.
02742'000000         0
             MZRXZ:  .TXT *          *
02743'020040
02744'020040
02745'020040
02746'020040
02747'000000
```

```
                    ;SUBROUTINE TO TRANSFER DATA FROM COLLECTION BUFFER
                    ;  TO OUTPUT BUFFER

02750'054421 TRNFR:  STA     3,TRANCE
02751'034421         LDA     3,ZSORC
02752'030421         LDA     2,ZDEST
02753'020421         LDA     0,TR16
02754'040421         STA     0,DTRX

02755'126400 TRLP1:  SUB     1,1
02756'021400         LDA     0,0,3
02757'101132         MOVZL#  0,0,SZC
02760'126000         ADC     1,1
02761'045000         STA     1,0,2
02762'041001         STA     0,1,2
02763'151400         INC     2,2
02764'151400         INC     2,2
02765'175400         INC     3,3
02766'014407         DSZ     DTRX
02767'000766         JMP     TRLP1

02770'002401         JMP@    TRANCE

02771'000000 TRANCE: 0
02772'000000 ZSORC:  0       ;BUFFER POINTER SOURCE
02773'002535'ZDEST:  BFADD
02774'000020 TR16:   16.
02775'000000 DTRX:   0
```

```
                   ; A/D CONVERSION TASK
                   ;TASK 17
                   ;PRIORITY 15
                   ;THIS TASK WILL PROVIDE A/D INFORMATION REQUIRED BY
                   ;DIG TASK, FAST CHANNEL SAMPLE TASK, AND CHECK TASK
                   ;THIS TASK WILL BECOME ACTIVE EVERY 10 MS

02776'020453 CNVRT:  LDA     0,CNR6  ;MASK OUT A/D
02777'062077         MSKO    0
03000'060221         NIOC    ADCV

03001'102400         SUB     0,0       ;CLEAR ALL REQUESTS
03002'040012-        STA     0,DIGRQ
03003'040014-        STA     0,CHKRQ

03004'020446         LDA     0,CLTIM ;SET UP USER CLOCK
03005'024072-        LDA     1,XSAMP
03006'006017         .SYSTM
03007'021001         .DUCLK
03010'006135-        JSR@    XERR

                   ;WAIT FOR SYSTEM CLOCK
03011'020073-CNV1:   LDA     0,XSMSG
03012'001660'        .REC

                   ;THIS SECTION MONITORS THE AGITATOR.
                   ;IT SETS OR CLEARS A FLAG "AGRUN" IDICATING
                   ;  IF THE AGITATOR IS RUNNING.
03013'020015-        LDA     0,FSTCHN        ;GET CHAN NUMBER
03014'061121         DOAS    0,ADCV
03015'063521         SKPBZ   ADCV
03016'000777         JMP     .-1
03017'062621         DICC    0,ADCV
03020'024426         LDA     1,AG2P5
03021'152400         SUB     2,2
03022'122032         ADCZ#   1,0,SZC ;SKIP IF INPUT LE 2.5V
03023'150000         COM     2,2
03024'024424         LDA     1,AGPST
03025'050423         STA     2,AGPST
03026'132414         SUB#    1,2,SZR
03027'000412         JMP     CNV10     ;NOT EQUAL
03030'010417         ISZ     AGCNT
03031'020416         LDA     0,AGCNT
03032'024421         LDA     1,AG200
03033'122033         ADCZ#   1,0,SNC ;SKIP IF AGCNT GT 200
03034'000420         JMP     CNV2
03035'102400         SUB     0,0
03036'040025-        STA     0,AGRUN
03037'040410         STA     0,AGCNT
03040'000414         JMP     CNV2
03041'102400 CNV10:  SUB     0,0
03042'040405         STA     0,AGCNT
03043'100000         COM     0,0
03044'040025-        STA     0,AGRUN
03045'000407         JMP     CNV2
03046'002000 AG2P5:  1024.   ;APROX 2.5V
03047'000000 AGCNT:  0
03050'000000 AGPST:  0       ;PAST READING
03051'177730 CNR6:   177730  ;MASK
```

```
03052'000001 CLTIM:  1        ;TIME INTERVAL 10MS
03053'000310 AG200:  200.     ;APROX 2 SEC (10MS PER COUNT)

              ;DOES DIG TASK REQUIRE A/D SAMPLES?
03054'020012-CNV2:   LDA      0,DIGRQ
03055'101005         MOV      0,0,SNR
03056'000505         JMP      CNV3      ;NO FOR DIGITIZE

03057'010552         ISZ      DGCNT
03060'020551         LDA      0,DGCNT
03061'024542         LDA      1,CNR7
03062'122433         SUBZ#    1,0,SNC ;SKIP IF DGCNT GE 5
03063'000726         JMP      CNV1

03064'020532         LDA      0,CNR1   ;LOOP COUNT 15, # OF CHAN -1
03065'040532         STA      0,CNR2   ;DOWN COUNT WORD
03066'020541         LDA      0,DGADD
03067'040531         STA      0,CNR3   ;ADDRESS FOR DATA STORE
03070'102400         SUB      0,0
03071'040540         STA      0,DGCNT
03072'061121         DOAS     0,ADCV   ;START A/D AT CHN 0
03073'101400 CNV4:   INC      0,0
03074'063521         SKPBZ    ADCV
03075'000777         JMP      .-1
03076'066621         DICC     1,ADCV
03077'061121         DOAS     0,ADCV
03100'046520         STA@     1,CNR3
03101'010517         ISZ      CNR3
03102'014515         DSZ      CNR2
03103'000770         JMP      CNV4
03104'063521         SKPBZ    ADCV
03105'000777         JMP      .-1
03106'062621         DICC     0,ADCV
03107'042511         STA@     0,CNR3   ;STORE LAST CHAN.

              ;THIS SECTION CHECKS CHAN ZERO TO SEE OF MATERIAL
              ;  IS BEING LOADED INTO KETTLE
03110'022517         LDA@     0,DGADD
03111'024421         LDA      1,MT2P5
03112'122033         ADCZ#    1,0,SNC ;SKIP IF AC0 GT 2.5
03113'000406         JMP      CNV11
03114'102400         SUB      0,0
03115'040416         STA      0,MTCNT
03116'100000         COM      0,0
03117'040026-        STA      0,MTRUN
03120'000415         JMP      CNV12
03121'010412 CNV11:  ISZ      MTCNT
03122'020411         LDA      0,MTCNT
03123'024411         LDA      1,MT600
03124'122033         ADCZ#    1,0,SNC ;SKIP IF AC0 GT 600 (30 SEC)
03125'000410         JMP      CNV12
03126'102400         SUB      0,0
03127'040404         STA      0,MTCNT
03130'040026-        STA      0,MTRUN
03131'000404         JMP      CNV12
03132'002000 MT2P5:  1024.    ;APPROX 2.5V
03133'000000 MTCNT:  0
03134'001130 MT600:  600.     ;30 SEC(50MS PER COUNT)
```

```
                  ;DOES CHECK NEED A/D VALUES, IF SO TRANSFER VALUES
                  ;FROM DIG TO CHECK.
03135'020014-CNV12:  LDA     0,CHKRQ
03136'101005         MOV     0,0,SNR
03137'000420         JMP     CNV5     ;NO CHECK DATA REQUIRED.

03140'020461         LDA     0,CNR4   ;NUMBER OF CHN
03141'040456         STA     0,CNR2   ;DOWN COUNT WORD
03142'020465         LDA     0,DGADD
03143'040455         STA     0,CNR3   ;ADDRESS OF DATA
03144'020464         LDA     0,CHKADD
03145'040455         STA     0,CNR5   ;ADDRESS OF WHERE TO MOVE DATA
03146'022452 CNV6:   LDA@    0,CNR3
03147'042453         STA@    0,CNR5
03150'010450         ISZ     CNR3
03151'010451         ISZ     CNR5
03152'014445         DSZ     CNR2
03153'000773         JMP     CNV6
03154'024452         LDA     1,CHKID
03155'002250'        .TIDR
03156'006135-        JSR@    XERR
03157'024445 CNV5:   LDA     1,DGID
03160'003155'        .TIDR
03161'006135-        JSR@    XERR
03162'000627         JMP     CNV1

                  ;SEE IF CHECK REQUIRES DATA
03163'020014-CNV3:   LDA     0,CHKRQ
03164'101005         MOV     0,0,SNR
03165'000624         JMP     CNV1
03166'020430         LDA     0,CNR1   ;LOOP COUNT 15. # OF CHN -1
03167'040430         STA     0,CNR2   ;DOWN COUNT WORD
03170'020440         LDA     0,CHKADD
03171'040427         STA     0,CNR3   ;STORE ADDRESS
03172'102400         SUB     0,0
03173'061121         DOAS    0,ADCV
03174'101400 CNV7:   INC     0,0
03175'063521         SKPBZ   ADCV
03176'000777         JMP     .-1
03177'066621         DICC    1,ADCV
03200'061121         DOAS    0,ADCV
03201'046417         STA@    1,CNR3
03202'010416         ISZ     CNR3
03203'014414         DSZ     CNR2
03204'000770         JMP     CNV7
03205'063521         SKPBZ   ADCV
03206'000777         JMP     .-1
03207'062621         DICC    0,ADCV
03210'042410         STA@    0,CNR3   ;STORE LAST CHAN
03211'024415         LDA     1,CHKID
03212'003160'        .TIDR
03213'006135-        JSR@    XERR
03214'002401         JMP@    XCNV1

03215'003011'XCNV1:  CNV1
03216'000017 CNR1:   15.      ;# OF CHN - 1
03217'000000 CNR2:   0        ;DOWN COUNT LOCATION
03220'000000 CNR3:   0        ;ADDRESS STORE
```

```
0041  MELTS
 03221'000020 CNR4:    16.       ;# OF CHN
 03222'000000 CNR5:    0         ;ADDRESS STORE
 03223'000005 CNR7:    5.
 03224'000006 DGID:    6
 03225'000030 FSTID:   30
 03226'000014 CHKID:   14
 03227'003735'DGADD:   DGAS
 03230'001732'CHKADD:  CHKBUF

 03231'000000 DGCNT:   0         ;COUNT FOR EVERY 5TH TIME INTERVAL F.OF SAMPLE.
```

```
                     ;SUBROUTINE TO CHECK TO SEE IF LISTING DATA
                     ;  REQUIRED AND TO INC CASETTE RECORD WRITTEN

03232'054432 RAIN:   STA     3,TRAIN

                     ;       INCREMENT TAPE RECORD COUNT
03233'034115-        LDA     3,TAPCN
03234'020116-        LDA     0,PTCN
03235'116414         SUB#    0,3,SZR
03236'000403         JMP     .+3
03237'010117-        ISZ     NPTCN
03240'000402         JMP     .+2
03241'010121-        ISZ     NSTCN

                     ;CHECK FOR LISTING OF DATA REQUIRED

03242'034010-        LDA     3,DOUTC
03243'175005         MOV     3,3,SNR
03244'002420         JMP@    TRAIN
03245'034422         LDA     3,RNN1   ;STORE TIME
03246'021775         LDA     0,-3,3
03247'042422         STA@    0,RNN3
03250'021776         LDA     0,-2,3
03251'042421         STA@    0,,RNN3+1
03252'021777         LDA     0,-1,3
03253'042420         STA@    0,RNN3+2
03254'020413         LDA     0,RNN1   ;STORE DATA
03255'042413         STA@    0,RNN2
03256'006410         JSR@    WTRNFR
03257'020406         LDA     0,ZTDMG
03260'024405         LDA     1,ZTDMG
03261'077777         .XMT             ;DATA READY FOR PRINT OUT
03262'006135-        JSR@    XERR
03263'002401         JMP@    TRAIN

03264'000000 TRAIN:  0
03265'003274'ZTDMG:  TDMG
03266'002750'WTRNFR: TRNFR
03267'006724'RNN1:   XBUF+6
03270'002772'RNN2:   ZSCRC
03271'000075-RNN3:   CRSC
03272'000076-        CRS1
03273'000077-        CRS2
03274'000000 TDMG:   0
```

```
                ;SUBROUTINE TO OUTPUT TIME
                ; TIME   XX XX XX
                ;PRINTS ORS0, ORS1, ORS2

03275'054421 PTIME:  STA     3,BPTXZ
03276'020422         LDA     0,PT2   ;3
03277'026422         LDA@    1,PT3   ;ORS0
03300'006011-        JSR@    XENDEC
03301'020430         LDA     0,PT7   ;BB
03302'006126-        JSR@    XWRLO
03303'020415         LDA     0,PT2
03304'026417         LDA@    1,PT5   ;ORS1
03305'006011-        JSR@    XENDEC
03306'020423         LDA     0,PT7   ;BB
03307'006126-        JSR@    XWRLO
03310'020410         LDA     0,PT2
03311'026413         LDA@    1,PT6   ;ORS2
03312'006011-        JSR@    XENDEC
03313'020407         LDA     0,PT4
03314'006126-        JSR@    XWRLO
03315'002401         JMP@    BPTXZ

03316'000000 BPTXZ:  0
03317'006652"PT1:    2*MS115
03320'000003 PT2:    3
03321'000075-PT3:    ORS0
03322'006664"PT4:    2*MS116
03323'000076-PT5:    ORS1
03324'000077-PT6:    ORS2
             MS115:  .TXT *TIME  *
03325'052111
03326'046505
03327'020040
03330'000000
03331'006670"PT7:    MS300*2
             MS116:  .TXT *  *
03332'020040
03333'000000
             MS300:  .TXT *:*
03334'035000
```

```
                     ;SUBROUTINE TO PRINT DATE
                     ;DATE XX XX XXXX
                     ;PRINTS ORSC, ORS1, ORS2

03335'054423 PDATE:  STA     3,BDTX2
03336'020424         LDA     0,PD2    ;3
03337'026424         LDA@    1,PD3    ;ORS0
03340'006011-        JSR@    XPNDEC
03341'020423         LDA     0,PD4    ;BB
03342'006126-        JSR@    XWRLO
03343'020417         LDA     0,PD2    ;3
03344'026421         LDA@    1,PD5    ;ORS1
03345'006011-        JSR@    XBNDEC
03346'020416         LDA     0,PD4    ;BB
03347'006126-        JSR@    XWRLO
03350'020416         LDA     0,PD6    ;1
03351'026416         LDA@    1,PD7    ;ORS2
03352'034416         LDA     3,PD8
03353'166433         SUBZ#   3,1,SNC
03354'020406         LDA     0,PD2
03355'006011-        JSR@    XBNDEC
03356'006066-        JSR@    XCRLF
03357'002401         JMP@    BDTX2

03360'000000 BDTX2:  0
03361'006762"PD1:    MS117*2
03362'000003 PD2:    3
03363'000075-PD3:    ORSC
03364'006772"PD4:    MS416*2
03365'000076-PD5:    ORS1
03366'000001 PD6:    1
03367'000077-PD7:    ORS2
03370'000144 PD8:    100.
             MS117:  .TXT *DATE  *
03371'042101
03372'052105
03373'020040
03374'000000
             MS416:  .TXT */*
03375'027400
```

```
                    ; SUBROUTINE TO PRINT THE NUMBER OF RECORDS
                    ;    WRITTEN ON CASSETTES USED IN TEST.

03376'054420 REPORT: STA      3,RPRET
03377'020420         LDA      0,RPMS1
03400'006126-        JSR@     XWRLO
03401'024117-        LDA      1,NPTCN
03402'020420         LDA      0,RPO
03403'006011-        JSR@     XBNDEC
03404'020414         LDA      0,RPMS2
03405'006126-        JSR@     XWRLO
03406'020413         LDA      0,RPMS3
03407'006126-        JSR@     XWRLO
03410'024121-        LDA      1,NSTCN
03411'020411         LDA      0,RPO
03412'006011-        JSR@     XBNDEC
03413'020405         LDA      0,RPMS2
03414'006126-        JSR@     XWRLO
03415'002401         JMP@     RPRET

03416'000000 RPRET:  0
03417'007046"RPMS1:  2*MS105
03420'007064"RPMS2:  2*MS106
03421'007100"RPMS3:  2*MS107
03422'000000 RPO:    0

             MS105:  .TXT *CASSETTE 0  *
03423'041501
03424'051523
03425'042524
03426'052105
03427'020060
03430'020040
03431'000000
             MS106:  .TXT *  RECORDS<15>*
03432'020040
03433'051105
03434'041517
03435'051104
03436'051415
03437'000000
             MS107:  .TXT *CASSETTE 1  *
03440'041501
03441'051523
03442'042524
03443'052105
03444'020061
03445'020040
03446'000000
```

```
                        ;BINARY TO DECIMAL
                        ;AC1= INPUT
                        ;AC0= NUMBER OF DIGITS REQUIRED
                        ;0 FOR 5, 1 FOR 4, 2 FOR 3, 3 FOR 2, 4 FOR 1 DIGIT
03447'054426 BNDEC:     STA     3,BSAVE
03450'034423            LDA     3,INST
03451'117000            ADD     0,3
03452'054401            STA     3,.+1
03453'000000 LOPP:      0
03454'020420            LDA     0,C60
03455'146443            SUBC    2,1,SNC
03456'101401            INC     0,0,SKP
03457'147001            ADD     2,1,SKP
03460'000775            JMP     .-3
03461'006104-           JSR@    XPUTC
03462'010771            ISZ     LOPP
03463'151203            MOVR    2,2,SNC
03464'000767            JMP     LOPP
03465'002410            JMP     @BSAVE
03466'023420 TENS:      23420   ;10000
03467'001750            1750    ;1000
03470'000144            144     ;100
03471'000012            12      ;10
03472'000001            1       ;1
03473'030413 INST:      LDA     2,.+TENS-LOPP
03474'000060 C60:       60
03475'000000 BSAVE:     0
```

```
                        .NREL
                        ;ACCEPT AN I.D. AND WRITE IT ON TAPE TASK
                        ;TASK I.D. NO. - 5
                        ;TASK PRIORITY - 10
                        ;-----------------------------------------------
03476'006071-ACPT:      JSR     @XCXBF
03477'020067-           LDA     0,X2BUF  ;GET CHARACTER BUFFER BYTE POINTER
03500'006125-           JSR     @XRDLK   ;GET I.D. TEXT
03501'102520            SUBZL   0,0      ;CONVERT BYTE COUNT TO A WORD COUNT
03502'107220            ADDZR   0,1
03503'020113-           LDA     0,K5     ;GET "WRITE" CODE
03504'107000            ADD     0,1      ;MAKE COMMAND WORD
03505'006124-           JSR     @XTVFE   ;WRITE RECORD ON TAPE
03506'002070-           JMP     @XDONE   ;EOT ON BACK-UP TAPE UNIT
03507'020405            LDA     0,DIGID
03510'024405            LDA     1,DIGAD
03511'001314'           .TASK
03512'006135-           JSR@    XERR
03513'002252'           .KILL
03514'003005 DIGID:     6B7+5
03515'003545'DIGAD:     DIG


                        .ZREL
00067-015634"X2BUF:     2*XBUF
00070-003516'XDONE:     DONE

                .NREL
03516'020406 DONE:      LDA     0,DDEOF
03517'006126-           JSR@    XWRLO
03520'024001-           LDA     1,KEYID
03521'003212'           .TIDR
03522'006135-           JSR@    XERR
03523'003513'           .KILL
03524'007252"DDEOF:     2*MS200
             MS200:     .TXT *END OF TAPE ON CASSETTE UNIT 1<15>*
03525'042516
03526'042040
03527'047506
03530'020124
03531'040520
03532'042440
03533'047516
03534'020103
03535'040523
03536'051505
03537'052124
03540'042440
03541'052516
03542'044524
03543'020061
03544'006400
```

```
                        .NREL
                        ;DIGITIZE 16 CHANNELS TASK
                        ;TASK I.D. NO. - 6
                        ;TASK PRIORITY - 5
                        ;--------------------------------------
                  DIG:
03545'102400            SUB     0,0
03546'040002-           STA     0,STOPC
03547'020543            LDA     0,MGDIG ;STRIKE ANY KEY FOR START OF TEST
03550'006126-           JSR@    XWRLO
03551'006103-           JSR@    XGETC
03552'020541            LDA     0,MGAG
03553'006126-           JSR@    XWRLO
03554'024001-           LDA     1,KEYID
03555'003521'           .TIDR
03556'006135-           JSR@    XERR
03557'024537            LDA     1,DWTID ;READY WAIT CHAR TASK
03560'003555'           .TIDR
03561'006135-           JSR@    XERR
03562'006071-DG1:       JSR     @XCXBF  ;CLEAR XBUF
03563'020140-           LDA     0,XXBUF ;INITIALIZE BUFFER POINTER
03564'040536            STA     0,CAHLD
03565'006017            .SYSTM          ;GET AND STORE DATE
03566'021006            .GDAY
03567'006135-           JSR     @XERR
03570'046532            STA     1,@CAHLD        ;MONTH
03571'010531            ISZ     CAHLD
03572'042530            STA     0,@CAHLD        ;DAY
03573'010527            ISZ     CAHLD
03574'052526            STA     2,@CAHLD        ;YEAR
03575'010525            ISZ     CAHLD
03576'020522            LDA     0,C12   ;SET SAMPLE COUNT
03577'040520            STA     0,SCNT
03600'006017 DG2:       .SYSTM          ;GET TIME OF DAY
03601'021003            .GTOD
03602'006135-           JSR     @XERR
03603'052517            STA     2,@CAHLD        ;HOUR
03604'010516            ISZ     CAHLD
03605'046515            STA     1,@CAHLD        ;MINUTE
03606'010514            ISZ     CAHLD
03607'042513            STA     0,@CAHLD        ;SECOND
03610'010512            ISZ     CAHLD

                  DGAVG:
                        ;CLEAR SUM LOCATIONS.
03611'020514            LDA     0,DGA1  ;NUMBER OF CHAN LOC.
03612'040514            STA     0,DGA2  ;LOOP COUNTER
03613'034514            LDA     3,DGA3  ;ADDRESS OF SUMMING LOC.
03614'102400            SUB     0,0
03615'041400 DGV1:      STA     0,0,3
03616'175400            INC     3,3
03617'014507            DSZ     DGA2
03620'000775            JMP     DGV1

                  ;COLLECT 100 SAMPLE POINTS
03621'020507            LDA     0,DGA4  ;NUMBER OF SAMPLE POINTS TO BE AVERAGED
03622'040504            STA     0,DGA2  ;LOOP COUNTER
03623'102000            ADC     0,0
03624'040012-           STA     0,DIGRQ ;REQUEST A/D INFORMATION
```

```
03625'001702'DGV3:    .SUSP              ;WAIT

                  ;ADD SAMPLES TO SUMS
 03626'020503          LDA     0,DGA5    ;# OF CHANNELS
 03627'040503          STA     0,DGA6    ;LOOP COUNTER
 03630'020503          LDA     0,DGA7    ;ADDRESS OF SAMPLES
 03631'040503          STA     0,DGA8    ;ADDRESS POINTER
 03632'034475          LDA     3,DGA3    ;ADDRESS OF NUMS
 03633'126400 DGV2:    SUB     1,1
 03634'022500          LDA@    0,DGA8    ;GET DATA SAMPLE
 03635'101132          MOVZL#  0,0,SZC   ;NEG?
 03636'126000          ADC     1,1       ;YES, AC1=177777
 03637'031401          LDA     2,1,3
 03640'113022          ADDZ    0,2,SZC
 03641'011400          ISZ     0,3
 03642'051401          STA     2,1,3
 03643'031400          LDA     2,0,3
 03644'133000          ADD     1,2
 03645'051400          STA     2,0,3

 03646'175400          INC     3,3
 03647'175400          INC     3,3
 03650'010464          ISZ     DGA8
 03651'014461          DSZ     DGA6
 03652'000761          JMP     DGV2

 03653'014453          DSZ     DGA2      ;100 SAMPLES YET?
 03654'000751          JMP     DGV3      ;NO

                  ;100 SAMPLES SUMMED TOGETHER.
                  ;DIVIDE BY 100 AND STORE IN OUT BUFFER
 03655'020454          LDA     0,DGA5    ;# OF CHAN
 03656'040454          STA     0,DGA6    ;LOOP COUNTER
 03657'020450          LDA     0,DGA3    ;ADDRES OF SUMS
 03660'040454          STA     0,DGA8    ;ADDRESS PCINTER
 03661'022453 DGV4:    LDA@    0,DGA8    ;MSP OF SUM
 03662'010452          ISZ     DGA8
 03663'026451          LDA@    1,DGA8    ;LSP OF SUM
 03664'010450          ISZ     DGA8
 03665'030443          LDA     2,DGA4    ;100., # OF SUMMED SAMPLES
 03666'006436          JSR@    ADIV
 03667'046433          STA@    1,CAHLD   ;STORE IN BUFFER
 03670'010432          ISZ     CAHLD
 03671'014441          DSZ     DGA6
 03672'000767          JMP     DGV4

                  ;PREPARE AUTO DATA
 03673'006422          JSR@    ZADATA


 03674'014423          DSZ     SCNT      ;YES, COUNT SAMPLE. 12 ?
 03675'000703          JMP     DG2       ;NO, WAIT FOR NEXT SAMPLE
 03676'006416          JSR@    ZRAIN

                  ;TRANSFER OUTPUT BUFFER TO CASSETTE WRITE BUFFER
 03677'030140-         LDA     2,XXBUF
 03700'034141-         LDA     3,XYBUF
 03701'024422          LDA     1,MRDLTH
 03702'021000 DG3:     LDA     0,0,2
```

```
 03703'041400          STA      0,0,3
 03704'151400          INC      2,2
 03705'175400          INC      3,3
 03706'125404          INC      1,1,SZR
 03707'000773          JMP      DG3

 03710'006106-         JSR      @XWDOT   ;YES, OUTPUT 12 SAMPLES
 03711'000651          JMP      DG1
 03712'010134"MGDIG:   2*MS100
 03713'010172"MGAC:    2*MS101
 03714'003232'ZRAIN:   RAIN
 03715'005446'ZADATA:  ADATA
 03716'000002 DWTID:   2        ;WAIT CHAR TASK ID

 03717'000000 SCNT:    0        ;SAMPLE COUNTER
 03720'000014 C12:     12.      ;NO. OF SAMPLES PER RECORD
 03721'000000 CAD16:   0        ;CHANNEL COUNTER
 03722'000000 CAHLD:   0        ;CURRENT ADDRESS HOLD
 03723'177430 MRDLTH:  -BUFL    ;NEG BUFFER LENGTH

 03724'077777 ADIV:    .DIV
 03725'000040 DGA1:    32.      ;NUMBER OF SUM LOCATIONS
 03726'000000 DGA2:    0        ;LOOP COUNTER
 03727'003755'DGA3:    DGA10    ;ADDRESS OF SUMMING LOC
 03730'000144 DGA4:    100.     ;NUMBER OF SAMPLES AVERAGED.
 03731'000020 DGA5:    16.      ;NUMBER OF CHAN SCANNED
 03732'000000 DGA6:    0        ;ANOTHER LOOP COUNTER
 03733'003735'DGA7:    DGA9     ;ADDRESS OF DATA SAMPLES
 03734'000000 DGA8:    0        ;ADDRESS OF POINTER

      000020 DGA9:     .BLK 16.
      000040 DGA10:    .BLK 32.




                       ;CLEAR XBUF ROUTINE
                       ;------------------
 04015'054413 CXBUF:   STA      3,CBO    ;SAVE RETURN
 04016'020140-         LDA      0,XXBUF  ;SET XBUF POINTER
 04017'040412          STA      0,CBO+1
 04020'020413          LDA      0,CBO+3  ;SET XBUF LENGTH
 04021'040411          STA      0,CBO+2
 04022'102400          SUB      0,0      ;CLEAR AC0
 04023'042406          STA      0,@CBO+1          ;STORE 0 IN XBUF
 04024'010405          ISZ      CBO+1
 04025'014405          DSZ      CBO+2    ;COUNT, DONE ?
 04026'000775          JMP      .-3      ;NO
 04027'002401          JMP      @CBO     ;YES, RETURN

      000003 CBO:      .BLK     3.
 04033'000350          BUFL

                       .ZREL
 00071-004015'XCXBF:   CXBUF
```

```
                         .NREL
                         ;USER CLOCK SERVICE ROUTINE
                         ;SENDS A MESSAGE INDICATING
                         ;TIME TO SAMPLE.
                         ;---------------------------
04034'054415 SAMP:       STA     3,SAMPO ;SAVE RETURN
04035'050415             STA     2,SAMPO+1
04036'044415             STA     1,SAMPO+2
04037'040415             STA     0,SAMPO+3
04040'020073-            LDA     0,XSMSG ;MESSAGE ADDRESS
04041'024414             LDA     1,SAMPO+4        ;START SAMPLING MESSAGE
04042'077777             .IXMT            ;SEND MESSAGE
04043'020411             LDA     0,SAMPO+3
04044'024407             LDA     1,SAMPO+2
04045'030405             LDA     2,SAMPO+1
04046'034403             LDA     3,SAMPO
04047'077777             .UCEX            ;EXIT FROM USER CLOCK ROUTINE

04050'000000 SMSG:       0
       000004 SAMPO:     .BLK    4.
04055'177777             -1

             MS100:      .TXT *STRIKE ANY KEY TO START TEST<15>*
04056'051524
04057'051111
04060'045505
04061'020101
04062'047131
04063'020113
04064'042531
04065'020124
04066'047440
04067'051524
04070'040522
04071'052040
04072'052105
04073'051524
04074'006400
             MS101:      .TXT *TEST STARTED<15>*
04075'052105
04076'051524
04077'020123
04100'052101
04101'051124
04102'042504
04103'006400

04104'020003-STPRD:      LDA     0,ZSTMES
04105'024003-            LDA     1,ZSTMES
04106'003261'            .XMT
04107'006135-            JSR@    XERR
04110'003523'            .KILL

                         .ZREL
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0052  MEI15
 00072-004034'XSAMP:   SAMP
 00073-004050'XSMSG:   SMSG
```

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1 ^ 0053  MEL15
                 .NREL
                 ;AUTO CONTROL TASK

                 AUTO:
                 ;CHECK TO SEE IF DIGITIZE TASK IS ACTIVE
                 ; IF IT IS NOT ACTIVE, MAKE IT ACTIVE
04111'024472             LDA     1,CUTID ;ID OF DIGITZE TASK
04112'001445'            .IDST
04113'024471             LDA     1,AUT10
04114'106414             SUB#    0,1,SZR
04115'000405             JMP     AUL1     ;DIGITIZE TASK IS ACTIVE

04116'020467             LDA     0,AUTTST           ;ID&PRIORITY OF "TEST"
04117'024467             LDA     1,AUATST           ;START ADDRES OF TEST
04120'003511'            .TASK
04121'006135-            JSR@    XERR

                 ;READY KEYBOARD CONTROL
04122'024001-AUL1:       LDA     1,KEYID
04123'003560'            .TIDR
04124'006135-            JSR@    XERR

                 ;GET BTU ZERO VALUE
                 ;SUSPEND THIS TASK AND WAIT FOR 5 SEC DATA UPDATE
04125'003625'            .SUSP
04126'020024-            LDA     0,BTUFST
04127'040035-            STA     0,BTUZER

                 ;NOW READY TO PREHEAT KETTLE.
                 ;TURN ON STEAM AND PRINT MESSAGE TO THAT AFFECT
04130'006021-            JSR@    XSTON

04131'020456             LDA     0,AUNO  ;MESSAGE 0 "PRE HEAT STARTED."
04132'006017-            JSR@    XMESS

                 ;NOW SET UP A LOOP TO WAIT FOR PREHEAT TO COMPLETE.
                 ;THIS IS DONE BY WAITING FOR AN INCREASING BTU
                 ;  THEN A DECREASING BTU.  KETTLE IS CONSIDERED
                 ;  TO BE PREHEATED WHEN BTU DROPS TO WITHIN .1V
                 ;  OF BTUZER
                 ;TIME LIMIT FOR PREHEAT IS .5 HR.
04133'020455             LDA     0,AU360 ;# OF 5 SEC INTERVAL TO GET .5 HR.
04134'040455             STA     0,AULOOP
04135'102400             SUB     0,0
04136'040454             STA     0,AUINC
04137'040454             STA     0,AUDEC

04140'004125'AUL2:       .SUSP
                 ;HAS THERE BEEN AN INCREASE IN BTU?
04141'020451             LDA     0,AUINC
04142'101004             MOV     0,0,SZR
04143'000410             JMP     AUL3     ;INCREASE ALREADY DETECTED
                 ;DID BTU INCREASE THIS TIME?
04144'020450             LDA     0,AUNUP
04145'024034-            LDA     1,BTUDIR
04146'106414             SUB#    0,1,SZR
04147'000423             JMP     AUL4     ;NO CHANGE
04150'102000             ADC     0,0
04151'040441             STA     0,AUINC ;INDICATE A INCREASE HAS OCCURED.
```

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04152'000420          JMP      AUL4

                 ;SINCE A BTU INCREASE HAS ALREADY OCCURED,
                 ;  CHECK FOR A DECREASE
04153'020440 AUL3:    LDA      0,AUDEC
04154'101004          MOV      0,0,SZR
04155'000410          JMP      AUL5     ;DECREASE ALREADY DETECTED
                 ;DID BTU DECREASE THIS TIME?
04156'020437          LDA      0,AUNDWN
04157'024034-         LDA      1,BTUDIR
04160'106414          SUB#     0,1,SZR
04161'000411          JMP      AUL4     ;NO CHANGE
04162'102000          ADC      0,0
04163'040430          STA      0,AUDEC ;INDICATE A DECREASE HAS OCCURED.
04164'000406          JMP      AUL4
                 ;INCREASE AND DECREASE HAVE BOTH OCCURED.
                 ;NOW "BTU" SHOULD DROP TO WITHIN "PREHEAT"
                 ; OF "BTUZER"
04165'020032-AUL5:    LDA      0,BTU
04166'024037-         LDA      1,PREHEAT
04167'122400          SUB      1,0
04170'101132          MOVZL#   0,0,SZC ;SKIP IF POSITIVE
04171'000406          JMP      AUL6     ;DONE WITH PREHEAT
                 ;HAS TIME OUT OCCURED FOR PREHEAT?
04172'014417 AUL4:    DSZ      AULOOP
04173'000745          JMP      AUL2     ;PREHEAT NOT COMPLETE

04174'020422          LDA      0,AUN1   ;PREHEAT TIME-OUT
04175'006017-         JSR@     XMESS
04176'000431          JMP      AUL7     ;GO AHEAD AS PLANNED ANYWAY.

                 ;PREHEAT COMPLETED OK
04177'020420 AUL6:    LDA      0,AUN2
04200'006017-         JSR@     XMESS    ;PREHEAT COMPLETE
04201'000426          JMP      AUL7

                 ;SECTION OF CONSTANTS
04202'003777 AU2048: 2047.
04203'000006 CUTID:  6         ;ID OF DIGITIZE TASK
04204'000010 AUT10:  10        ;CODE FOR TASK ID NOT IN USE
04205'001405 AUTTST: 3B7+5     ;ID& PRIORITY USED TO START TEST
04206'001242'AUATST: TEST
04207'000000 AUN0:   0
04210'000550 AU360:  360.      ;#OF 5 SEC INTERVALS IN .5 HR.
04211'000000 AULOOP: 0         ;LOOP COUNTER
04212'000000 AUINC:  0         ;BTU HAS INCREASED IF '1'
04213'000000 AUDEC:  0         ;BTU HAS DECREASED IF '1'
04214'000001 AUNUP:  1         ;CODE FOR INCREASE
04215'177777 AUNDWN: -1        ;CODE FOR DECREASE
04216'000001 AUN1:   1
04217'000002 AUN2:   2
04220'000003 AUN3:   3
04221'000315 AU205:  205.      ;COMPARE LEVEL FOR DESNITOMETER
                               ;  IN OPERTATION
04222'000004 AUN4:   4
04223'000005 AUN5:   5
04224'000006 AUN6:   6
04225'000007 BUN7:   7
04226'000010 BUN8:   8.
```

```
                    ;NOW CHECK TO SEE OF AGITATOR IS RUNNING
                    ; IF NOT, REQUEST THAT IT BE TURNED ON.
                    AUL7:
04227'020025-           LDA     0,AGRUN
04230'101004            MOV     0,0,SZR
04231'000403            JMP     AUL8    ;AGITATOR ALREADY RUNNING
04232'020766            LDA     0,AUN3  ;REQUEST AGITATOR
04233'006017-           JSR@    XMESS

                    ;NOW CHECK TO SEE IF DENSITOMETER IS IN OPERATE MODE.
04234'020036-AUL8:      LDA     0,DENSE
04235'024764            LDA     1,AU205
04236'122433            SUBZ#   1,0,SNC ;SKIP IF DENSITOMETER GT .5V
04237'000403            JMP     AUL9    ;DENSITOMETER IN OPERATE
04240'020762            LDA     0,AUN4
04241'006017-           JSR@    XMESS

                    ;WAIT TILL AGITATOR IS RUNNING
04242'004140'AUL9:      .SUSP
04243'020025-           LDA     0,AGRUN
04244'101005            MOV     0,0,SNR
04245'000775            JMP     AUL9    ;AGITATOR NOT RUNNING YET

                    ;WAIT FOR DENSITOMETER IN OPERATE POSTION
04246'020036-AUL10:     LDA     0,DENSE
04247'024752            LDA     1,AU205
04250'122423            SUBZ    1,0,SNC
04251'000403            JMP     AUL11   ;DENSITOMETER READY
04252'004242'           .SUSP
04253'000773            JMP     AUL10

                    ;WAIT FOR "TQWAIT" 5 SEC INTERVALS AFTER AGITATOR
                    ;DETERMINED TO BE RUNNING BEFORE CHECKING TORQUE.
                    ;TORQUE SHOULD BE LESS THAN "TQNLD" AT THIS TIME.
04254'020040-AUL11:     LDA     0,TQWAIT
04255'040734            STA     0,AULOOP
04256'004252'AUL12:     .SUSP
04257'014732            DSZ     AULOOP
04260'000776            JMP     AUL12

04261'020041-           LDA     0,TQNLD
04262'024027-           LDA     1,TORQUE
04263'106433            SUBZ#   0,1,SNC ;SKIP OF TORQUE GT NO LOAD
04264'000404            JMP     AUL13   ;TORQUE OK

                    ;OUTPUT MESSAGE SAYING TORQUE TO HIGH
04265'020736            LDA     0,AUN5
04266'006017-           JSR@    XMESS
04267'004110'           .KILL

                    ;NOW READY TO START ADDING MATERIAL TO KETTLE
04270'020734 AUL13:     LDA     0,AUN6
04271'006017-           JSR@    XMESS

                    ;WAIT FOR MATERIAL TO BE ENTERED INTO KETTLE
04272'004256'AUL14:     .SUSP
04273'020026-           LDA     0,MTRUN
04274'101005            MOV     0,0,SNR
04275'000775            JMP     AUL14
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              ;INITIALIZE INTEGRATION OF BTU
04276'020024-         LDA     0,BTUFST
04277'040035-         STA     0,BTUZER
04300'102400          SUB     0,0
04301'040033-         STA     0,BTUSUM

              ;IF THE EQUIPMENT IS FUNCTIONING CORRETLY, THE
              ; TORQUE AND BTU SHOULD BE GREATER THAN TQSPT AND BTUSPT
              ;WITH IN STIME
04302'020044-         LDA     0,STIME
04303'040706          STA     0,AULOOP
04304'004272'AUL15:   .SUSP
04305'020030-         LDA     0,TQDIR
04306'024706          LDA     1,AUNUP
04307'106414          SUB#    0,1,SZR
04310'000404          JMP     AUL16   ;TORQUE HAS NOT STARTED TO INCREASE
04311'020034-         LDA     0,BTUDIR
04312'106415          SUB#    0,1,SNR
04313'000406          JMP     AUL17   ;BOTH TORQUE AND BTU HAVE INCREASED
04314'014675 AUL16:   DSZ     AULOOP
04315'000767          JMP     AUL15

              ;TIME HAS RUN OUT
              ;PRINT MESSAGE THAT TORQUE OR STEAM HAS FAILED TO
              ;  RISE IN ALLOTTED TIME
              ;ABORT AUTO TASK
04316'020707          LDA     0,BUN7
04317'006017-         JSR@    XMESS
04320'004267'         .KILL

              ;NOW THE MAIN LOOP WHICH MONITORS FOR STEAM SHUT OFF.

              ;FIRST CHECK FOR TORQUE OVERLOAD.
04321'004304'AUL17:   .SUSP
04322'020027-         LDA     0,TORQUE
04323'024045-         LDA     1,TQOVER
04324'122433          SUBZ#   1,0,SNC ;SKIP IF TORQUE GT OVERLOAD
04325'000412          JMP     AUL19   ;TORQUE OK

              ;TORQUE IS IN OVERLOAD CONDITION
              ;REQUEST THAT MATERIAL BE TURNED OFF.
04326'020700          LDA     0,BUN8
04327'006017-         JSR@    XMESS
              ;WAIT FOR TORQUE TO GET BELOW OVERLOAD
04330'004321'AUL18:   .SUSP
04331'020027-         LDA     0,TORQUE
04332'024045-         LDA     1,TQOVER
04333'106033          ADCZ#   0,1,SNC ;SKIP IF TORQUE LT OVERLOAD
04334'000774          JMP     AUL18
              ;TORQUE IS BACK IN PROPER RANGE
04335'020667          LDA     0,AUN6
04336'006017-         JSR@    XMESS

              ;CHECK BTU INTEGRAL
              ;IF BTUSUM IS GT SLMT1 AND BTU
              ;  IS LESS THAN BLMT THEN IT IS TIME TO SHUT STEAM OFF
04337'020033-AUL19:   LDA     0,BTUSUM
              ;IF BTUSUM IS NEG, THEN NO BTUSUM CHECK IS MADE.
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04340'101132          MOVZL#  0,0,SZC
04341'000424          JMP     AUL21

04342'024047-         LDA     1,SLMT1
04343'122433          SUBZ#   1,0,SNC ;SKIP IF BTUSUM GE SLMT1
04344'000411          JMP     AUL20   ;NOT READY BY THIS TEST
04345'020032-         LDA     0,BTU
04346'024050-         LDA     1,BLMT
04347'106033          ADCZ#   0,1,SNC ;SKIP IF BTU LE BLMT
04350'000405          JMP     AUL20
                ;READY TO SHUT STEAM OFF.
04351'006020-         JSR@    XSTOFF
04352'020462          LDA     0,AUN9
04353'006017-         JSR@    XMESS
04354'000514          JMP     AUL22

                ;CHECK TO SEE IF THE MAX CONTINOUS BTU HAS BEEN PUT IN.
                ; IF BTUSUM GT SLMT2. SHUT STEAM OFF.
04355'020033-AUL20:   LDA     0,BTUSUM
04356'024051-         LDA     1,SLMT2
04357'122433          SUBZ#   1,0,SNC ;SKIP IF BTUSUM GE SLMT2
04360'000405          JMP     AUL21
                ;SHUT STEAM OFF BY EXCEEDING MAX CONTINOUS INPUT OF STEAM
04361'006020-         JSR@    XSTOFF
04362'020453          LDA     0,AUN10
04363'006017-         JSR@    XMESS
04364'000504          JMP     AUL22

                ;CHECK TO SEE IF STEAM SHOULD BE SHUT OFF BY
                ;  TOO LOW TORQUE AND FALLING.
                ;IF TORQUE FALLING AND TORQUE LT TQLOW. STEAM OFF.
                ;IF THINGS GO RIGHT. THIS SHOULD NOT HAPPEN
04365'020030-AUL21:   LDA     0,TQDIR
04366'024453          LDA     1,AUDOWN
04367'106414          SUB#    0,1,SZR
04370'000731          JMP     AUL17
04371'020027-         LDA     0,TORQUE          ;TORQUE IS FALLING
04372'024052-         LDA     1,TQLOW
04373'106033          ADCZ#   0,1,SNC ;SKIP IF TORQUE LT TQLOW
04374'000725          JMP     AUL17

                ;TORQUE FALLING AND LOWER THAN TQLOW,
                ;  SO SHUT STEAM OFF.
04375'006020-         JSR@    XSTOFF
04376'020440          LDA     0,AUN11
04377'006017-         JSR@    XMESS

                ;IS MATERIAL STILL BEING PUT IN KETTLE?
04400'004330'AUL23:   .SUSP
04401'020026-         LDA     0,MTRUN
04402'101005          MOV     0,0,SNR
04403'000415          JMP     AUL24   ;MATERIAL NOT BEING LOADED.
                ;IS TORQUE INCREASING AND ABOVE TQLOW?
04404'020030-         LDA     0,TQDIR
04405'024435          LDA     1,AUGUP
04406'106414          SUB#    0,1,SZR
04407'000771          JMP     AUL23   ;NOT INCREASING
04410'020027-         LDA     0,TORQUE
04411'024052-         LDA     1,TQLOW
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 04412'122435          SUBZ#    1,0,SNR ;SKIP IF TORQUE GT TOLOW
 04413'000765          JMP      AUL23   ;TORQUE LT TOLOW
                 ;TURN STEAM BACK ON AND GO TO NORMAL SHUT OFF ROUTINE
 04414'006021-AUL46:   JSR@     XSTON
 04415'020422          LDA      0,AUN12
 04416'006017-         JSR@     XMESS
 04417'000702          JMP      AUL17

                 ;MATERIAL IS NOT BEING PUT INTO KETTLE
                 ;TORQUE CAN REMAIN BELOW TOLOW ONLY TOTIM
                 ;BEFORE GOING INTO NORMAL BATCH GOOD CHECK.
 04420'020423 AUL24:   LDA      0,AULOP
 04421'040053-         STA      0,TOTIM
 04422'004400'AUL25:   .SUSP
 04423'020027-         LDA      0,TORQUE
 04424'024052-         LDA      1,TOLOW
 04425'106433          SUBZ#    0,1,SNC ;SKIP IF TORQUE LT TOLOW
 04426'000766          JMP      AUL46
 04427'014414          DSZ      AULOP
 04430'000772          JMP      AUL25
 04431'000437          JMP      AUL22


 04432'000007 AUN7:    7
 04433'000010 AUN8:    8.
 04434'000011 AUN9:    9.
 04435'000012 AUN10:   10.
 04436'000013 AUN11:   11.
 04437'000014 AUN12:   12.
 04440'000015 AUN13:   13.
 04441'177777 AUDOWN:  -1
 04442'000001 AUGUP:   1
 04443'000000 AULOP:   0


                 ;SUBROUTINE TO SHUT STEAM OFF
 04444'102400 STMOFF:  SUB      0,0
 04445'062023          DOB      0,DACV
 04446'061023          DOA      0,DACV
 04447'040022-         STA      0,DA0
 04450'126520          SUBZL    1,1
 04451'066023          DOB      1,DACV
 04452'061023          DOA      0,DACV
 04453'040023-         STA      0,DA1
 04454'001400          JMP      0,3
                 ;SUBROUTINE TO TURN STEAM ON
 04455'102400 STMON:   SUB      0,0
 04456'024411          LDA      1,U2048
 04457'062023          DOB      0,DACV
 04460'065023          DOA      1,DACV
 04461'044022-         STA      1,DA0
 04462'102520          SUBZL    0,0
 04463'062023          DOB      0,DACV
 04464'065023          DOA      1,DACV
 04465'044023-         STA      1,DA1
 04466'001400          JMP      0,3
 04467'004000 U2048:   2048.
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                  ;THIS SECTION WILL DETERMINE IF BATCH IS READY
                  ;AND ADD MORE STEAM IF NECESSARY

                  ;FIRST SEE IF BATCH READY BY DENSITOMETER
04470'004422'AUL22:  .SUSP
04471'020036-        LDA     0,DENSE
04472'024054-        LDA     1,DREADY
04473'122433         SUBZ#   1,0,SNC ;SKIP IF DENSE GT DREADY
04474'000404         JMP     AUL26
                  ;BATCH READY BY DENSITOMETER READING.
04475'020743         LDA     0,AUN13
04476'006017-        JSR@    XMESS
                  ;      JMP     AUL27
04477'000401         JMP     .+1        ;NOP FOR THIS TEST

                  ;CHECK TO SEE IF BATCH IS READY BY TORQUE
04500'020027-AUL26:  LDA     0,TORQUE
04501'024055-        LDA     1,TREADY
04502'106433         SUBZ#   0,1,SNC ;SKIP IF TORQUE LT TREADY
04503'000404         JMP     AUL32
                  ;BATCH READY BY TORQUE READING
04504'020467         LDA     0,AUN14
04505'006017-        JSR@    XMESS
04506'000454         JMP     AUL27

                  ;IS TORQUE GT TQOVER
                  ;IF SO ADD STEAM UNTIL TORQUE GOES BELOW TQUMAX
04507'020027-AUL32:  LDA     0,TORQUE
04510'024045-        LDA     1,TQOVER
04511'122433         SUBZ#   1,0,SNC ;SKIP IF TORQUE GT TQOER
04512'000414         JMP     AUL28   ;TORQUE OK.
04513'006021-        JSR@    XSTON   ;TURN STEAM ON
04514'020464         LDA     0,AUN23
04515'006017-        JSR@    XMESS   ;STEAM ON BECAUSE MAX TORQUE EXCEDED
04516'004470'AUL33:  .SUSP
04517'020027-        LDA     0,TORQUE
04520'024046-        LDA     1,TQUMAX
04521'106033         ADCZ#   0,1,SNC ;SKIP IF TORQUE LT TQUMAX
04522'000656         JMP     AUL23
04523'006020-        JSR@    XSTOFF
04524'020451         LDA     0,AUN16
04525'006017-        JSR@    XMESS

                  ;IS TORQUE RISING
04526'020030-AUL28:  LDA     0,TQDIR
04527'024713         LDA     1,AUGUP
04530'106415         SUB#    0,1,SNR
04531'000415         JMP     AUL29   ;TORQUE IS RISING.
04532'020031-        LDA     0,TORAT
04533'024057-        LDA     1,RTLMT
04534'106433         SUBZ#   0,1,SNC ;SKIP IF TORATE LT RTLMT
04535'000733         JMP     AUL22   ;TORQUE RATE OK
                  ;ADD 5 SEC STEAM
04536'006021-        JSR@    XSTON
04537'020435         LDA     0,AUN15
04540'006017-        JSR@    XMESS
04541'004516'        .SUSP
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0066  FELTS
 04542'006020-            JSR@     XSTOFF
 04543'020432             LDA      0,AUN16
 04544'006017-            JSR@     XMESS
 04545'000723             JMP      AUL22

                    ;ADD MORE STEAM BECAUSE TORQUE IS NOT FALLING.
                    ;CONTINUE TO ADD STEAM UNTIL TORQUE STARTS TO FALL.
 04546'006021-AUL29:      JSR@     XSTON
 04547'020427             LDA      0,AUN17
 04550'006017-            JSR@     XMESS
 04551'004541'AUL30:      .SUSP
 04552'020030-            LDA      0,TQDIR
 04553'024417             LDA      1,AUDWN
 04554'106414             SUB#     0,1,SZR
 04555'000774             JMP      AUL30
                    ;TURN STEAM OFF BECAUSE TORQUE IS NOW FALLING
 04556'006020-            JSR@     XSTOFF
 04557'020416             LDA      0,AUN16
 04560'006017-            JSR@     XMESS
 04561'000707             JMP      AUL22
                    ;BATCH READY, WAIT 15 MINUTES AND OUTPUT
                    ;  MESSAGE INDICATING AUTO DONE BUT TEST TASK IS STILL RUNNING
 04562'020417 AUL27:      LDA      0,AULEAV
 04563'040660             STA      0,AULOP
 04564'004551'AUL31:      .SUSP
 04565'014656             DSZ      AULOP
 04566'000776             JMP      AUL31

 04567'020410             LDA      0,AUN18
 04570'006017-            JSR@     XMESS

 04571'004320'            .KILL


 04572'177777 AUDWN:      -1
 04573'000016 AUN14:      14.
 04574'000017 AUN15:      15.
 04575'000020 AUN16:      16.
 04576'000021 AUN17:      17.
 04577'000022 AUN18:      18.
 04600'000027 AUN23:      23.
 04601'000264 AULEAV:     180.     ;NUMBER OF 5 SEC INTERVALS




                    ;SUBROUTINE TO PRINT MESAGE
                    ;  AC0 GIVES MESSAGE #
 04602'054412 MESS:       STA      3,MSRTN
 04603'040412             STA      0,MTMP
 04604'006413             JSR@     MGTIME
 04605'006411             JSR@     MTIME
 04606'034412             LDA      3,MSLST
 04607'020406             LDA      0,MTMP
 04610'117000             ADD      0,3
 04611'021400             LDA      0,0,3
 04612'006126-            JSR@     XWRLO
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0061  MELTS
 04613'C02401            JMPR     MSRTN
 04614'000000 MSRTN:  0
 04615'000000 MTMP:   0
 04616'003275'MTIME:  PTIME
 04617'005726'MGTIME: GTIME
 04620'004621'MSLST:  .+1
 04621'011522"        MSG0*2
 04622'011552"        MSG1*2
 04623'011574"        MSG2*2
 04624'011616"        MSG3*2
 04625'011636"        MSG4*2
 04626'011704"        MSG5*2
 04627'011760"        MSG6*2
 04630'012022"        MSG7*2
 04631'012122"        MSG8*2
 04632'012162"        MSG9*2
 04633'012214"        MSG10*2
 04634'012246"        MSG11*2
 04635'012300"        MSG12*2
 04636'012334"        MSG13*2
 04637'012372"        MSG14*2
 04640'012422"        MSG15*2
 04641'012442"        MSG16*2
 04642'012456"        MSG17*2
 04643'012522"        MSG18*2
 04644'012576"        MSG19*2
 04645'012636"        MSG20*2
 04646'012670"        MSG21*2
 04647'012712"        MSG22*2
 04650'012734"        MSG23*2

              MSG0:   .TXT *KETTLE PREHEAT STARTED<15>*
 04651'045505
 04652'052124
 04653'046105
 04654'020120
 04655'051105
 04656'044105
 04657'040524
 04660'020123
 04661'052101
 04662'051124
 04663'042504
 04664'006400
              MSG1:   .TXT *PREHEAT TIME OUT<15>*
 04665'050122
 04666'042510
 04667'042501
 04670'052040
 04671'052111
 04672'046505
 04673'020117
 04674'052524
 04675'006400
              MSG2:   .TXT *PREHEAT COMPLETE<15>*
 04676'050122
 04677'042510
 04700'042501
```

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0062  MELTS
 04701'052040
 04702'041517
 04703'046520
 04704'046105
 04705'052105
 04706'006400
                         MSG3:    .TXT *START AGITATOR<15>*
 04707'051524
 04710'040522
 04711'052040
 04712'040507
 04713'044524
 04714'040524
 04715'047522
 04716'006400
                         MSG4:    .TXT *PUT DENSITOMETER IN OPERATE POSITION<15>*
 04717'050125
 04720'052040
 04721'042105
 04722'047123
 04723'044524
 04724'047515
 04725'042524
 04726'042522
 04727'020111
 04730'047040
 04731'047520
 04732'042522
 04733'040524
 04734'042440
 04735'050117
 04736'051511
 04737'052111
 04740'047516
 04741'006400
                         MSG5:    .TXT *NO LOAD TORQUE TOO HIGH, AUTO TASK ABORTED<15>*
 04742'047117
 04743'020114
 04744'047501
 04745'042040
 04746'052117
 04747'051121
 04750'052505
 04751'020124
 04752'047517
 04753'020110
 04754'044507
 04755'044054
 04756'020101
 04757'052524
 04760'047440
 04761'052101
 04762'051513
 04763'020101
 04764'041117
 04765'051124
 04766'042504
 04767'006400
                         MSG6:    .TXT *START ADDING MATERIAL TO KETTLE<15>*
```

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0063  MELT5
 04770'051524
 04771'040522
 04772'052040
 04773'040504
 04774'042111
 04775'047107
 04776'020115
 04777'040524
 05000'042522
 05001'044501
 05002'046040
 05003'052117
 05004'020113
 05005'042524
 05006'052114
 05007'042415
 05010'000000
                MSG7:    .TXT *TORQUE OR BTU FAILED TO RISE IN GIVEN TIME,
 05011'052117
 05012'051121
 05013'052505
 05014'020117
 05015'051040
 05016'041124
 05017'052440
 05020'043101
 05021'044514
 05022'042504
 05023'020124
 05024'047440
 05025'051111
 05026'051505
 05027'020111
 05030'047040
 05031'043511
 05032'053105
 05033'047040
 05034'052111
 05035'046505
 05036'026040   AUTO TASK ABORTED<15>*
 05037'040525
 05040'052117
 05041'020124
 05042'040523
 05043'045440
 05044'040502
 05045'047522
 05046'052105
 05047'042015
 05050'000000
                MSG8:    .TXT *STOP MATERIAL, TORQUE TOO HIGH<15>*
 05051'051524
 05052'047520
 05053'020115
 05054'040524
 05055'042522
 05056'044501
 05057'046054
 05060'020124
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0064  MEI15
 05061'047522
 05062'050525
 05063'042440
 05064'052117
 05065'047440
 05066'044111
 05067'043510
 05070'006400
                  MSG9:    .TXT *STEAM OFF BY LOW BTU USE<15>*
 05071'051524
 05072'042501
 05073'046440
 05074'047506
 05075'043040
 05076'041131
 05077'020114
 05100'047527
 05101'020102
 05102'052125
 05103'020125
 05104'051505
 05105'006400
                  MSG10:   .TXT *STEAM OFF BY MAX BTU SUM<15>*
 05106'051524
 05107'042501
 05110'046440
 05111'047506
 05112'043040
 05113'041131
 05114'020115
 05115'040530
 05116'020102
 05117'052125
 05120'020123
 05121'052515
 05122'006400
                  MSG11:   .TXT *STEAM OFF BY LOW TORQUE<15>*
 05123'051524
 05124'042501
 05125'046440
 05126'047506
 05127'043040
 05130'041131
 05131'020114
 05132'047527
 05133'020124
 05134'047522
 05135'050525
 05136'042415
 05137'000000
                  MSG12:   .TXT *STEAM ON AFTER LOW TORQUE<15>*
 05140'051524
 05141'042501
 05142'046440
 05143'047516
 05144'020101
 05145'043124
 05146'042522
 05147'020114
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0065  MEL15
 05150'047527
 05151'020124
 05152'047522
 05153'050525
 05154'042415
 05155'000000
                    MSG13:   .TXT *BATCH READY BY DENSITOMETER<15>*
 05156'041101
 05157'052103
 05160'044040
 05161'051105
 05162'040504
 05163'054440
 05164'041131
 05165'020104
 05166'042516
 05167'051511
 05170'052117
 05171'046505
 05172'052105
 05173'051015
 05174'000000
                    MSG14:   .TXT *BATCH READY BY TORQUE<15>*
 05175'041101
 05176'052103
 05177'044040
 05200'051105
 05201'040504
 05202'054440
 05203'041131
 05204'020124
 05205'047522
 05206'050525
 05207'042415
 05210'000000
                    MSG15:   .TXT *STEAM ON 5 SEC<15>*
 05211'051524
 05212'042501
 05213'046440
 05214'047516
 05215'020065
 05216'020123
 05217'042503
 05220'006400
                    MSG16:   .TXT *STEAM OFF<15>*
 05221'051524
 05222'042501
 05223'046440
 05224'047506
 05225'043015
 05226'000000
                    MSG17:   .TXT *STEAM ON BECAUSE OF RISING TORQUE<15>*
 05227'051524
 05230'042501
 05231'046440
 05232'047516
 05233'020102
 05234'042503
 05235'040525
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 05236'051505
 05237'020117
 05240'043040
 05241'051111
 05242'051511
 05243'047107
 05244'020124
 05245'047522
 05246'050525
 05247'042415
 05250'000000
                  MSG18:   .TXT *AUTC TERMINATED - TEST TASK STILL RUNNING<15>*
 05251'040525
 05252'052117
 05253'020124
 05254'042522
 05255'046511
 05256'047101
 05257'052105
 05260'042040
 05261'026440
 05262'052105
 05263'051524
 05264'020124
 05265'040523
 05266'045440
 05267'051524
 05270'044514
 05271'046040
 05272'051125
 05273'047116
 05274'044516
 05275'043415
 05276'000000
                  MSG19:   .TXT *AUTC TERMINATED FROM KEYBOARD<15>*
 05277'040525
 05300'052117
 05301'020124
 05302'042522
 05303'046511
 05304'047101
 05305'052105
 05306'042040
 05307'043122
 05310'047515
 05311'020113
 05312'042531
 05313'041117
 05314'040522
 05315'042015
 05316'000000
                  MSG20:   .TXT *AUTC TASK IS NOT RUNNING<15>*
 05317'040525
 05320'052117
 05321'020124
 05322'040523
 05323'045440
 05324'044523
 05325'020116
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0067  MFIT5
 05326'047524
 05327'020122
 05330'052516
 05331'047111
 05332'047107
 05333'006400
                 MSG21:   .TXT *MANUAL STEAM OFF<15>*
 05334'046501
 05335'047125
 05336'040514
 05337'020123
 05340'052105
 05341'040515
 05342'020117
 05343'043106
 05344'006400
                 MSG22:   .TXT *MANUAL STEAM ON<15>*
 05345'046501
 05346'047125
 05347'040514
 05350'020123
 05351'052105
 05352'040515
 05353'020117
 05354'047015
 05355'000000
                 MSG23:   .TXT *STEAM ON BECAUSE MAX TORQUE EXCEEDED<15>*
 05356'051524
 05357'042501
 05360'046440
 05361'047516
 05362'020102
 05363'042503
 05364'040525
 05365'051505
 05366'020115
 05367'040530
 05370'020124
 05371'047522
 05372'050525
 05373'042440
 05374'042530
 05375'041505
 05376'042504
 05377'042504
 05400'006400
```

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                  ;MANUAL STEAM OFF TASK
                  SOFF:
05401'006020-             JSR@     XSTOFF
05402'020415              LDA      0,MN21
05403'006017-             JSR@     XMESS
05404'024001-             LDA      1,KEYID
05405'004123'             .TIDR
05406'006135-             JSR@     XERR
05407'004571'             .KILL

                  ;MANUAL STEAM ON TASK
                  SON:
05410'006021-             JSR@     XSTON
05411'020407              LDA      0,MN22
05412'006017-             JSR@     XMESS
05413'024001-             LDA      1,KEYID
05414'005405'             .TIDR
05415'006135-             JSR@     XERR
05416'005407'             .KILL

05417'000025 MN21:        21.
05420'000026 MN22:        22.

                  ;MANUAL
                  ;THIS TASK ABORTS THE AUTO CONTROL TASK
                  ;STEAM IS LEFT AS IS WHEN TASK ABORTED
                  MANUAL:
05421'024423              LDA      1,MATOID
05422'004112'             .IDST
05423'024422              LDA      1,MTN10
05424'106415              SUB#     0,1,SNR
05425'000412              JMP      MNL1
05426'024416              LDA      1,MATOID
05427'001466'             .TIDK
05430'006135-             JSR@     XERR
05431'020411              LDA      0,MN19
05432'006017-             JSR@     XMESS
05433'024001-MNL2:        LDA      1,KEYID
05434'005414'             .TIDR
05435'006135-             JSR@     XERR

05436'005416'             .KILL

05437'020404 MNL1:        LDA      0,MN20
05440'006017-             JSR@     XMESS
05441'000772              JMP      MNL2

05442'000023 MN19:        19.
05443'000024 MN20:        20.
05444'000040 MATOID:      40
05445'000010 MTN10:       10
```

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                 ;==================================================

                 ;THIS SUBROUTINE TAKES DATA GENERATED BY DIGITIZE TASK
                 ; AND GENERATES SOME PARAMETERS NEEDED BY AUTO CONTROL.
                 ;THESE ARE:
                 ;       BTU INTEGRATION
                 ;       BTU        - RISE OR FALL
                 ;       TORQUE     - RISE OR FALL
                 ;       TORQUE     - RATE OF CHANGE
05446'054507 ADATA:  STA     3,ADBCK

                 ;AC3 WILL BE INDEX ADDRESS FOR DATA
                 ;       -9  TORQUE
                 ;       -4  DENSITOMETER
                 ;       -3  BTU
05447'036507         LDA@    3,VCAHLD
05450'021774         LDA     0,-4,3
05451'101132         MOVZL#  0,0,SZC
05452'102400         SUB     0,0     ;IF NEG, MAKE 0.
05453'040036-        STA     0,DENSE ;MOVE DENSITOMETER
                 ;SET TORQUE VALUE.  CHECK, IS TORQUE RISING OR FALLING
                 ;   AND AT WHAT RATE.
                 ;THESE CALCULATIONS ARE MADE OVER
                 ;  A PERIOD OF 5 SEC INTERVALS AS INDICATED BY DELAY.
05454'021767         LDA     0,-9.,3 ;NEW TORQUE VALUE
05455'004504         JSR     PCPTQ   ;OLD TORQUE VALUE, "DELAY" OLD.
05456'152400         SUB     2,2
05457'050030-        STA     2,TQDIR ;CLEAR TQDIR
05460'152520         SUBZL   2,2
05461'034056-        LDA     3,NOISE
05462'174400         NEG     3,3
05463'117000         ADD     0,3
05464'166433         SUBZ#   3,1,SNC ;SKIP IF TQNEW-NOISE LT TQOLD
05465'050030-        STA     2,TQDIR
05466'152000         ADC     2,2
05467'034056-        LDA     3,NOISE
05470'117000         ADD     0,3
05471'136033         ADCZ#   1,3,SNC ;SKIP IF TQNEW+NOISE GT TQOLD
05472'050030-        STA     2,TQDIR

05473'106400         SUB     0,1
05474'125132         MOVZL#  1,1,SZC
05475'124400         NEG     1,1     ;MAKE RATE OF CHANGE ALWAYS POS.
05476'044031-        STA     1,TQRATE
05477'040027-        STA     0,TORQUE

                 ;DETERMINE BTU RISE OR FALL AND ADD TO INTERGAL
05500'036456         LDA@    3,VCAHLD
05501'021775         LDA     0,-3,3
05502'040024-        STA     0,BTUFST
05503'024032-        LDA     1,BTU
05504'030035-        LDA     2,BTUZER
05505'142400         SUB     2,0
                 ;IF NEG NO CHECK
05506'101132         MOVZL#  0,0,SZC
05507'000420         JMP     ADL2
05510'125132         MOVZL#  1,1,SZC
05511'000416         JMP     ADL2
```

```
0070  MELTS
 05512'152400            SUB     2,2
 05513'050034-           STA     2,BTUDIR
 05514'152520            SUBZL   2,2
 05515'034056-           LDA     3,NOISE
 05516'174400            NEG     3,3
 05517'117000            ADD     0,3
 05520'166433            SUBZ#   3,1,SNC
 05521'050034-           STA     2,BTUDIR
 05522'152000            ADC     2,2
 05523'034056-           LDA     3,NOISE
 05524'117000            ADD     0,3
 05525'136033            ADCZ#   1,3,SNC
 05526'050034-           STA     2,BTUDIR

 05527'040032-ADL2:      STA     0,BTU
 05530'024033-           LDA     1,BTUSUM
 05531'107000            ADD     0,1
 05532'044033-           STA     1,BTUSUM
 05533'125132            MOVZL#  1,1,SZC
 05534'124400            NEG     1,1
 05535'030422            LDA     2,ADBMX ;COMPARE WITH 30,000
 05536'146033            ADCZ#   2,1,SNC ;SKIP IF SUM GT 30000
 05537'000405            JMP     ADL1
 05540'024033-           LDA     1,BTUSUM
 05541'125132            MOVZL#  1,1,SZC
 05542'150400            NEG     2,2
 05543'050033-           STA     2,BTUSUM


                   ;STORE DA VALUES IN OUTPUT BUFFER
                   ;DA0     -8      CHAN 8
                   ;DA1     -7      CHAN 9
 05544'036412 ADL1:      LDA@    3,VCAHLD
 05545'020022-           LDA     0,DA0
 05546'041770            STA     0,-8.,3
 05547'020023-           LDA     0,DA1
 05550'041771            STA     0,-7.,3


                   ;READY AUTO CONTROL TASK
                   ;NO CHECK IS MADE TO SEE IF TASK EXIST.
 05551'024407            LDA     1,AUTID
 05552'005434'           .TIDR
 05553'000401            JMP     .+1

 05554'002401            JMP@    ADBCK

 05555'000000 ADBCK:     0       ;RETURN ADDRESS
 05556'003722'VCAHLD:    CAHLD
 05557'072460 ADBMX:     30000.  ;MAX LIMIT ON BTUSUM
 05560'000040 AUTID:     40      ;AUTO TASKID



                   ;AC0 CONTAINS NEW VALUE OF TORQUE WHEN ENTERING
                   ;AC1 WILL BE LOADED WITH THE PAST VALUE OF TORQUE
                   ;DELAY CONTAINS THE # OF 5 SEC INTERVALS FOR THE AGE OF OLD
 05561'054417 POPTQ:     STA     3,PPRET                             VALUE.
```

```
05562'034420          LDA     3,PPBASE
05563'030060-         LDA     2,DELAY
05564'173000          ADD     3,2      ;AC3= BASE ADDRESS + DELAY
05565'030414          LDA     2,PPADD
05566'151400          INC     2,2
05567'156433          SUBZ#   2,3,SNC ;SKIP IF AC2 LT AC3
05570'030412          LDA     2,PPBASE
                ;MAKE SURE ADDRESS IS NOT LESS THAN BASE ADDRESS
05571'034411          LDA     3,PPBASE ;ADDRESS
05572'156032          ADCZ#   2,3,SZC ;SKIP IF AC2 GE AC3
05573'034407          LDA     3,PPBASE
05574'050405          STA     2,PPADD
05575'025000          LDA     1,0,2
05576'041000          STA     0,0,2
05577'002401          JMP@    PPRET
05600'000000 PPRET:   0
05601'005603'PPADD:   PBASE
05602'005603'PPBASE:  PBASE
     000044 PBASE:    .BLK    36.
```

```
                  .NREL
                  ;INITIALIZATION TASK
                  ;TASK I.D. NO. - 4
                  ;TASK PRIORITY - 50
                  ;-----------------------------------------------
              INIT:
05647'102400      SUB     0,0       ;CLEAR CASSETTES INITIALIZED INDICATOR
05650'040016-     STA     0,INITL

05651'020142-     LDA     0,XTVFB ;INIT. PRIMARY UNIT
05652'126400      SUB     1,1       ;PARTIAL INITIALIZATION
05653'006017      .SYSTM
05654'004000      .INIT
05655'006135-     JSR     @XERR
05656'006017      .SYSTM            ;GET AN OPEN CHANNEL NUMBER
05657'021052      .GCHN
05660'006135-     JSR     @XERR     ;NO FREE CHANNELS
05661'050116-     STA     2,PTCN
05662'050115-     STA     2,TAPCN
05663'020142-     LDA     0,XTVFB ;OPEN THE DESIGNATED TAPE UNIT
05664'006017      .SYSTM
05665'025077      .MTOPD  77
05666'006135-     JSR     @XERR
05667'020143-     LDA     0,XTVFS ;INIT. SECONDARY UNIT
05670'126400      SUB     1,1       ;PARTIAL INITIALIZATION
05671'006017      .SYSTM
05672'004000      .INIT
05673'006135-     JSR     @XERR
05674'006017      .SYSTM            ;GET AN OPEN CHANNEL NUMBER
05675'021052      .GCHN
05676'006135-     JSR     @XERR     ;NO FREE CHANNELS
05677'050120-     STA     2,STCN
05700'020143-     LDA     0,XTVFS ;OPEN THE DESIGNATED TAPE UNIT
05701'006017      .SYSTM
05702'025077      .MTOPD  77
05703'006135-     JSR     @XERR
05704'126400      SUB     1,1
05705'044123-     STA     1,PSTF
05706'044117-     STA     1,NPTCN ;NM OF RECORD PRIMARY
05707'044121-     STA     1,NSTCN ;NUM OF RECORD SECONDARY
05710'126520      SUBZL   1,1
05711'044122-     STA     1,NCHN

05712'102000      ADC     0,0
05713'040016-     STA     0,INITL ;CASSETTES INITIALIZED

05714'005436'     .KILL
```

```
                        ;GET DATE ROUTINE
                        ;-----------------
05715'054410 GDATE:     STA     3,GDO
05716'006017            .SYSTM
05717'021006            .GDAY
05720'006135-           JSR     @XERR
05721'040076-           STA     0,ORS1    ;DAY
05722'044075-           STA     1,ORS0    ;MONTH
05723'050077-           STA     2,ORS2    ;YEAR
05724'002401            JMP     @GDO
05725'000000 GDO:       0

                        ;GET TIME ROUTINE
                        ;-----------------
05726'054410 GTIME:     STA     3,GTO
05727'006017            .SYSTM
05730'021003            .GTOD
05731'006135-           JSR     @XERR
05732'040077-           STA     0,ORS2    ;SECOND
05733'044076-           STA     1,ORS1    ;MINUTE
05734'050075-           STA     2,ORS0    ;HOUR
05735'002401            JMP     @GTO
05736'000000 GTO:       0

                        .EXTN   .BIND
                        .ZREL
00074-077777 XBIND:     .BIND
00075-000000 ORS0:      0
00076-000000 ORS1:      0
00077-000000 ORS2:      0
```

```
                         .NREL
                         ;SCAN XXXXX RECORDS OR FILES TASK
                         ;TASK I.D. NO. - 16
                         ;TASK PRIORITY - 10
                         ;-----------------------------------
05737'020000-SCAN:       LDA     0,TINPR
05740'102404             SUB     0,0,SZR
05741'000442             JMP     SC7
05742'020472             LDA     0,SC9
05743'006126-            JSR@    XWRLO
05744'004451             JSR     SDCID   ;DECIDE IF FORWARD OR REVERSE
05745'030111-            LDA     2,K3    ;F RETURN, LOAD CODE
05746'020473             LDA     0,SCN   ;LOAD MESSAGE BYTE POINTER
05747'000403             JMP     SC1
05750'030112-            LDA     2,K4    ;R RETURN, LOAD CODE
05751'020471             LDA     0,SCN+1 ;LOAD MESSAGE BYTE POINTER
05752'050464 SC1:        STA     2,SCNK  ;SAVE CODE
05753'006126-            JSR     @XWRLO  ;OUTPUT MESSAGE
05754'006100-SC2:        JSR     @XDBIN  ;CONVERT NUMBER TO BINARY
05755'030460             LDA     2,SCSP
05756'142404             SUB     2,0,SZR ;FINISHED?
05757'000775             JMP     SC2     ;NO
05760'044457             STA     1,SCNN  ;YES, SAVE NUMBER
05761'004434             JSR     SDCID   ;DECIDE IF FILES OR RECORDS
05762'020461             LDA     0,SCN+2 ;F RETURN, LOAD MESSAGE BYTE POINTER
05763'006126-            JSR     @XWRLO  ;OUTPUT MESSAGE
05764'000411             JMP     SC3
05765'020457             LDA     0,SCN+3 ;R RETURN, LOAD MESSAGE BYTE POINTER
05766'006126-            JSR     @XWRLO  ;OUTPUT MESSAGE
05767'024447             LDA     1,SCNK  ;COMBINE VALUES FOR COMMAND WORD
05770'020447             LDA     0,SCNN
05771'107000             ADD     0,1
05772'006124-            JSR     @XTVFE  ;EXERCISE TAPE UNIT
05773'000416             JMP     SC5     ;READ AN EOF OR EOT
05774'000411             JMP     SC4
05775'024441 SC3:        LDA     1,SCNK  ;GET COMMAND WORD
05776'006124-            JSR     @XTVFE  ;EXERCISE TAPE UNIT
05777'000406             JMP     SC4
06000'014437             DSZ     SCNN    ;FINISHED?
06001'000774             JMP     SC3     ;NO, CONTINUE
06002'000403             JMP     SC4
06003'020430 SC7:        LDA     0,SC8
06004'006126-            JSR@    XWRLO
06005'024001-SC4:        LDA     1,KEYID ;YES, IDENTIFY KEYBOARD TASK TO SYSTEM
06006'005552'            .TIDR
06007'006135-            JSR@    XERR
06010'005714'            .KILL
06011'006074-SC5:        JSR     @XBIND  ;OUTPUT NUMBER OF RECORDS SCANNED
06012'020420             LDA     0,SCA   ;MESSAGE BYTE POINTER
06013'006126-            JSR     @XWRLO
06014'000771             JMP     SC4     ;EXIT

                         ;DECIDE IF F OR R ROUTINE
                         ;-----------------------
06015'054412 SDCID:      STA     3,SDRT  ;SAVE RETURN
06016'006103-            JSR     @XGETC  ;GET CHARACTER
06017'030411             LDA     2,SDF
06020'112405             SUB     0,2,SNR ;IS CHARACTER AN "F"?
06021'002406             JMP     @SDRT   ;YES, RETURN
```

```
 06022'030407          LDA     2,SDR
 06023'112404          SUB     0,2,SZR ;IS CHARACTER AN "R"?
 06024'000772          JMP     SDCID+1 ;NO, TRY FOR A NEW CHARACTER
 06025'034402          LDA     3,SDRT  ;YES, RETURN
 06026'001403          JMP     3,3

 06027'000000 SDRT:    0
 06030'000106 SDF:     "F
 06031'000122 SDR:     "R
 06032'014112"SCA:     2*MRCSN
 06033'003724"SC8:     2*MS110
 06034'014204"SC9:     2*MSCAN
 06035'000040 SCSP:    "
 06036'000000 SCNR:    0
 06037'000000 SCNN:    0
 06040'000000 SCNP:    0
 06041'014136"SCN:     2*MFWD
 06042'014150"         2*MREV
 06043'014162"         2*MFILE
 06044'014172"         2*MRECD
              MRCSN:   .TXT    " RECORDS SCANNED<15><12>"
 06045'020122
 06046'042503
 06047'047522
 06050'042123
 06051'020123
 06052'041501
 06053'047116
 06054'042504
 06055'006412
 06056'000000
              MFWD:    .TXT    "FORWARD "
 06057'043117
 06060'051127
 06061'040522
 06062'042040
 06063'000000
              MREV:    .TXT    "REVERSE "
 06064'051105
 06065'053105
 06066'051123
 06067'042440
 06070'000000
              MFILE:   .TXT    "FILES<15><12>"
 06071'043111
 06072'046105
 06073'051415
 06074'005000
              MRECD:   .TXT    "RECORDS<15><12>"
 06075'051105
 06076'041517
 06077'051104
 06100'051415
 06101'005000
              MSCAN:   .TXT    *SCAN *
 06102'051503
 06103'040516
 06104'020000
```

```
                          .NREL
                          ;INITIALIZE DATE ROUTINE
                          ;-----------------------
06105'054417 INTDT:       STA       3,DTO     ;SAVE RETURN
06106'020417              LDA       0,DT      ;OUTPUT MESSAGE
06107'004437              JSR       INTGN     ;GET DATE
06110'131000              MOV       1,2       ;YEAR INTO AC2
06111'020453              LDA       0,GN2     ;DAY INTO AC0
06112'024451              LDA       1,GN1     ;MONTH INTO AC1
06113'006017              .SYSTM              ;SET DATE INTO REAL TIME CLOCK
06114'021005              .SDAY
06115'000403              JMP       DTER
06116'006066-             JSR       @XCRLF
06117'002405              JMP       @DTO      ;RETURN

06120'020403 DTER:        LDA       0,MDERR
06121'006126-             JSR@      XWRLO
06122'000764              JMP       INTDT+1

06123'002330"MDERR:       MGUST*2
06124'000000 DTO:         0
06125'014430"DT:          2*MUDAT

                          ;INITIALIZE TIME ROUTINE
                          ;-----------------------
06126'054416 INTTM:       STA       3,TMO     ;SAVE RETURN
06127'020416              LDA       0,TM      ;OUTPUT MESSAGE
06130'004416              JSR       INTGN     ;GET TIME
06131'121000              MOV       1,0       ;SECOND INTO AC0
06132'024432              LDA       1,GN2     ;MINUTE INTO AC1
06133'030430              LDA       2,GN1     ;HOUR INTO AC2  (24 HOUR CLOCK)
06134'006017              .SYSTM              ;SET TIME INTO REAL TIME CLOCK
06135'021004              .STOD
06136'000403              JMP       STER
06137'006066-             JSR       @XCRLF
06140'002404              JMP       @TMO      ;RETURN
06141'020762 STER:        LDA       0,MDERR
06142'006126-             JSR@      XWRLO
06143'000764              JMP       INTTM+1

06144'000000 TMO:         0
06145'014476"TM:          2*MUTIM
06146'054414 INTGN:       STA       3,GNO
06147'006126-             JSR       @XWRLO
06150'020415              LDA       0,GN3
06151'006126-             JSR       @XWRLO
06152'004414              JSR       GNDBN     ;GET MONTH OR HOUR
06153'044410              STA       1,GN1
06154'004430              JSR       GNSPO
06155'004411              JSR       GNDBN     ;GET DAY OR MINUTE
06156'044406              STA       1,GN2
06157'004425              JSR       GNSPO
06160'004406              JSR       GNDBN     ;GET YEAR OR SECOND
06161'002401              JMP       @GNO

06162'000000 GNO:         0
06163'000000 GN1:         0
06164'000000 GN2:         0
06165'014544"GN3:         2*MSP14
```

```
06166'054414 GNDBN:  STA      3,BNO
06167'006100-        JSR      @XDBIN
06170'030413         LDA      2,BNSP
06171'142415         SUB#     2,0,SNR
06172'002410         JMP@     BNO
06173'030404         LDA      2,BNCR
06174'142415         SUB#     2,0,SNR
06175'002405         JMP@     BNO
06176'000771         JMP      GNDBN+1
06177'000015 BNCR:   15
06200'000775         JMP      .-3
06201'002401         JMP      @BNO      ;EXIT, BINARY NO. IN AC1
06202'000000 BNO:    0
06203'000040 BNSP:   "

06204'054405 GNSPO:  STA      3,PO0
06205'020405         LDA      0,PO1
06206'024405         LDA      1,PO2
06207'006126-        JSR      @XWRLO
06210'002401         JMP      @PO0

06211'000000 PO0:    0
06212'014564"PO1:    2*MSP5
06213'000020 PO2:    20
             MUDAT:  .TXT     "ENTER DATE  MONTH      DAY       YEAR<15><12>"
06214'042516
06215'052105
06216'051040
06217'042101
06220'052105
06221'020040
06222'046517
06223'047124
06224'044040
06225'020040
06226'020040
06227'042101
06230'054440
06231'020040
06232'020040
06233'054505
06234'040522
06235'006412
06236'000000
             MUTIM:  .TXT     "ENTER TIME   HOUR   MINUTE   SECOND<15><12>"
06237'042516
06240'052105
06241'051040
06242'052111
06243'046505
06244'020040
06245'020110
06246'047525
06247'051040
06250'020040
06251'046511
06252'047125
06253'052105
```

```
0078  MELTS
 06254'020040
 06255'051505
 06256'041517
 06257'047104
 06260'006412
 06261'000000
                MSP14:    .TXT     "                    "
 06262'020040
 06263'020040
 06264'020040
 06265'020040
 06266'020040
 06267'020040
 06270'020040
 06271'000000
                MSP5:     .TXT     "     "
 06272'020040
 06273'020040
 06274'020000


                          .EXTN    .DBIN
                          .ZREL
 00100-077777 XDBIN:      .DBIN



                          .NREL
                          ;GET CHARACTER FROM KEYBOARD ROUTINE
                          ;-----------------------------------
 06275'054405 GETZ:       STA      3,GETO
 06276'006017             .SYSTM
 06277'007400             .GCHAR
 06300'006135-            JSR      @XERR
 06301'002401             JMP      @GETO
 06302'000000 GETO:       0

                          ;PRINT A CHARACTER ON TTO ROUTINE
                          ;--------------------------------
 06303'054405 PUTZ:       STA      3,PUTO
 06304'006017             .SYSTM
 06305'010000             .PCHAR
 06306'006135-            JSR      @XERR
 06307'002401             JMP      @PUTO
 06310'000000 PUTO:       0

 06311'054404 GTCH:       STA      3,GTCO
 06312'006103-            JSR      @XGETC
 06313'006104-            JSR      @XPUTC
 06314'002401             JMP      @GTCO
 06315'000000 GTCO:       0


                          .ZREL
 00101-006311'.GTCH:      GTCH
 00102-006303'.PTCH:      PUTZ
 00103-006275'XGETC:      GETZ
 00104-006303'XPUTC:      PUTZ
```

0079 MFLTS

```
                          .NREL
                          ;WRITE DATA ON TAPE ROUTINE
                          ;----------------------------------------
06316'054417 WDOT:        STA     3,WDO     ;SAVE RETURN

                   ;IDENTIFY TASK TO WRITE DIGITIZE DATA ON TAPE
06317'020417              LDA     0,WD1     ;ID AND PRIORITY
06320'024417              LDA     1,WD2     ;TASK START
06321'004120'             .TASK
06322'006135-             JSR@    XERR
06323'002412              JMP@    WDO

06324'020113-WD3:         LDA     0,K5      ;WRITE DATA RECORD ON TAPE
06325'024105-             LDA     1,RDLTH   ;DATA RECORD LENGTH
06326'107000              ADD     0,1       ;MAKE COMMAND WORD
06327'006124-             JSR     @XTVFE    ;WRITE RECORD
06330'002070-             JMP     @XDONE    ;EOT ON BACK-UP TAPE UNIT

                   ;CHECK TO SEE IF TEST FINISHED
06331'020002-             LDA     0,STOPC
06332'101004              MOV     0,0,SZR
06333'002405              JMP@    ZSTPRD

06334'006010'             .KILL             ;TASK COMPLETE

06335'000000 WDO:         0
06336'015025 WD1:         3287+25
06337'006324'WD2:         WD3
06340'004104'ZSTPRD:      STPRD

                          .ZREL
00105-000350 RDLTH:       BUFL      ;RECORD LENGTH
00106-006316'XWDOT:       WDOT
```

```
                   .NREL
                   ;TAPE VARIABLE FILE I/O ROUTINE
                   ;-------------------------------
06341'054465 TVFI0: STA    3,TVFO  ;SAVE RETURN
06342'020141-       LDA    0,XYBUF ;DATA BUFFER POINTER
06343'044470        STA    1,TVFF  ;SAVE TAPE CODE
06344'030115-       LDA    2,TAPCN ;DEVICE CODE
06345'006017 TVF6:  .SYSTM         ;EXERCISE TAPE UNIT
06346'023077        .MTDIC 77
06347'000403        JMP    TVF2    ;ERROR RETURN
06350'034456 TVF1:  LDA    3,TVFO  ;NORMAL RETURN
06351'001401        JMP    1,3     ;EXIT TO NORMAL RETURN
06352'151113 TVF2:  MOVL#  2,2,SNC ;IS THIS A SYSTEM ERROR?
06353'006135-       JSR    @XERR   ;YES
06354'044461        STA    1,TVFH  ;NO. SAVE RECORD COUNT
06355'020452        LDA    0,TVFA
06356'143404        AND    2,0,SZR ;IS EOT BIT ON?
06357'000422        JMP    TVF3    ;YES
06360'020452        LDA    0,TVFE  ;NO
06361'143405        AND    2,0,SNR ;IS EOF BIT ON?
06362'000440        JMP    TVF4    ;NO
06363'020114-       LDA    0,K6    ;YES
06364'034447        LDA    3,TVFF  ;GET TAPE CODE USED
06365'162405        SUB    3,0,SNR ;WAS CODE "WRITE EOF"?
06366'000762        JMP    TVF1    ;YES, TAKE NORMAL RETURN
06367'020111-       LDA    0,K3    ;NO
06370'162405        SUB    3,0,SNR ;WAS CODE SCAN FORWARD EOF'S?
06371'000757        JMP    TVF1    ;YES, TAKE NORMAL RETURN
06372'020112-       LDA    0,K4    ;NO
06373'162405        SUB    3,0,SNR ;WAS CODE SCAN REVERSE EOF'S?
06374'000754        JMP    TVF1    ;YES,TAKE NORMAL RETURN
06375'020433        LDA    0,TVFC  ;NO
06376'006126-       JSR    @XWRLO  ;WRITE EOF MESSAGE
06377'024436        LDA    1,TVFH  ;GET RECORD COUNT
06400'002426        JMP    @TVFO   ;ABNORMAL RETURN
06401'024123-TVF3:  LDA    1,PSTF
06402'125004        MOV    1,1,SZR ;EOT ON PRIMARY TAPE UNIT ?
06403'000413        JMP    TVF5    ;NO, WAS EOT ON BACK-UP ?
06404'030122-       LDA    2,NCHN  ;YES
06405'151005        MOV    2,2,SNR ;HAVE A BACK-UP ?
06406'000410        JMP    TVF5    ;NO, WRITE EOF MESSAGE
06407'125400        INC    1,1     ;YES, REWRITE ON BACK-UP
06410'044123-       STA    1,PSTF  ;SET FLAG TO BACK-UP TAPE
06411'030120-       LDA    2,STCN  ;MAKE BACK-UP THE ACTIVE UNIT
06412'050115-       STA    2,TAPCN
06413'024420        LDA    1,TVFF  ;GET TAPE CODE
06414'020140-       LDA    0,XXBUF ;GET DATA BUFFER POINTER
06415'000730        JMP    TVF6    ;REWRITE ON BACK-UP
06416'020413 TVF5:  LDA    0,TVFD
06417'006126-       JSR    @XWRLO  ;WRITE EOT MESSAGE
06420'024415        LDA    1,TVFH  ;GET RECORD COUNT
06421'002405        JMP    @TVFO   ;ABNORMAL RETURN
06422'020412 TVF4:  LDA    0,TVFG  ;OTHER THAN EOT OR EOF TAPE ERROR
06423'006126-       JSR    @XWRLO
06424'006135-       JSR    @XERR   ;IGNORE RTOS SYSTEM ERROR NO.
06425'002401        JMP    @TVFO   ;ABNORMAL RETURN

06426'000000 TVFO:  0
06427'001000 TVFA:  1B6
```

AD-A070 561 NAVAL AMMUNITION PRODUCTION ENGINEERING CENTER CRANE IND F/G 19/1
AUTOMATIC MIX-MELT PRODUCTION PROCESS DEVELOPMENT FOR TRITONAL,--ETC(U)
MAY 78 G A GROH

UNCLASSIFIED NL

3 OF 3
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END
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```
 06430'015074"TVFC:    2*MECF
 06431'015120"TVFD:    2*MECT
 06432'000400 TVFE:    1B7
 06433'000000 TVFF:    0
 06434'015136"TVFG:    2*MTISN
 06435'000000 TVFH:    0
              MEOF:    .TXT     "END OF FILE MARK<15><12>"
 06436'042516
 06437'042040
 06440'047506
 06441'020106
 06442'044514
 06443'042440
 06444'046501
 06445'051113
 06446'006412
 06447'000000
              MEOT:    .TXT     "END OF TAPE<15><12>"
 06450'042516
 06451'042040
 06452'047506
 06453'020124
 06454'040520
 06455'042415
 06456'005000
              MTISN:   .TXT     "TAPE ERROR, BUT NOT EOF OR EOT<15><12>"
 06457'052101
 06460'050105
 06461'020105
 06462'051122
 06463'047522
 06464'026040
 06465'041125
 06466'052040
 06467'047117
 06470'052040
 06471'042517
 06472'043040
 06473'047522
 06474'020105
 06475'047524
 06476'006412
 06477'000000


                       .ZREL
 00107-100000 K0:      100000
 00110-110000 K1:      110000
 00111-130000 K3:      130000
 00112-140000 K4:      140000
 00113-150000 K5:      150000
 00114-160000 K6:      160000
 00115-000000 TAPCN:   0                  ;ACTIVE TAPE CHANNEL NO.
 00116-000000 PTCN:    0                  ;PRIMARY TAPE CHANNEL NO.
 00117-000000 NPTCN:   0
 00120-000000 STCN:    0                  ;BACK-UP TAPE CHANNEL NO.
 00121-000000 NSTCN:   0
 00122-000000 NCHN:    0                  ;MULTI-TAPE INDICATOR
 00123-000000 PSTF:    0                  ;PRI-SEC. TAPE INDICATOR
```

```
0083   MEI75
 00124-006341'XTVFF1   TVFIC
```

```
                         .NREL
                         ;READ A LINE FROM KEYBOARD ROUTINE
                         ;---------------------------------
06500'054412 RDLK:       STA     3,RDO
06501'004412             JSR     RDSU
06502'006130-            JSR     @XRVFL
06503'006131-            JSR     @XCVF
06504'002406             JMP     @RDO
06505'054405 RDSK:       STA     3,RDO
06506'004405             JSR     RDSU
06507'006134-            JSR     @XRVFS
06510'006131-            JSR     @XCVF
06511'002401             JMP     @RDO
06512'000000 RDO:        0
06513'054414 RDSU:       STA     3,RDU0
06514'040414             STA     0,RDU1
06515'044414             STA     1,RDU2
06516'020414             LDA     0,.TTI
06517'126400             SUB     1,1
06520'006017             .SYSTM
06521'021052             .GCHN
06522'006135-            JSR     @XERR
06523'006127-            JSR     @XOVF
06524'020404             LDA     0,RDU1
06525'024404             LDA     1,RDU2
06526'002401             JMP     @RDU0

06527'000000 RDU0:       0
06530'000000 RDU1:       0
06531'000000 RDU2:       0
06532'015266".TTI:       .+1*2
                         .TXT    "$TTI"
06533'022124
06534'052111
06535'000000

                         .ZREL
00125-006500'XRDLK:      RDLK

                         .NREL
                         ;WRITE A LINE ON TTO ROUTINE
                         ;---------------------------
06536'054412 WRLO:       STA     3,WRO
06537'004412             JSR     WRSU
06540'006132-            JSR     @XWVFL
06541'006131-            JSR     @XCVF
06542'002406             JMP     @WRO
06543'054405 WRSO:       STA     3,WRO
06544'004405             JSR     WRSU
06545'006133-            JSR     @XWVFS
06546'006131-            JSR     @XCVF
06547'002401             JMP     @WRO
06550'000000 WRO:        0
06551'054414 WRSU:       STA     3,WRU0
06552'040414             STA     0,WRU1
06553'044414             STA     1,WRU2
06554'020414             LDA     0,.TTO
06555'126400             SUB     1,1
06556'006017             .SYSTM
```

```
06557'021052            .GCHN
06560'006135-           JSR     @XERR
06561'006127-           JSR     @XOVF
06562'020404            LDA     0,WRU1
06563'024404            LDA     1,WRU2
06564'002401            JMP     @WRU0

06565'000000 WRU0:      0
06566'000000 WRU1:      0
06567'000000 WRU2:      0
06570'015362".TTO:      .+1*2
                        .TXT    "$TTO"
06571'022124
06572'052117
06573'000000

                        .ZREL
00126-006536'XWRLO:     WRLC


                        .NREL
06574'054405 OVF:       STA     3,OVFO
06575'006017            .SYSTM
06576'014077            .OPEN   77
06577'006135-           JSR     @XERR
06600'002401            JMP     @OVFO
06601'000000 OVFO:      0
06602'054405 RVFL:      STA     3,RVFLO
06603'006017            .SYSTM
06604'015477            .RDL    77
06605'006135-           JSR     @XERR
06606'002401            JMP     @RVFLO
06607'000000 RVFLO:     0
06610'054405 RVFS:      STA     3,RVFSO
06611'006017            .SYSTM
06612'015077            .RDS    77
06613'006135-           JSR     @XERR
06614'002401            JMP     @RVFSO
06615'000000 RVFSO:     0
06616'054405 WVFL:      STA     3,WVFLO
06617'006017            .SYSTM
06620'017077            .WRL    77
06621'006135-           JSR     @XERR
06622'002401            JMP     @WVFLO
06623'000000 WVFLO:     0
06624'054405 WVFS:      STA     3,WVFSO
06625'006017            .SYSTM
06626'017077            .WRL    77
06627'006135-           JSR     @XERR
06630'002401            JMP     @WVFSO
06631'000000 WVFSO:     0
06632'054405 CVF:       STA     3,CVFO
06633'006017            .SYSTM
06634'014477            .CLOSE  77
06635'006135-           JSR     @XERR
06636'002401            JMP     @CVFO
06637'000000 CVFO:      0
```

```
0086  MELTS

                    .ZREL
 00127-006574'XOVF:    OVF
 00130-006602'XRVFL:   RVFL
 00131-006632'XCVF:    CVF
 00132-006616'XWVFL:   WVFL
 00133-006624'XWVFS:   WVFS
 00134-006610'XRVFS:   RVFS
```

```
                          .NREL
                          ;PRINT RTCS SYSTEM ERROR ROUTINE
                          ;------------------------------
06640'054422 ERR:         STA      3,ERO
06641'050424              STA      2,ERC
06642'020421              LDA      0,ERA
06643'006126-             JSR      @XWRLO
06644'024421              LDA      1,ERC
06645'006136-             JSR      @XBINO
06646'006066-             JSR      @XCRLF
06647'020415              LDA      0,ERB
06650'006126-             JSR      @XWRLO
06651'024411              LDA      1,ERO
06652'124400              NEG      1,1
06653'124000              COM      1,1
06654'006136-             JSR      @XBINO
06655'006066-             JSR      @XCRLF

06656'024001-             LDA      1,KEYID
06657'006006'             .TIDR
06660'063077              HALT
06661'006334'             .KILL

06662'000000 ERO:         0
06663'015554"ERA:         2*MRTSE
06664'015602"ERB:         2*MATLO
06665'000000 ERC:         0
             MRTSE:       .TXT     "<12>RTOS SYSTEM ERROR '"
06666'005122
06667'052117
06670'051440
06671'051531
06672'051524
06673'042515
06674'020105
06675'051122
06676'047522
06677'020047
06700'000000
             MATLO:       .TXT     "AT LOCATION '"
06701'040524
06702'020114
06703'047503
06704'040524
06705'044517
06706'047040
06707'023400


                          .EXTN    .BINO
                          .ZREL
00135-006640'XERR:        ERR
00136-077777 XBINO:       .BINO
00137-177770 XMSKO:       177770
```

```
^ 0088  MELTS

                        .NREL
        000350          .DUSR   BUFL=232.
             TVFB:      .TXT    "CT0:0"
06710'041524
06711'030072
06712'030000
             TVFS:      .TXT    "CT1:0"
06713'041524
06714'030472
06715'030000
        000350 XBUF:    .BLK    BUFL
07266'000000            0
        000350 YBUF:    .BLK BUFL
07637'000000            0

                        .ZREL
00140-006716'XXBUF:     XBUF
00141-007267'XYBUF:     YBUF
00142-015620"XTVFB:     2*TVFB
00143-015626"XTVFS:     2*TVFS

                        .NREL
        000000'         .END    START
```

0089	MELTS	0090	MELTS	0091	MELTS	0092	MELTS
ACPT	003476'	AULCC	004211'	C12	003720'	DFPF	002450'
ADATA	005446'	AULOP	004443'	C60	003474'	DG1	003562'
ADBCK	005555'	AUN0	004207'	CAD16	003721'	DG2	003600'
ADBMX	005557'	AUN1	004216'	CADOU	001726'	DG3	003702'
ADIV	003724'	AUN10	004435'	CAHLD	003722'	DGA1	003725'
ADL1	005544'	AUN11	004436'	CB0	004030'	DGA10	003755'
ADL2	005527'	AUN12	004437'	CB03	001230'	DGA2	003726'
ADLIS	002523'	AUN13	004440'	CB20	001231'	DGA3	003727'
ADOUT	002434'	AUN14	004573'	CB99	001221'	DGA4	003730'
ADRTN	002446'	AUN15	004574'	CHECK	001701'	DGA5	003731'
AG200	003053'	AUN16	004575'	CHK1	001730'	DGA6	003732'
AG2P5	003046'	AUN17	004576'	CHK2	001731'	DGA7	003733'
AGCNT	003047'	AUN18	004577'	CHKAD	003230'	DGA8	003734'
AGPST	003050'	AUN2	004217'	CHKBU	001732'	DGA9	003735'
AGRUN	000025-	AUN23	004600'	CHKEP	001720'	DGADD	003227'
AU204	004202'	AUN3	004220'	CHKID	003226'	DGAVG	003611'
AU205	004221'	AUN4	004222'	CHKRC	000014-	DGCNT	003231'
AU360	004210'	AUN5	004223'	CHMS	001727'	DGID	003224'
AUATS	004206'	AUN6	004224'	CLO	001236'	DGV1	003615'
AUDEC	004213'	AUN7	004432'	CLTIM	003052'	DGV2	003633'
AUDCK	004441'	AUN8	004433'	CMADD	000760'	DGV3	003625'
AUDWN	004572'	AUN9	004434'	CMD	001076'	DGV4	003661'
AUGUP	004442'	AUNDW	004215'	CMDW	000764'	DIG	003545'
AUINC	004212'	AUNUP	004214'	CMOVE	001725'	DIGAD	003515'
AUL1	004122'	AUT10	004204'	CNR1	003216'	DIGID	003514'
AUL10	004246'	AUTID	005560'	CNR2	003217'	DIGRC	000012-
AUL11	004254'	AUTO	004111'	CNR3	003220'	DNLIN	000056'
AUL12	004256'	AUTTS	004205'	CNR4	003221'	DNTRY	000766'
AUL13	004270'	BDTX2	003360'	CNR5	003222'	DONE	003516'
AUL14	004272'	BFADD	002535'	CNR6	003051'	DOUTC	000010-
AUL15	004304'	BFDNS	002514'	CNR7	003223'	DREAD	000054-
AUL16	004314'	BFLOC	002451'	CNV1	003011'	DT	006125'
AUL17	004321'	BFMBK	002510'	CNV10	003041'	DTO	006124'
AUL18	004330'	BFMSG	002521'	CNV11	003121'	DTER	006120'
AUL19	004337'	BFMSX	002522'	CNV12	003135'	DTRX	002775'
AUL2	004140'	BFN16	002516'	CNV2	003054'	DWTID	003716'
AUL20	004355'	BFPLC	002515'	CNV3	003163'	ERO	006662'
AUL21	004365'	BFPNT	002452'	CNV4	003073'	ERA	006663'
AUL22	004470'	BFRD1	002456'	CNV5	003157'	ERB	006664'
AUL23	004400'	BFRD2	002505'	CNV6	003146'	ERC	006665'
AUL24	004420'	BFRD3	002500'	CNV7	003174'	ERR	006640'
AUL25	004422'	BFRUN	002453'	CNVIP	000063'	F409P	002517'
AUL26	004500'	BFTMS	002513'	CNVRT	002776'	FENT	002466'X
AUL27	004562'	BLMT	000050-	CNVSA	000064'	FINT	000000'X
AUL28	004526'	BNO	006202'	CRLF	001232'	FSTCH	000015-
AUL29	004546'	BNCR	006177'	CTIME	002043'	FSTID	003225'
AUL3	004153'	BNDEC	003447'	CTM1	002054'	FSTRC	000013-
AUL30	004551'	BNSP	006203'	CTM2	002057'	GDO	005725'
AUL31	004564'	BPTX2	003316'	CTM3	002050'	GDATE	005715'
AUL32	004507'	BSAVE	003475'	CUTID	004203'	GETO	006302'
AUL33	004516'	BTU	000032-	CVF	006632'	GETC	000005-
AUL4	004172'	BTUDI	000034-	CVFO	006637'	GETCH	001201'
AUL46	004414'	BTUFS	000024-	CXBUF	004015'	GETZ	006275'
AUL5	004165'	BTUSR	000043-	DA0	000022-	GGRET	001214'
AUL6	004177'	BTUSU	000033-	DA1	000023-	GN0	006162'
AUL7	004227'	BTUZE	000035-	DDEOF	003524'	GN1	006163'
AUL8	004234'	BUN7	004225'	DEBUG	077777 X	GN2	006164'
AUL9	004242'	BUN8	004226'	DELAY	000060-	GN3	006165'
AULEA	004601'	BXRTN	002512'	DENSE	000036-	GNDBN	006166'

0093	MELT5	0094	MELT5	0095	MELT5	0096	MELT5
GNSPC	006204'	LST13	002175'	MKC5	000217'	MSG19	005277'
GPOIN	001215'	LST14	002266'	MKC6	000237'	MSG2	004676'
GTO	005736'	LST18	002267'	MKC7	000260'	MSG20	005317'
GTCO	006315'	LST19	002270'	MKC8	000300'	MSG21	005334'
GTCH	006311'	LST2	002110'	MKC9	000320'	MSG22	005345'
GTIME	005726'	LST20	002271'	MN19	005442'	MSG23	005356'
HELP	000032'	LST21	002272'	MN20	005443'	MSG3	004707'
HOME	001714'	LST22	002273'	MN21	005417'	MSG4	004717'
IKCT	000574'	LST23	002274'	MN22	005420'	MSG5	004742'
IKCTO	000602'	LST24	002275'	MNL1	005437'	MSG6	004770'
INE	001330'	LST25	002276'	MNL2	005433'	MSG7	005011'
INIT	005647'	LST26	002277'	MPY	001216'	MSG8	005051'
INITI	000061'	LST27	002300'	MOUST	001154'	MSG9	005071'
INITL	000016-	LST28	002301'	MPCSN	006045'	MSLST	004620'
INST	003473'	LST29	002302'	MPDLT	003723'	MSP14	006262'
INTAD	000062'	LST3	002065'	MPECD	006075'	MSP5	006272'
INTDT	006105'	LST30	002217'	MPEV	006064'	MSRIN	004614'
INTGN	006146'	LST31	002304'	MPTSE	006666'	MSTRT	000111'
INTTM	006126'	LST32	002247'	MS100	004056'	MT2P5	003132'
K0	000107-	LST33	002303'	MS101	004075'	MT600	003134'
K1	000110-	LST4	002257'	MS102	001514'	MTCAS	001336'
K100	000750'	LST5	002116'	MS103	001556'	MTCNT	003133'
K101	000751'	LST6	002260'	MS104	001567'	MTIME	004616'
K132	000752'	LST60	002255'	MS105	003423'	MTISN	006457'
K25	000754'	LST61	002256'	MS106	003432'	MTMP	004615'
K3	000111-	LST7	002261'	MS107	003440'	MTN10	005445'
K36D	000762'	LST8	002137'	MS108	002533'	MTRUN	000026-
K4	000112-	LST9	002263'	MS109	001157'	MUDAT	006214'
K5	000113-	LSTER	002245'	MS110	001752'	MUTIM	006237'
K6	000114-	LSTTP	002253'	MS111	002022'	MZRXZ	002743'
K60	000753'	MACPT	001376'	MS112	002033'	NCHN	000122-
K71	000761'	MANUA	005421'	MS115	003325'	NLINE	000055'
KBLK	000770'	MATLC	006701'	MS116	003332'	NOISE	000056-
KCC	001021'	MATCI	005444'	MS117	003371'	NPTCN	000117-
KCD	001020'	MEGN	000047'	MS120	002307'	NSTCN	000121-
KCEND	000111'	MCRLF	001240'	MS121	002333'	ORS0	000075-
KCLST	000065'	MDERR	006123'	MS122	002342'	ORS1	000076-
KCR	000767'	MEOF	006436'	MS123	002351'	ORS2	000077-
KCT	000665'	MEOT	006450'	MS124	002372'	OVF	006574'
KCTIP	000604'	MESS	004602'	MS125	002400'	OVFO	006601'
KCTSA	000603'	MFILE	006071'	MS126	002405'	PBASE	005603'
KEYID	000001-	MFWD	006057'	MS127	002426'	PD1	003361'
KLP0	000700'	MGAG	003713'	MS200	003525'	PD2	003362'
KLP1	000740'	MGDIG	003712'	MS201	000553'	PD3	003363'
KLP2	000717'	MGK	001213'	MS300	003334'	PD4	003364'
KLP3	000726'	MGTIM	004617'	MS401	001602'	PD5	003365'
KLP4	001005'	MKBCT	001143'	MS416	003375'	PD6	003366'
KLP5	000772'	MKC0	000132'	MSCAN	006102'	PD7	003367'
KLP6	001010'	MKC1	000133'	MSG0	004651'	PD8	003370'
KLP7	000777'	MKC10	000364'	MSG1	004665'	PDATE	003335'
KWRDS	000771'	MKC11	000346'	MSG10	005106'	PHNAS	000052'
LEAVE	001473'	MKC12	000416'	MSG11	005123'	PNTS	000060'
LIST	002062'	MKC13	000532'	MSG12	005140'	PC0	006211'
LISTC	002262'	MKC14	000470'	MSG13	005156'	PC1	006212'
LOPP	003453'	MKC15	000446'	MSG14	005175'	PC2	006213'
LST1	002254'	MKC16	000511'	MSG15	005211'	PCINT	000747'
LST10	002143'	MKC2	000145'	MSG16	005221'	PCPIC	005561'
LST11	002264'	MKC3	000166'	MSG17	005227'	PPADD	005601'
LST12	002265'	MKC4	000200'	MSG18	005251'	PPBAS	005602'

0097	MELTS	0098	MELTS	0099	MELTS	0100	MELTS
PPRET	005600'	SCNN	006037'	TPRI2	000065-	WSA	000007-
PR5	001657'	SCNP	006040'	TPRI7	000063-	WTPRY	001334'
PR6	001666'	SCNT	003717'	TODIR	000030-	WTRO	000613'
PR7	001677'	SCSP	006035'	TOLOW	000052-	WTRIP	000615'
PR8	001700'	SDCID	006015'	TONLD	000041-	WTRNF	003266'
PREHE	000037-	SDF	006030'	TOOVE	000045-	WTRSA	000614'
PRINT	001650'	SDR	006031'	TORAT	000031-	WTST	001333'
PSTF	000123-	SDRT	006027'	TOSRT	000042-	WTT1	000660'
PT1	003317'	SLMT1	000047-	TOTIM	000053-	WTT2	000661'
PT2	003320'	SLMT2	000051-	TOUMA	000046-	WTT3	000634'
PT3	003321'	SMSG	004050'	TOWAI	000040-	WTT4	000662'
PT4	003322'	SOFF	005401'	TR16	002774'	WTT5	000654'
PT5	003323'	SON	005410'	TRAIN	003264'	WTT6	000644'
PT6	003324'	START	000000'	TRANC	002771'	WTT7	000664'
PT7	003331'	STATU	002003'	TRAY	000765'	WVFL	006616'
PTCN	000116-	STCMP	001506'	TREAD	000055-	WVFLO	006623'
PTIME	003275'	STCN	000120-	TRLP1	002755'	WVFS	006624'
PUTO	006310'	STCON	001502'	TRNFR	002750'	WVFSO	006631'
PUTC	000006-	STEP	006141'	TST1	001271'	X2BUF	000067-
PUTZ	006303'	STIME	000044-	TST2	001264'	XBIND	000074-
RAIN	003232'	STLP1	000036'	TSTCA	001325'	XBINC	000136-
RDO	006512'	STMES	001505'	TTRG	001416'	XBNDE	000011-
RDLK	006500'	STMCF	004444'	TVF0	006426'	XBUF	006716'
RDLTH	000105-	STMON	004455'	TVF1	006350'	XCMD	000763'
RDSK	006505'	STN10	001512'	TVF2	006352'	XCNV1	003215'
RDSU	006513'	STNC	001477'	TVF3	006401'	XCRLF	000066-
RDU0	006527'	STOP	001441'	TVF4	006422'	XCVF	000131-
RDU1	006530'	STOPC	000002-	TVF5	006416'	XCXBF	000071-
RDU2	006531'	STPER	001501'	TVF6	006345'	XDBIN	000100-
REPCR	003376'	STPID	001513'	TVFA	006427'	XDONE	000070-
RNN1	003267'	STPRD	004104'	TVFB	006710'	XERR	000135-
RNN2	003270'	STPTR	001504'	TVFC	006430'	XGETC	000103-
RNN3	003271'	STPXX	001507'	TVFD	006431'	XGTCH	000755'
RPO	003422'	STPYY	001510'	TVFE	006432'	XIKCT	000061-
RPMS1	003417'	STRBU	002305'	TVFF	006433'	XMESS	000017-
RPMS2	003420'	STRKY	001360'	TVFG	006434'	XMPY	000757'
RPMS3	003421'	STT1	002011'	TVFH	006435'	XMSKO	000137-
RPRET	003416'	STT2	002020'	TVFIC	006341'	XOVF	000127-
RTLPT	000057-	STT3	002013'	TVFS	006713'	XPUTC	000104-
RUNPR	001335'	STT4	002021'	U2048	004467'	XRDLK	000125-
RVFL	006602'	TABLE	001024'	VCAHL	005556'	XRVFL	000130-
RVFLO	006607'	TAPCN	000115-	WAITR	000605'	XRVFS	000134-
RVFS	006610'	TBEND	001076'	WATCH	000663'	XSAMP	000072-
RVFSO	006615'	TCHAR	000756'	WATT	000616'	XSMSG	000073-
SAMP	004034'	TDMG	003274'	WD0	006335'	XSTCF	000020-
SAMPO	004051'	TENS	003466'	WD1	006336'	XSTCN	000021-
SAUTI	001511'	TEST	001242'	WD2	006337'	XTABL	001022'
SC1	005752'	TIME	001633'	WD3	006324'	XTVFB	000142-
SC2	005754'	TINPR	000000-	WDOT	006316'	XTVFE	000124-
SC3	005775'	TLONG	001023'	WFPF	002447'	XTVFS	000143-
SC4	006005'	TM	006145'	WR0	006550'	XWDCT	000106-
SC5	006011'	TMO	006144'	WRITA	002576'	XWRLC	000126-
SC7	006003'	TME1	001644'	WRKBU	002306'	XWVFL	000132-
SC8	006033'	TME2	001645'	WRLO	006536'	XWVFS	000133-
SC9	006034'	TME3	001646'	WRSO	006543'	XXBUF	000140-
SCA	006032'	TME4	001647'	WRSU	006551'	XYBUF	000141-
SCAN	005737'	TCRCU	000027-	WRU0	006565'	YBUF	007267'
SCN	006041'	TPRI	000062-	WRU1	006566'	YDUM	001317'
SCNK	006036'	TPRI1	000064-	WRU2	006567'	YINTC	002060'

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  0101   MELTS
YINIT    002061'
YPTIM    001676'
YTDMG    001675'
ZADAT    003715'
ZADGU    001674'
ZBFAC    002511'
ZDEST    002773'
ZGTIM    001723'
ZINTD    000053'
ZINIT    000054'
ZLST     000057'
ZPTIM    001724'
ZRAIN    003714'
ZREPO    000004-
ZSORC    002772'
ZSTME    000003-
ZSTFR    006340'
ZTDMG    003265'
ZWAIT    000051'
.AKIL    077777 X
.ARDY    077777 X
.ASUS    077777 X
.BINC    000074-X
.BINC    000136-X
.DBIN    000100-X
.DIV     003724'X
.GTCH    000101-
.IDST    005422'X
.IXMT    004042'X
.KILL    006661'X
.PRI     001270'X
.PTCH    000102-
.REC     003012'X
.SUSP    004564'X
.TASK    006321'X
.TIDK    005427'X
.TIDP    006657'X
.TIDS    001250'X
.TTI     006532'
.TTC     006570'
.UCEX    004047'X
.UIEX    077777 X
.XMT     004106'X
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APPENDIX B

ECONOMIC BENEFITS

OF AN

IMPROVED CONTROL SYSTEM

FOR

TNT MIX-MELTING

15 May 1978

ECONOMIC BENEFITS OF AN IMPROVED CONTROL SYSTEM
FOR
TNT MIX-MELTING

I. INVESTMENT COSTS

A. Manufacturing Technology Development Project Costs.

Labor, Equipment and Testing $266,000

B. Typical System Component Costs

	Item	Purchase Cost	Installation	Total Cost
1.	Torque Meter	$ 2,600	$ 1,500	$ 4,100
2.	Thermal Energy Calculator	5,400	2,600	8,000
3.	Stripchart Recorder	1,200	850	2,050
4.	Mini-computer	15,000	4,000	19,000

II. SAVINGS

The project was initiated not as a cost savings measure but as a necessary part of an overall, directed, cost effective modernization of the bomb loading facility at McAlester Army Ammunition Plant (formerly Naval Ammunition Depot McAlester). However, cost savings will occur and will come from at least 3 sources.

A. Peace Time

1. Batch Monitoring System

Improved batch control could lead to reduced batch times and a resulting increase in plant output. A ten percent reduction in batch time (considered conservative since actual test data demonstrated 40 percent to be possible) would reduce end item costs by $1.83 for each Mk 82 bomb produced. Considering a peace time buy of 25,000 bombs per year, the gross cost savings would be $45,750/year. Using an investment cost of $14,150 for equipment it would take the loading of only 7,700 bombs to obtain a pay back.

2. Semi-Automatic Batch Control

The reduced batch time plus elimination of the cap-off operation because of reduced explosive shrinkage could yield savings of $56,750 per year based on 25,000 bombs per year. Using an investment cost of $33,150 for equipment, it would take the loading of 14,600 bombs to obtain a pay back.

3. Automatic Batch Control and Material Feed

The elimination of three kettle operators plus the elimination of the cap-off operation at McAlester "A" Plant would result in an estimated yearly cost savings of $26,984 for 25,000 Mk 82 bombs. Computer systmes in the present "A" Plant control network would be used for mix-melt control. Using an investment cost of $14,150, pay back would result after 13,100 bombs are loaded.

B. War or Mobilization Savings

The real purpose of any bomb production line is to support war efforts. Therefore savings must be considered for these conditions. Production cost savings using a yearly estimate of 780,00 bombs would amount to the following based on the sophistication of the system used:

1.	Batch Monitoring System	$1,427,400
2.	Semi-Automatic Batch Control	$1,770,600
3.	Automatic Batch Control	$ 841,900

C. One time accident prevention savings due to the elimination of large scale testing programs to determine quality could amount to over 1 million dollars. Cost savings from the reduction or elimination of the hot probe process for casting TNT loaded Army projectiles would amount to much more than can be obtained in bomb loading. This is duto the numbers of people and projectiles involved and the extensive time required to perform the multiple-step probe method.