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CASS - A MICROCOMPUTER CONTROL SYSTEM FOR GRAND COULEE AGC SIGNALS

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16. ABSTRACT

The CASS (Coulee AGC Signal Stuffer) is a microprocessor-based support control system to assist the large PMSC computers in the AGC control function at Grand Coulee Powerplant. The theory, operation, and program flow charts are presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

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CASS - A MICROCOMPUTER CONTROL SYSTEM FOR GRAND COULEE AGC SIGNALS

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Division of Research
Engineering and Research Center
Denver, Colorado
August 1981

UNITED STATES DEPARTMENT OF THE INTERIOR * BUREAU OF RECLAMATION

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

In May of 1981, the Secretary of the Interior approved changing the Water and Power Resources Service back to its former name, the Bureau of Reclamation. All references in this publication to the Water and Power Resources Service should be considered synonymous with the Bureau of Reclamation.

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FIGURES

INTRODUCTION

In March 1979, it became apparent that the Grand Coulee PMSC (programmable master supervisory control) had timing problems which would result in poor AGC (automatic generation control). Under heavy processing of changing data within the plant, the total generated power may not be calulated as rapidly as required. This delay, which can range from 8 to 30 seconds, or more, will cause oscillation in the BPA (Bonneville Power Administration) control signals. The theoretical maximum delay around the loop is about 10 seconds before oscillation occurs.

At that time, the Power and Instrumentation Branch was requested to provide a processor that could substitute the total plant generation value sent from PMSC to BPA with a value derived from the presently used analog system. Construction of this processor, dubbed CASS (Coulee AGC signal stuffer), was begun in June 1980.

CONCLUSIONS

A processor was developed and installed at Grand Coulee in November 1980. This processor allows BPA to receive the actual plant total power generation with minimal delay, thus allowing BPA to implement AGC control of Grand Coulee.

As an added benefit, the installed processor derives and sends to PMSC a value for substitute generation. The operator is now relieved of the duty of manually entering changes in substitute generation.

The AGC control should be more predictable and stable as a result of this installation.

GENERAL DESCRIPTION

A block diagram of how CASS fits into the Grand Coulee PMSC system is shown in figure 1. The message sent from BPA Dittmer control center to Coulee PMSC, and vice versa, is intercepted by CASS. These messages are modified and then retransmitted. In the case of the message from PMSC to BPA, the total plant generation sent from the PMSC is replaced by the total plant generation as reflected by the analog chart recording system. This allows BPA to receive the total plant generation with minimal delay, the primary function of CASS.

In addition, CASS provides a secondary function to the operators of PMSC by intercepting and adding a quantity called substitute generation to the message from BPA to PMSC. This quantity is the total generation of Grand Coulee which is not under the control of PMSC. This quantity was previously entered by the operator into PMSC via a CRT (cathode ray tube) terminal. Figure 2 shows a block diagram of CASS. Within CASS is an integrator sensitive to any error between the total generation transmitted from PMSC and the total generation from the analog recording system. The output of this integrator is the derived value of substitute generation sent and automatically entered into PMSC, relieving the operator from doing so. The effect of this control loop is to force the total generation transmitted from PMSC to match that value measured by the analog recording system.

CASS has a front panel from which a number of quantities can be monitored, several of which can be outputted through D/A (digital-to-analog) converters for recording on strip charts. The front panel and its operation will be subsequently described.

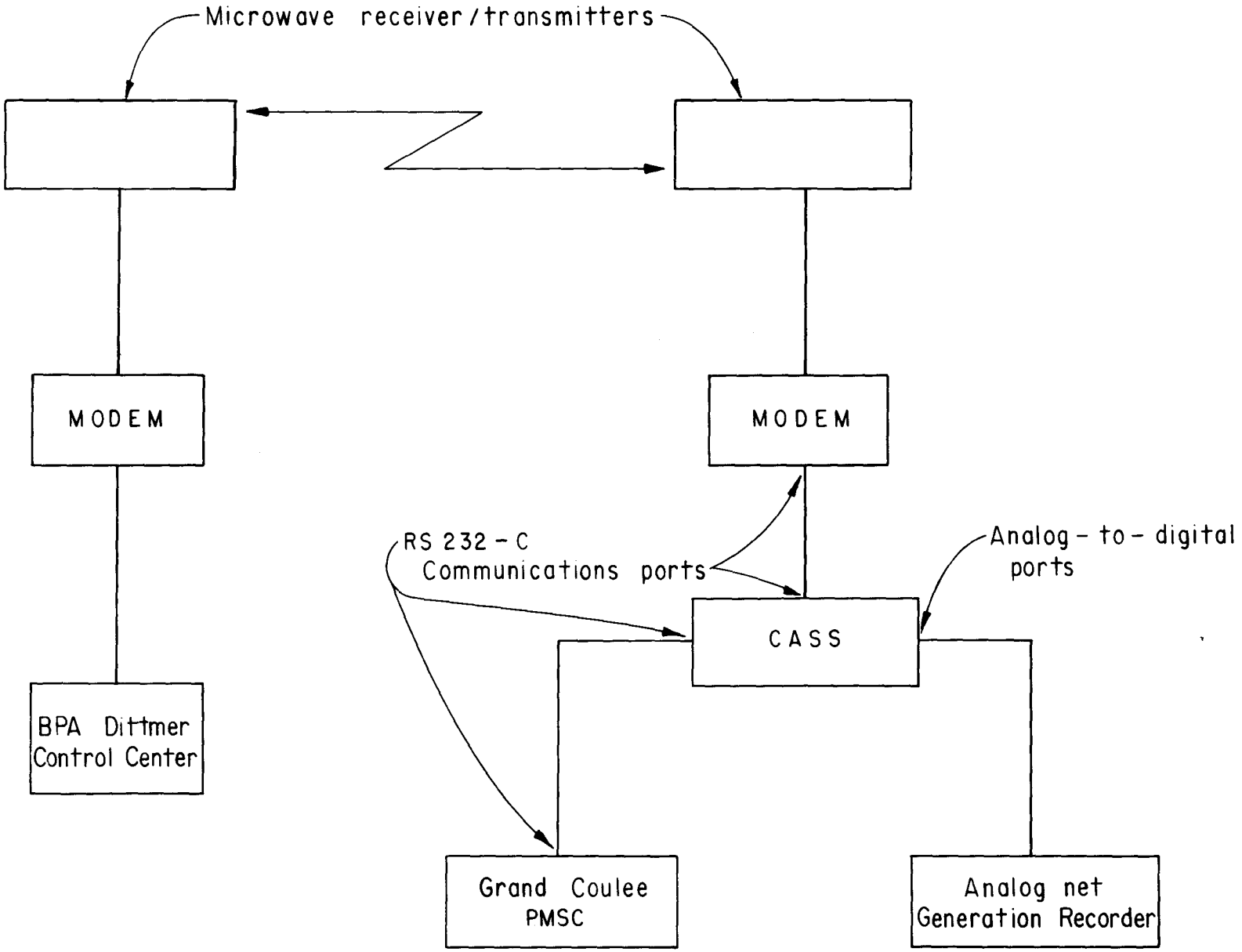


Figure 1.—Overview of communications system.

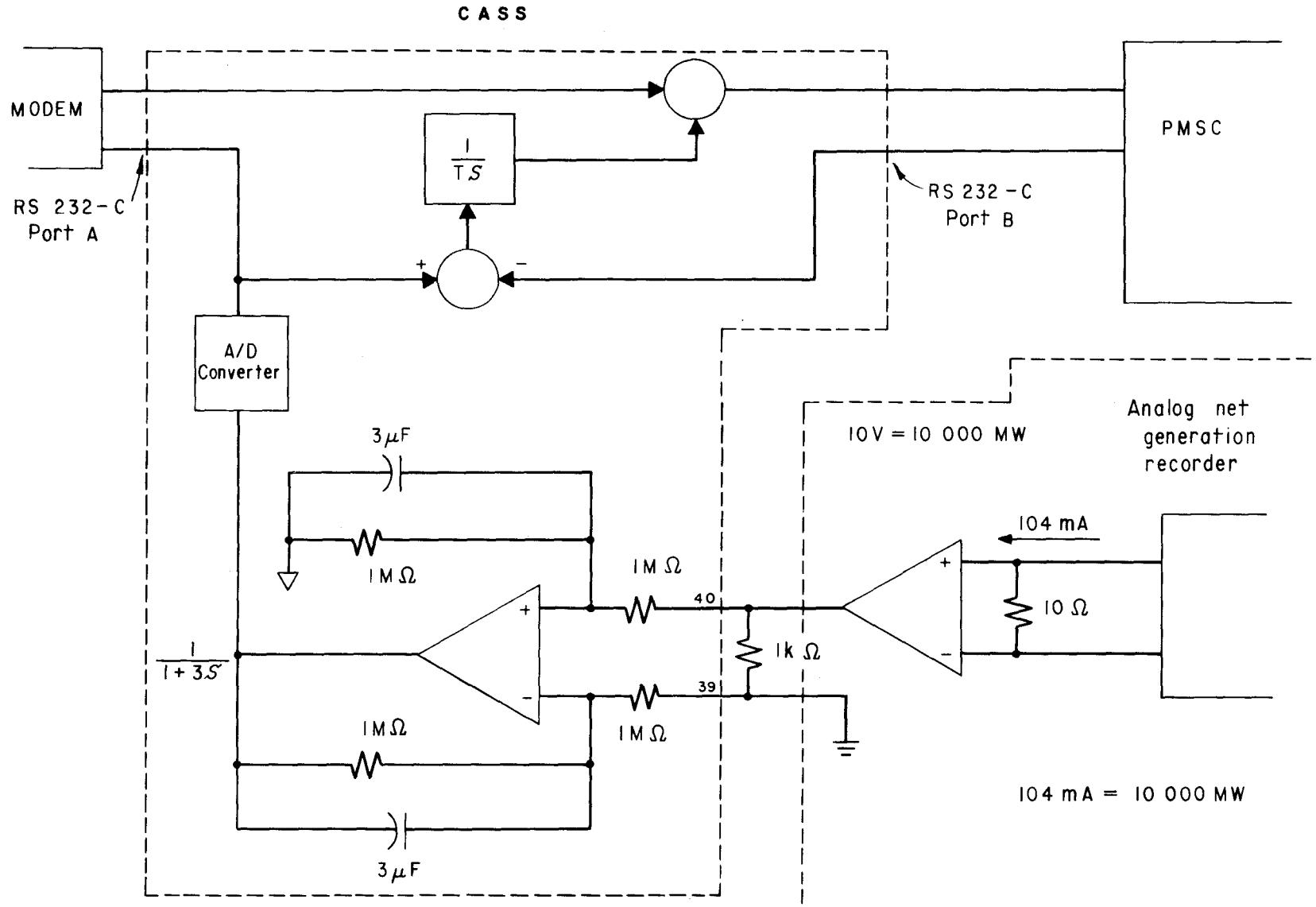


Figure 2.—Block diagram of CASS.

ANALOG AND DIGITAL MODELS

In order to verify the stability of the control loop associated with adding the integrator to derive substitute generation, a model of the system including CASS, PMSC, and BPA was tested on an analog computer. A block diagram of that model is shown in figure 3. The use of the analog computer provided a rapid means of showing the theory was valid, as well as providing step responses to compare with responses from digital models to verify their accuracy.

Subsequent to analog computer testing, the CASS software was developed along with digital models of BPA and PMSC. To test CASS, the digital models of BPA and PMSC were run on separate processors connected to CASS by RS232-C communications links. Step responses recorded on the digital model proved to be nearly identical to step responses recorded on the analog model.

HARDWARE DESCRIPTION

The CASS computer consists of five plug-in printed circuit cards described as follows:

1. A single-board, 16-bit microcomputer with vectored interrupts; one RS232-C compatible serial data port; two interval timers; a 16-bit parallel data port; 4096 words (4k) of ultraviolet-light-erasable, programmable read-only-memory (EPROM); and 512 words (0.5k) of random-access-memory (RAM).

2. A communication expansion card with four RS232-C compatible serial data ports and four interval timers.

3. An input-output expansion card with three 16-bit parallel data ports and three interval timers.

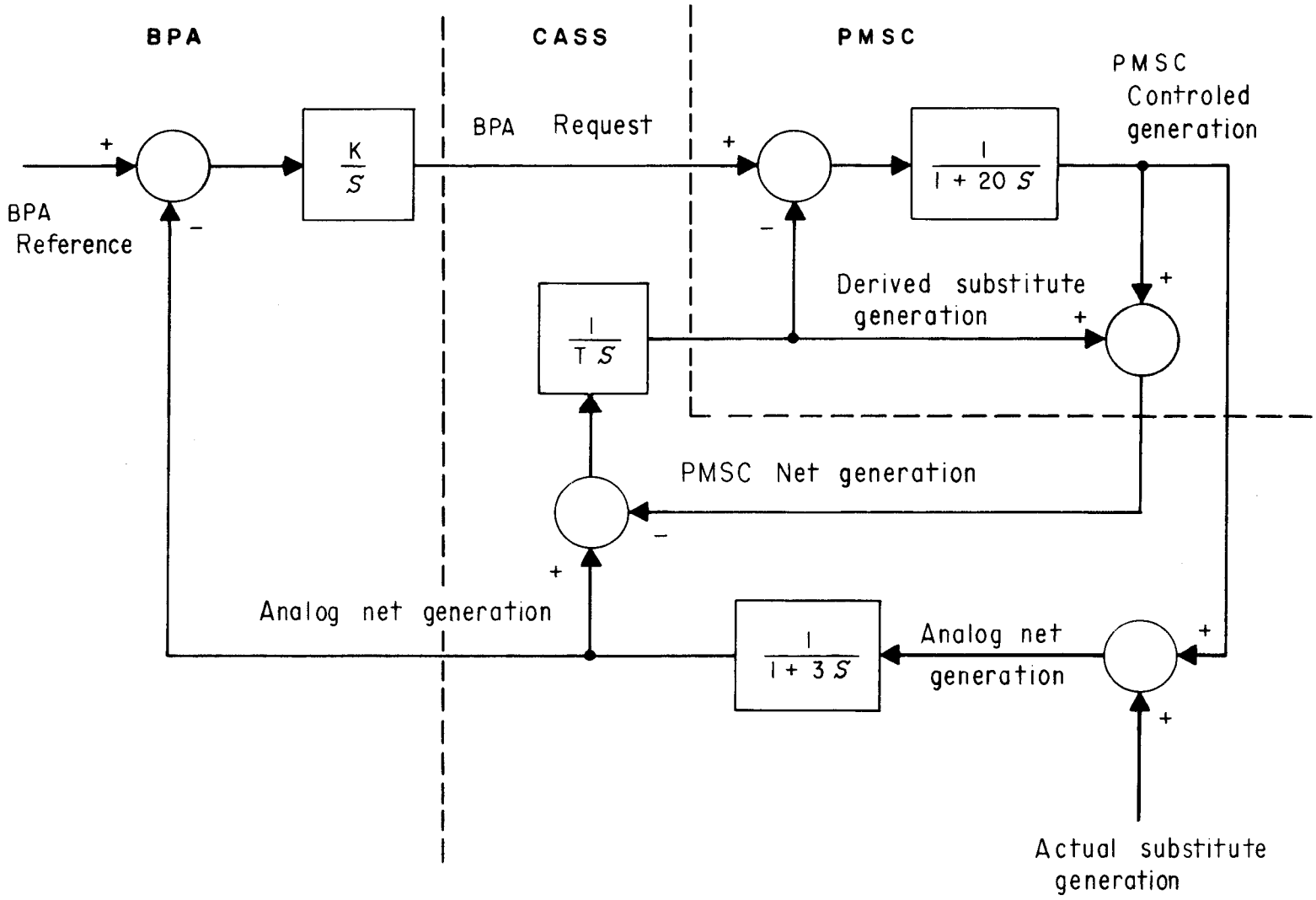


Figure 3.—Block diagram of system model.

4. An analog input-output card with 32 multiplexed, single-ended input channels and two analog output channels, each with 12 bits of resolution.

5. A prototyping board on which the Power and Instrumentation Branch built a differential input amplifier; three single-pole, double-throw switches; and five trimming potentiometers.

CASS has a front panel as shown in figure 4. This panel displays internal quantities, status, alarms, two D/A outputs, and two A/D (analog-to-digital) inputs.

SOFTWARE DESCRIPTION

The CASS software can be divided into five main routines. A brief description of each follows. The software is described more completely in the flow charts in appendix C and assembly language listings which are available upon request from the Power and Instrumentation Branch.

Communications

The software controlling the communications with BPA and PMSC uses two standard RS232-C serial data ports. These ports convert 7-bit parallel data to the standard 10-bit ASCII (American Standard Code for Information Interchange) serial format. This format consists of a 7-bit ASCII code representing the character to be transmitted, a parity bit, a start bit, and a stop bit. CASS uses even parity. The message structure consists of STX (start of text), up to 48 alphanumeric characters comprising the message, an ETX (end of text), a block check character, and an EOT (end of transmission).

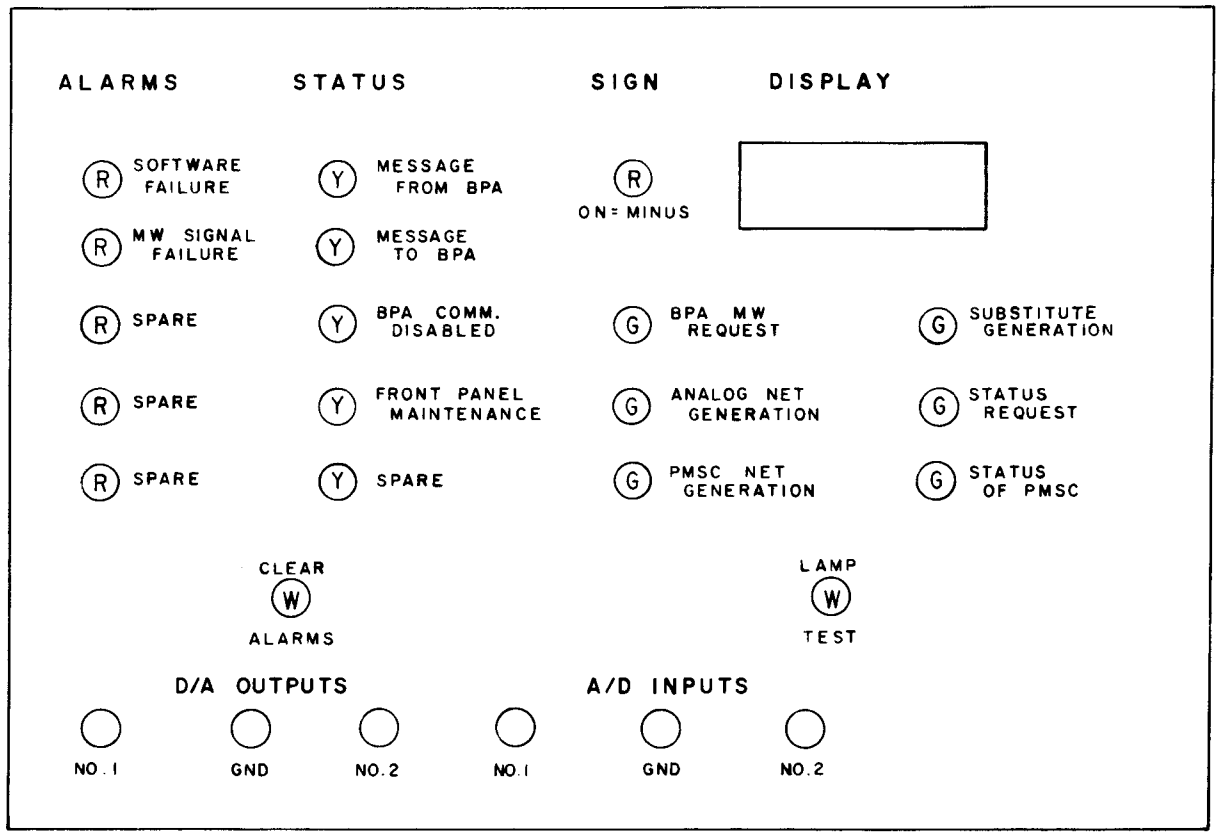


Figure 4.—Front panel.

A message is normally transmitted from BPA to PMSC every 2 seconds. This message is intercepted and received by the communications software which adds substitute generation to the message and initiates transmission to PMSC. When PMSC responds, this message is also intercepted and received by the communications software which removes the net generation calculated by PMSC and substitutes the net generation as measured by the analog recording system. This message is then transmitted to BPA.

If a transmission error is detected during receipt of a message, the checksum of the message, when retransmitted, will be set incorrectly, thus enabling BPA and PMSC to be aware of transmission errors. There are one flag and five error counters for each communications port. The flag and counters can be read from the front panel. See appendix A for address codes.

Analog-to-Digital and Digital-to-Analog

Another software routine controls the A/D and D/A conversions. The analog net generation signal from the analog recording system and the value of the five potentiometers are converted to digital values and stored in RAM. The routine also controls which of the four quantities will be outputted to the two D/A converters.

Front Panel

The front panel driver routine controls the display, all LED's (light-emitting diodes), and pushbuttons. The routine scans the pushbuttons for changes, provides debounce, decodes the address, and displays the appropriate quantity.

Integrator

The integrator routine derives the value of substitute generation. This routine is called every time a message is received from PMSC. The equation used for integration is:

$$SUBGEN_{NEW} = SUBGEN_{OLD} + \frac{(ANALGEN - DIGGEN)}{(INTEGRATION\ TIME)}$$

Because this equation assumes a sample interval of 1 second, the integration time must be scaled appropriately for different sample intervals. The sample interval is determined by the communications interval. For a communications interval of 2 seconds, integration time must be divided by two. This routine also reduces round off error by accumulating the remainder from the division.

Memory Maintenance

The fifth routine is memory maintenance. The software of this routing continually checks EPROM and RAM memory locations; if any location produces an error, the CPU enters an infinite loop. By using TIBUG, the type of error can be determined by examining "BADF" in the memory maintenance workspace. Details are given on the flow charts.

INSTALLATION AND OPERATION

To connect CASS into the system four connections are needed. They are:

1. 115 V, 60 Hz, a.c.

2. RS232 compatible connector carrying communications with BPA is connected to port A on the communications expander board.

3. RS232 compatible connector carrying communications with PMSC is connected to port B on the communcations expander board.

4. A 40-pin edge connector with the output of the analog strip chart connected to pins 40 (plus) and 39 (minus) is connected to P-3 on the prototype board. This is a differential input. All switches on this board should be off (to the left) for the power-up.

Power is applied by the switch labled "power" on the right side of the CASS chassis. Under normal circumstances, this should be all that is required for CASS to operate. Normal operation is signified by the left most red LED on the communications expander board blinking at 1 hertz and status LED's on the front panel, labled "Message from BPA" and "Message to BPA", blinking at the communications rate.

The front panel, shown in figure 4, displays alarms, status, and interval quantities via the display and button selector. In addition, there are two channels of D/A output and two channels of A/D input (not used).

There are two alarm LED's, one of which is a "Software Failure" alarm. This alarm is activated and the computer enters an infinite loop when a checksum error occurs on a ROM sector or a RAM location fails to either set or clear properly. Location of the error can only be determined by using the TIBUG monitor routine described in appendix B. The alarm can be cleared by restarting the program with TIBUG, by operating the reset switch on the right of the CPU card, or with a power-down/power-up sequence.

The second alarm "MW Signal Failure" occurs when the power signal from the analog recording system is below 250 MW (+0.25 V) or above 9900 MW (+9.9 V). This alarm suspends all communications. Initially, the LED will flash; the alarm can be acknowledged by pressing the alarm clear button, then the LED will remain on. When the problem has been corrected, pushing the alarm clear button will turn the LED off and enable communications.

There are four status LED's. The one labled "Message from BPA" indicates a message has been received from BPA and transmitted to PMSC. A STX received from BPA enables the LED. Therefore, the LED should flash for each message being received from BPA and transmitted to PMSC. The status LED labled "Message to BPA" provides the same function as the previously described LED but for transmission from PMSC to BPA.

The third LED labled "BPA Communications Disabled" is an indication that S1 on the protoboard has been turned on. The fourth LED labled "Front Panel Maintenance" is an indication that S3 on the protoboard has been turned on. The function of these switches will be subsequently described.

The front panel has a four-digit display with an LED to indicate polarity. This display will indicate those values requested by pushing one of the six pushbuttons below the display. These six quantities are: (1) the setpoint, in megawatts, for Grand Coulee being requested by BPA, (2) the total generation, in megawatts, of Grand Coulee as recorded by the analog recording system, (3) the total generation, in megawatts, of Grand Coulee as measured by the PMSC, (4) the substitute generation, in megawatts, being derived and sent to PMSC by CASS, (5) the plant status requested by BPA (-1 = auto or base load; 0 = standby or off), and (6) the plant status of the PMSC (-1 = auto, 0 = off). The quantity being displayed is indicated by an LED within the pushbutton which selects that quantity.

There are two D/A outputs available on the front panel. The scaling for both outputs is 10 V = 10 000 MW. D/A No. 1 provides an analog output of the substitute generation derived by CASS with an option for an analog output of the total generation of Grand Coulee as totaled by the analog recording system. D/A No. 2 provides an analog output of the total generation as totaled by the PMSC with an option for an analog output of the setpoint requested by BPA. Exercising the options is described in appendix A. There are two A/D channels available but not used.

The lamp test button will light all LED's and all segments and decimal points in the display.

There is a program in ROM that will test the display on the front panel. This program will repeatedly increment each digit from 0 through 9 and flash the decimal points. This program must be run from TIBUG. To start, set the PC (program counter) to 16010 octal and the ST (status) register to zero, then press the letter E (execute). To return to TIBUG, use either the reset button on the CPU or the halt switch on the chassis.

For other than normal operation of CASS, there are three switches located on the prototype board. All switches should be off for normal operation. Switch S1, labled "BPA Communication Disabled", when turned on allows communications between CASS and PMSC only. This operating mode is to provide automatic substitute generation updating to PMSC when communications with BPA have been lost and are anticipated to be lost for a considerable length of time. The message transmitted from CASS to PMSC will request a plant status of "off" and a BPA request of no power. In this mode, the first two status lights will alternately flash as messages are transmitted and received. This substitute message is transmitted at an interval set by R4. In order to maintain the same integration gain in CASS while in this mode, the communications interval should be the same as that from BPA. Upon restoration of communications with BPA, switch S1 must be returned to the "off" position in order to enable the BPA communication interrupts.

Switch S2, labled "Power-up Vector", when turned on forces CASS to power-up into the TIBUG monitor routine instead of the main program. This debug routine allows one to examine and change registers, examine and change RAM memory locations, manipulate input and output lines, set breakpoints, single step through programs, and execute programs. The routine is described in appendix B.

Switch S3, labled "Front Panel Maintenance", when turned on, puts the front panel in the maintenance mode. In this mode, the six pushbuttons on the front panel can be used to address 1 of 77 octal locations for display. The least significant digit is the right row of

three buttons with the top button being the least significant bit. Any button pushed will light if unlit or extinguish if lit. Those buttons lit indicate the octal code for the quantity being displayed. Appendix A lists the quantities that can be displayed and their octal address codes.

There are five trimming potentiometers located on the prototype board. The first four are used; the last is a spare. Potentiometer R1 is used to set the integration time on the integrator within CASS which derives substitute generation. This value is displayed on the front panel by using octal address 11. This integration time is the quantity displayed times the communications interval in seconds. Thus, with a display of 25 and a communication interval of 2 seconds, the integration time is 50 seconds resulting in an integration gain of 0.02. This potentiometer has a range of 0 to 199 on the display.

Trimming potentiometer R2 sets a timer with a range of 0 to 19 seconds and an octal address of 12. Upon power-up, CASS attempts to set substitute generation to approximately the right value. This is accomplished by initially setting substitute generation to zero on the messages being sent to PMSC. After the first message is received from PMSC, the timer set by R2 begins to time out. At the end of the time interval, the total generation from BPA is subtracted from the total generation as measured by the analog recording system. The result approximates the value of substitute generation. This timer should be set for the minimum amount of time necessary for PMSC to call the AGC algorithm after receiving the substitute generation value of zero.

Trimming potentiometer R3 is a calibration adjustment for the total generation measured by the analog recording system. This value is addressed by octal code 13 and has a range of -10.0 to $+9.9$ percent.

Trimming potentiometer R4 sets the communications interval for the substitute message being transmitted by CASS to PMSC (S1 on) when BPA communications is disabled. The potentiometer has a range of 0.0 to 19.9 seconds and is addressed by octal code 14. The time interval should be set the same as the communications interval from BPA.

FIELD TESTS

In November 1980, CASS was installed in the PMSC computer room in the 480-mm (19-in) rack containing the primary communications preprocessor. Testing revealed two minor software problems in the PMSC master. The first problem prevented the status bit in the message from PMSC to BPA from indicating "auto" when the PMSC was in the "BPA" mode. The second problem related to declaring the AGC communications port down on the PMSC; declaring this port down opens the control loop between CASS and PMSC because the master no longer provides current data to the communication preprocessor. This control loop derives substitute generation. With the port declared down, the communications preprocessor continues to respond to messages from CASS, returning data that are no longer current. This causes the integrator within CASS which derives substitute generation to continually integrate. This will be corrected by a software change in the PMSC master which will, when the AGC port is declared down, instruct the communications preprocessor not to respond to messages from CASS. This will maintain the derived value of substitute generation at the value it was prior to declaring the port down.

Because the BPA computer system was not ready for AGC tests, we were unable to test the AGC mode with BPA, although communications were tested and found to operate correctly. AGC testing was then accomplished by using another processor to simulate BPA. Some results from these tests are shown in figures 5 through 8. These figures show a step change of 40 MW in the reference on the BPA model. The integration time in the BPA model and CASS is 20 and 50 seconds, respectively. The left side of figure 3 shows the model used for BPA.

The top trace of figure 5 shows the total generation as measured by the analog system and read by CASS. This total generation value for Grand Coulee is being sent to BPA in lieu of the value measured by the PMSC system. Figure 6 shows the total generation as measured by PMSC. This is the quantity that can be as much as 28 seconds behind real time under heavy processing of changing data within the plant. At this time, the delay is

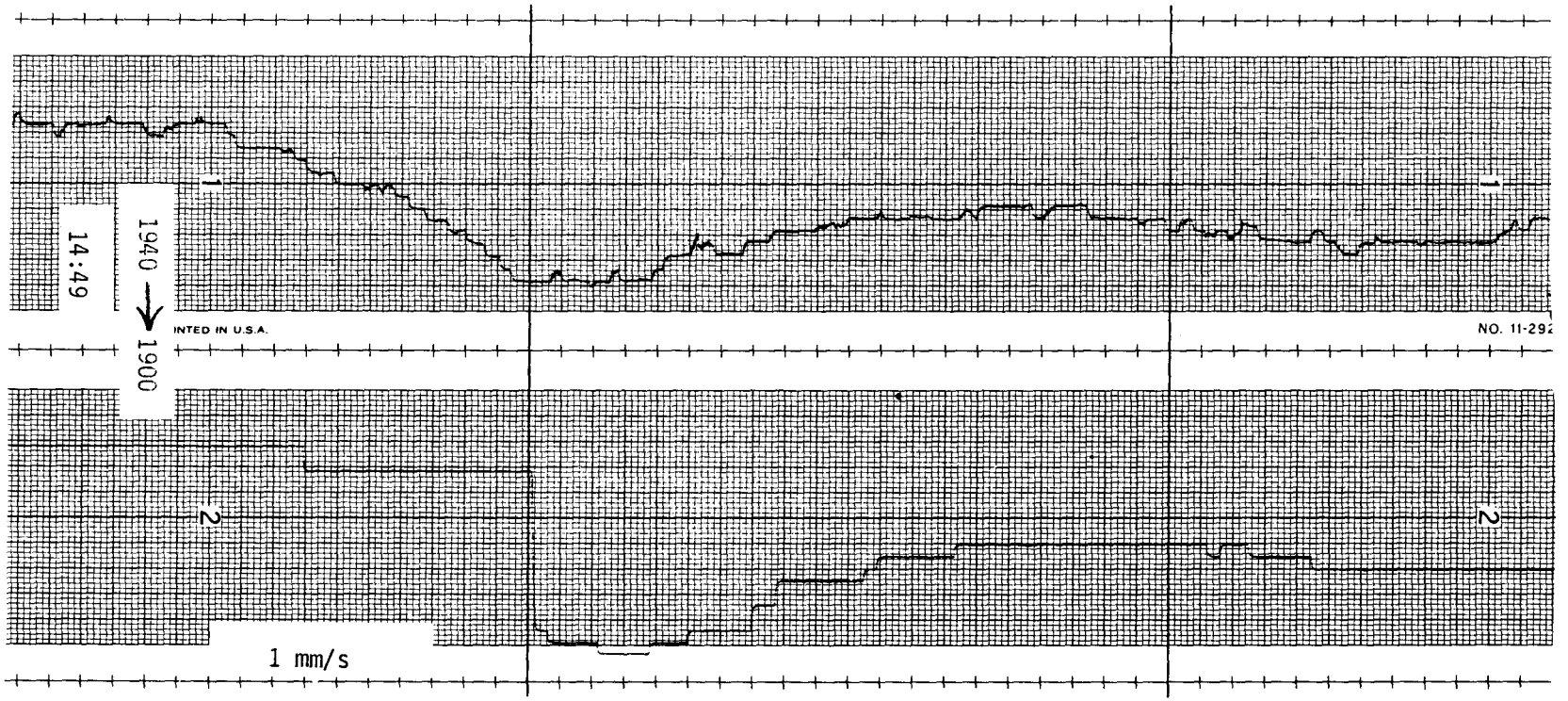


Figure 5.—Comparison of analog and PMSC plant totals, case I.

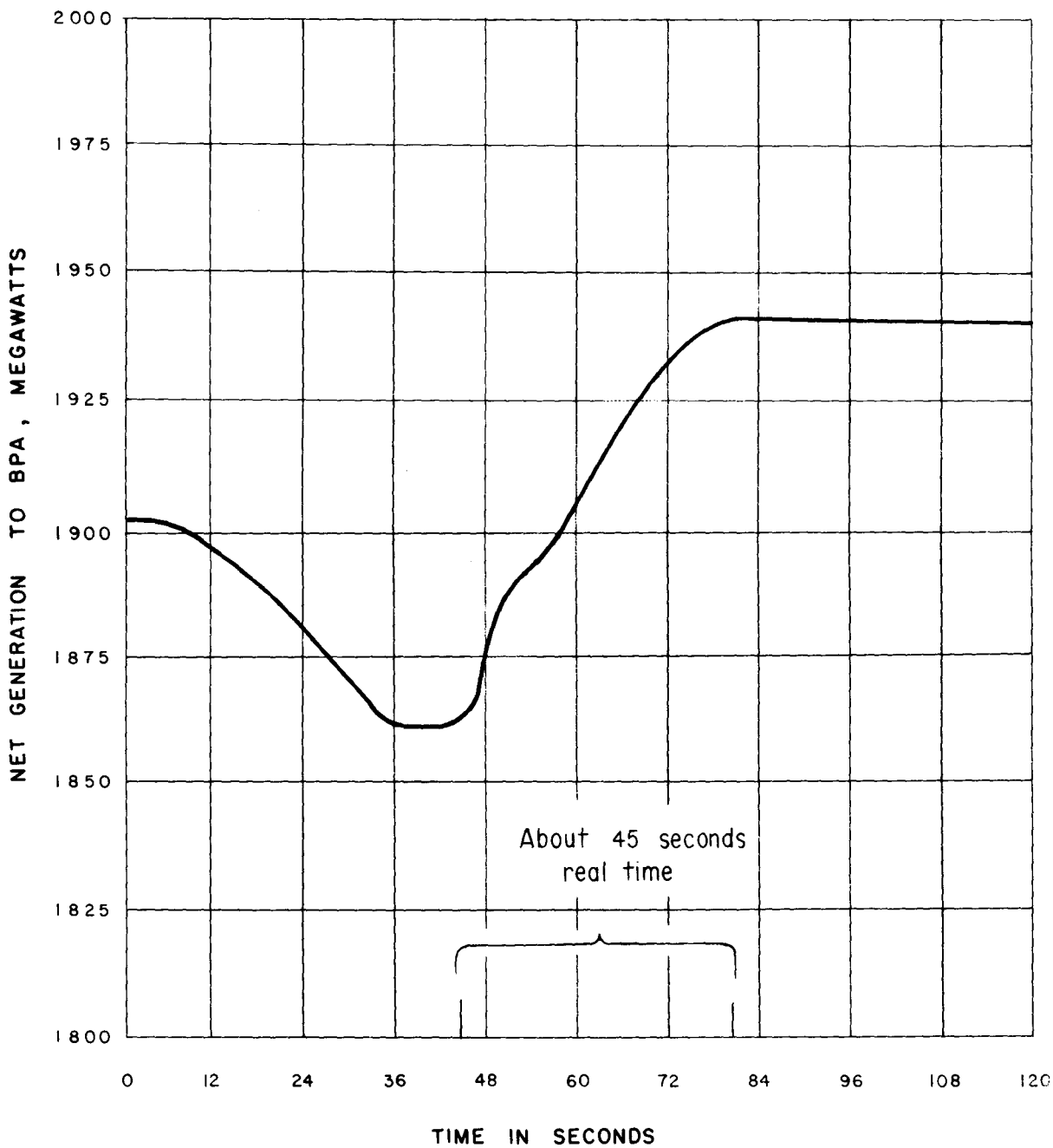


Figure 6.—Total generation as measured by PMSC, case I.

TIME IN SECONDS

not evident as the master is communicating with only a small number of RTU's (remote terminal units). The upper trace of figure 5 and figure 6 compare very well, except for the time axis on figure 6. This axis is based on the PMSC master calling the AGC routine every 2 seconds, when in fact, the time varies considerably and averaged, under the lightly loaded conditions, about 2.5 seconds.

The lower trace of figure 5 shows the total generation as measured by the PMSC (fig. 2) after being transferred to the communications preprocessor and then transmitted to CASS. The interesting point of this record is the appearance of a previously unknown system hangup between the PMSC master and the communications preprocessor of about 35 seconds during which current data were not being transferred from the master to the preprocessor. This time delay was observed in five of six records and ranged from 15 to 40 seconds. Because CASS does not send this value to BPA but uses it only to derive substitute generation, there will be very little effect on the AGC control loop as long as the CASS integrator time is large, at least 50 seconds. This problem is being investigated.

Figures 7 and 8 show the same quantities as figures 5 and 6, but in this case, there does not appear to be a system hangup. The change is relatively stable with about 30 percent overshoot on the first swing. Recovery to within 10 percent of the setpoint occurs in less than 3.5 minutes. These values result from an integration time of 20 seconds in the BPA model. In reality, the integration time of BPA is probably larger which will result in more stable operations.

The control loop deriving substitute generation, although purposely set slow so as not to affect the PMSC AGC mode, was a beneficial addition to CASS. The operators are now relieved of periodically entering changes in the generation quantities not being measured by the PMSC.

BIBLIOGRAPHY

[1] Gish, W. B., "Load and Voltage Control Algorithms for Grand Coulee Powerplant," Research Report REC-ERC-76-3, Bureau of Reclamation, March 1976.

[2] Specification, "Grand Coulee Complex Programmable Master Supervisory Control," DS7049, issued by Bureau of Reclamation, June 1974.

[3] Hogg, R. S., "Supervisory Control of Grand Coulee Dam Complex," paper presented at American Public Power Association Engineering and Operations Workshop, Bureau of Reclamation, February 1978.

APPENDIX A

Descriptions of Interval Variables and Corresponding Octal Address Codes

Octal Code	Description
01	Substitute generation (megawatts)
02	Status requested by BPA (−1 = Auto or Base, 0 = Standby or Off)
03	Front panel A/D No. 1
04	Status of PMSC (−1 = Auto, 0 = Off)
05	Front panel A/D No. 2
06	Spare
07	Spare
10	BPA request (megawatts)
11	Potentiometer No. 1 Integration rate (Must be multiplied by communications interval to obtain integration time)
12	Potentiometer No. 2 Integrator reset time (0 to 19 seconds)
13	Potentiometer No. 3 Analog calibration (−10.0 to +9.9 percent)
14	Potentiometer No. 4 Communications time interval (0.0 to 19.9 seconds)
15	Potentiometer No. 5 Spare
16	Spare
17	Spare
20	Total generation measured by analog recording system (megawatts)
21-37	Spares
40	Total generation measured by PMSC (megawatts)
41-47	Spares

APPENDIX A

Descriptions of Interval Variables and Corresponding Octal Address Codes — Continued

Octal Code	Description	
50	BPA communications error flag (A minus 1 indicates there was an error in the last message)	
51	BPA checksum error counter	Detected by the communications controller TMS 9902
52	BPA parity error counter	
53	BPA framing error counter	
54	BPA overrun error counter	
55	BPA receive buffer overrun error counter	
56	Spare	
57	Spare	
60	PMSC communications error flag (A minus 1 indicates there was an error in the last message)	
61	PMSC checksum error counter	Detected by the communications controller TMS 9902
62	PMSC parity error counter	
63	PMSC framing error counter	
64	PMSC overrun error counter	
65	PMSC receive buffer overrun error counter	
66-67	Spares	
	All locations above 70 (octal) can be flags that are toggled from 0 to −1, when selected, by the lamp test button.	
70	Spare	
71	Selects the output for D/A No. 1 (0 = Substitute generation; −1 = Total generation from analog recording system)	
72	Selects the output for D/A No. 2 (0 = Total generation from PMSC; −1 = BPA request)	
73-77	Spares	

APPENDIX B
Description of TIBUG

The TIBUG is a debug monitor which provides an interactive interface between the user and the CPU. This monitor was supplied by TI (Texas Instruments) with the 990/100M CPU boards and subsequently modified by the Power and Instrumentation Branch to better suit our needs.

Communication with TIBUG is through the RS232-C port on the CPU board at a baud rate of 2400.

The TIBUG commands are listed in table B1. The original **D** and **A** commands have been deleted, the function of the **T** command changed, and the **G** command added to TI's original version. Further information on TI's TIBUG and detailed descriptions of the commands are available in TI publication "TM 900/100M Microcomputer User's Guide."

Table B1

T – TABLE

Table Pointer =	WP	PC	ST					
WP =	R0	R1	R2	R3	R4	R5	R6	R7
	R8	R9	R10	R11	R12	R13	R14	R15
PC – 10B =	I	I	I ↓ C	I ↓ C	Next I Branch Address	I ↓ C	I ↓ C	I
Memory Address =	C	C+2	C+4	C+6	C+10	C+12	C+14	C+16
	C+20	C+22	C+24	C+26	C+30	C+32	C+34	C+36

EXECUTERS - Use restart and/or halt to get out of last breakpoints.

B ⟨address⟩ ⟨CR⟩	Sets breakpoint at address and executes.
G ⟨address⟩ ⟨CR⟩	Single steps to breakpoint (used for breakpoints within ROM)
S	Single steps from present PC
E	Execute beginning at present WP and PC

Examine/Change

M ⟨add 1⟩, ⟨add 2⟩ ⟨CR⟩	List memory from address 1 to address 2
M ⟨address⟩ ⟨CR⟩	Opens memory location

M ⟨CR⟩	Opens last memory location
⟨space⟩	Increments through memory
⟨minus⟩	Decrements through memory
C ⟨base address⟩, ⟨number of bits⟩ ⟨CR⟩	CRU examine
W ⟨register number⟩ ⟨CR⟩	Opens appropriate register
W ⟨CR⟩	Opens last register
⟨space⟩	Increments through registers
⟨minus⟩	Decrements through registers
R	Opens WP
⟨space⟩	Increments to PC and ST
⟨minus⟩	Displays the present position again
L	Load from right magnetic tape on an HP 2645A terminal.
F ⟨add 1⟩, ⟨add 2⟩, ⟨pattern⟩, ⟨CR⟩	Finds and lists all locations, with the particular pattern between address 1 and address 2.

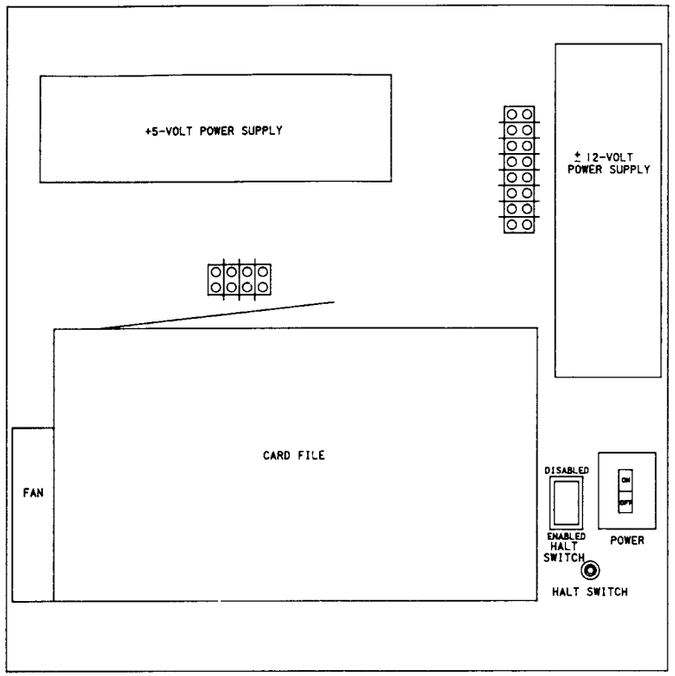
Abbreviations and symbols used in table B1

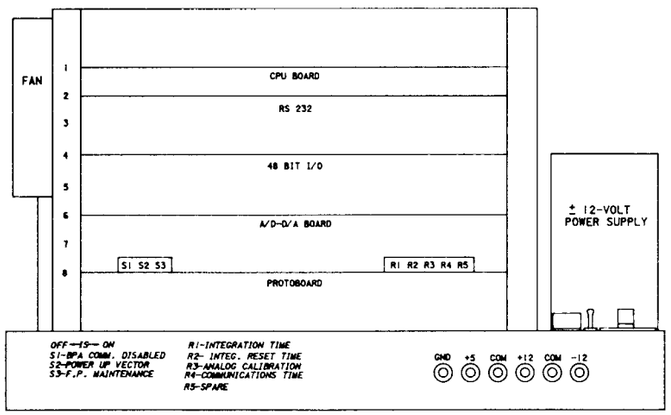
⟨ ⟩	Items within the brackets are supplied by the user. All addresses, registers, and contents must be in octal.
I	Instruction
C	Contents
WP	Workspace pointer
PC	Program counter pointer
ST	Status register
CR	Carriage return
CRU	Communications register unit

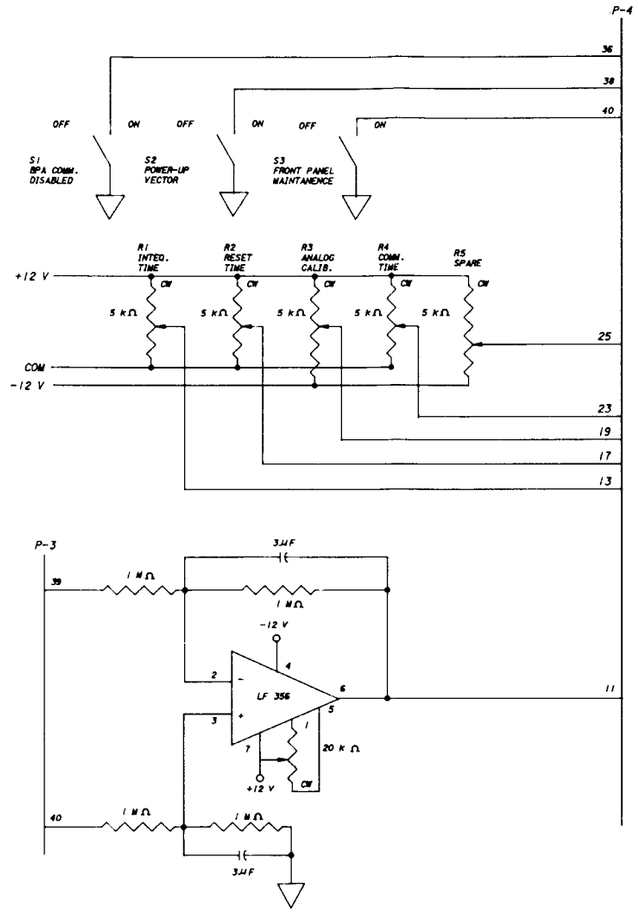
APPENDIX C

Drawings and Flow Charts

Drawings	*Number*
Chassis layout and protoboard	100-PI-001
CPU chassis wiring diagram	100-PI-002
Card file wiring	100-PI-003
Front panel layout and wiring	100-PI-004
Flow Charts	
Executive	100-PI-005
A/D and D/A converter and calibration	100-PI-006
Front panel driver, sheet 1	100-PI-007
Front panel driver, sheet 2	100-PI-008
Display driver	100-PI-009
BPA communications interrupt	100-PI-010
BPA communications formatter	100-PI-011
PMSC communications interrupt	100-PI-012
PMSC communications formatter	100-PI-013
Integrator	100-PI-014
Memory maintenance	100-PI-015
Scale XOP 0	100-PI-016
ASCII to binary XOP 1, binary to ASCII XOP 2	100-PI-017







PROTOBOARD

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DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

STANDARD DESIGNS

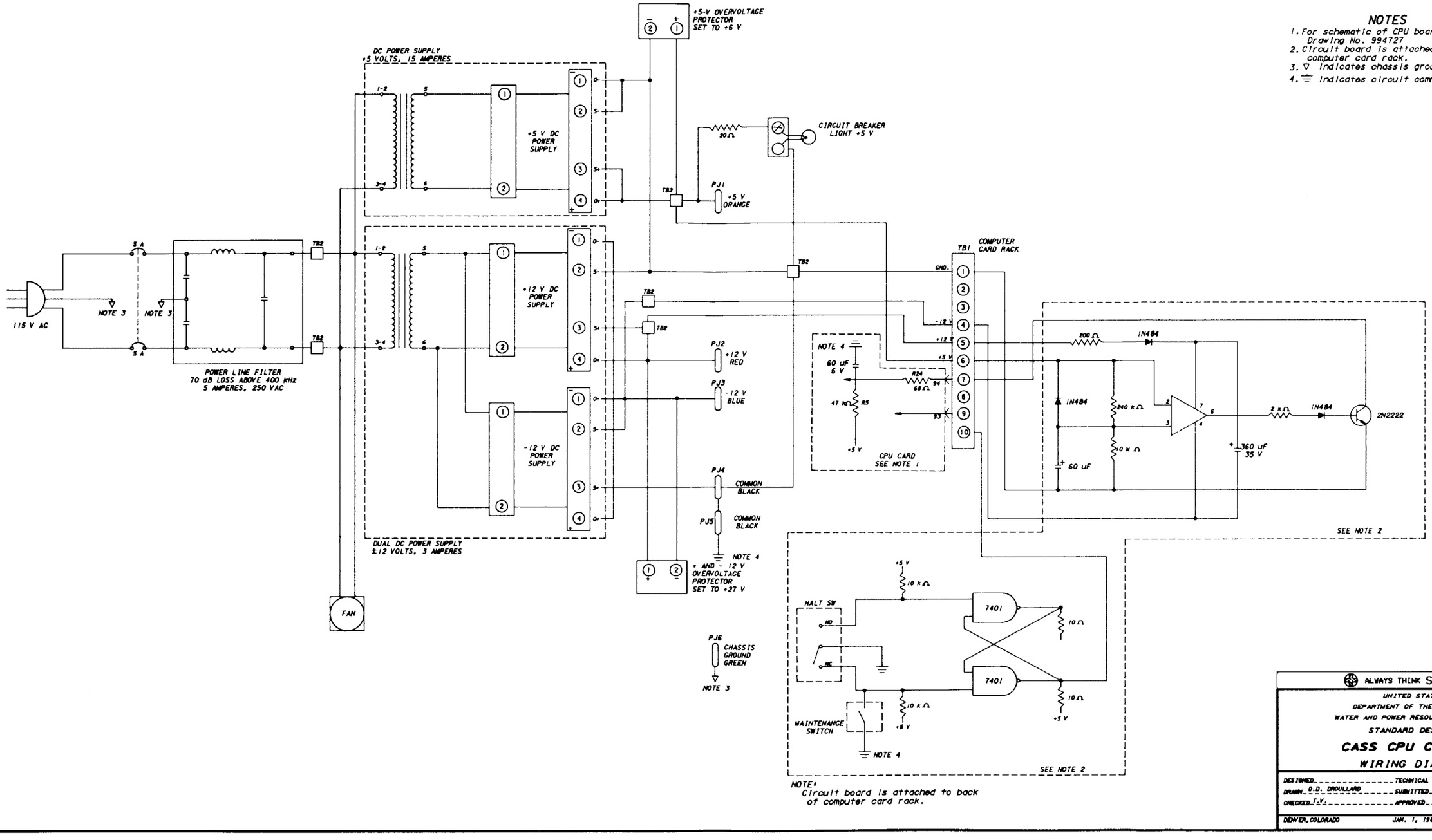
CASS

CHASSIS LAYOUT & PROTOBOARD

DESIGNED	TECHNICAL APPROVAL
DRAWN T.V.	C.W. OPIE SUBMITTED
CHECKED T.V.	APPROVED
DENVER, COLORADO JAN. 1, 1981	100-PI-001

NOTES

1. For schematic of CPU board see TI Drawing No. 994727
2. Circuit board is attached to back of computer card rack.
3. ▽ Indicates chassis ground.
4. ⏚ Indicates circuit common.



NOTE:
Circuit board is attached to back of computer card rack.

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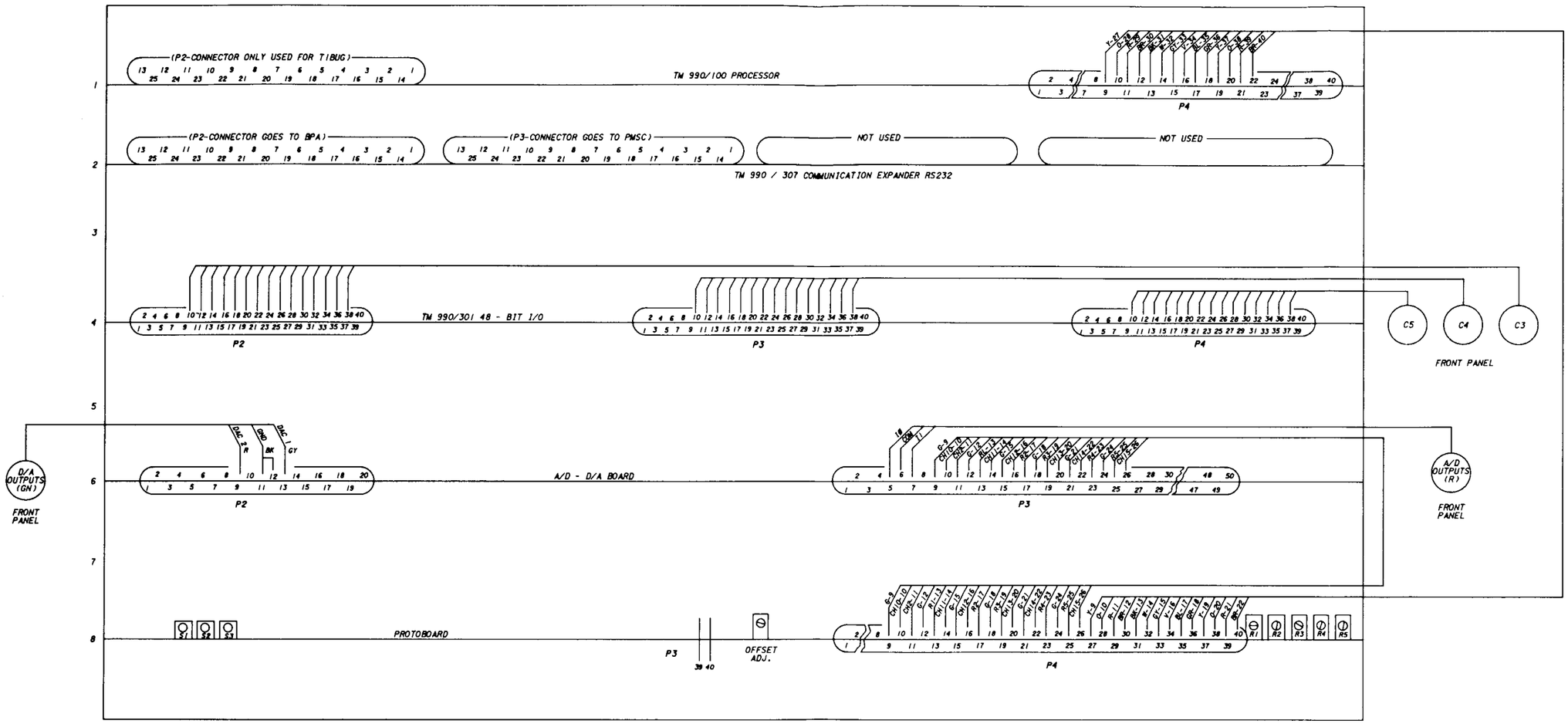
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS CPU CHASSIS
WIRING DIAGRAM

DESIGNED	TECHNICAL APPROVAL
DRAWN O.D. DROUILLARD	SUBMITTED
CHECKED T.V.	APPROVED
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-P1-002



COMMUNICATIONS CABLES

MODEM		CASS PORT A		CASS PORT B		PWSC
AB (7)	COM	COM (7)	(7)	COM	COM	(7)
BA (2)	E DATA	X OUT (3)	(3)	X OUT	R IN	(3)
BB (3)	R DATA	R IN (2)	(2)	R IN	X OUT	(2)
CA (4)	RTS	RTS (8)	(8)	RTS	RTS	(4)
CB (5)	CTS	CTS (16)	(16)	CTS	CTS	(5)
CF (8)	CD				CD	(8)

PROTOBOARD TABLES

S1-BPA COMM. DISABLED
S2-POWER-UP VECTOR
S3-FRONT PANEL MAINTENANCE

P3-39 } ANALOG SIGNAL INPUT
P3-40 }

R1-INTEGRATION TIME
R2-INTEGRATION RESET TIME
R3-ANALOG CALIBRATION
R4-COMMUNICATION TIME
R5-SPARE

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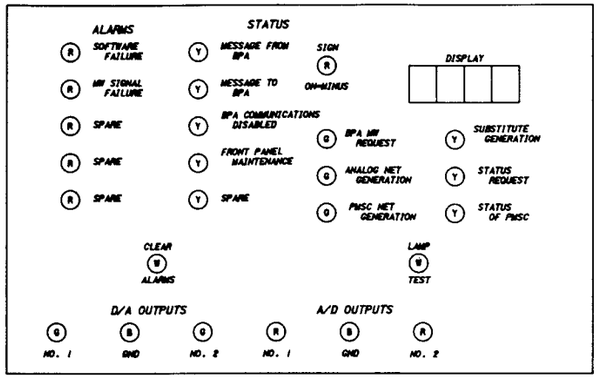
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS

CARD FILE-WIRING DIAGRAM

DESIGNED	TECHNICAL APPROVAL
DRAWN D.E. BINGAMAN	SUBMITTED
CHECKED T.V.	APPROVED
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-P1-003



WIRING DIAGRAM
REAR VIEW

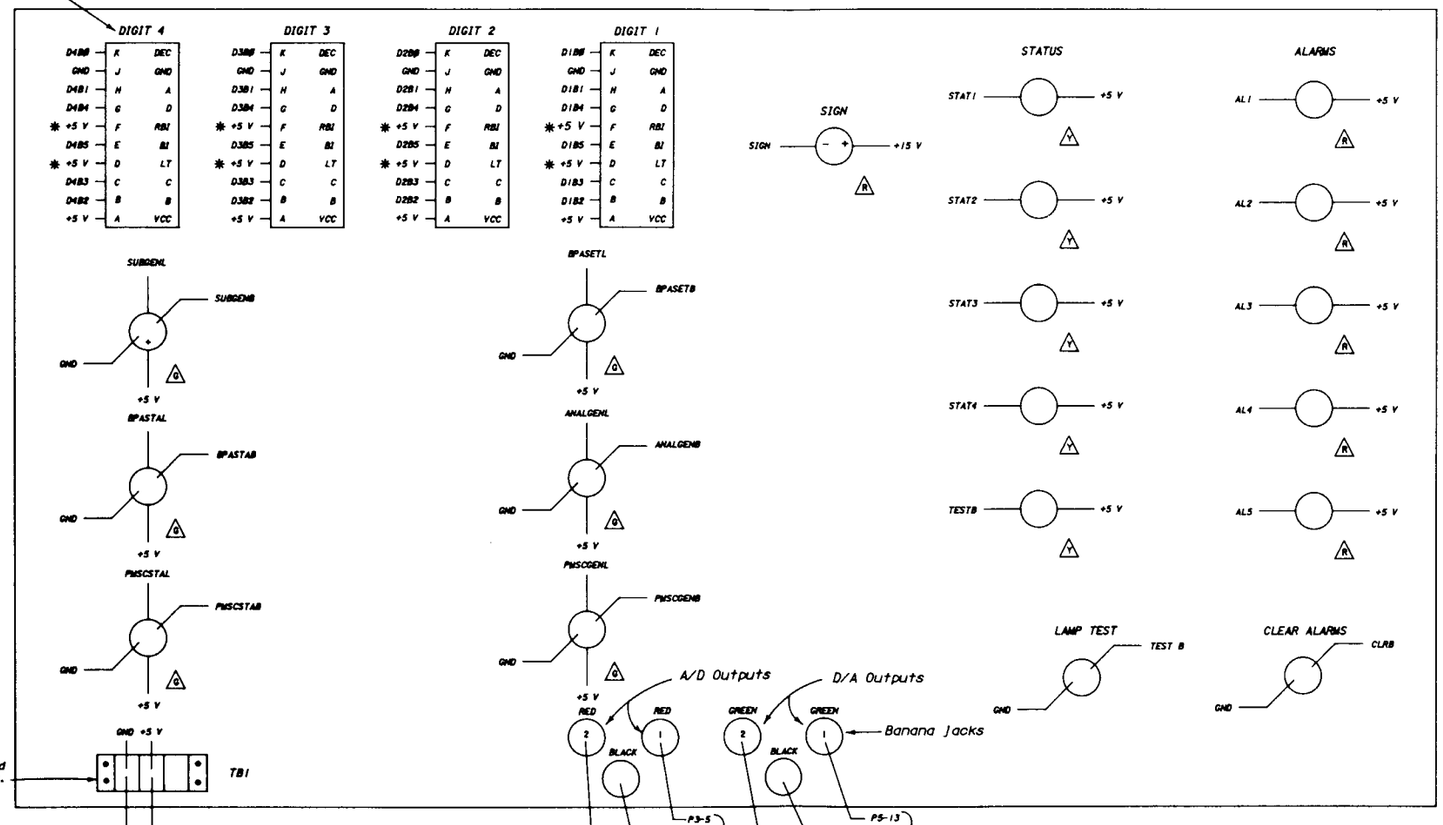
Least significant digit of display

* Pins F & D of the displays shall be wired as follows*

DIGIT 4 PIN F
DIGIT 4 PIN D
DIGIT 3 PIN F
DIGIT 3 PIN D
— P2 (PIN 3) CABLE C3

DIGIT 2 PIN F
DIGIT 2 PIN D
DIGIT 1 PIN F
DIGIT 1 PIN D
— P3 (PIN 3) CABLE C3

All other +5 V & GND points shall be wired to terminal block TB1.



To 48-bit I/O card P2 connector
CABLE C3

	CONNECTOR PIN NO.	CABLE DESIGNATION	DEVICE		CRU BASE (B)
P0	P2-20	D4B0	DEC	UNITS DIGIT	1040
P1	22	D4B1	1	OF DISPLAY	1042
P2	14	D4B2	2	(DIGIT 4)	1044
P3	16	D4B3	4		1046
P4	18	D4B4	8		1050
P5	10	D4B5	BLNK		1052
P6	12	D3B0	DEC	TENS DIGIT	1054
P7	24	D3B1	1	OF DISPLAY	1056
P8	26	D3B2	2	(DIGIT 3)	1060
P9	28	D3B3	4		1062
P10	30	D3B4	8		1064
P11	32	D3B5	BLNK		1066
P12	34	D2B0	DEC	HUNDREDS DIGIT	1070
P13	36	D2B1	1	OF DISPLAY	1072
P14	38	D2B2	2	(DIGIT 2)	1074
P15	40	D2B3	4		1076

To 48-bit I/O card P3 connector
CABLE C4

P0	P3-24	D2B4	8		1240
P1	22	D2B5	BLNK		1242
P2	14	D1B0	DEC	THOUSANDS DIGIT	1244
P3	16	D1B1	1	OF DISPLAY	1246
P4	18	D1B2	2	(DIGIT 1)	1250
P5	10	D1B3	4		1252
P6	12	D1B4	8		1254
P7	24	D1B5	BLNK		1256
P8	26	SIGN	SIGN LED		1260
P9	28	SUBGENB	DISPLAY SELECTORS (BUTTONS)		1262
P10	30	BPASTAB			1264
P11	32	PMSCSTAB			1266
P12	34	BPASETB			1270
P13	36	ANALGENB			1272
P14	38	PMSCGENB	DISPLAY SELECTORS		1274
P15	40	SUBGENL	DISPLAY SELECTOR LED'S		1276

To 48-bit I/O card P4 connector
CABLE C5

P0	P4-20	BPASTAL	DISPLAY SELECTOR LED'S		1440
P1	22	PMSCSTAL			1442
P2	14	BPASETL			1444
P3	16	ANALGENL			1446
P4	18	PMSCGENL	DISPLAY SELECTOR LED'S		1450
P5	10	AL1	ALARM LED'S		1452
P6	12	AL2			1454
P7	24	AL3			1456
P8	26	AL4			1460
P9	28	AL5	ALARM LED'S		1462
P10	30	STAT1	STATUS LED'S		1464
P11	32	STAT2			1466
P12	34	STAT3			1470
P13	36	STAT4	STATUS LED'S		1472
P14	38	TESTB	LAMP TEST BUTTON		1474
P15	40	CLRB	CLEAR ALARMS BUTTON		1476

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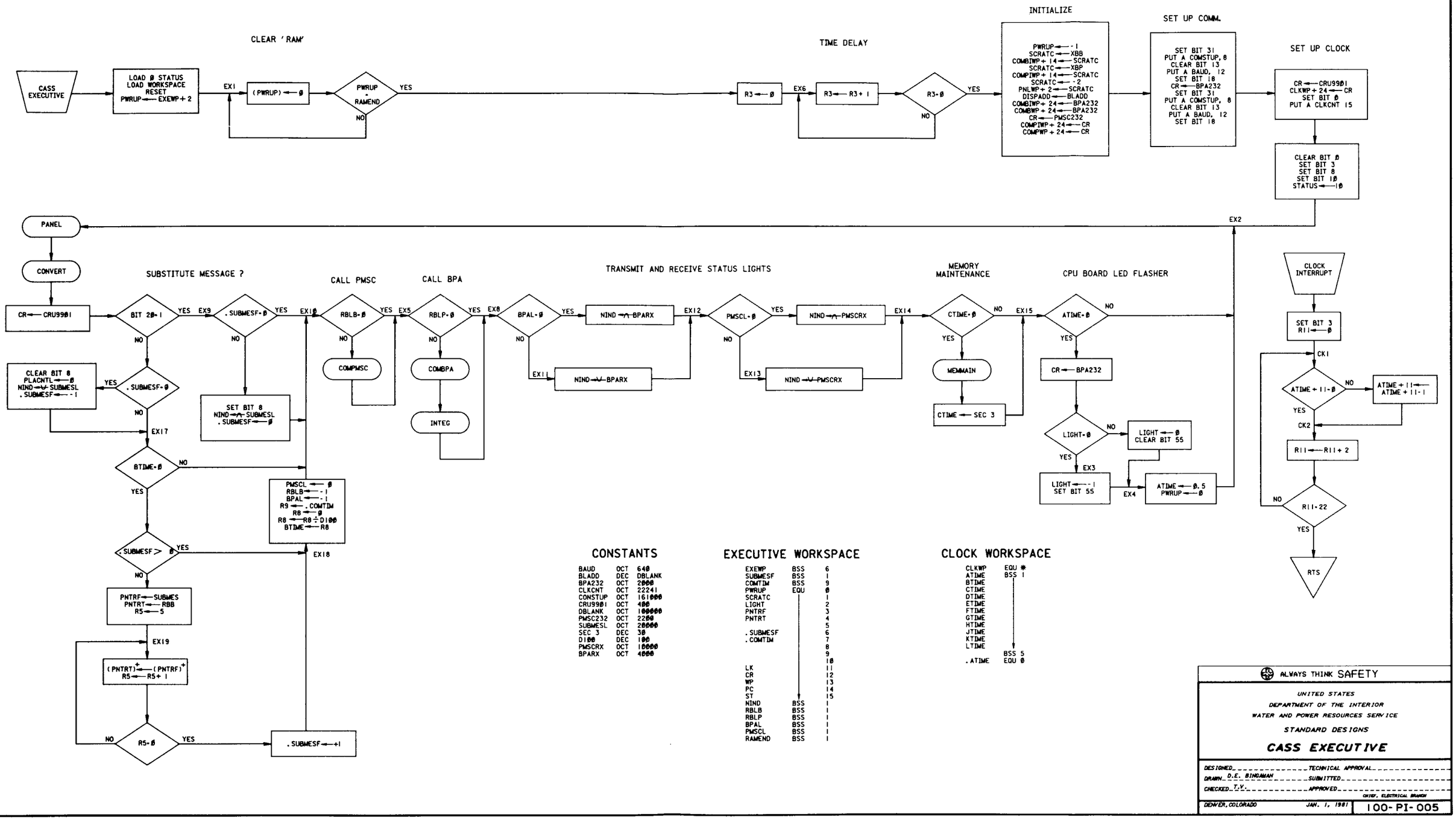
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS
FRONT PANEL LAYOUT AND WIRING

DESIGNED		TECHNICAL APPROVAL	
DRAWN T.V.	C.W. OPIE	SUBMITTED	
CHECKED T.V.		APPROVED	
DENVER, COLORADO	JAN. 1, 1981	100-PI-004	



CONSTANTS

```
BAUD     OCT   64Ø
BLADD    DEC   DBLANK
BPA232   OCT   2ØØØ
CLKCNT   OCT   22241
CONSTUP  OCT   161ØØØ
CRU99Ø1  OCT   4ØØ
DBLANK   OCT   1ØØØØØ
PMSC232  OCT   22ØØ
SUBMESL  OCT   2ØØØØ
SEC_3    DEC   3Ø
D1ØØ     DEC   1ØØ
PMSCRX   OCT   1ØØØØ
BPARX    OCT   4ØØØ
```

EXECUTIVE WORKSPACE

```
EXEWP     BSS   6
SUBMESF   BSS   1
COMTIM    BSS   9
PWRUP     EQU   Ø
SCRATC          1
LIGHT           2
PNTRF           3
PNTRT           4
                5
. SUBMESF       6
. COMTIM        7
                8
                9
                1Ø
LK              11
CR              12
WP              13
PC              14
ST              15
NIND      BSS   1
RBLB      BSS   1
RBLP      BSS   1
BPAL      BSS   1
PMSCL     BSS   1
RAMEND    BSS   1
```

CLOCK WORKSPACE

```
CLKWP    EQU *
ATIME    BSS 1
BTIME
CTIME
DTIME
ETIME
FTIME
GTIME
HTIME
JTIME
KTIME
LTIME
         BSS 5
. ATIME  EQU Ø
```

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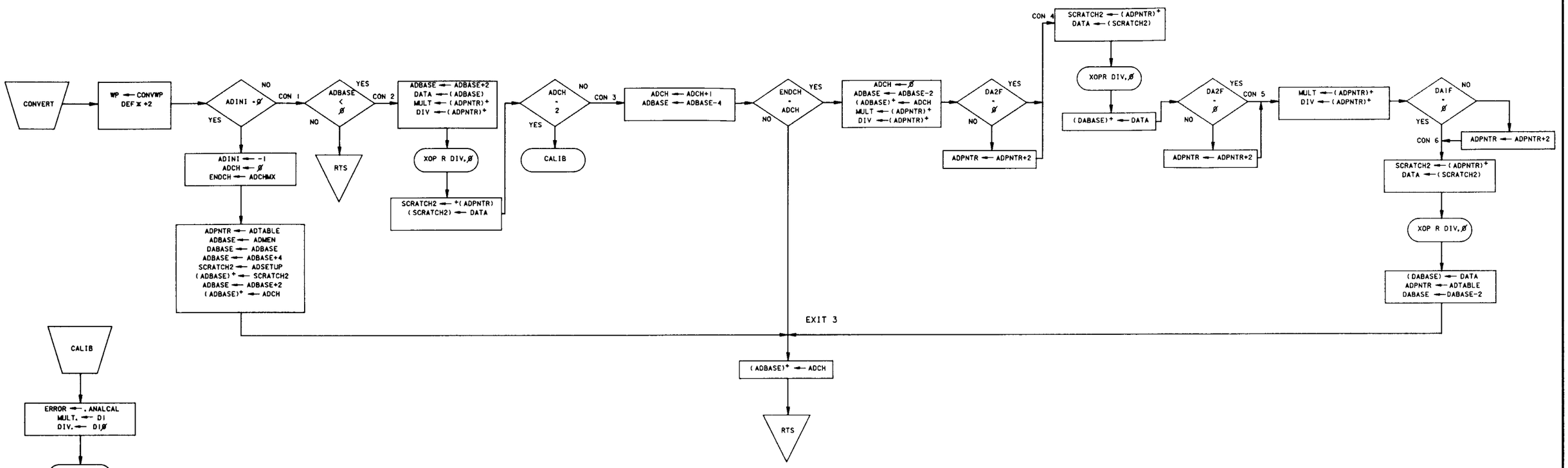
STANDARD DESIGNS

CASS EXECUTIVE

DESIGNED	TECHNICAL APPROVAL
DRAWN D.E. BINGAMAN	SUBMITTED
CHECKED T.V.	APPROVED
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-PI-005



ROM CONSTANTS

```
DI          DEC   1
DIO         DEC   10
PU          DEC   10000
CRU9901     OCT   4000
GENMAX      DEC   9900
GENMIN      DEC   250

INTEGWP     EQU   0
.RESET      EQU   0
.INTEGTM          1
.ANALGEN          2
.DIGGEN           3
.SUBGEN           4
.REMD             5
.ANALCAL          6
.RESETIM          7
DIV.              8
ERROR             9
MULT.             10
```

CONVERT WORKSPACE

```
CONVWP      BSS   16
ADINI       EQU   0
ADBASE            1
ADCH              2
ADPNTR            3
ENDCH             4
SCRATCH2          5
DA BASE           6
                  7
DIV               8
DATA              9
MULT              10
```

VARIABLES

```
ADMEN       EQU   6000000B
ADSETUP     EQU   4000000B
ADCHMX      EQU   8
AD*1        BSS   1
AD*2        BSS   1

POT*5       BSS   1
DA1F        BSS   1
DA2F        BSS   1
```

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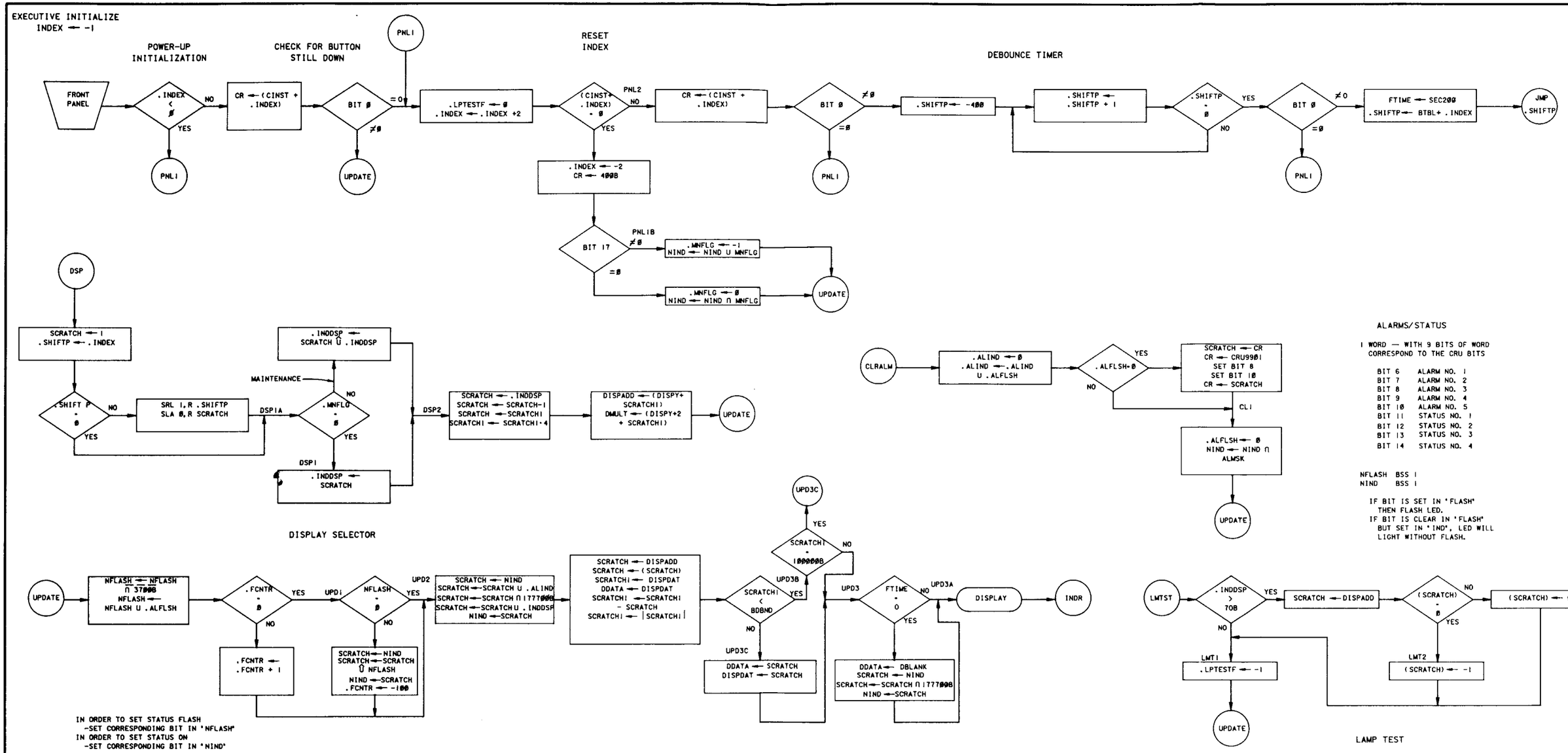
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS SOFTWARE

A/D AND D/A CONVERTER CALIBRATION

DESIGNED _____ TECHNICAL APPROVAL _____
DRAWN B.J. GARCIA SUBMITTED _____
CHECKED T.V. APPROVED _____
CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981 100-PI-006



ALARMS/STATUS

1 WORD — WITH 9 BITS OF WORD CORRESPOND TO THE CRU BITS

BIT 6	ALARM NO. 1
BIT 7	ALARM NO. 2
BIT 8	ALARM NO. 3
BIT 9	ALARM NO. 4
BIT 1Ø	ALARM NO. 5
BIT 11	STATUS NO. 1
BIT 12	STATUS NO. 2
BIT 13	STATUS NO. 3
BIT 14	STATUS NO. 4

```
NFLASH  BSS 1
NIND    BSS 1
```

IF BIT IS SET IN 'FLASH' THEN FLASH LED.
IF BIT IS CLEAR IN 'FLASH' BUT SET IN 'IND', LED WILL LIGHT WITHOUT FLASH.

IN ORDER TO SET STATUS FLASH
-SET CORRESPONDING BIT IN 'NFLASH'
IN ORDER TO SET STATUS ON
-SET CORRESPONDING BIT IN 'NIND'

CRU PUSHBUTTON TABLE

```
CINST   OCT   1262   SUBSTITUTE GEN
        OCT   1264   STATUS REQUEST
        OCT   1266   STATUS OF PMSC
        OCT   127Ø   BPA MW REQUEST
        OCT   1272   ANALOG NET GEN.
        OCT   1274   PMSC NET GEN.
        OCT   1474   LAMP TEST
        OCT   1476   CLEAR ALARMS
        OCT   Ø
```

TABLE OF CRU ADDRESSES FOR PUSHBUTTONS

INDICATION

INDEX			INDEX
Ø	ØØØ ØØØ	ØØØ ØØ1	1
2	ØØØ Ø1Ø	ØØØ 1Ø	2
4	ØØØ 1ØØ	ØØØ 1ØØ	4
6	ØØØ 11Ø	ØØ1 ØØØ	8
8	ØØ1 ØØØ	1Ø ØØØ	16
1Ø	ØØ1 Ø1Ø	1ØØ ØØØ	32

INDICATION ← 2 (INDEX/2)

PUSHBUTTON EXECUTION TABLE

```
BTBL   DEF   DSP      *SUBSTITUTE GENERATION*
       DEF   DSP      *STATUS REQUEST*
       DEF   DSP      *STATUS OF PMSC*
       DEF   DSP      *BPA MW REQUEST*
       DEF   DSP      *ANALOG NET GENERATION*
       DEF   DSP      *PMSC NET GENERATION*
       DEF   LMTST    *LAMP TEST*
       DEF   CLRALM   *CLEAR ALARMS*
```

DISPLAY TABLE

64 SETS OF DATA WITH 2 WORDS IN EACH SET.

FIRST WORD-DATA POINTER
SECOND WORD-MULTIPLIER

INDICATION VARIABLE IS USED TO GENERATE TABLE POINTER.
POINTER ← (INDICATION-1)*6

1 →4
2 →6
3 →12
4 →18

NOTE: FOR ALL FRONT PANEL CODES ≥ 7ØB THE QUANTITY MAY BE SET AND CLEARED WITH LAMP TEST BUTTON

WORKSPACE

```
PNLLWP BSS 8
ALFLSH BSS 8
. SHIFTP   EQU   Ø
. INDEX    EQU   1
. LPTESTF  EQU   2
. MNFLG    EQU   3
. INDDSP   EQU   4
SCRATCH    EQU   5
SCRATCH1   EQU   6
. ALIND    EQU   7
. ALFLSH   EQU   8
. NOUPD    EQU   9
. FCNTR    EQU   1Ø
. DISPDAT  EQU   11
```

OTHER DATA

```
DDBND DEC 1
DBLANK OCT 1ØØØØØ
ALMSK OCT 37ØØ

CR      EQU   12
C9901   EQU   44DB

DSPCRU EQU 1Ø4ØB
DISPADD BSS   1
DMULT   BSS   1
NIND    BSS   1
IND     BSS   1
NFLASH  BSS   1
```

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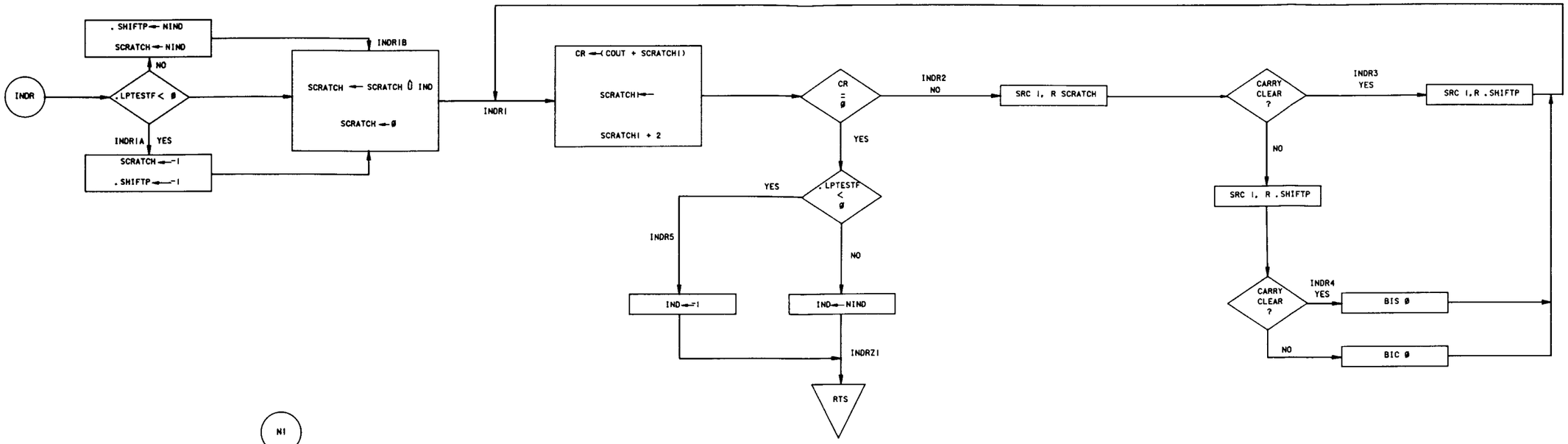
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS SOFTWARE
FRONT PANEL DRIVER
SHEET 1

DESIGNED	TECHNICAL APPROVAL
DRAWN B.J. GARCIA	SUBMITTED
CHECKED T.V.	APPROVED
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-PI-007

INDICATOR UPDATE



DISPLAY TEST

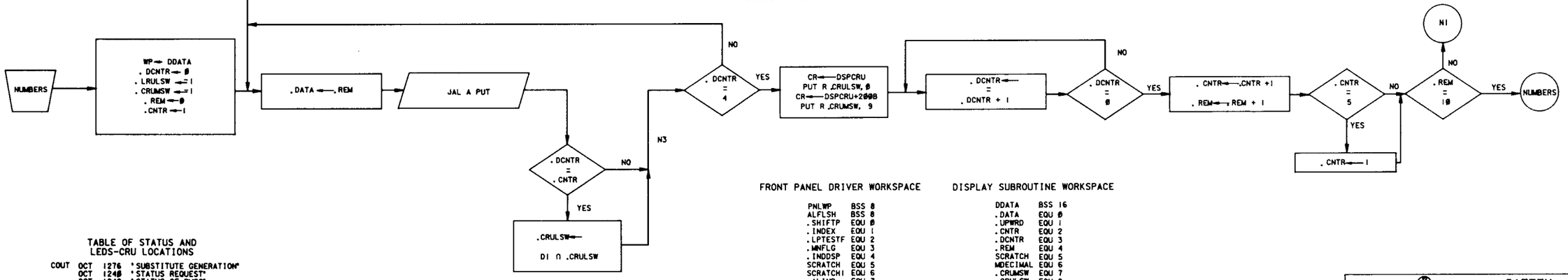


TABLE OF STATUS AND LEDS-CRU LOCATIONS

```
COUT  OCT  1276  'SUBSTITUTE GENERATION'
      OCT  1240  'STATUS REQUEST'
      OCT  1242  'STATUS OF PMSC'
      OCT  1244  'BPA MW REQUEST'
      OCT  1246  'ANALOG NET GENERATION'
      OCT  1250  'PMSC NET GENERATION'
      OCT  1252  ALARM NO. 1
      OCT  1254  ALARM NO. 2
      OCT  1256  ALARM NO. 3
      OCT  1260  ALARM NO. 4
      OCT  1262  ALARM NO. 5
      OCT  1264  STATUS NO. 1
      OCT  1266  STATUS NO. 2
      OCT  1270  STATUS NO. 3
      OCT  1272  STATUS NO. 4
      OCT  Ø
```

FRONT PANEL DRIVER WORKSPACE

```
PNLWP    BSS 8
ALFLSH   BSS 8
. SHIFTP  EQU Ø
. INDEX   EQU 1
. LPTESTF EQU 2
. MNFLG   EQU 3
. INDDSP  EQU 4
SCRATCH  EQU 5
SCRATCH1 EQU 6
. ALIND   EQU 7
. ALFLSH  EQU 8
. NOUPD   EQU 9
. FCNTR   EQU 1Ø
DISPDAT  EQU 11
```

DISPLAY SUBROUTINE WORKSPACE

```
DDATA    BSS 16
. DATA    EQU Ø
. UPWRD   EQU 1
. CNTR    EQU 2
. DCNTR   EQU 3
. REM     EQU 4
SCRATCH  EQU 5
MDECIMAL EQU 6
. CRUMSW  EQU 7
. CRULSW  EQU 8
. SIGN    EQU 9
```

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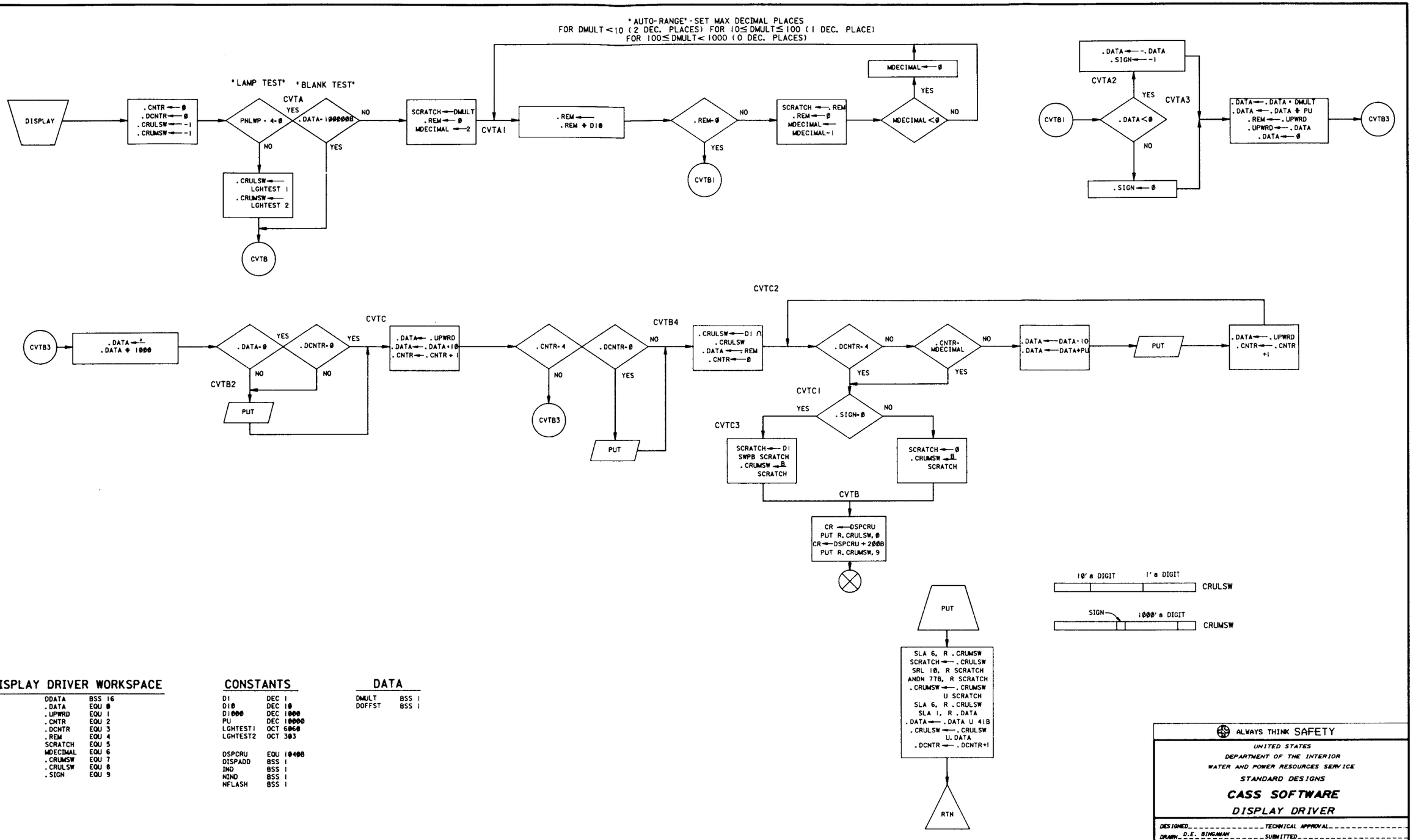
STANDARD DESIGNS

CASS SOFTWARE

FRONT PANEL DRIVER

SHEET 2

DESIGNED _____ TECHNICAL APPROVAL _____
DRAWN T.V. C.W. Ople SUBMITTED _____
CHECKED T.V. APPROVED _____
DENVER, COLORADO JAN. 1, 1981 | 100-PI-008



DISPLAY DRIVER WORKSPACE

```
ODATA     BSS 16
. DATA    EQU 0
. UPWRD   EQU 1
. CNTR    EQU 2
. DCNTR   EQU 3
. REM     EQU 4
SCRATCH   EQU 5
MDECIMAL  EQU 6
. CRUMSW  EQU 7
. CRULSW  EQU 8
. SIGN    EQU 9
```

CONSTANTS

```
DI        DEC 1
DI0       DEC 10
DI000     DEC 1000
PU        DEC 10000
LGHTEST1  OCT 6060
LGHTEST2  OCT 303

DSPCRU    EQU 1040B
DISPADD   BSS 1
IND       BSS 1
NIND      BSS 1
NFLASH    BSS 1
```

DATA

```
DMULT     BSS 1
DOFFST    BSS 1
```

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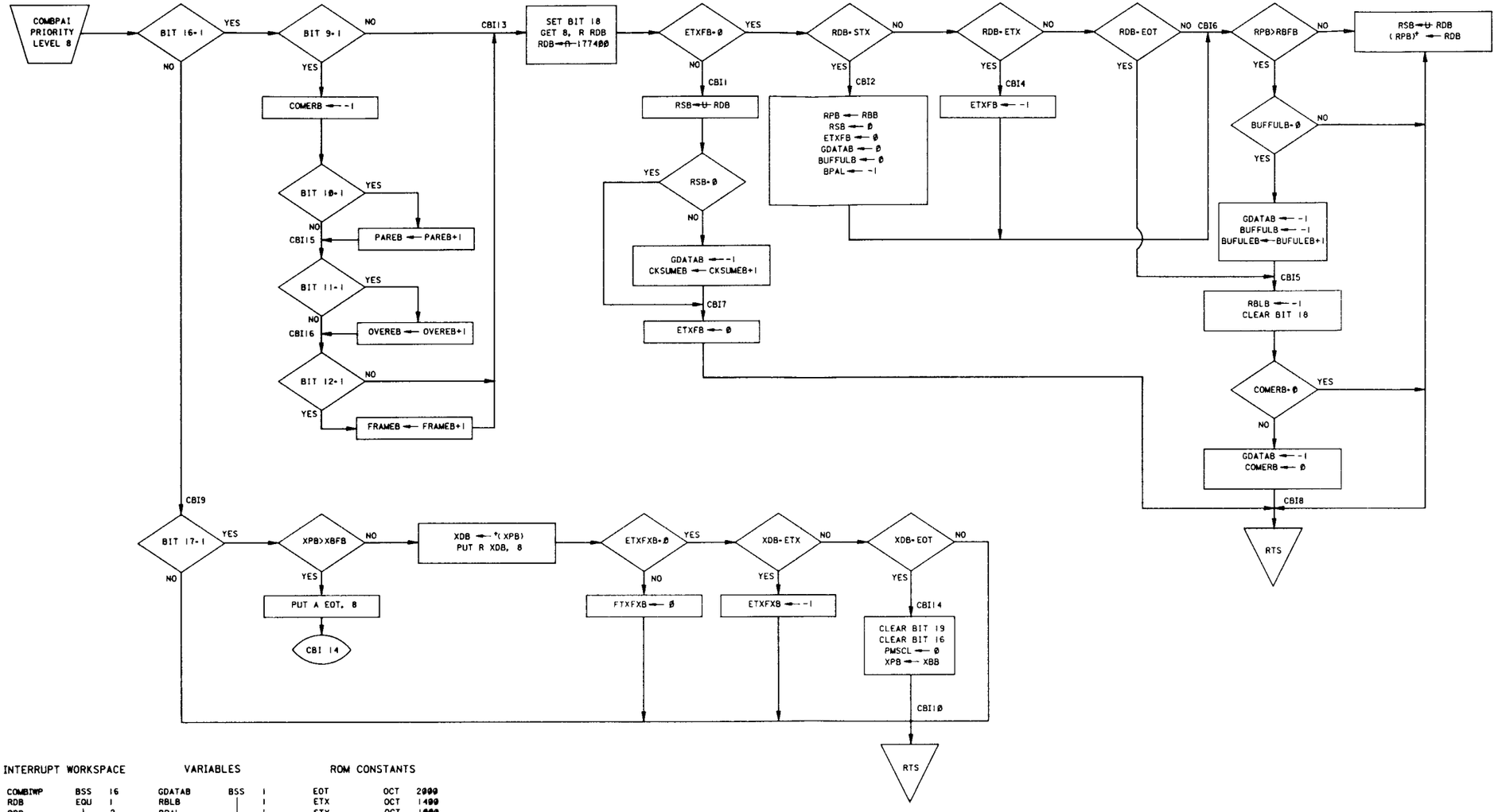
WATER AND POWER RESOURCES SERVICE

STANDARD DESIGNS

CASS SOFTWARE

DISPLAY DRIVER

DESIGNED	TECHNICAL APPROVAL
DRAWN D.E. BINGAMAN	SUBMITTED
CHECKED T.V.	APPROVED
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-PI-009



INTERRUPT WORKSPACE

COMBIWP	BSS	16
RDB	EQU	1
RPB		2
RSB		3
ETXFB		4
COMERB		5
BUFFULB		6
XPB		7
XDB		8
ETXFXB		9

VARIABLES

GDATAB	BSS	1
RBLB		1
BPAL		1
CKSUMEB		1
PAREB		1
FRAMEB		1
OVEREB		1
BUFULEB		1
RBB		49
XBB		31

ROM CONSTANTS

EOT	OCT	2000
ETX	OCT	1400
STX	OCT	1000

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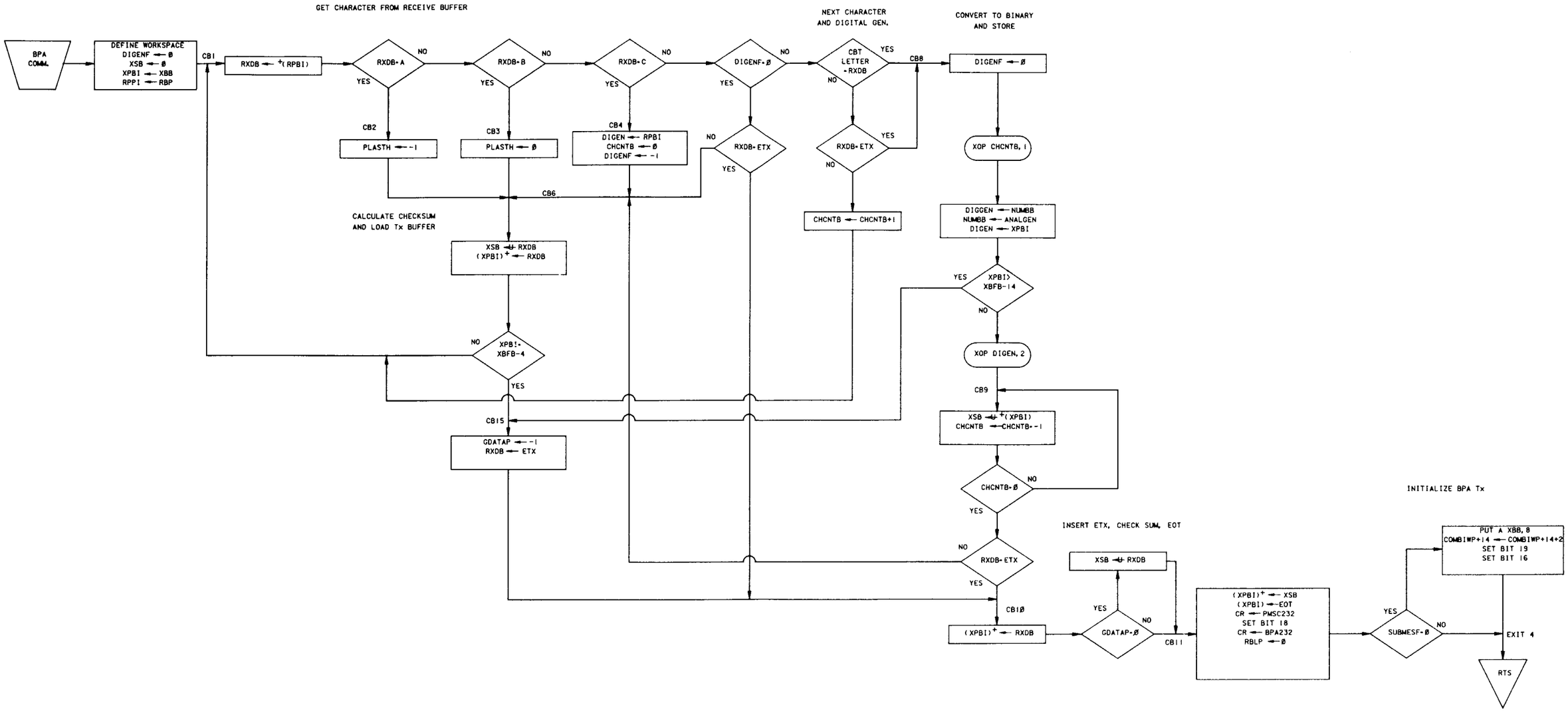
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS SOFTWARE

BPA COMMUNICATIONS INTERRUPT PRIORITY LEVEL 8

DESIGNED	TECHNICAL APPROVAL
DRAWN M.D.BUSTILLOS	SUBMITTED
CHECKED T.V.	APPROVED
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-PI-010



ROM CONSTANTS

A	OCT	40400
B		41000
C		41400
BPA232		2000
PWSC232		2200
EOT		2000
ETX		1400
LETTER		40000

WORKSPACE AND VARIABLES

COMBWP	BSS	16
	EQU	0
RXDB		1
RPBI		2
XSB		3
XPBI		4
DIGENF		5
		6
		7
CHCNTB		8
DIGEN		9
NUMBB		10
PLASTA	BSS	1
DIGGEN	BSS	1

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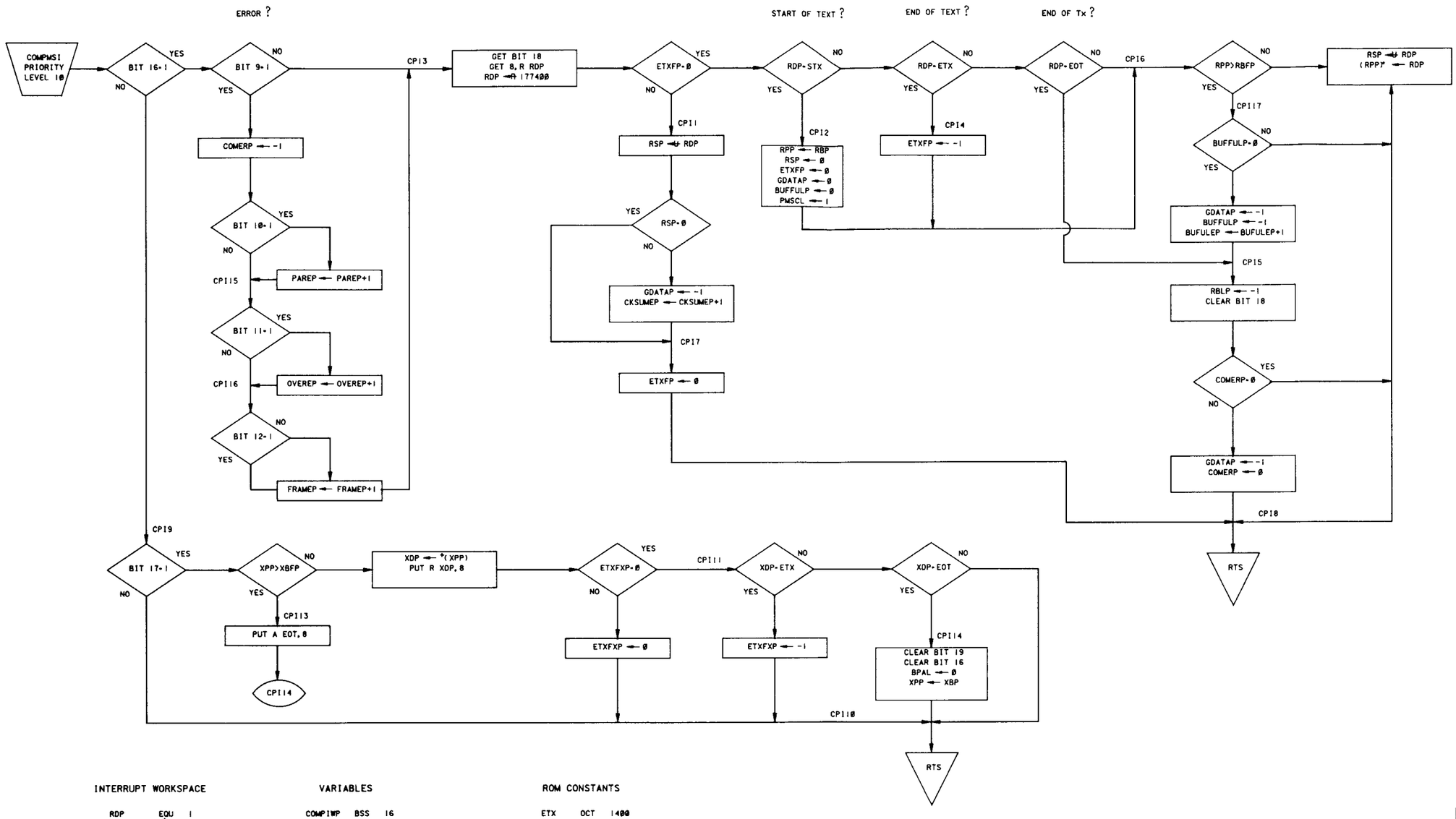
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
STANDARD DESIGNS

CASS SOFTWARE

BPA COMMUNICATIONS FORMATTER

DESIGNED _____ TECHNICAL APPROVAL _____
DRAWN A. J. GARCIA SUBMITTED _____
CHECKED T.V. APPROVED _____
CHIEF, ELECTRICAL BRANCH

DENVER, COLORADO JAN. 1, 1981 100-PI-011



INTERRUPT WORKSPACE

RDP	EQU	1
RPP		2
RSP		3
ETXFP		4
COMERP		5
BUFFULP		6
XPP		7
XDP		8
ETXFXP		9

VARIABLES

COMPIWP	BSS	16
GDATAP		1
RBLP		1
PMSCL		1
CKSUMEP		1
PAREP		1
FRAMEP		1
OVEREP		1
BUFULEP		1
XBP		57
RBP		29

ROM CONSTANTS

ETX	OCT	1400
EOT	OCT	2000
STX	OCT	1000

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UNITED STATES
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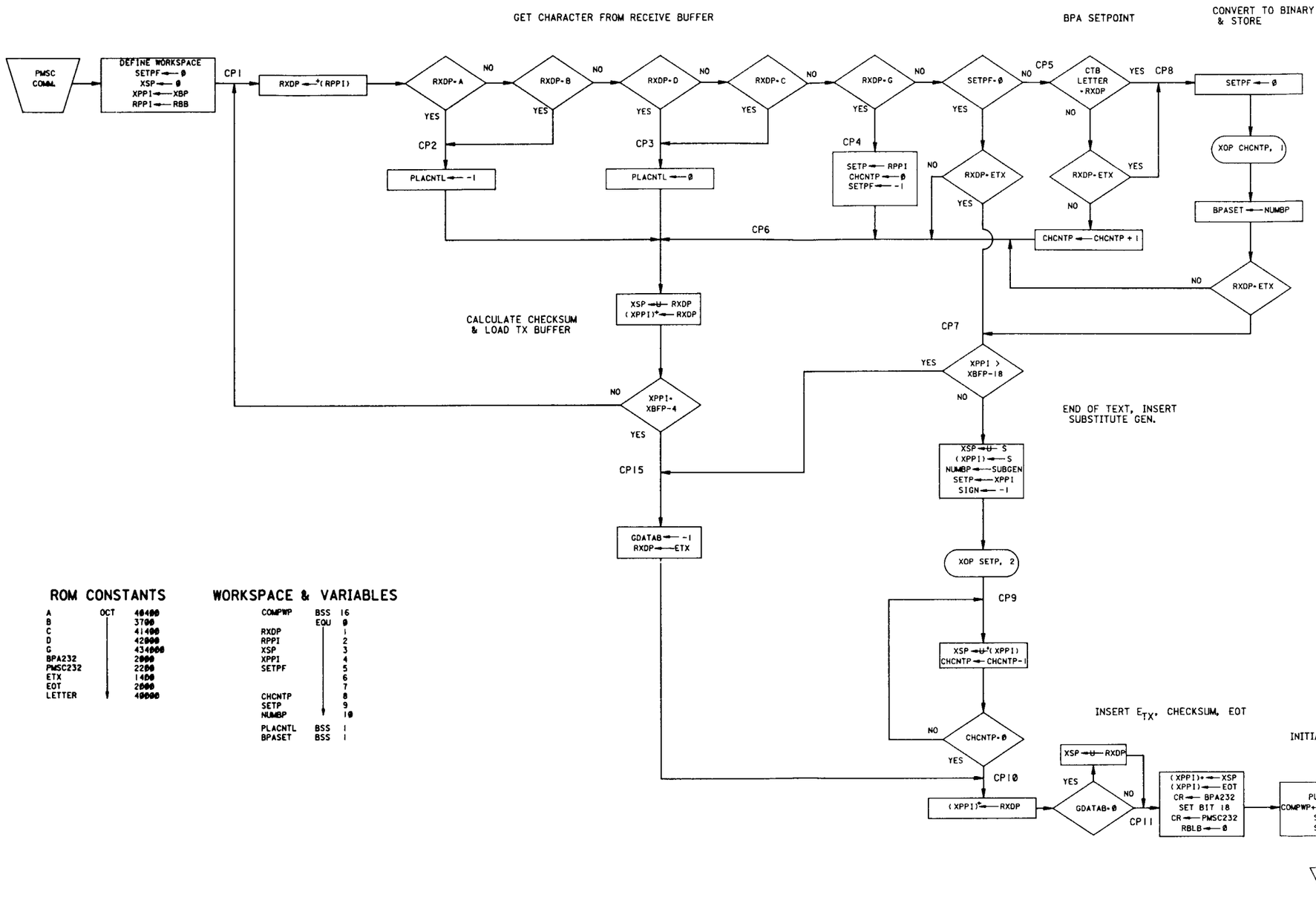
STANDARD DESIGNS

CASS SOFTWARE

PMSC COMMUNICATION INTERRUPT
PRIORITY LEVEL 10

DESIGNED		TECHNICAL APPROVAL
DRAWN	B.J. GARCIA	SUBMITTED
CHECKED	T.Y.	APPROVED
		CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO	JAN. 1, 1981	100-PI-012



ROM CONSTANTS

A	OCT	40400
B		3700
C		41400
D		42000
G		434000
BPA232		2000
PMSC232		2200
ETX		1400
EOT		2000
LETTER		40000

WORKSPACE & VARIABLES

COMPWP	BSS	16
	EQU	Ø
RXDP		1
RPPI		2
XSP		3
XPPI		4
SETPF		5
		6
		7
CHCNTP		8
SETP		9
NUMBP		10
PLACNTL	BSS	1
BPASET	BSS	1

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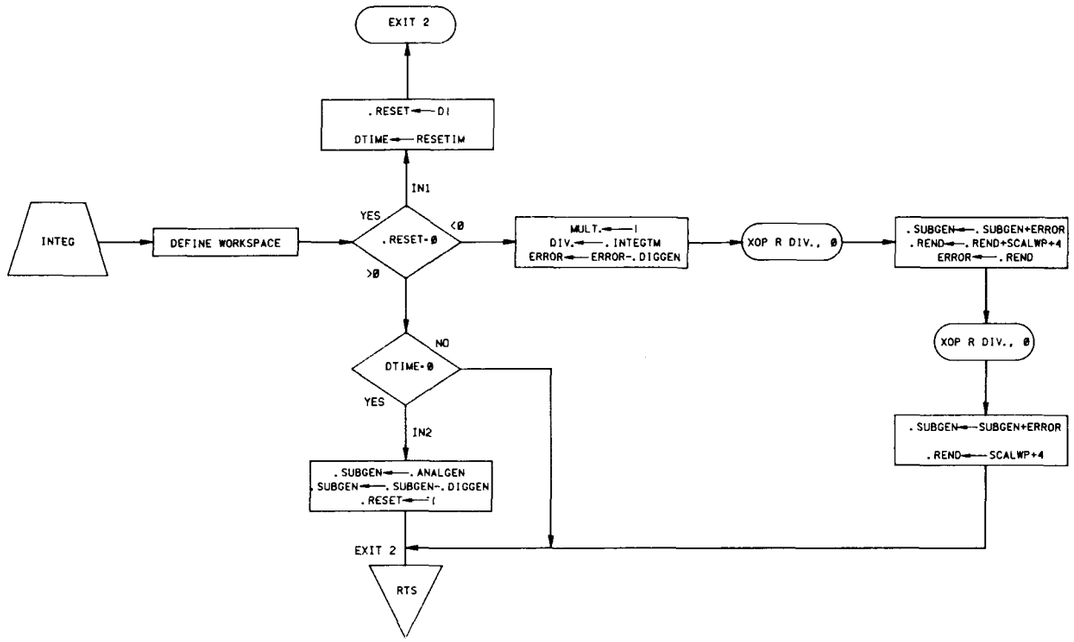
DENVER, COLORADO	JAN. 1, 1981

100-PI-013



INTEGRATE WORKSPACE

INTEGWP	EQU	*
RESET	BSS	1
INTEGTM		1
ANALGEN		1
DIGGEN		1
SUBGEN		1
REND.		1
ANALCAL		1
RESETIM		9
SCALWP		16

EQUIVLENTS

.RESET	EQU	Ø
.INTEGTM		1
.ANALGEN		2
.DIGGEN		3
.SUBGEN		4
.REND		5
.ANALCAL		6
.RESETIM		7
DIV.		8
ERROR		9
MULT.		10

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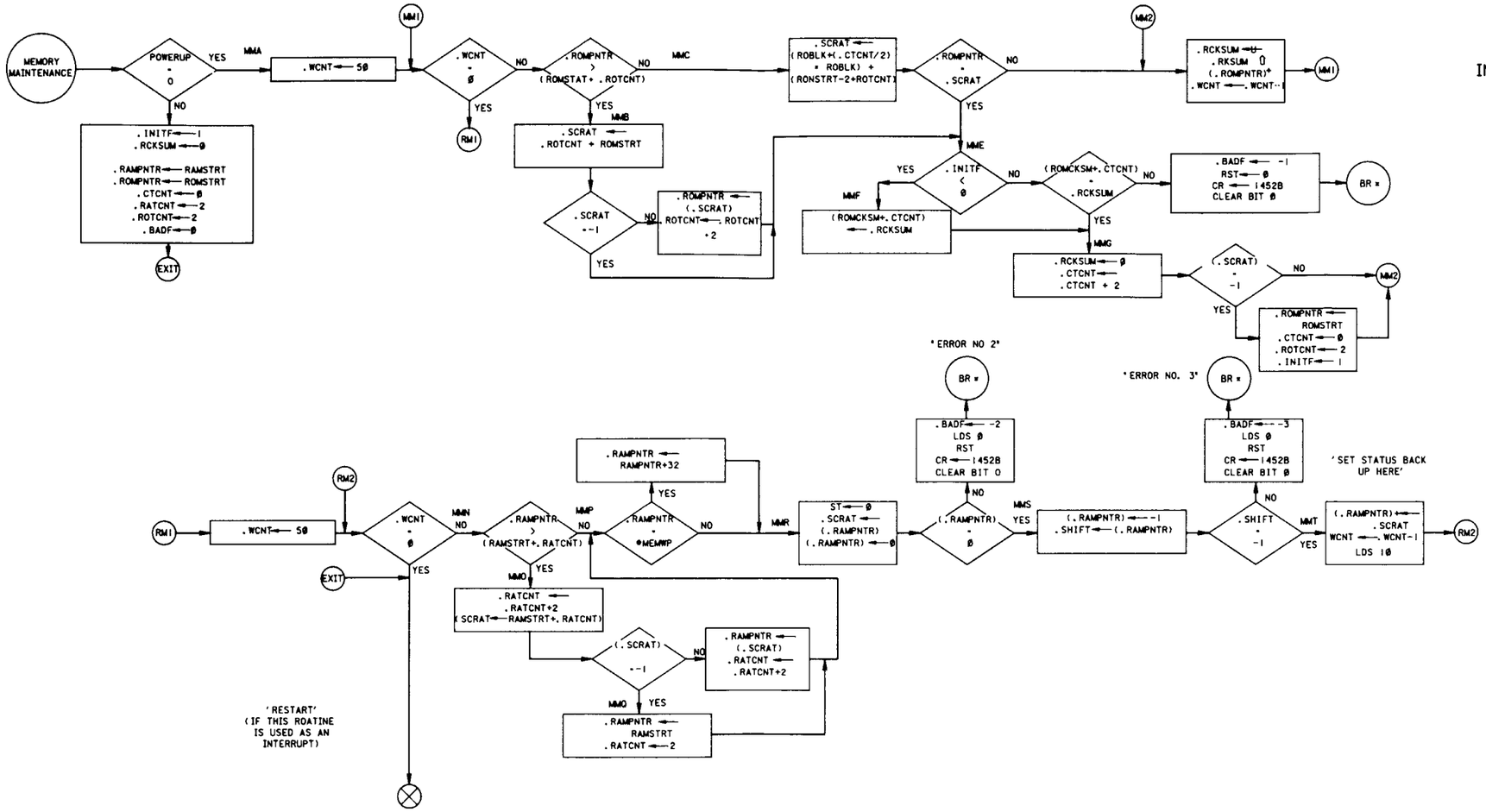

INSTRUCTIONS FOR ERROR DETECTION

ERROR NO. 1 — 1) CHECK '.BADF', IF = -1 THEN ROM ERROR WAS FOUND.
2) '. CTCNT' CONTAINS THE ROM BLOCK NUMBER WHERE THE ERROR OCCURED.

EXAMPLE — FOR THE ROM TABLE BELOW (AT LEFT)
ROMSTRT OCT 0
OCT 17776
DEC — 1

THERE ARE TWO BLOCKS
BLOCK NO. 1 — (ADDRESS 0 THRU 7776B)
BLOCK NO. 2 (ADDRESS 10000B THRU 17776O)
FOR '. CTCNT' = 2, THE ERROR IS IN BLOCK NO. 2
BLOCK NO. = (. CTCNT/2) +1

ALSO, COMPARING THE SECOND WORD IN THE 'ROMCKSM' TABLE WITH '. RCKSM' WILL SHOW WHETHER THE HIGH OR LOW BYTE IS IN ERROR.

ERROR NO. 2 1) '.BADF' = -2 INDICATES RAM ERROR NO. 2
2) 'RAMPNTR' CONTAINS ADDRESS WHERE FAILURE OCCURED. LOCATION, WOULD NOT CLEAR

ERROR NO. 3 1) '.BADF' = -3 INCICATES RAM ERROR NO. 3
2) '. RAMPNTR' CONTAINS ADDRESS WHERE FAILURE OCCURED. LOCATION WOULD NOT SET (-1)

ADDRESS TABLES

```
ROMSTRT  OCT 0
         OCT 17776
         DEC -1
```
ROM TABLE CONTAINS ADDRESS AREAS. TABLE IS TERMINATED WITH A -1

```
RAMSTRT  OCT 176000
         OCT 177776
         DEC -1
```
RAM TABLE IS SIMILIAR TO ROM TABLE.

MEMORY MAINTENANCE WORKSPACE

```
MEMWP   BSS  16
.RAMPNTR  EQU  10  - RAM POINTER
.ROMPNTR  EQU  1   - ROM POINTER
.RCKSUM   EQU  2   - CALCULATED ROM CHECKSUM
.CTCNT    EQU  3   - CHECKSUM TABLE OFFSET
.INITF    EQU  4   - LOCAL INITIALIZE F2AG
.WCNT     EQU  5   - WORDS/PASS
.RATCNT   EQU  6   - TABLE OFFSET (RAM)
.ROTCNT   EQU  7   - TABLE OFFSET (RAM)
.BADF     EQU  8   - ERROR FLAG (-1=ROM ERROR)
.SCRAT    EQU  9             (-2=RAM ERROR)
.SHIFT    EQU  0             (-3=RAM ERROR)
```

COMMON

```
POWERUP  BSS  1
MAINTFLG BSS  1
```

DATA

```
ROMCKSM  BSS  2  (NO. OF 2K ROM BLOCKS)
```

CONSTANTS

```
ROBLK  DEC  4096
```

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CASS SOFTWARE
MEMORY MAINTENANCE SOFTWARE

DESIGNED	TECHNICAL APPROVAL
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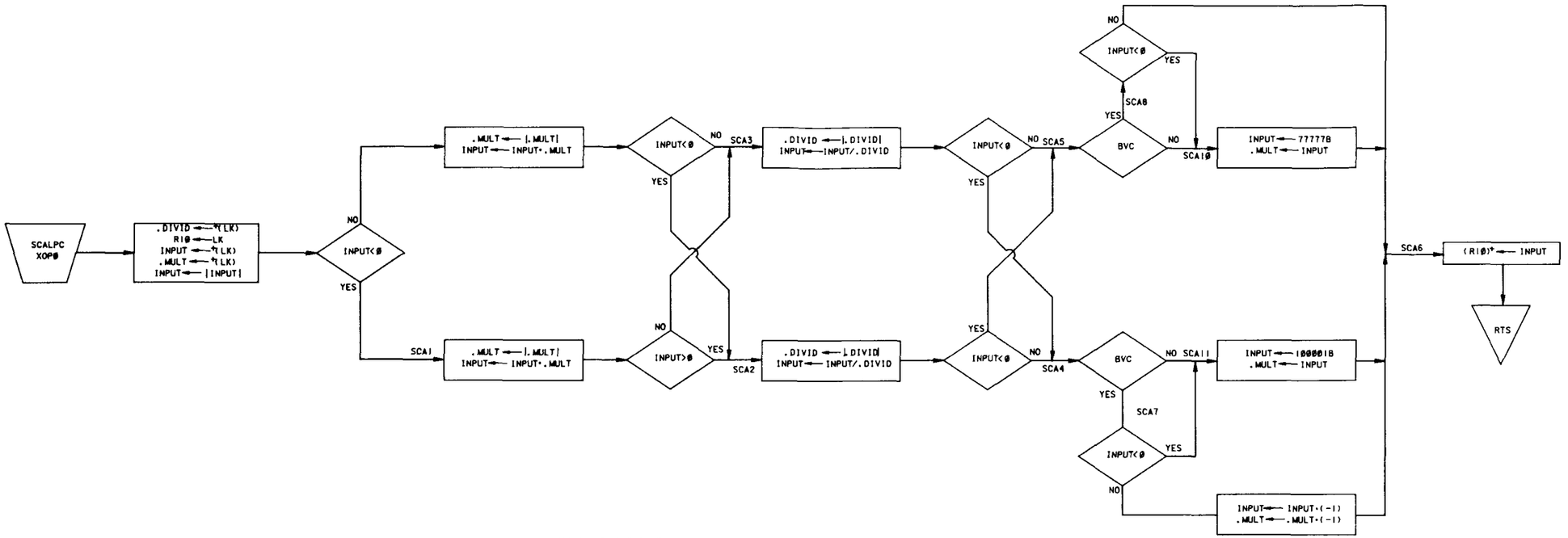
	CHIEF, ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981	100-PI-015



SCALE XOP 0

WORKSPACE AND EQUIVLENTS

```
SCALWP      BSS   16
.DIVID      EQU   0
INPUT       EQU   1
.MULT       EQU   2
LK          EQU   11
```

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SCALE XOP 0
(R9*R10) /R8

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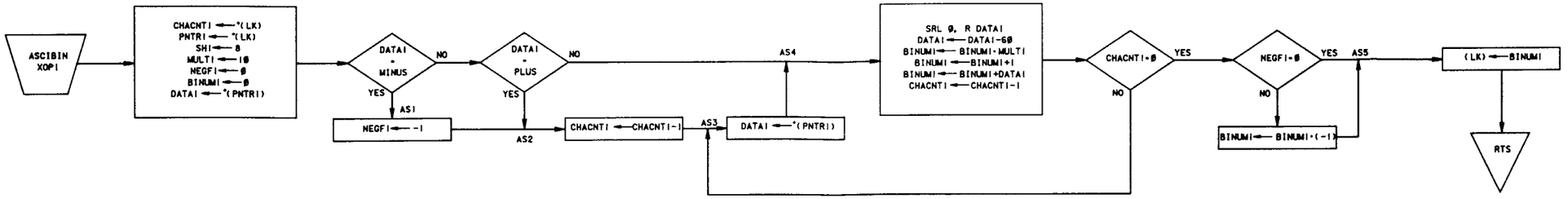
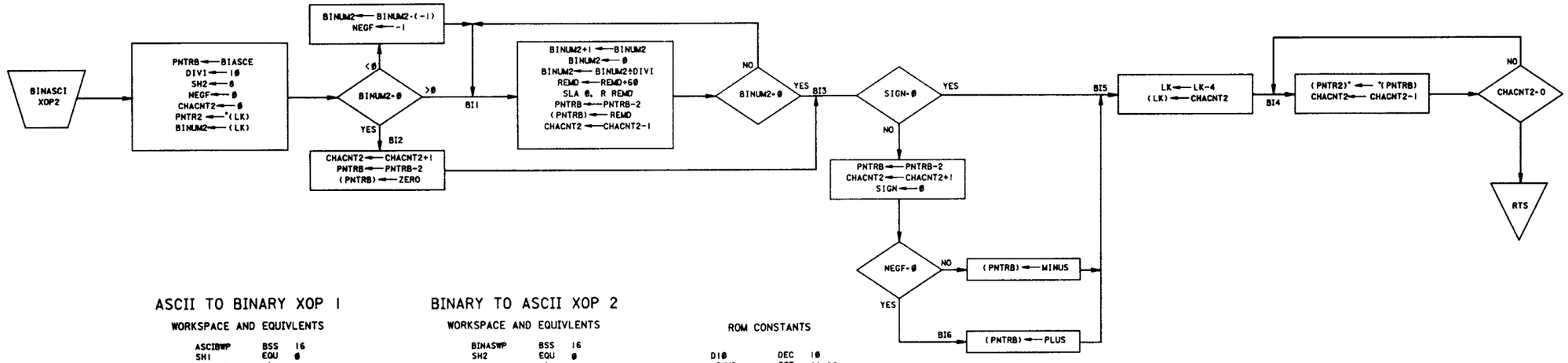
DENVER, COLORADO JAN. 1, 1981	100-PI-016





ASCII TO BINARY XOP 1

WORKSPACE AND EQUIVLENTS

ASCIBWP	BSS	16
SH1	EQU	0
CHACNT1		1
PNTR1		2
DATA		3
MULT1		4
BINUM1		5
NEGF1		7
LK	EQU	11

BINARY TO ASCII XOP 2

WORKSPACE AND EQUIVLENTS

BINASWP	BSS	16
SH2	EQU	0
CHACNT2		1
PNTR2		2
PNTRB		3
BINUM2		4
REMD		5
DIV1		6
NEGF	EQU	7
SIGN	BSS	1
BIASC	BSS	6
BIASCE	EQU	$

ROM CONSTANTS

D10	DEC	10
MINUS	OCT	26400
PLUS	OCT	25400
ZERO	OCT	30000

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ASCII TO BINARY XOP1
BINARY TO ASCII XOP2

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GEOPHY. ELECTRICAL BRANCH
DENVER, COLORADO JAN. 1, 1981 100-PI-017

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