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AUTOMATED INPUT/OUTPUT DIAGNOSTICS FOR A REAL-TIME SIMULATION RESEARCH SYSTEM

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Foreword

This effort was conducted by the Simulation Techniques Branch, Training Research Division, Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. The work was performed in support of Project 6114, "Simulation Techniques for Aerospace Crew Training," and Task 611408, "Simulation Computers." This study was begun in April 1964 and was completed in April 1965.

Acknowledgment is made of the assistance provided the authors by Mr. Duncan Ewing of Illinois Institute of Technology Research Institute, who prepared the ADIOCE Calibration/Diagnostic Program, and Airman First Class Victor A. Wagner, who prepared the decimal input/output subroutines used by the diagnostic programs.

This technical report has been reviewed and is approved.

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Abstract

This report describes a library of automated diagnostic test-programs for the real-time input/output section of a digital training simulation research system. The application of such automated tests to simulation-system acceptance testing is explored. Included is a description of real-time simulation as a training technique and the Real-Time Simulation Research Systems (RTSRS) for which the test-programs were prepared. Detailed program listings, flow charts, and abstracts of each test and of utility subroutines are also provided.

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SECTION I.

Introduction

This report (1) describes in detail a library of automated diagnostic programs for the input/output portion of a Real-Time Simulation Research System, and (2) discusses the application of such a library of programs for the acceptance testing of simulation systems and subsequent preventive and diagnostic maintenance.

The programs were designed and coded to operate on a Raytheon 440 computer, which is part of the Real-Time Simulation Research System in the Simulation Techniques Branch of the Aerospace Medical Research Laboratories. Their functional designs are applicable, however, to a wide range of digital computers and associated analog-discrete input/output equipment.

This report includes some background material on training-simulation in general and a description of the Real-Time Simulation Research System for which the programs were specifically designed and coded. The programs themselves are explained from the functional standpoint, including the objectives and specific operational features of each.

The described diagnostic programs apply only to the real-time input/output portions of the simulation system. Their recommended use, therefore, is to supplement, not replace, present test procedures; since a complete test must naturally include computer diagnostics and tests for non-real-time input/output equipment used in the preparation of programs.

SECTION II.

Training Simulation

The type of simulation referred to in this report is real-time flight simulation for training crews in the operation of aerospace vehicles. A flight simulator for this purpose is a device composed chiefly of a vehicle cockpit, an instructor station, and a digital computer, all interconnected through various input/output devices and designed to replicate the vehicle being simulated as closely as possible from an operator's standpoint. The computer is programmed to solve the flight equations of the vehicle, process the inputs from pilot and instructor controls, and generate information for cockpit and instructor-station displays. On the basis of the position of the controls and the history of flight, the computer determines various vehicle parameters such as velocity, altitude, position, and attitude, and feeds these computed values through the input/output system to the pilot and instructor instrument pointers and indicator lights.

During the simulated flight, the instructor arbitrarily introduces through his console various circumstances such as icing, rough air, or system malfunctions which may be encountered during actual flight. The computer receives these inputs and alters its computations to simulate the vehicle's performance under these conditions. The pilot's reactions to these various conditions are monitored by the instructor. Thus, the simulator provides a means for training crews for emergency situations which may be too hazardous to attempt in the actual vehicle. The overall result is a duplication of the actual vehicle being simulated that is realistic to the trainee and which provides an effective training environment if properly utilized.

The forerunner of the complex digital flight simulators of today were the simple air-activated instrument trainers of World War II vintage. These trainers eventually progressed to electrified models, then to trainers using electronic and electromechanical analog computing elements. Through further research on simulation techniques evolved the approach of using an aircraft mathematical model with aircraft data programmed on a special-purpose analog computer to implement a full mission simulator.

These analog-computer-driven simulators were very effective; however, many problems arose when changes were implemented. The characteristics of the analog approach, having an equivalent component for each major vehicle component, and the special-purpose design of the computer made simulator changes rather difficult and time-consuming. If a part or system were added, deleted, or replaced in the vehicle, the analog computer would be affected in the same manner. In addition, other undesirable characteristics such as poor small-signal response and performance degradation with age were prevalent.

With the advent of the digital computer, the feasibility of using a digital computer for the central computing element was investigated, using the same mathematical model and computer solution approach. The digital computer was investigated primarily because of its prominent advantages over analog computers, such as programming and model solution flexibility and superior accuracy and resolution. Its flexibility would be limited only by any special-purpose restrictions imposed on its design; and the ease with which the program could be changed would be controlled chiefly by its program input/output equipment and software. The desired accuracy and resolution could be achieved by the use of a suitable computer word-length or by double-precision programming techniques. The digital computer's inherent "go—no go" characteristics also offered certain maintenance advantages. The solution would be consistently accurate from one day to the next and would not be affected by component degradation; however, if a failure did occur in the computer, the entire simulation would be likely to fail.

A study was, therefore, undertaken to determine the digital computer speed and other characteristics required for such a simulator. It was determined that at that time a digital computer of the required capabilities did not exist as a state-of-the-art device. An effort was then initiated to design such a computer. A digital computer of the established design was constructed, programmed to simulate a high-performance aircraft (F-100A), and tested to prove its feasibility. This system was called the Universal Digital Operational Flight Trainer (UDOFT). (See reference 7.)

Several years after the UDOFT program was successfully completed, commercial computers capable of handling such a simulation became available. More efficient programming techniques were also developed. The requirement for digital computation was then added to Air Force simulator specifications. Today, the majority of Air Force aerospace vehicle simulators being procured are required to be activated by digital computers.

SECTION III.

The Real-Time Simulation Research System

To enable a better understanding of the automated diagnostic test programs which are representative of the type recommended for use in simulation system acceptance testing, a description follows of the system for which the tests were prepared. Parallels may be drawn between this system and others to observe the applications which may be made of at least the functional designs of the diagnostic programs.

The major components of the system which has been named the Real-Time Simulation Research System (RTSRS) are a Raytheon 440 digital computer (ref 1), an Electronics Associates TR-48 analog computer, and some special analog and discrete input/output conversion equipment. The program input/output equipment of the system consists of a magnetic tape unit, a paper tape reader and punch, an on-line typewriter, a high-speed line printer, and a computer-controlled Cathode Ray Tube (CRT) display.

The primary function of the RTSRS is to enable the Aerospace Medical Research Laboratories to conduct applied research in simulation techniques for training aerospace crews. Work currently in progress which involves the use of the RTSRS includes the development and implementation of an orbital-reentry simulation program. This program will be used in studies of hybrid simulation techniques, numerical integration methods for real-time simulation, automatic monitoring of human performance, and real-time displays for training purposes.

Following is a brief description of each equipment-component of the RTSRS. Since the TR-48 analog computer is not used by the automated diagnostic programs, it will not be described in this report.

RAYTHEON 440 DIGITAL COMPUTER

The Raytheon 440 is a medium-sized, medium-speed, general-purpose digital computer. It is designed to permit programming at several levels. The machine micro language may be used directly; a group of micro coded routines may be used to make-up various macro commands or languages; or FORTRAN programming may be used. The micro programming feature of the computer, which permits the programmer to literally define his own command set, sets the Raytheon 440 apart from and above other general-purpose digital computers in which the (macro level) command set is fixed. (See reference 1.)

Major software components of the 440 include a Micro Assembly Program (MAP 440), a FORTRAN compiler, and a macro level assembler. The latter is based upon a Systems Command Set of instructions (ref 6) designed for real-time applications. Accompanying the Systems Command Set assembler is a Systems Command Set Generator, the use of which permits the programmer to specify which commands of a group of over 100 standard commands he wishes to use in his program. The programmer, however, is limited to 64 commands in a given program. The Generator may be altered to permit the programmer to define and use his own commands which may not be included in the Systems Command Set. The alteration may be quickly accomplished through a conversational-type program entitled the Generator-Generator.

Complete diagnostic programs exist for all peripheral equipment. Some of these programs were furnished by Raytheon for equipment purchased from them and some were prepared in-house. An extensive library of utility softwear has been prepared by the Aerospace Medical Research Laboratories to aid in standard input/output, program debugging, and program documentation. Included are decimal input/output routines; tape reproducers; I/O commands for rapid access to the printer, punch, typewriter, and magnetic tape unit; source program listing routines; special commands for referencing the analog-discrete input/output system; and several typewriter input routines.

The computer has two 4K modules of 2-microsecond cycle time memory and a 512-word module of 1-microsecond, nondestructive access memory. The two 4K modules comprise what is referred to as main memory, which is normally used for program and data storage. The 512-word module is referred to as logic or fast memory and is where the micro coded macro-commands and micro coded subroutines are normally stored. Main and fast memory may be expanded to 28,672 and 4096 words capacity, respectively. (See references 1 and 5.)

ANALOG-DISCRETE INPUT/OUTPUT CONVERSION EQUIPMENT (ADIOCE)

ADIOCE, which is an acronym for analog and discrete input/output conversion equipment, is a special device which, together with the 440 and TR-48 computers, makes up the major equipment of the RTSRS. It provides the link between the digital computer and the simulator cockpit instruments and controls. It is also the link between the analog and digital computers for use in hybrid computation problems. (See reference 3.)

There are 6 major sections in ADIOCE: the I/O controller, real-time clock, digital to analog converters, analog to digital converter and multiplexer, discrete inputs, and discrete outputs. Prompted by the appropriate input/output commands in the 440, the I/O controller selects the proper section and address in ADIOCE and causes the correct function to be performed. The ADIOCE I/O controller is very similar to all other 440 I/O controllers, so further attention will not be given it at this time. The remaining five sections in ADIOCE are briefly described as follows:

REAL-TIME CLOCK

The real-time clock is used most often for controlling the iteration rate of a program relying upon real-time inputs, i.e., a simulation program. It has also been used as a timing reference for several diagnostic routines. The clock may be set under program control to intervals ranging from 100 microseconds to 1.6383 seconds. The contents of the clock may also be read under program control. A 100,000 CPS crystal oscillator supplies the basic pulse rate for the clock.

Once set, the clock counts continuously and supplies an interrupt to the computer once every interval when the clock count register (CCR) reaches zero. Upon reaching zero, the CCR is automatically loaded again with the previously specified interval (retained in a time interval register (TIR)) and continues to count.

DIGITAL TO ANALOG CONVERTERS

The digital to analog conversion section of ADIOCE is composed of 64 individual D to A converters. Fifty-six of the channels are 10-bit bipolar converters and eight channels are 14-bit biopolar converters. The 10-bit converters are adequate for most of the standard simulator instruments, while the 14-bit converters are required for some of the longer scale displays such as vertical tape instruments. The larger number of bits are required for resolution rather than accuracy, because with a larger type instrument scale and a short word-length, converter changes of the least significant bit cause quantitized detectable changes on the instrument rather than a smooth movement. The high precision 14-bit converters also provide a standard for an automated closed-loop A to D and D to A calibration program.

The 10-bit converters are built up from Computer Control Corporation digital modules. Each channel is composed of a 10-bit storage register, a ladder network, and an isolation amplifier. The eight 14-bit converters are composed of a Packard Bell DAC 20 system. The output voltage range of the converters is ±10 volts, with a full positive computer word corresponding to +10 volts and a full negative 2's complement word corresponding to −10 volts.

All of the input/output sections in ADIOCE with the exception of the real-time clock can be accessed in either a Random or a Sequential mode. In the Random mode, the address of every I/O channel must be supplied to ADIOCE with every I/O command. In the Sequential mode, the address of the first channel to be referenced is sent during the selection of ADIOCE. With successive data transfer accesses to ADIOCE, the section being accessed is automatically stepped to the next higher channel, not requiring the address to be sent along with each access. The chief advantage of the Sequential mode is not time savings, since the access time in either mode is approximately equivalent, but that it does not require the construction of a channel address for each access.

ANALOG TO DIGITAL CONVERTER AND MULTIPLEXER

The 32 channels of analog input are provided through the use of a 12-bit analog to digital converter and a 32-channel multiplexer. The converter is a Texas Instruments Model 834 and the multiplexer is a Texas Instruments Model 845A.

In addition to the Random and Sequential modes mentioned previously, the A/I section can be accessed in a Free Run mode. In this mode, immediately after an access the A/I section is automatically stepped to the next higher channel and the conversion is initiated. The computer is free during the actual conversion period and is only charged for the data-transfer time during the access. This is only true, however, if the time between accesses is greater than the conversion time. With accesses spaced properly, this mode will permit maximum multiplexer and converter operation rate.

Although 2's complement notation is normally used in conjunction with ADIOCE, a Sign Magnitude mode of access exists to facilitate scaling operations when they are needed.

The input voltage range of the A/I system is also ±10 volts.

DISCRETE INPUTS

ADIOCE is capable of handling 72 discrete inputs. They are divided into three groups of 24 each and brought into the computer one 24-bit word at a time. The bits of this 24-bit word must be interrogated separately to determine the state of a particular discrete input. This can be accomplished by masking the input word or shifting the bits to a position in the word that can be tested by a standard command.

The switch-inputs connect directly into ADIOCE as logic levels to the digital modules, with the switch providing the only storage. No voltage levels are required to be routed through the switch; it provides a "one" input by being open and a "zero" input by being switched to ground.

DISCRETE OUTPUTS

ADIOCE is capable of providing 70 external discrete outputs. They are arranged into 7 groups of 10 each and are left justified in the computer word. The discrete outputs are in the form of either flip-flop outputs or lamp driver outputs. The lamp drivers can operate incandescent indicator lights or low current relays. An additional group of 10 discrete outputs is used to pull special mode control relays, some of which are used for the calibrate mode of ADIOCE, and some for the analog computer mode control.

Since the discrete outputs are sent out in groups of 10, the individual outputs must be set by a masking or shifting technique similar to that used for interrogating the discrete inputs.

SECTION IV.

Automated Diagnostic Test Programs

TEST OBJECTIVES

All of the automated diagnostic tests for ADIOCE except the calibration test were written specifically for system acceptance testing. The ADIOCE calibration test (reference 2) was written by the system contractor as an initial and permanent diagnostic for ADIOCE. All tests, however, were used for acceptance testing and have become part of a permanent system-diagnostic library.

The diagnostic tests were designed to be as automated as possible with respect to operator instructions, execution, and result-recording so that maximum operational efficiency could be achieved. The tests proved to be quite useful in detecting and resolving several system malfunctions during the testing phases. Due to the success encountered with these tests and the applicability of their design to other input/output systems and computers, they are described herein as an example of tests to be added to the standard simulator system acceptance tests and used for permanent diagnostics for a digital simulator system. Similar automated techniques could be applied to other areas of acceptance testing, i.e., simulator model testing. Such tests could save a considerable amount of test time while providing more reliable and more rapid test results. The extra effort involved in the preparation of such a battery of automated tests for a single simulator may be greater than the effort saved in testing in some cases; however, when several simulators of a similar type are involved, the extra effort required initially may be well justified on a time-savings basis alone, in addition to adding increased efficiency, accuracy, and reliability to test procedures and results.

TEST DESCRIPTIONS

1. Discrete Input/Output Test

This test provides a means of exercising the discrete input and output channels in a closed-loop fashion to determine if they are operating properly. For this test, the output channels are connected to the input channels through an external cable. The program first types or prints the title and operating instructions. In this case, the instructions are for the operator to select by the use of sense switches whether or not a listing is desired of the input/output connections prior to test execution. This list is useful if a malfunction is detected, in that the output as well as the input channels involved can be determined. If an error is detected, this means that either the input or its associated output channel are malfunctioning. This ambiguity can be resolved by the use of manual discrete input switches on a test panel in ADIOCE. If the test responds properly using the manual inputs, the malfunction is in the output channel; otherwise, it is in the input channel.

The test sends out all ones and all zeros on the output channels and tests for the same on the input channels. If no malfunctions are detected, the test outputs the phrase "End of Test" and the computer halts. If a malfunction is detected, the program outputs the input channel number associated with the malfunction and indicates whether a zero or a one should have been received. The program then completes the test and outputs "End of Test" and the computer halts. (See sample output in Appendix I.)

2. Discrete Output Dynamic Test

This test provides a means of dynamically testing the discrete output channels. For this test, an indicator lamp is connected to the lamp driver of the discrete output channel. The program begins by typing the test title and operator instructions. The operator can specify a single channel or all channels to be exercised during any one execution of the program. If a single channel is selected, its group address and the number corresponding to its position in the group must be specified through the typewriter. The test then asks for a time T which determines the rate at which the channel is cycled on and off.

The test determines whether or not the channel functions properly under load and whether the selection circuitry selects only the proper channel. Through sense switch options, the operator can enter a new time T, restart the test to select a new channel or all channels, or indicate that a malfunction has occurred on the channel being tested. In case of the latter, the program records the malfunction so that a complete and permanent copy of the test results is maintained. (See sample output in Appendix I.)

3. Analog Output Accuracy Test

This test provides a means for measuring the accuracy of the low precision and high precision digital to analog converters. The equipment required for this test is a high precision digital voltmeter connected to the channel output which is under test. The test title and operator instructions are supplied to the operator via the typewriter. The operator types the address of the channel to be tested.

The test is designed to automatically record all results. A total of 21 points over the full range of the converter is checked. The typewriter types the voltage and the computer number corresponding to this voltage for the current test point. With the voltmeter connected to the channel output, the computer number is sent to the converter. If the proper voltage appears on the channel output as observed on the voltmeter, the computer number that was originally sent out to produce this voltage is typed as the number required. If the voltage is not the proper value, the output number is slewed by the operator through the use of sense switches until the proper voltage appears on the channel output. When the proper voltage is reached, the required output number is typed and the test continues to the next test-point.

The difference between the required number and the number originally outputted is the converter error in least significant bits. With this test, the entire range of the converter can be checked and the results recorded in a matter of minutes. This test can be used to select one of the high precision converters for use as a reference in the analog calibration test. (See sample output in Appendix I.)

4. Analog Output Dynamic Test

This test provides a means of dynamically testing the analog output channels. The test first outputs the test title and operator instructions through the typewriter. The program then sends information to the selected analog output channel which should produce a square wave on the output of this channel. The amplitude and period of the test signal are controllable by either of two methods: one is through typewriter inputs, where the amplitude and period are typed in; the other is through the use of two analog input channels. If the latter method is used, the operator may request a type-out of the current amplitude and period any time during the test.

With this test, the frequency response of the analog output channel, which is mainly determined by the output amplifier, can be measured and the dynamic functioning of the digital storage register and converter can be checked. It also provides a means of easily determining whether the selection circuitry selects only the proper channel.

Through sense switch options, the operator can enter a new time and amplitude to alter the test signal, restart the test to select a new channel, or indicate that distortion has occurred on the channel under test. In case of the latter, the point where the output was considered to be distorted was arbitrarily chosen to be where the output waveform was all rise-and-fall time. The program provides a printed record of all cases of distortion to provide complete test results. (See sample output in Appendix I.)

5. Computer and Real-Time Clock Tests

This test compares the operational accuracy of the computer and real-time clocks with external timing references. There are three parts to this test: one checks the computer clock against two types of external references, one checks the real time clock against the same two types of external references, and the third compares the computer clock with the real-time clock. The two external references used by the first two parts are a 60-cycle line and a sweep-second-hand clock.

For the computer clock part of the test, when a clock reference is used, the program cycles in a timing loop and accumulates time in 1-second intervals. This loop time is determined by the instructions in the loop and their respective execution times. Since the instruction times are controlled by the computer clock, the program measures (indirectly) the computer clock rate. The result outputted from this mode is the accumulated time in seconds. Sense switches are used to initiate and terminate the timing period.

With this reference, the timing period should be approximately 3 hours for a resolution of 0.01%.

When the 60-cycle line reference is used, it is fed in through a discrete input channel and its time is accumulated in 8.333-millisecond intervals. This is the half-period time of the reference signal. The computer timing loop, of which a part is the interrogation of the reference input channel, has a 1-millisecond loop. The 8.333-millisecond interval is caused by the reference signal cycling positive and negative once each cycle, and the interrogation part of the loop tests for a change in the input. The computer loop must have an interval less than this so as not to miss the reference signal change; therefore, the interval was chosen to be 1 millisecond, the next lowest power of 10 of 1 second. This mode is also initiated and terminated by sense switches. The results outputted are the reference and computer clock times in seconds and the percent error. With this reference, the timing period should be approximately 2 minutes for a resolution of 0.01%. However, since the 60-cycle line reference is more accurate over an extended period, approximately 2 hours should be used.

The real-time clock part of the test also has two modes as above and is identical except that a time interval of 10 milliseconds is set in the real-time clock. This clock provides interrupts to the computer at the interval rate, and the interrupts are accumulated in a computer register. The program output results are in the same form as the computer clock part of the test. This test not only checks the real-time clock for accuracy but accesses the clock in most of its usable modes, thereby testing its functional characteristics.

The third part is a test to cross-check the results of the first two in that it tests the computer clock against the real-time clock. There is only one mode to this part and the outputted results are in the same form as the 60-cycle reference mode of the first two parts.

Like the other automated diagnostics, this test uses conversational programming, providing complete operating instructions and hard copy results. (See sample output in Appendix I.)

6. ADIOCE Calibration/Diagnostic Program

This program was prepared by the system contractor, Illinois Institute of Technology. For a complete description, including flow charts, the reader is referred to a documentation report prepared for this branch entitled "ADIOCE Calibration/Diagnostic Program for Real-Time Training Simulation Research System."

This program provides a check on the performance of the analog-to-digital converter (ADC) and multiplexer (MX) and the digital-to-analog converters (DAC). Also, a simple check is made on the discrete input/output control facilities.

Tests are made by comparing the input from the ADC against (1) bit patterns corresponding to known voltage sources, either signal ground or output from a high-precision, hand-calibrated DAC; or (2) bit patterns which have been outputted to the DAC being tested. If the difference between these patterns exceeds prescribed limits, a print-out is produced listing the test being made, the channel used, the bit pattern inputted, the correct bit pattern, and the absolute value of their difference.

The tests are arranged so that, when they are performed in their normal order, no part of the system is used in checking out another part until its own operation has been verified. If the hand-calibrated DAC (one of eight 14-bit DAC selected with analog output accuracy test) is correct, and if the tests are performed in order, any failure can be traced to the defective device. If no errors are indicated, all devices are functioning within the prescribed limits, since the program outputs only diagnostic information when the limits are exceeded.

Before the tests of the analog equipment begin, ADIOCE is checked for status response and for its ability to return an EKO signal when accessing discrete input and output channels. Then the individual tests are performed in sequence. Following is a brief description of each test:

Test 1 — Zero Offset of ADC: The signal ground is connected to the ADC, a conversion is made, and the output is compared with zero.

Test 2 — Linearity of ADC: The reference high precision DAC is connected directly to the input to the ADC, bypassing the multiplexer. The program cycles through all possible 14-bit configurations, sends each to the reference DAC, performs conversion, and compares the ADC output with the original configuration.

Test 3 — Zero Test of Multiplexer: The signal ground is conected to the input terminals of each of the multiplexer channels, and a conversion is made through the ADC for each channel. The output is compared with zero.

Test 4 — Linearity of Multiplexer Test: The reference high-precision DAC is connected to the input terminals of each multiplexer channel in turn, while the program cycles through all possible 14-bit configurations. Each configuration is converted to a voltage by the DAC, and an AD conversion is made through a multiplexer channel. The output is compared with the original configuration.

Test 5 — DA Check, Low Precision: Each of the low precision DAC's is connected to one of the multiplexer channels, and conversions are made for every 10-bit configuration on each channel. The ADC output is compared with the original configuration.

Test 6 — DA Check, High Precision: Each of the high precision DAC's is connected to one of the multiplexer channels, and conversions are made for every 14-bit configuration on each channel. The ADC output is compared with the original configuration.

SECTION V.

Application of Automated Diagnostic Test Programs to the Acceptance-Testing of Simulation Systems

CURRENT ACCEPTANCE-TESTING PROCEDURES

Present techniques used for the acceptance-testing of digitally-activated flight simulation systems do not ordinarily include the use of automated diagnostic routines to test the input/output capabilities of the system. In fact, little emphasis is placed upon testing the digital computer and associated I/O equipment as an entity independent of the cockpit. The lack of emphasis in this area is probably a carryover from the days of all analog simulation, when there really was no simulator input/output equipment and the entire system was thought of as a single piece of equipment — a simulator — rather than a computer, input/output equipment, and a cockpit.

Most simulator tests are conducted in a manner similar to that of flight testing an actual aircraft. In fact, the tests are often designed, outlined, and run, by the airframe contractor. The simulator is usually "flown" to certain altitudes, power-settings, orientations, etc.; then human stimuli are applied to the simulator model through the cockpit controls, and the performance responses of the simulated vehicle are observed via the cockpit instruments. Primary emphasis is upon the performance characteristics of the simulated flight vehicle as observed subjectively, and relatively little attention is given to the hardware responsible for conveying them accurately and reliably from computer to cockpit.

A more desirable procedure for model and simulation-program testing which has been used in the testing of some research digital simulators consists of using a computer controlled test program. This type of program automatically initializes the simulator to specific test conditions, inserts standard computer controlled stimuli in the simulation model, and records the results for evaluation. This method is very desirable not only because of its increased operational efficiency, but because it assures more validity by removing the human element from the test.

Present techniques for maintenance-oriented diagnostic testing of the digital computer and input/output portions of a simulation system are often inadequate and difficult to apply. The diagnostic tests required and provided are not usually automated; as a result, their execution requires a great amount of operator intervention and console monitoring. In fact, these diagnostic "tests" are often not supplied as computer programs but instead as a list of manual procedures (which could just as easily have been incorporated into a computer program). Therefore, the entire diagnostic facility is unsatisfactory merely because it is so difficult and time-consuming to use.

THE ADVANTAGE OF USING AUTOMATED DIAGNOSTIC TEST PROGRAMS

The use of automated diagnostic programs for the real-time input/output portion of a digital simulation system would greatly simplify the task of running acceptance tests on this portion. This is obvious, since the test programs as described in this report are designed to require as little operator effort as necessary. Further, tests such as those described would check-out the real-time input/output hardware thoroughly and would thus enable more rapid isolation of system malfunctions as the acceptance testing proceeded. Their use would eliminate the need for trial-and-error troubleshooting of the real-time input/output equipment each time it was suspected that a malfunction existed in that equipment.

A second important advantage of using automated diagnostics is that their use would not be limited to the acceptance testing of the simulator, and their development would therefore be justified on two accounts. These test programs could be used by personnel in the field for preventive maintenance checks and regular system diagnostics after the simulator is in operation. Further, because of the simple operational features of the tests, using personnel would not need to be familiar with detailed aspects of the computer or the real-time input/output hardware.

The application of automated diagnostic test programs in general is not limited to real-time input/output equipment. Automated tests could be prepared for nearly every portion of a simulation system, including the mathematical vehicle model itself but, perhaps, excluding certain human engineering features of the total system.

Appendices

Appendices I and II consist of detailed descriptions of the automated diagnostic tests prepared for ADIOCE. The descriptions are composed of abstracts, sample output, flow charts, and assembled program listings. The format of the abstracts was designed for file records of computer programs. Essentially, the abstracts explain the function or purpose of the program, a sketch of the techniques used in accomplishing the purpose, operating procedures, and computer storage requirements and allocations.

In the assembled program listings produced by the micro assembler, MAP-440, the left-most number is the internal address of the corresponding micro pair and the next number is the octal equivalent of the micropair. These are followed horizontally by the micro command and the comments.

For uniformity, all of the test programs are coded to begin at location $70{,}100_8$ and execute from logic memory. Since many of the tests use common subroutines, these are stored at fixed locations for all diagnostics and are discussed as a group in Appendix II.

All the tests are coded on the micro or machine level. A brief description of the micro commands used in the coding will be found in Appendix III. (See reference 4.) Appendix IV contains a list and brief description of the Systems Command Set instructions, presented here to supplement the abbreviated description of the Raytheon 440 computer software discussed in the text. (See reference 6.)

Appendix I.

AUTOMATED DIAGNOSTIC TEST MAIN PROGRAMS

PB-440 PROGRAM ABSTRACT

PROGRAM TITLE:	DISCRETE INPUT/OUTPUT TEST
PROGRAMMER:	P. A. KNOOP
DATE:	10 March 1965
ID:	None
FUNCTION:	The purpose of this program is to test for accuracy all discrete I/O bits in the PB-440 ADIOCE system. This is one of the ADIOCE Acceptance Test programs.
TECHNIQUE:	The program outputs all zeros, then all ones, to all bits in DSO groups 1 - 8. The DSI groups, linked physically with the DSO groups, are then tested for the correct response. In the event of an error, the program outputs the DSI group and bit number at which the error occurred.
LOADING PROCEDURE:	Load with Binary Loader I. The program is not relocatable.
OPERATING PROCEDURE & LINKAGE REQUIRED:	The DSI-DSO linkage must be established prior to execution. Once the program is initiated, no special console monitoring is required. Prior to execution one of two sense switches must be set, depending upon the output mode desired, i.e., typewriter or line printer.

PROGRAM STORAGE:

Program Segment	*Octal Locs.*	*Total*
Main Program	70100-70210	111
Micro Print	400-426	27
Micro Type	450-461	12
Comments	1000-1775	776
		1150_8

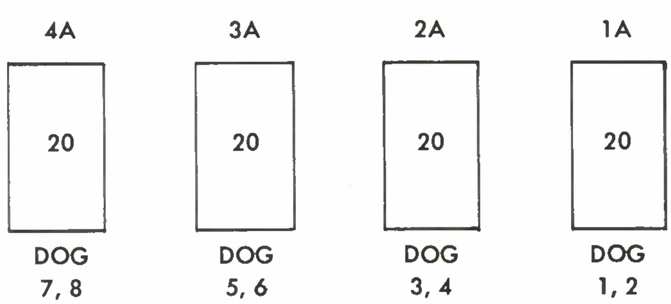
INTERMEDIATE STORAGE:

Working Storage:
0 Address of selected output routine
1 Save D register during error routine
2 Save A register during error routine
3 Save D register during error output
4 Storage of output word in error routine

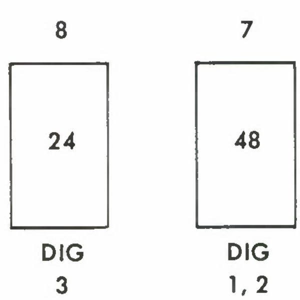
SPECIAL STORAGE:	None used
EXECUTION TIME:	Not applicable
REGISTERS:	All used

SENSE SWITCHES:	1 Typewriter output 2 Line printer output 5 DSI-DSO connections output 6 No DSI-DSO connections output
I/O DEVICES:	Typewriter Line Printer ADIOCE
PROGRAM FLAGS:	1 On if outputting zeros, off if outputting 1's 3 On if error has occurred
PROGRAM HALTS:	70100 Test completed

CONNECTOR AND CABLE DIAGRAMS FOR DISCRETE INPUT-OUTPUT TEST

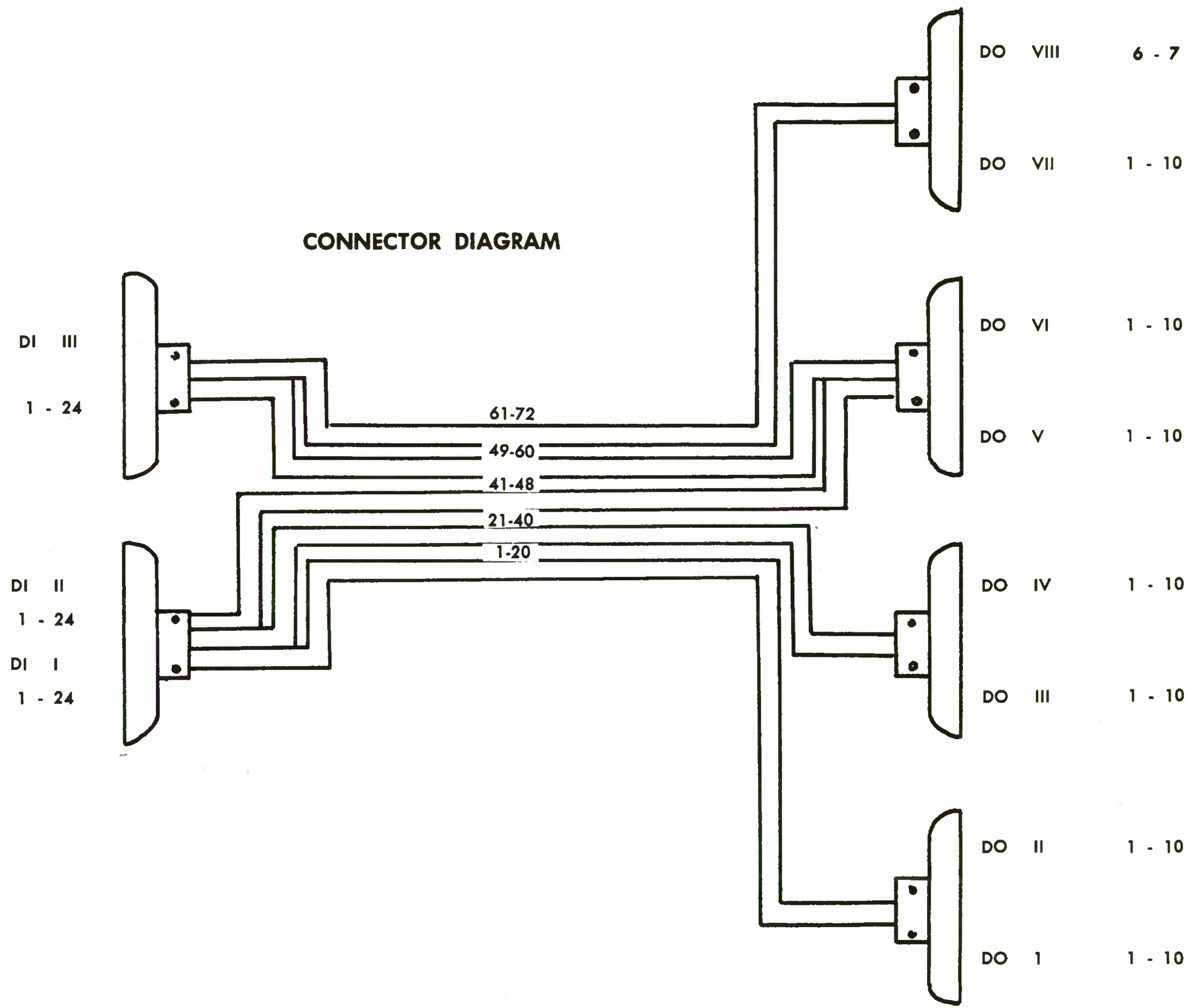


20 pin receptacles in Bay A; also receptacles 1B, 2B, 3B, and 4B in between the ones shown.



20 Pin Plugs in Bay C

CONNECTOR DIAGRAM



CONNECTOR CHART

DI I in Bay C Connector 7 To

DO I, II, and III in Bay A Connectors

IA and 2A.

Group	*No.*	*Bit*	*Pin*	*Group*	*No.*	*Bit*	*Pin*
DI I	1	0	1	DO I	1	0	17
	2	1	2		2	1	15
	3	2	3		3	2	13
	4	3	4		4	3	11
	5	4	5		5	4	9
	6	5	6		6	5	7
	7	6	7		7	6	5
	8	7	8		8	7	3
	9	8	9		9	8	33
	10	9	10	DO I	10	9	31
	11	10	11	DO II	1	0	50
	12	11	12		2	1	48
	13	12	13		3	2	46
	14	13	14		4	3	44
	15	14	15		5	4	42
	16	15	16		6	5	40
	17	16	17		7	6	38
	18	17	18		8	7	36
	19	18	19		9	8	18
	20	19	20	DO II	10	9	20
	21	20	21	DO III	1	0	17
	22	21	22		2	1	15
	23	22	23		3	2	13
DI I	24	23	24	DO III	4	3	11

CONNECTOR CHART

DI II in Bay C Connector 7 To

DO III, IV, and V in Bay A Connectors

2A and 3A.

Group	*No.*	*Bit*	*Pin*	*Group*	*No.*	*Bit*	*Pin*
DI II	1	0	26	DO III	5	4	9
	2	1	27		6	5	7
	3	2	28		7	6	5
	4	3	29		8	7	3
	5	4	30		9	8	33
	6	5	31	DO III	10	9	31
	7	6	32	DO IV	1	0	50
	8	7	33		2	1	48
	9	8	34		3	2	46
	10	9	35		4	3	44
	11	10	36		5	4	42
	12	11	37		6	5	40
	13	12	38		7	6	38
	14	13	39		8	7	36
	15	14	40		9	8	18
	16	15	41	DO IV	10	9	20
	17	16	42	DO V	1	0	17
	18	17	43		2	1	15
	19	18	44		3	2	13
	20	19	45		4	3	11
	21	20	46		5	4	9
	22	21	47		6	5	7
	23	22	48		7	6	5
DI II	24	23	49	DO V	8	7	3

CONNECTOR CHART

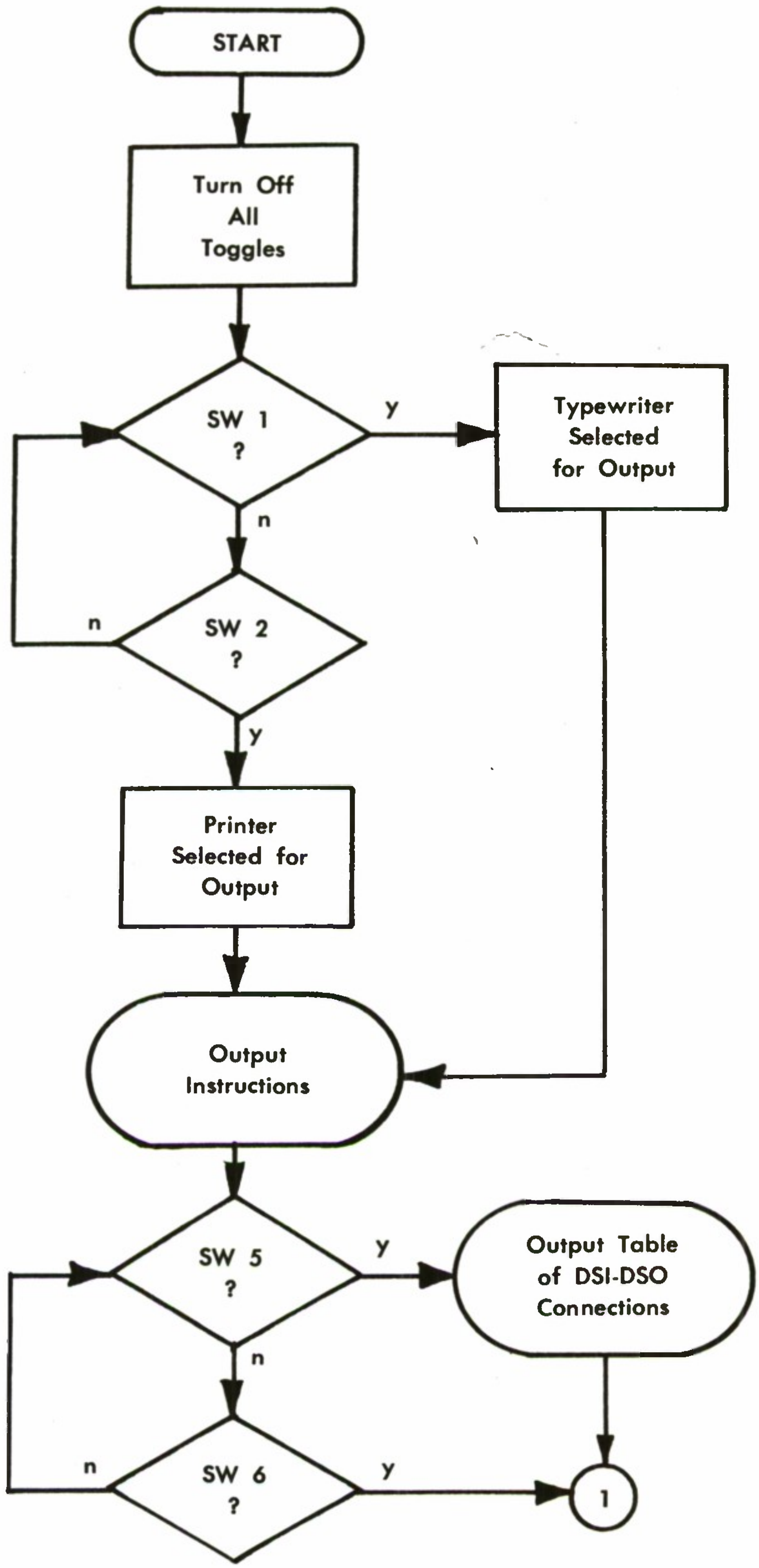
DI III in Bay C Connector 8 To

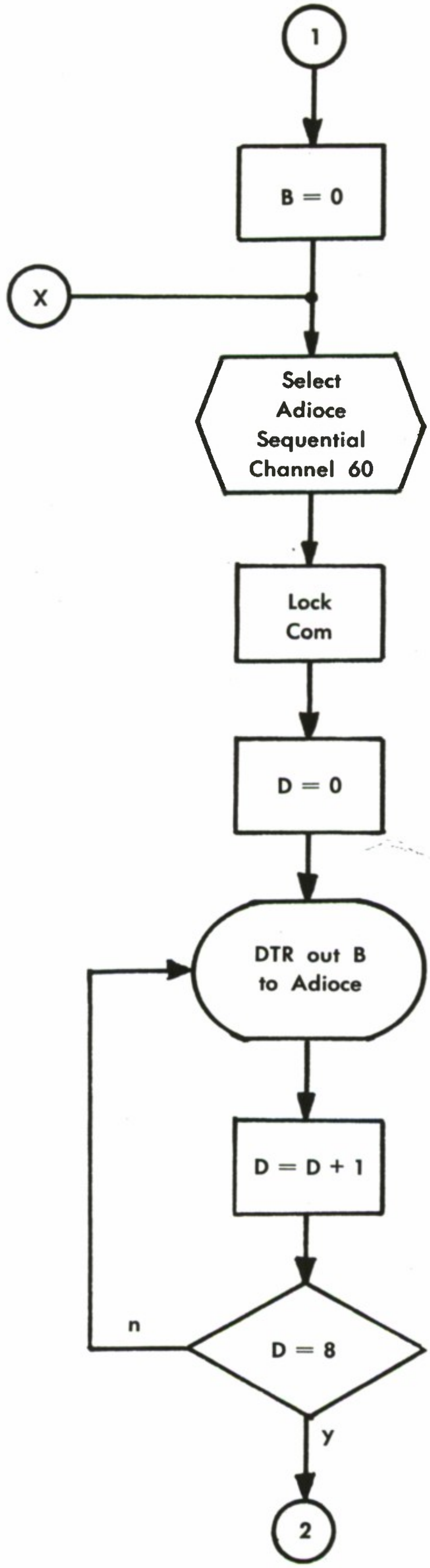
DO V, VI, VII, and VIII in Bay A

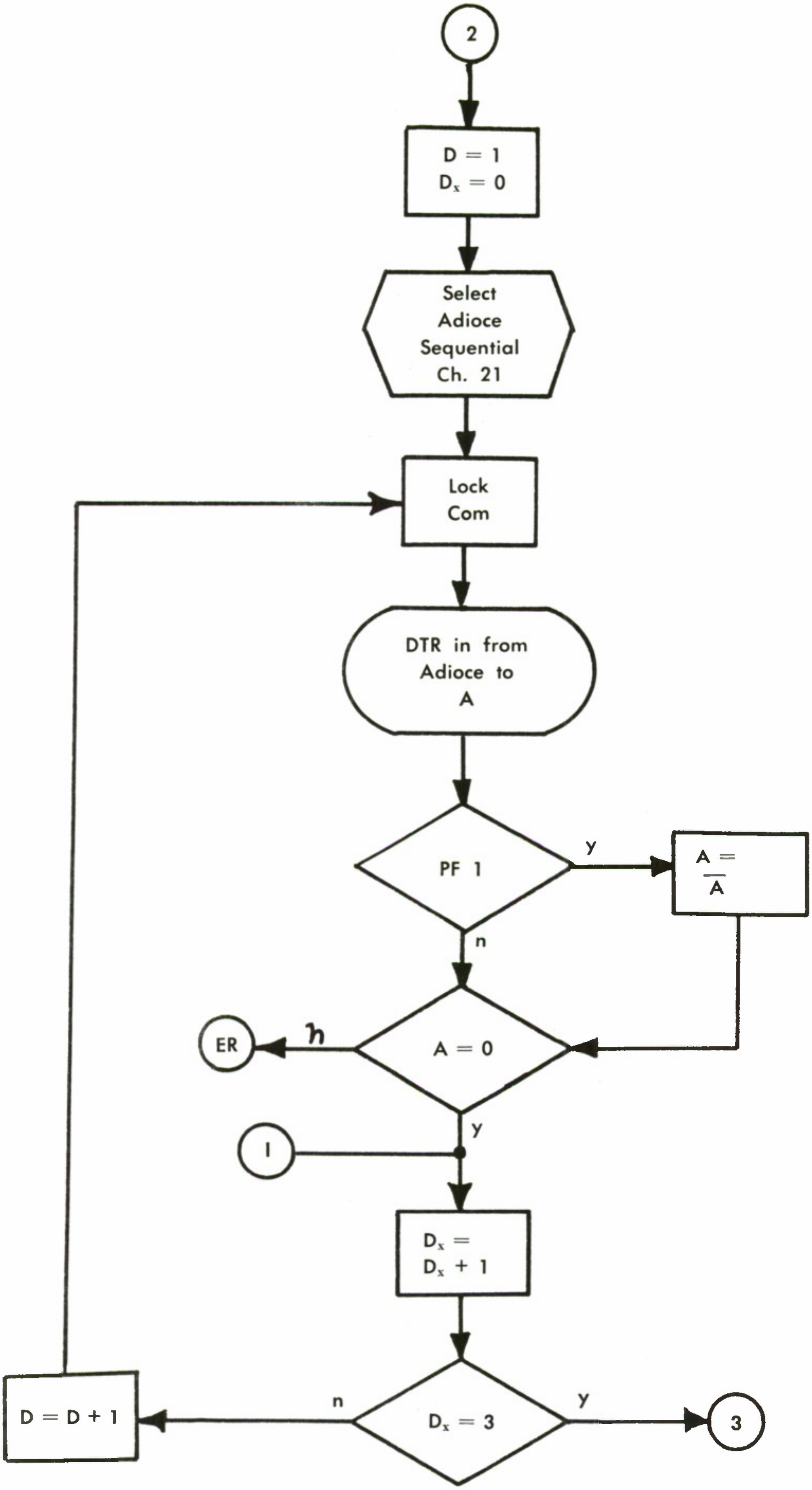
Connectors 3A and 4A.

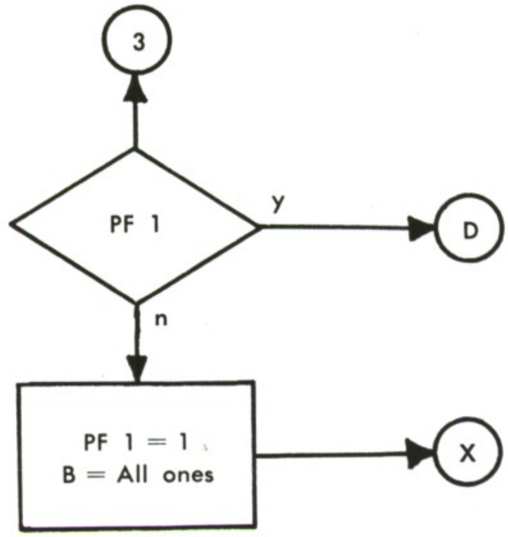
Group	*No.*	*Bit*	*Pin*	*Group*	*No.*	*Bit*	*Pin*
DI III	1	0	1	DO V	9	8	33
	2	1	2	DO V	10	9	31
	3	2	3	DO VI	1	0	50
	4	3	4		2	1	48
	5	4	5		3	2	46
	6	5	6		4	3	44
	7	6	7		5	4	42
	8	7	8		6	5	40
	9	8	9		7	6	38
	10	9	10		8	7	36
	11	10	11		9	8	18
	12	11	12	DO VI	10	9	20
	13	12	13	DO VII	1	0	17
	14	13	14		2	1	15
	15	14	15		3	2	13
	16	15	16		4	3	11
	17	16	17		5	4	9
	18	17	18		6	5	7
	19	18	19		7	6	4
	20	19	20		8	7	3
	21	20	21		9	8	33
	22	21	22	DO VII	10	9	31
	23	22	23	DO VIII	6	5	40
DI III	24	23	24	DO VIII	7	6	38

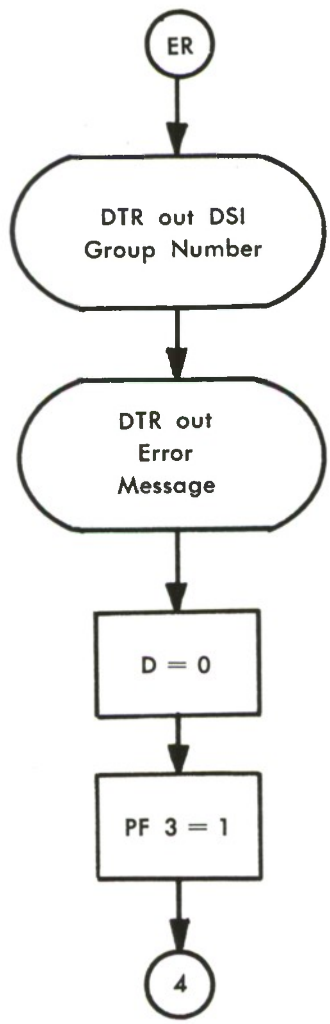
DISCRETE INPUT-OUTPUT TEST

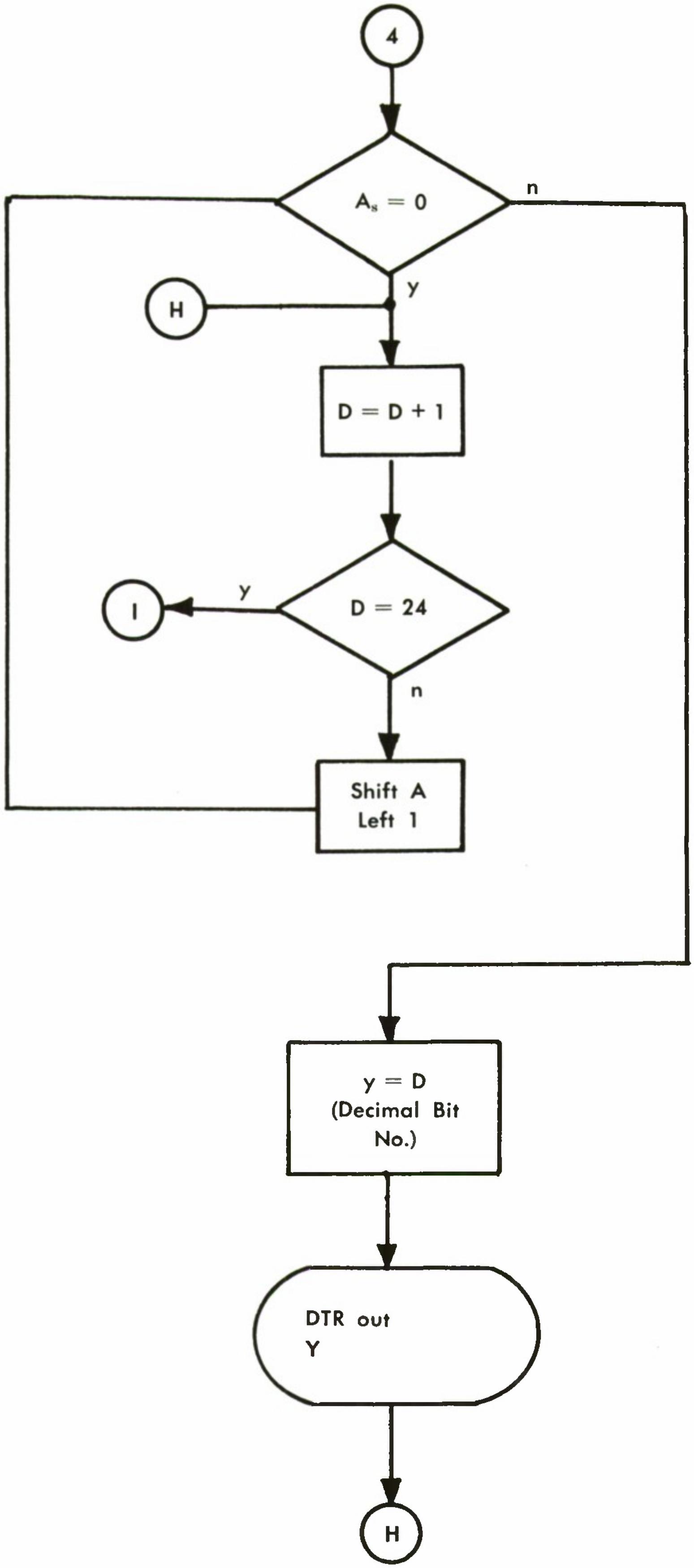


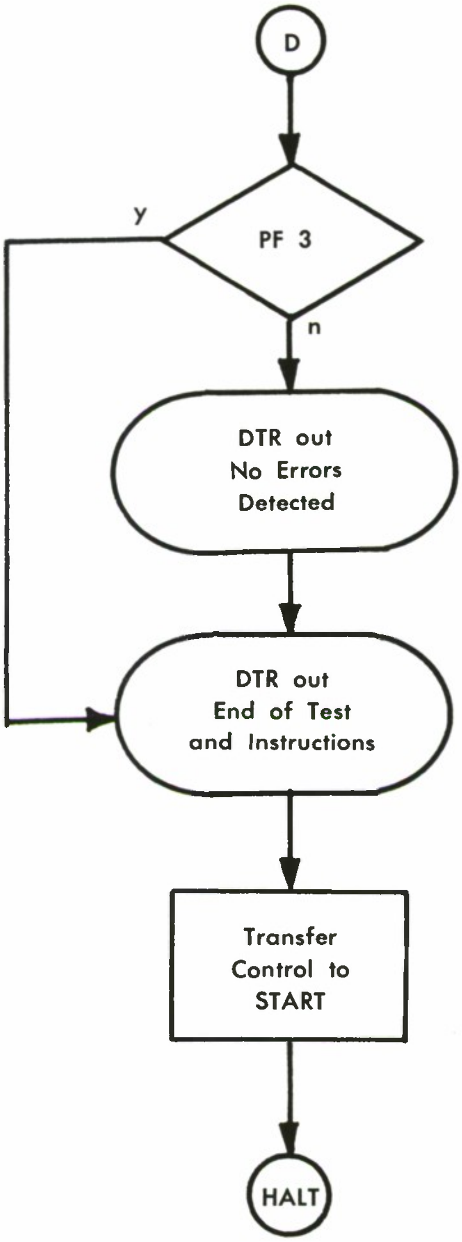

1
B = 0
X
Select Adioce Sequential Channel 60
Lock Com
D = 0
DTR out B to Adioce
D = D + 1
n
D = 8
y
2


2
D = 1
D_x = 0
Select
Adioce
Sequential
Ch. 21
Lock
Com
DTR in from
Adioce to
A
PF 1
y
n
A =
$\overline{A}$
A = 0
ER
h
y
I
D_x =
D_x + 1
D_x = 3
n
y
D = D + 1
3


3
PF 1
y
D
n
PF 1 = 1
B = All ones
X


ER
DTR out DSI
Group Number
DTR out
Error
Message
D = 0
PF 3 = 1
4


4
$A_s = 0$
n
y
H
D = D + 1
D = 24
y
I
n
Shift A
Left 1
y = D
(Decimal Bit
No.)
DTR out
Y
H


D
PF 3
y
n
DTR out
No Errors
Detected
DTR out
End of Test
and Instructions
Transfer
Control to
START
HALT

```
                          LDR      .     DISCRETE I/O TEST

                          LDR      .     15 FEBRUARY 1965

                          LDR

         *                LOCO 70100

  70100* 02704604         CTS 7 Q  .     TURN OFF ALL TOGGLES
                          CPL 0 D  .     D = 0

  70101* 37321602         TCT SW 2 .     LOOP UNTIL OUTPUT MODE
                          FTR 2    .     IS SELECTED

  70102* 35311476         TCF SW 1
                          BTR 1

  70103* 07500000         CLD 0 50 .     D = 50 FOR TYPE OPTION
                          NOP

  70104* 26735543         LDI P C
                          ADL D C

  70105* 00000400         0000
                          0400

  70106* 21034573         STW 0 C  .     ADDRESS OF SELECTED
                          EXC P C  .     OUTPUT ROUTINE TO WSO

  70107* 03201000         0320
                          1000     .     CONTROL WORD  FORMAT 1

  70110* 37361605         TCT SW 6
                          FTR 5    .     TABLE NOT DESIRED

  70111* 35351476         TCF SW 5
                          BTR 1

  70112* 23034573         LDW 0 C  .     TABLE IS DESIRED
                          EXC P C

  70113* 37301032         3730     .     CONTROL WORD
                          1032     .     FORMAT 2

  70114* 23034573         LDW 0 C
                          EXC P C

  70115* 26101425         2610
                          1425

  70116* 46020000         CPL 0 B  .     B = 0
                          NOP

  70117* 26731233         LDI P C
                          SEL C C  .     SELECT ADIOCE

  70120* 32002060         3200     .     SEQUENTIAL
                          2060     .     CHANNEL 60

  70121* 65614604         COM 6 A  .     LOCK COM TO 01
                          CPL 0 D
```

```
70122* 10625244     DTR 6 B   .   DTR TO ADIOCE
                    CIX D D

70123* 31071476     TMF 0 7   .   D EXP = 10??
                    BTR 1     .   NO

70124* 44042673     CIL 0 D   .   YES - SET D TO 1
                    LDI P C

70125* 32002021     3200      .   SEQUENTIAL
                    2021      .   CHANNEL 21

70126* 12330000     SEL C C   .   SELECT ADIOCE
                    NOP

70127* 65611051     COM 6 A   .   LOCK COM TO 01
                    DTR 5 A   .   DTR FROM ADIOCE

70130* 37016311     TCT PF 1  .   PF1 ON??
                    CCL A A   .   YES - COMPLEMENT INPUT WORD

70131* 30171605     TNZ A SXF .   A = 0??
                    FTR 5     .   NO - INCORRECT RESPONSE

70132* 52443137     CIX D D   .   YES
                    TMF 3 7   .   D EXP = 3??

70133* 14734444     BTR 4     .   NO
                    CIL D D   .   D = D + 1

70134* 37011645     TCT PF 1  .   YES - PF1 ON??
                    FTR 37    .   IF SO, FINISHED

70135* 36016302     STT PF 1  .   IF NOT, SET PF1 ON
                    CCL 0 B   .   B = ALL ONES

70136* 14600000     BTR 15
                    NOP

70137* 21142121     STW 1 D   .   ERROR ROUTINE
                    STW 2 A   .   SAVE D AND A

70140* 26734143     LDI P C
                    ADF D C

70141* 60606000     6060
                    6000

70142* 26752553     LDI P L
                    STM L C

70143* 00001716     0000      .   ADDRESS FOR STORAGE
                    1716      .   OF DSI GROUP NUMBER

70144* 23034573     LDW 0 C
                    EXC P C

70145* 01101706     0110      .   CONTROL WORD
                    1706      .   FORMAT 3

70146* 37011603     TCT PF 1
                    FTR 3
```

```
70147* 23034573     LDW 0 C
                    EXC P C

70150* 01701717     0170          .    CONTROL WORD
                    1717          .    FORMAT 4

70151* 16020000     FTR 2
                    NOP

70152* 23034573     LDW 0 C
                    EXC P C

70153* 01701736     0170          .    CONTROL WORD
                    1736          .    FORMAT 5

70154* 46043603     CPL @ D       .    D = 0
                    STT PF 3      .    PF3 INDICATES ERROR HAS OCCURRED

70155* 23213014     LDW 2 A
                    TNZ A S       .    A SIGN ≠ 0??

70156* 16070000     FTR 7         .    YES - THIS BIT IN ERROR
                    NOP

70157* 44442673     CIL D D
                    LDI P C

70160* 77777750     7777          .    - 24.0
                    7750

70161* 55433234     ADL D C       .    C = D - 24
                    TZO C S       .    IS C POSITIVE??

70162* 23141447     LDW 1 D       .    YES - FINISHED
                    BTR 24

70163* 23210501     LDW 2 A       .    NO
                    LRC 1

70164* 66312121     SSL LOL A
                    STW 2 A       .    SHIFT WS2 LEFT 1

70165* 14670000     BTR 8
                    NOP

70166* 21344642     STW 3 D       .    TYPE/PRINT ROUTINE
                    CPL D B       .    BIT NUMBER TO B

70167* 46012673     CPL @ A       .    A = 0
                    LDI P C

70170* 77777766     7777          .     - 12
                    7766

70171* 05271731     LRC 23        .    N = 23
                    DVS C A       .    GET DECIMAL BIT NUMBER

70172* 26736722     LDI P C
                    SL6 B B

70173* 60000052     6000
```

```
                      0052

70174* 67226423       SL6 B B
                      LOR B C

70175* 67116413       SL6 A A
                      LOR A C

70176* 21430000       STW 4 C    .    OUTPUT WORD TO WS4
                      NOP

70177* 23034573       LDW 0 C
                      EXC P C

70200* 00100174       0010       .    WS4 OCTAL ADDRESS
                      0174       .    AND NO. WORDS

70201* 23341455       LDW 3 D
                      BTR 18

70202* 37031602       TCT PF 3   .    PF3 ON??
                      FTR 2      .    YES

70203* 23034573       LDW 0 C    .    NO
                      EXC P C

70204* 00701755       0070       .    CONTROL WORD
                      1755       .    FORMAT 6

70205* 23034573       LDW 0 C
                      EXC P C

70206* 01201764       0120       .    CONTROL WORD
                      1764       .    FORMAT 7

70207* 27770100       LDM P P    .    RETURN TO START
                      HLT        .    AND HALT

70210* 00070100       0007
                      0100

                      LDR

                      LDR        .    END DISCRETE I/O TEST

     * 00070100       ENDO 70100
```

DISCRETE I/O TEST

IF OUTPUT OF DISCRETE I/O CONNECTIONS IS DESIRED, HIT SW5;
IF NOT, HIT SW6.

DISCRETE I/O CONNECTIONS

DSI		DSO		DSI		DSO		DSI		DSO	
GRP.	BIT	GRP.	BIT	GRP.	BIT	GRP.	BIT	GRP.	BIT	GRP.	BIT
1	0	1	0	2	0	3	4	3	0	5	8
1	1	1	1	2	1	3	5	3	1	5	9
1	2	1	2	2	2	3	6	3	2	6	0
1	3	1	3	2	3	3	7	3	3	6	1
1	4	1	4	2	4	3	8	3	4	6	2
1	5	1	5	2	5	3	9	3	5	6	3
1	6	1	6	2	6	4	0	3	6	6	4
1	7	1	7	2	7	4	1	3	7	6	5
1	8	1	8	2	8	4	2	3	8	6	6
1	9	1	9	2	9	4	3	3	9	6	7
1	10	2	0	2	10	4	4	3	10	6	8
1	11	2	1	2	11	4	5	3	11	6	9
1	12	2	2	2	12	4	6	3	12	7	0
1	13	2	3	2	13	4	7	3	13	7	1
1	14	2	4	2	14	4	8	3	14	7	2
1	15	2	5	2	15	4	9	3	15	7	3
1	16	2	6	2	16	5	0	3	16	7	4
1	17	2	7	2	17	5	1	3	17	7	5
1	18	2	8	2	18	5	2	3	18	7	6
1	19	2	9	2	19	5	3	3	19	7	7
1	20	3	0	2	20	5	4	3	20	7	8
1	21	3	1	2	21	5	5	3	21	7	9
1	22	3	2	2	22	5	6	3	22	8	0
1	23	3	3	2	23	5	7	3	23	8	1

* NO ERRORS DETECTED*

END OF TEST - HIT COMP. TO RESTART

PB-440 PROGRAM ABSTRACT

PROGRAM TITLE:	DISCRETE OUTPUT DYNAMIC TEST
PROGRAMMER:	P. A. KNOOP
DATE:	15 February 1965
ID:	None
FUNCTION:	The purpose of this program is to test the response time of the discrete output channels in the PB-440 ADIOCE system.
TECHNIQUE:	This program performs either of two tests: (1) Given the time base T, it outputs to all DSO groups alternating 1's and 0's and, upon request, types out an error message. (2) Given the DSO group number, the output word, and the time base T, it outputs the word alternately with its complement to the specified channel and, upon request, types out an error message.
LOADING PROCEDURE:	Load with Binary Loader I. This program is not relocatable.
OPERATING PROCEDURES & LINKAGE REQUIRED:	The program will type instructions to the operator as the test proceeds. Prior to execution, the necessary DSO linkage must be established for those groups being tested.

PROGRAM STORAGE:

Program Segment	*Octal Locs.*	*Total*
Micro Multiply	70040-70051	12
Main Program	70100-70256	157
Micro Type	450-461	12
Decimal Input	650-777	130
		333_8

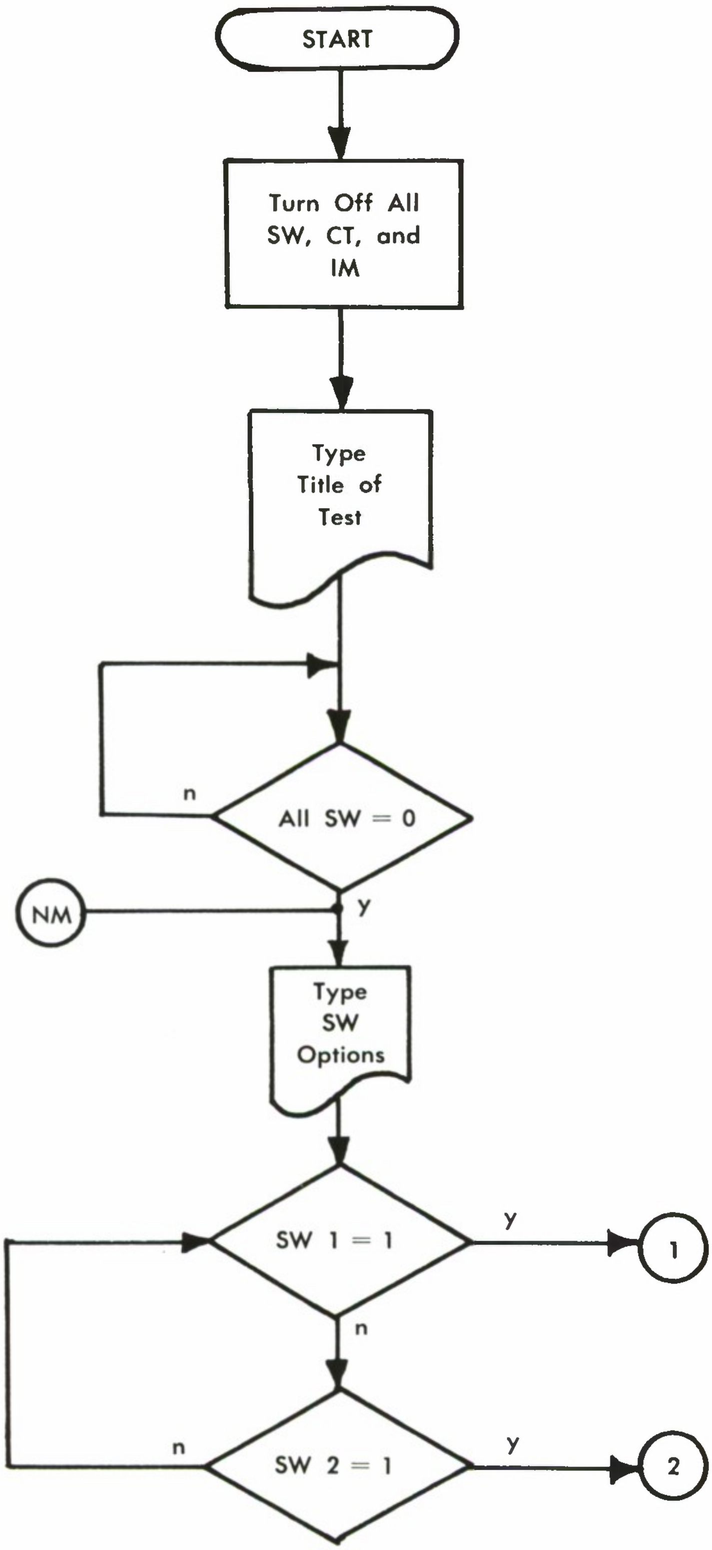
INTERMEDIATE STORAGE:

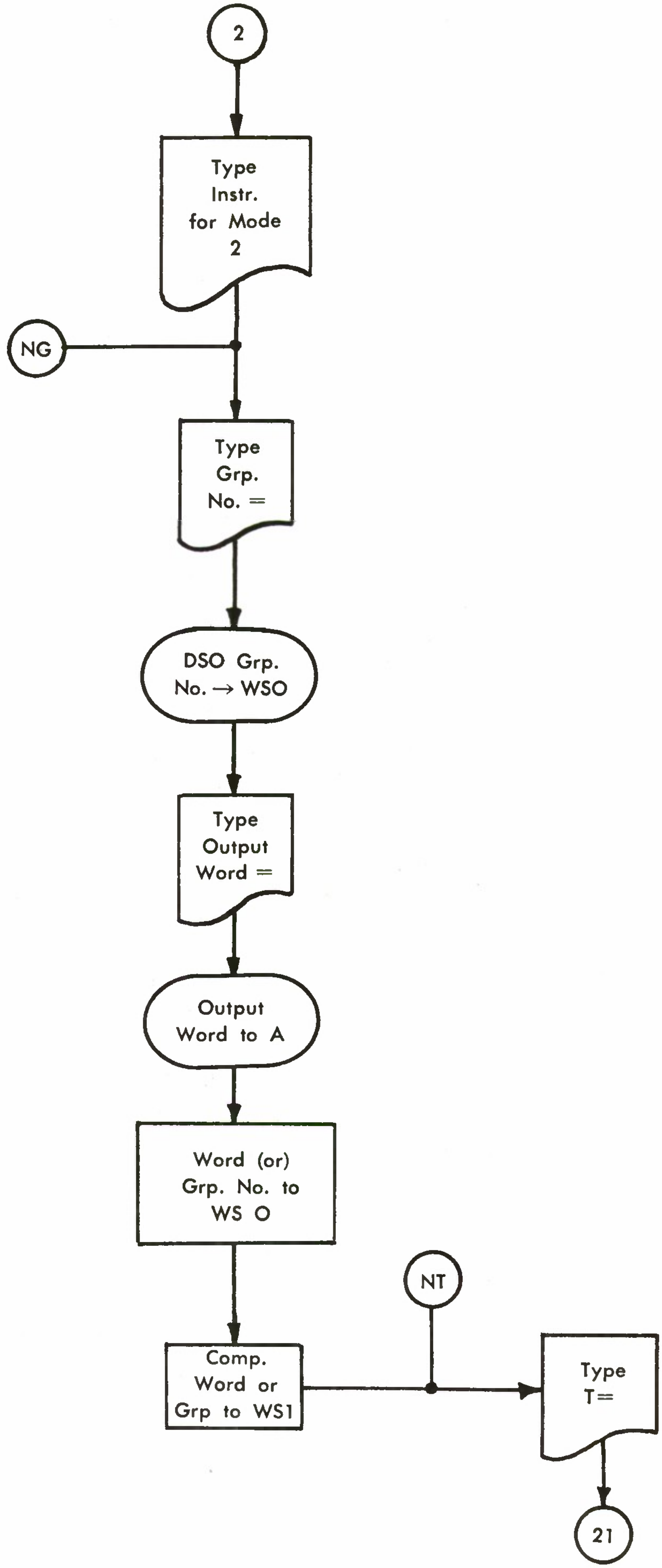
Working Storage:
- 0 Group address and output word
- 1 Group address and complement output word
- 3 Time
- 5 Timing counter
- 6 Address of Micro Type routine

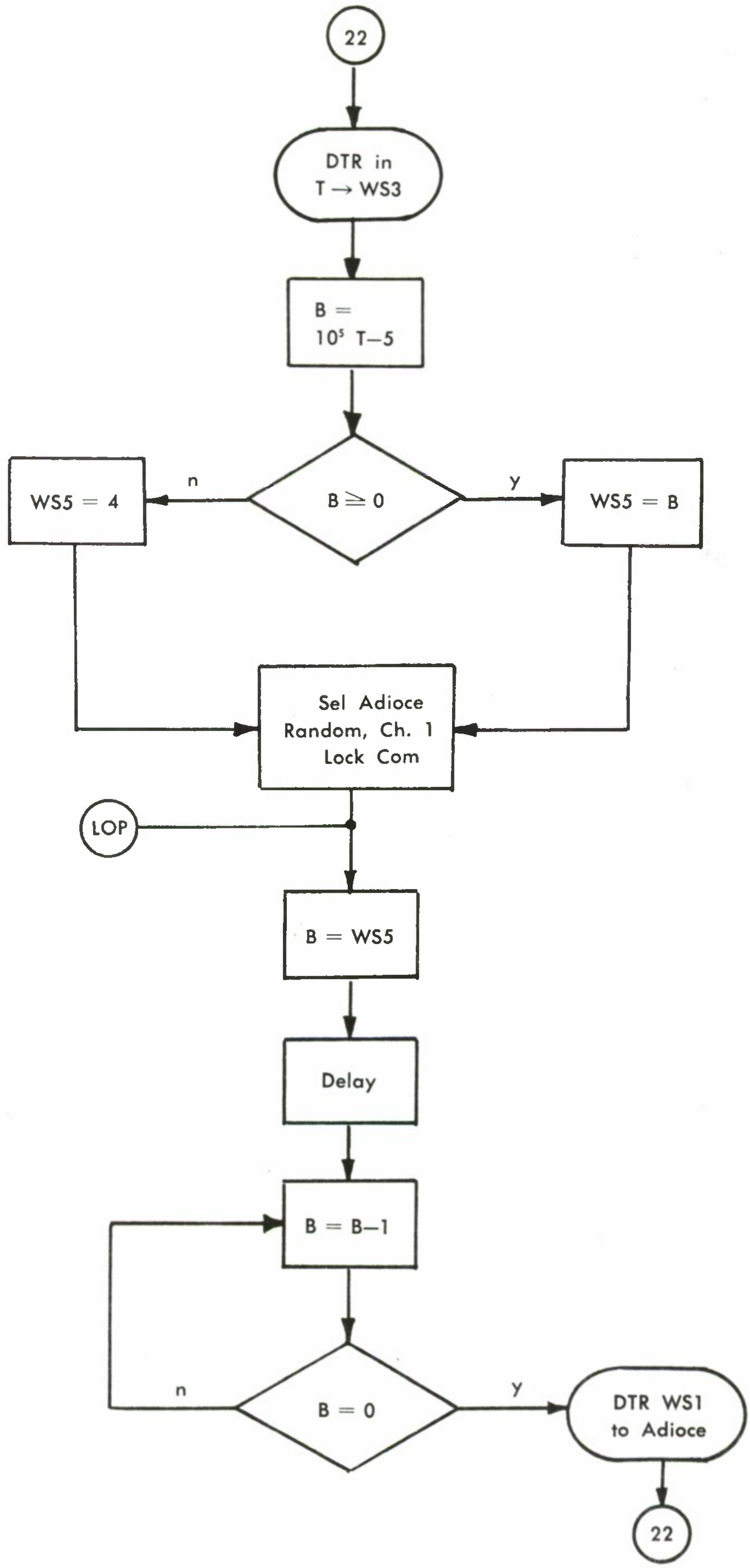
SPECIAL STORAGE:	None used
EXECUTION TIME:	Not applicable
REGISTERS:	All registers used

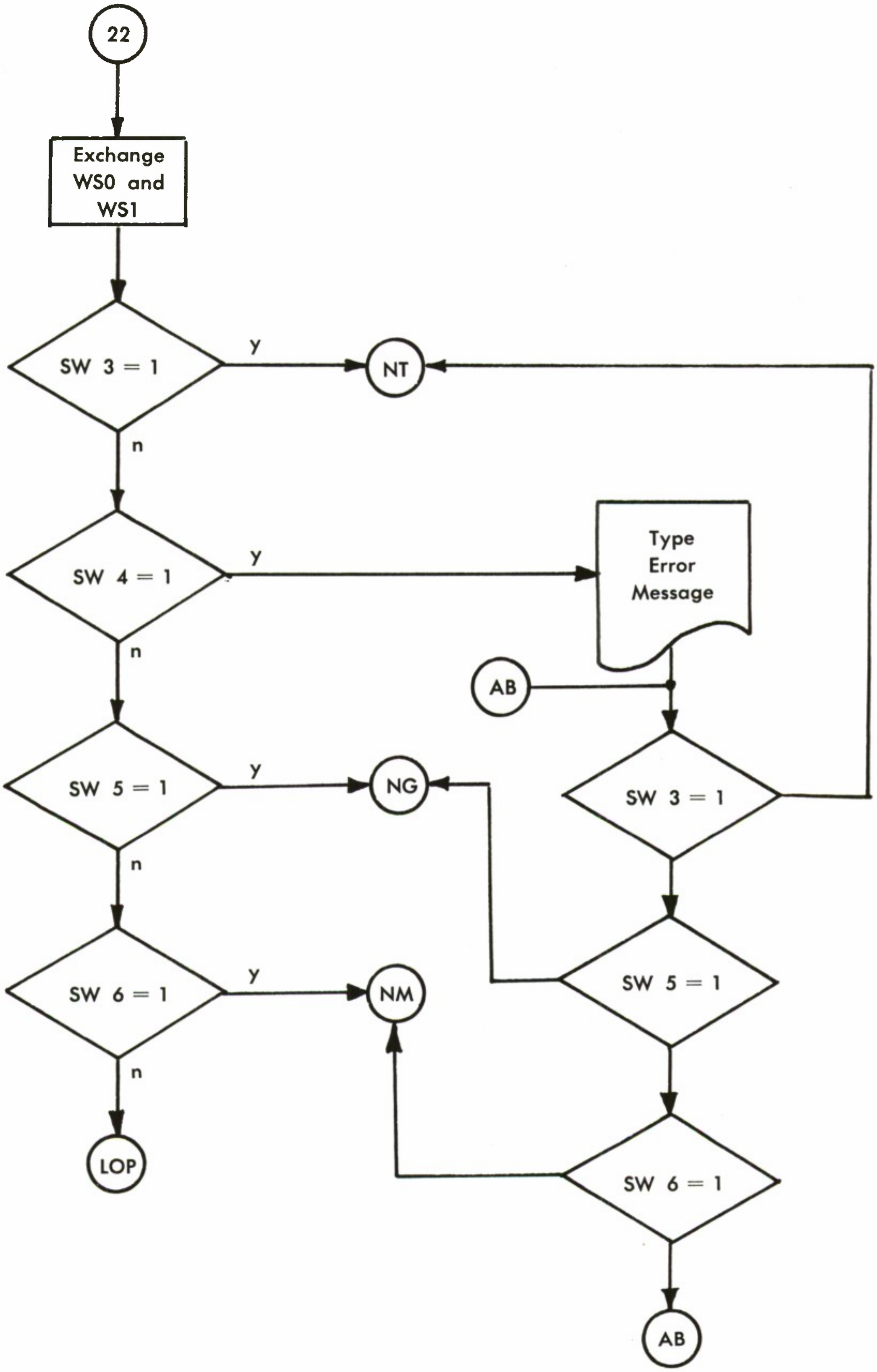
SENSE SWITCHES:	1 Mode 1: All DSO Groups 2 Mode 2: Single DSO Group 3 New time 4 Channel malfunction 5 New group number and output word 6 New mode-selection
PROGRAM FLAGS:	None used
I/O DEVICES:	Typewriter ADIOCE Oscilloscope
PROGRAM HALTS:	None

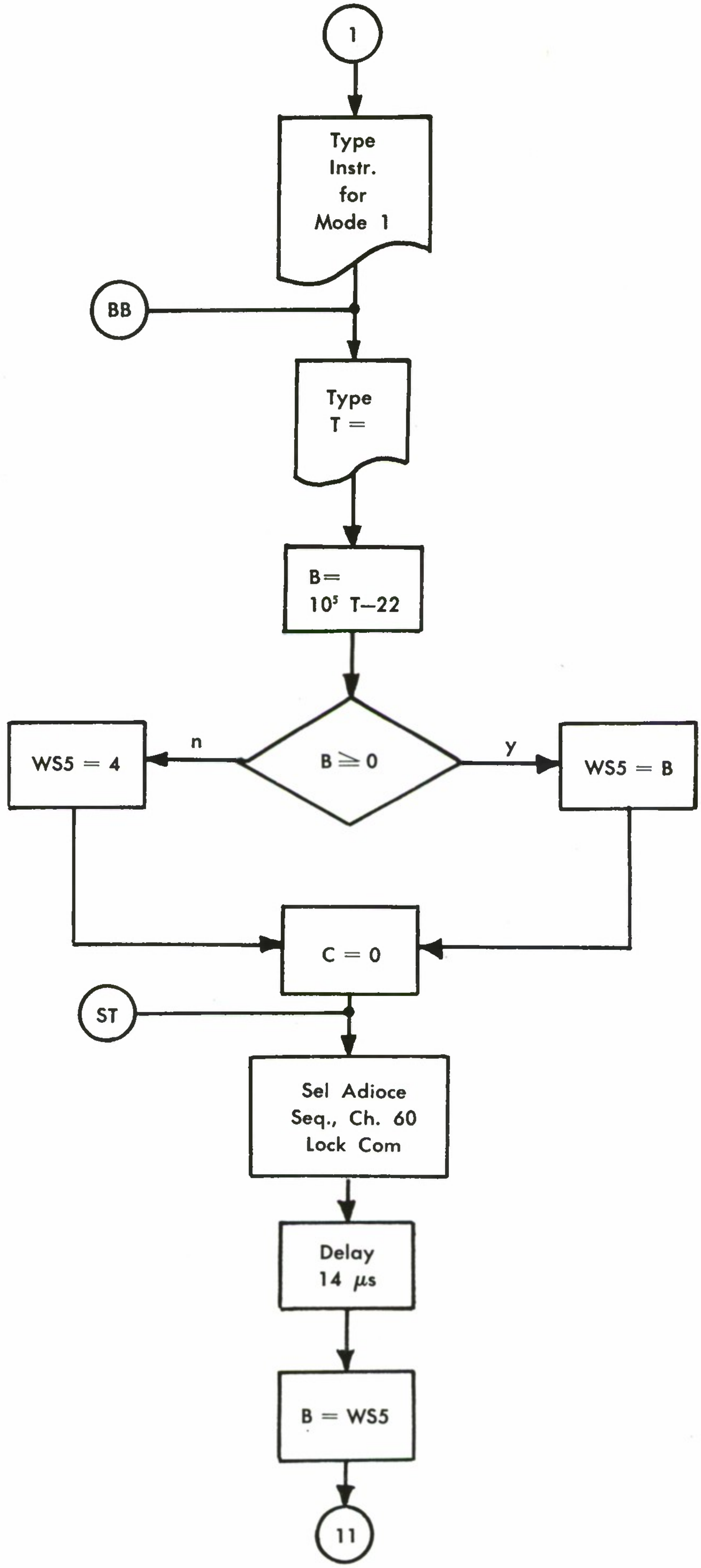
DISCRETE OUTPUT DYNAMIC TEST

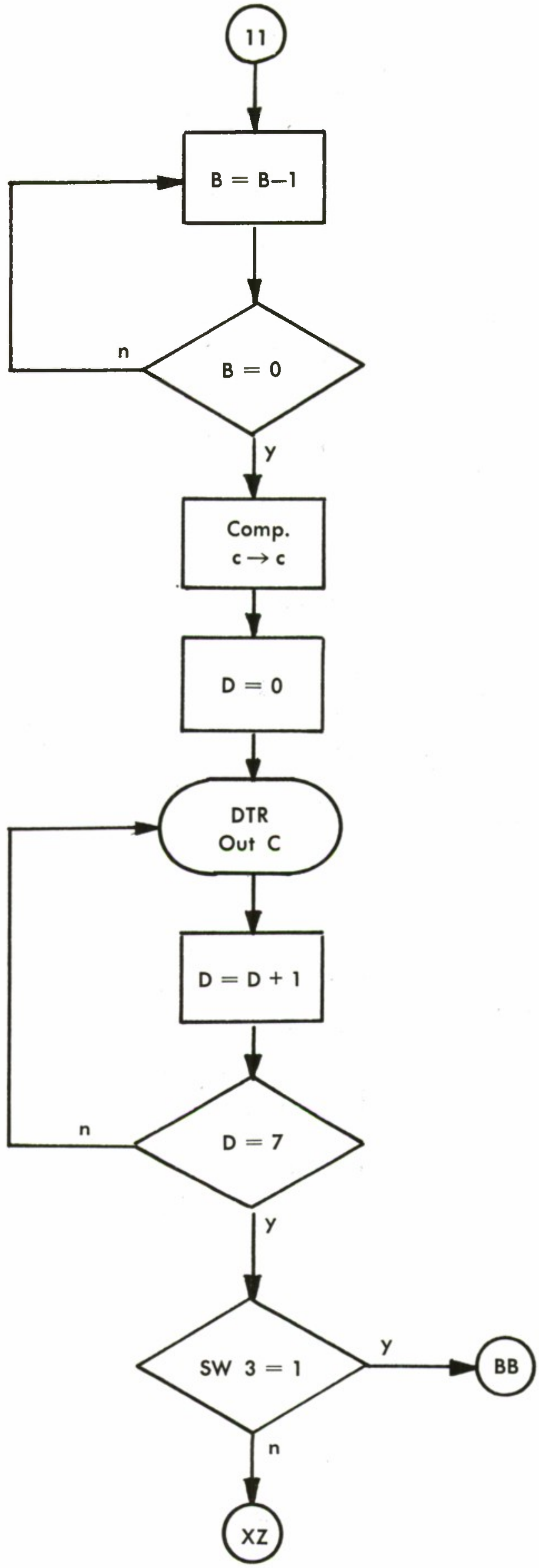


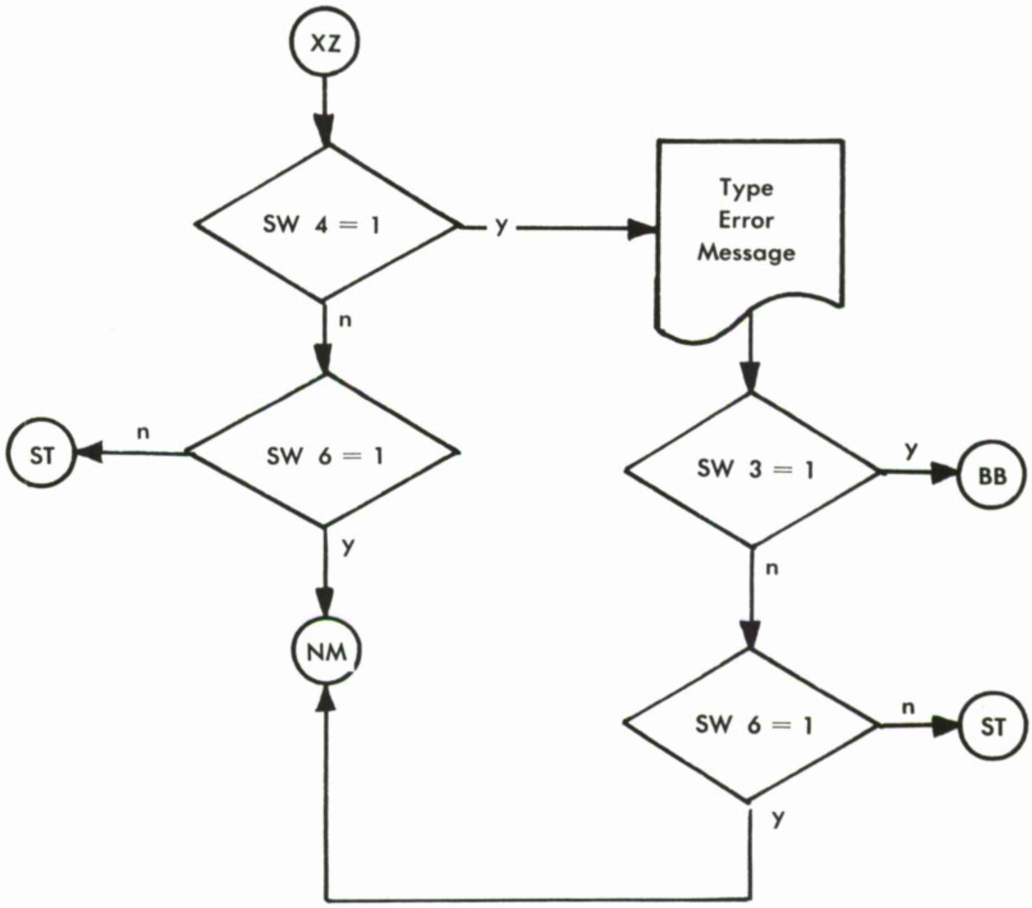

2
Type
Instr.
for Mode
2
NG
Type
Grp.
No. =
DSO Grp.
No. → WSO
Type
Output
Word =
Output
Word to A
Word (or)
Grp. No. to
WS O
NT
Comp.
Word or
Grp to WS1
Type
T=
21


22
DTR in
T → WS3
B =
10⁵ T–5
B ≧ 0
n
y
WS5 = 4
WS5 = B
Sel Adioce
Random, Ch. 1
Lock Com
LOP
B = WS5
Delay
B = B–1
B = 0
n
y
DTR WS1
to Adioce
22


22
Exchange WS0 and WS1
SW 3 = 1
y
n
NT
SW 4 = 1
y
n
Type Error Message
AB
SW 5 = 1
y
n
NG
SW 3 = 1
SW 6 = 1
y
n
NM
SW 5 = 1
LOP
SW 6 = 1
AB


1
Type
Instr.
for
Mode 1
BB
Type
T =
B=
10⁵ T—22
n
B ≥ 0
y
WS5 = 4
WS5 = B
C = 0
ST
Sel Adioce
Seq., Ch. 60
Lock Com
Delay
14 μs
B = WS5
11


11
B = B–1
B = 0
n
y
Comp.
c → c
D = 0
DTR
Out C
D = D + 1
D = 7
n
y
SW 3 = 1
y
BB
n
XZ


XZ
SW 4 = 1
y
Type
Error
Message
n
ST
n
SW 6 = 1
SW 3 = 1
y
BB
y
n
NM
SW 6 = 1
n
ST
y

```
                    LDR         .      DSO ON-OFF RESPONSE
                    LDR         .      15 FEBRUARY 1965
                    LDR
       *            LOC O 70100
70100* 02702673     CTS 7 O     .      TURN OFF ALL TOGGLES
                    LDI P C
70101* 00000450     0000        .      ADDRESS OF
                    0450        .      MICRO TYPE ROUTINE
70102* 21634573     STW 6 C
                    EXC P C
70103* 02401000     0240        .      CONTROL WORD
                    1000        .      FORMAT 1
70104* 35301477     TCF SW X
                    BTR     0   .      SW OFF.
70105* 23634573     LDW 6 C
                    EXC P C
70106* 04201024     0420        .      CONTROL WORD
                    1024        .      FORMAT 2
70107* 37311671     TCT SW 1    .      SW1 ON?
                    FTR    57   .      YES - TO MODE 1
70110* 35321476     TCF SW 2    .      SW2 ON?
                    BTR     1   .      NO - LOOP
70111* 23634573     LDW 6 C     .      MODE 2 TEST
                    EXC P C
70112* 15201066     1520        .      CONTROL WORD
                    1066        .      FORMAT 3
70113* 70751601     CPF P L
                    FTR     1   .      JUMP TO OCTAL TYPE-IN
70114* 21011613     STW 0 A     .      GRP. ADDRESS TO WSO
                    FTR    11   .      UNCONDITIONAL TRANSFER
70115* 26731233     LDI P C     .      OCTAL TYPE-IN
                    SEL C C     .      SELECT TYPEWRITER
70116* 02006100     0200        .      FOR INPUT
                    6100
70117* 65635711     COM 6 C     .      LOCK COM TO 03
                    XOR A A     .      CLEAR A
70120* 07617043     CLD O 61
                    CPF D C     .      C = 61 (SLASH)
70121* 07120503     CLD O 12    .      D = 12 (BACKSPACE)
                    LRC     3   .      N = 3
```

```
70122* 10120000     BTR 1 B
                    NOP

70123* 57243241     XOR B D
                    TZO D F    .     BACKSPACE?

70124* 70576501     CPF L P    .     YES - RETURN TO PROGRAM
                    COM 0      . A*     UNLOCK COM

70125* 66315723     SSL LOL A  .     SHIFT A LEFT 3
                    XOR B C

70126* 32311470     TZO C F    .     SLASH?
                    BTR   7    .     YES - BEGIN OVER

70127* 64211470     LOR B A    .     PACK WORD
                    BTR   7

70130* 23634573     LDW 6 C
                    EXC P C

70131* 01601240     0160       .     CONTROL WORD
                    1240       .     FORMAT 4

70132* 70751462     CPF P L
                    BTR  13

70133* 23026412     LDW 0 B
                    LOR A B    .     OUTPUT WORD TO B

70134* 63110000     CCL A A
                    NOP

70135* 23035613     LDW 0 C
                    AND A C

70136* 21022113     STW 0 B
                    STW 1 C    .     SAVE OUTPUT WORDS

70137* 23634573     LDW 6 C
                    EXC P C

70140* 01101256     0110       .     CONTROL WORD
                    1256       .     FORMAT 5

70141* 05022675     LRC    2   .     SCALE = 2
                    LDI P L

70142* 00000650     0000       .     ADDRESS OF
                    0650       .     DECIMAL TYPE-IN

70143* 45750000     EXC P L
                    NOP

70144* 21322673     STW 3 B
                    LDI P C

70145* 30324000     3032
                    4000

70146* 46750440     CPL P L
                    CLP 0 40   .     JUMP TO MPY ROUTINE
```

```
70147* 26745514    LDI P D
                   ADL A D

70150* 77777660    7777
                   7660

70151* 32441601    TZ0 D S
                   FTR 1

70152* 07041601    CLD 4
                   FTR 1

70153* 05046674    LRC 4
                   SSL R0L D

70154* 21540000    STW 5 D
                   N0P

70155* 00000000    N0P
                   N0P

70156* 00000000    N0P
                   N0P

70157* 00000000    N0P
                   N0P

70160* 26731233    LDI P C
                   SEL C C     .    SELECT ADI0CE

70161* 32003000    3200        .    SELECT W0RD
                   3000        .    RAND0M: CH. 01

70162* 65610000    C0M 6 A     .    L0CK C0M T0 01
                   N0P

70163* 23522352    LDW 5 B     .    WS5 T0 B
                   LDW 5 B     .    KILL TIME

70164* 54223027    CDL B B     .    B = B-1
                   TNZ B SXF   .    B = 0?

70165* 14760000    BTR      1  .    N0 - L00P
                   N0P

70166* 23111021    LDW 1 A
                   DTR 2 A     .    DTR 0UT WS1

70167* 23042101    LDW 0 D
                   STW 0 A

70170* 21143733    STW 1 D     .    EXCHANGE WS0 AND WS1
                   TCT SW 3    .    SW3 = 0?

70171* 14450000    BTR    26   .    N0 - GET NEW T
                   N0P

70172* 37341607    TCT SW 4    .    SW4 = 0?
                   FTR    7    .    N0 - CHANNEL MALFUNCTI0N

70173* 37351602    TCT SW 5    .    SW5 = 0?
```

```
                  FTR    2  .     NØ - RESELECT GRP. AND D. Ø.

70174* 37361410   TCT SW 6  .     SW6 = 0?
                  BTR   55  .     NØ - RESELECT MØDE

70175* 14650000   BTR   10  .     YES - SAME TEST
                  NØP

70176* 23634573   LDW 6 C
                  EXC P C

70177* 01501223   0150      .     CØNTRØL WØRD
                  1223      .     FØRMAT 3A.

70200* 14120000   BTR   53  .     GET NEW GRP. ADD.
                  NØP

70201* 16060000   FTR    6  .     INTERMEDIATE JUMP
                  NØP       .     TØ MØDE 1

70202* 23634573   LDW 6 C   .     ERRØR RØUTINE
                  EXC P C

70203* 00601267   0060      .     CØNTRØL WØRD
                  1267      .     FØRMAT 6

70204* 37331464   TCT SW 3  .     NEW T
                  BTR   11

70205* 37351470   TCT SW 5  .     NEW GRP. AND DØ. NØ.
                  BTR    7

70206* 35361475   TCF SW 6
                  BTR    2

70207* 14651410   BTR   10
                  BTR   55

70210* 23634573   LDW 6 C   .     MØDE 1 TEST
                  EXC P C

70211* 07701275   0770      .     CØNTRØL WØRD
                  1275      .     FØRMAT 7

70212* 23634573   LDW 6 C
                  EXC P C

70213* 01101256   0110      .     CØNTRØL WØRD
                  1256      .     FØRMAT 5

70214* 05020000   LRC    2  .     SCALE = 2
                  NØP

70215* 26754575   LDI P L
                  EXC P L

70216* 00000650   0000      .     ADDRESS ØF
                  0650      .     DECIMAL TYPE-IN

70217* 21322673   STW 3 B   .     T TØ WS3
```

```
                         LDI P C

70220* 30324000          3032
                         4000

70221* 46750440          CPL P L
                         CLP Ø 40   .     TØ MPY RØUTINE

70222* 26745514          LDI P D
                         ADL A D

70223* 77777340          7777
                         7340

70224* 32441601          TZØ D S
                         FTR 1

70225* 07041601          CLD 4
                         FTR 1

70226* 05046674          LRC 4
                         SSL RØL D

70227* 21540000          STW 5 D
                         NØP

70230* 00000000          NØP
                         NØP

70231* 00000000          NØP
                         NØP

70232* 00000000          NØP
                         NØP

70233* 46030000          CPL Ø C    .     C = 0
                         NØP

70234* 26740000          LDI P D
                         NØP

70235* 32002060          3200       .     SELECT WØRD
                         2060       .     SEQUENTIAL - 60

70236* 05036632          LRC 3
                         SSL LØL B  .     MICRØSECØNDS

70237* 12440000          SEL D D    .     SELECT ADIØCE
                         NØP

70240* 23526561          LDW 5 B    .     WS5 TØ B
                         CØM 6 A    .     LØCK CØM TØ 01

70241* 54223027          CDL 8 B    .     B = B-1
                         TNZ B SXF  .     B = 0?

70242* 14760000          BTR 1
                         NØP

70243* 63334604          CCL C C    .     C = CØMP. (C)
                         CPL Ø D    .     D = 0
```

```
70244* 10635244      DTR 6 C    .    DTR ØUT C
                     CIX D D

70245* 31771476      TMF 7 7
                     BTR   1

70246* 37331443      TCT SW 3   .    SW 3 = 1?
                     BTR    28  .    YES - GET NEW T

70247* 37341602      TCT SW 4   .    SW4 = 1?
                     FTR    2   .    YES - CHANNEL MALFUNCTIØN

70250* 35361463      TCF SW 6   .    SW 6 = 1?
                     BTR    12  .    NØ - SAME TEST

70251* 14350000      BTR    34  .    YES - RESELECT MØDE
                     NØP

70252* 23634573      LDW 6 C    .    ERRØR RØUTINE
                     EXC P C

70253* 00601267      0060       .    CØNTRØL WØRD
                     1267       .    FØRMAT 6

70254* 37331435      TCT SW 3   .    NEW T
                     BTR    34

70255* 35361476      TCF SW 6   .    NEW MØDE
                     BTR    1

70256* 14300000      BTR    39
                     NØP

                     LDR

                     LDR        .    END DSØ ØN-ØFF RESPØNSE TEST

     * 00070100      END Ø 70100
```

```
DISCRETE  OUTPUT  ON-OFF  RESPONSE  TEST

      TURN OFF ALL SENSE SWITCHES.

      SELECT MODE:

                  SW1    MODE 1 - ALL DISCRETE OUTPUTS
                  SW2    MODE 2 - SINGLE DISCRETE OUTPUT


           MODE 2 SELECTED.
           TYPE IN GROUP ADDRESS AND DISCRETE OUTPUT NUMBER IN OCTAL.
           THEN TYPE T IN SECONDS AND OBSERVE OUTPUT.
           SENSE SWITCH OPTIONS ARE AS FOLLOWS:

                  SW3    NEW T
                  SW4    CHANNEL MALFUNCTION
                  SW5    NEW GROUP AND D/O NUMBER
                  SW6    NEW MODE SELECTION


                          GROUP ADDRESS =   6Ø
                          DISCRETE OUTPUT NUMBER =  7777ØØØØ

                          T =   1.Ø

                          T =   .1     CHANNEL MALFUNCTION
      SELECT MODE:

                  SW1    MODE 1 - ALL DISCRETE OUTPUTS
                  SW2    MODE 2 - SINGLE DISCRETE OUTPUT


           MODE 1 SELECTED.
           TYPE IN T IN SECONDS AND OBSERVE OUTPUT.
           SENSE SWITCH OPTIONS ARE AS FOLLOWS:

                  SW3    NEW T
                  SW4    CHANNEL MALFUNCTION
                  SW6    NEW MODE SELECTION


                          T =   .ØØØ1

                          T =   1.Ø

                          T =   .5
```

PB-440 PROGRAM ABSTRACT

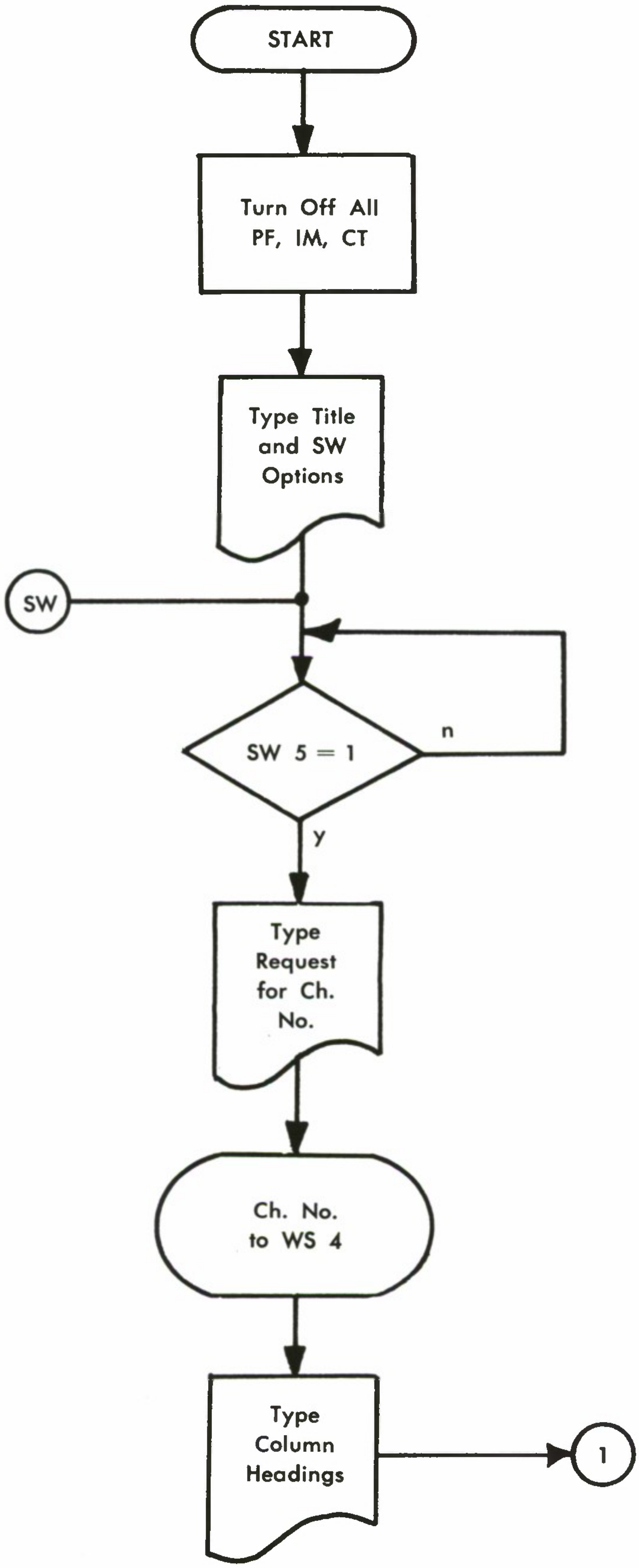
PROGRAM TITLE:	ANALOG OUTPUT ACCURACY TEST
PROGRAMMER:	P. A. KNOOP
DATE:	7 April 1965
ID:	None
FUNCTION:	The purpose of this program, part of the ADIOCE Acceptance Test package, is to test the accuracy of the 8 high-accuracy and 56 low-accuracy digital-to-analog channels in the PB-440 ADIOCE system.
TECHNIQUE:	After the user types in the number of the channel selected for testing, the program types the first correct output number and its true reference voltage. Then, when instructed, the program outputs the digital number over the selected AO channel. Using sense switches and a null volt meter, the user examines the output and may instruct the program to slew the output number up or down until an accurate response is observed. He then instructs the program to print the digital number actually required to obtain the true reference voltage. The test continues for output voltages ranging from plus 10 to minus 10 by decrements of approximately one volt.
LOADING PROCEDURES:	Load with Binary Loader I. This program is not relocatable.
OPERATING PROCEDURES & LINKAGE REQUIRED:	Hardware linkage between the null volt meter and the AO channel being tested must be established prior to execution. The program types out instructions for operation which are self explanatory. The channel number should be typed in octal and terminated with a backspace. If an error is made while typing, striking a slash (/) will permit the user to rebegin.

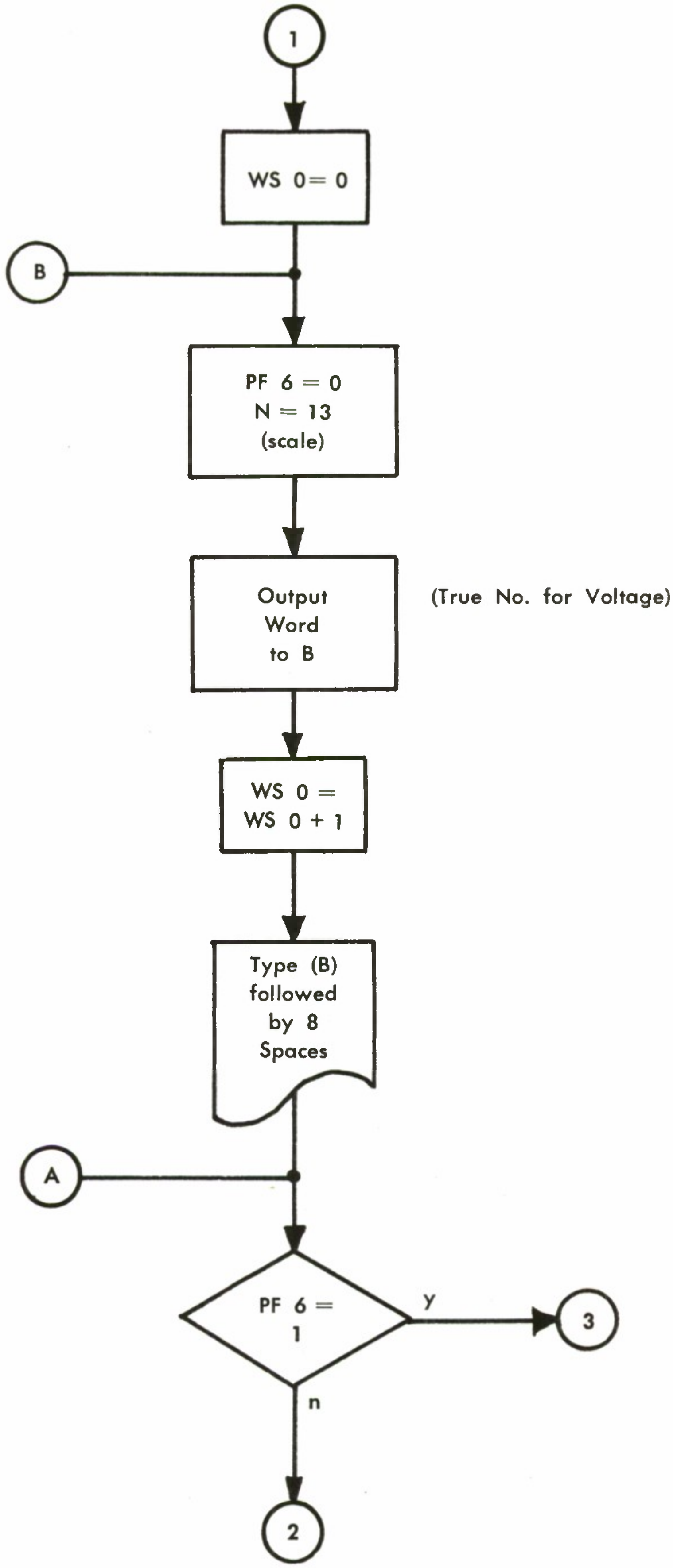
PROGRAM STORAGE:

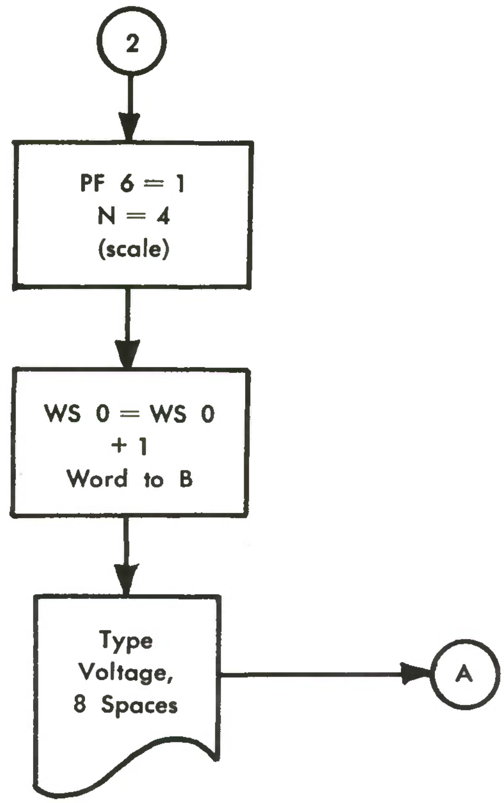
Program Segment	*Octal Locs.*	*Total*
Main Program	70100-70224	125
Output words & ref. voltages	200-251	52
Micro Type	450-461	12
Decimal Out	500-621	122
Comments	1000-1233	234
		567_8

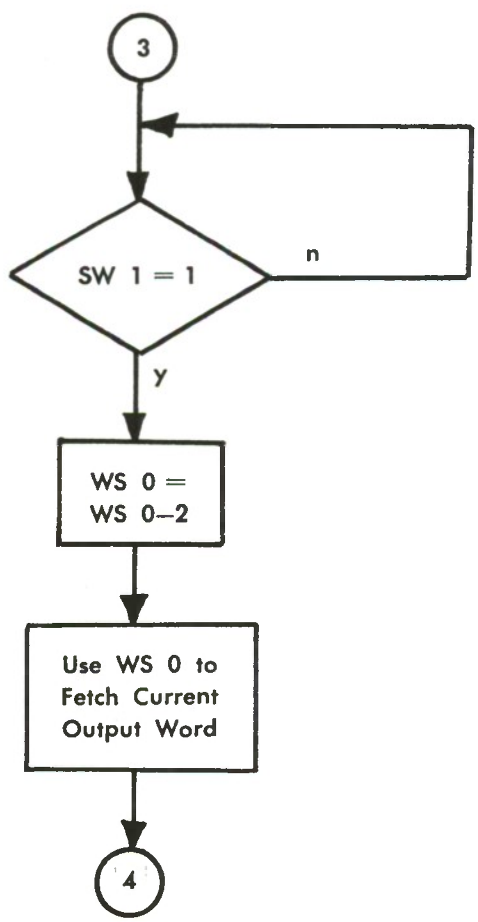
INTERMEDIATE STORAGE:	Working Storage: 0 Storage of channel number 1 Storage of address-counter for fetching current output word and voltage 4 Storage of word and channel to be output to ADIOCE
SPECIAL STORAGE:	200-251 Output words and ref. voltages
EXECUTION TIME:	Not applicable
REGISTERS:	All Used
SENSE SWITCHES:	1 Set when meter has been set to typed voltage; zeroed when ready for next test-point 2 Slew-up 3 Slew-down 4 Set to type required number; zeroed when ready for next point 5 For AO channel number request
PROGRAM FLAGS:	6 on when typing correct number; off when typing true reference voltage; used as program toggle only
I/O DEVICES:	Typewriter ADIOCE Null Volt Meter
PROGRAM HALTS:	None

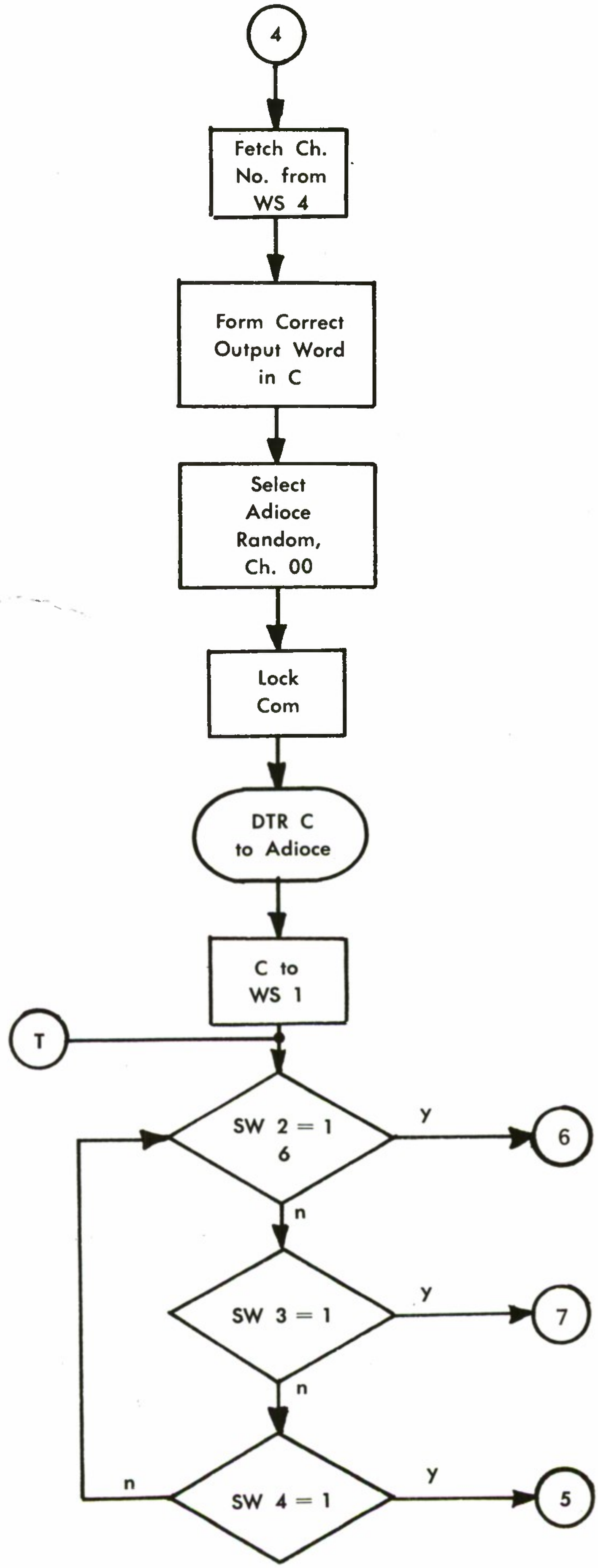
ANALOG OUTPUT ACCURACY TEST

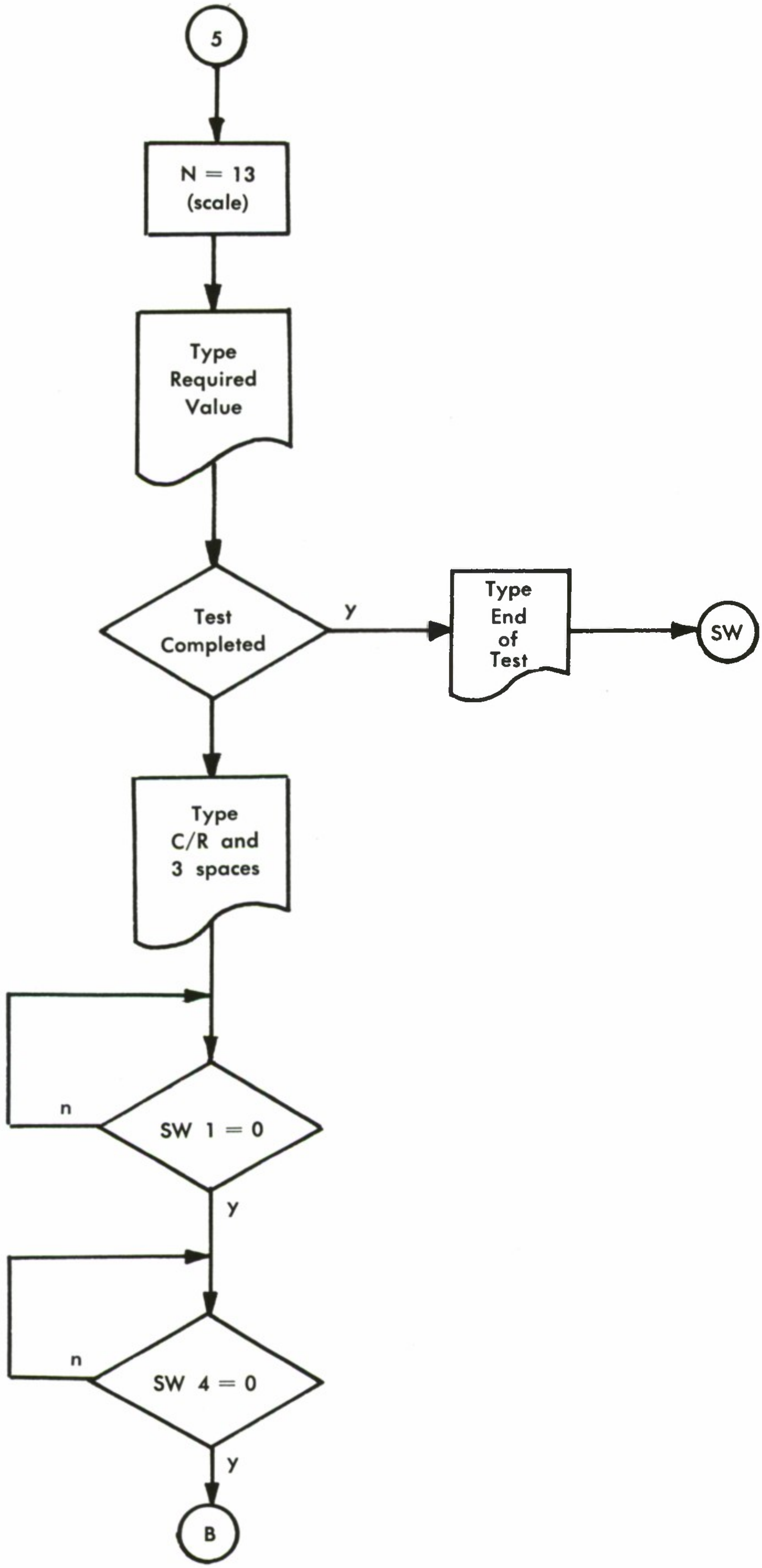


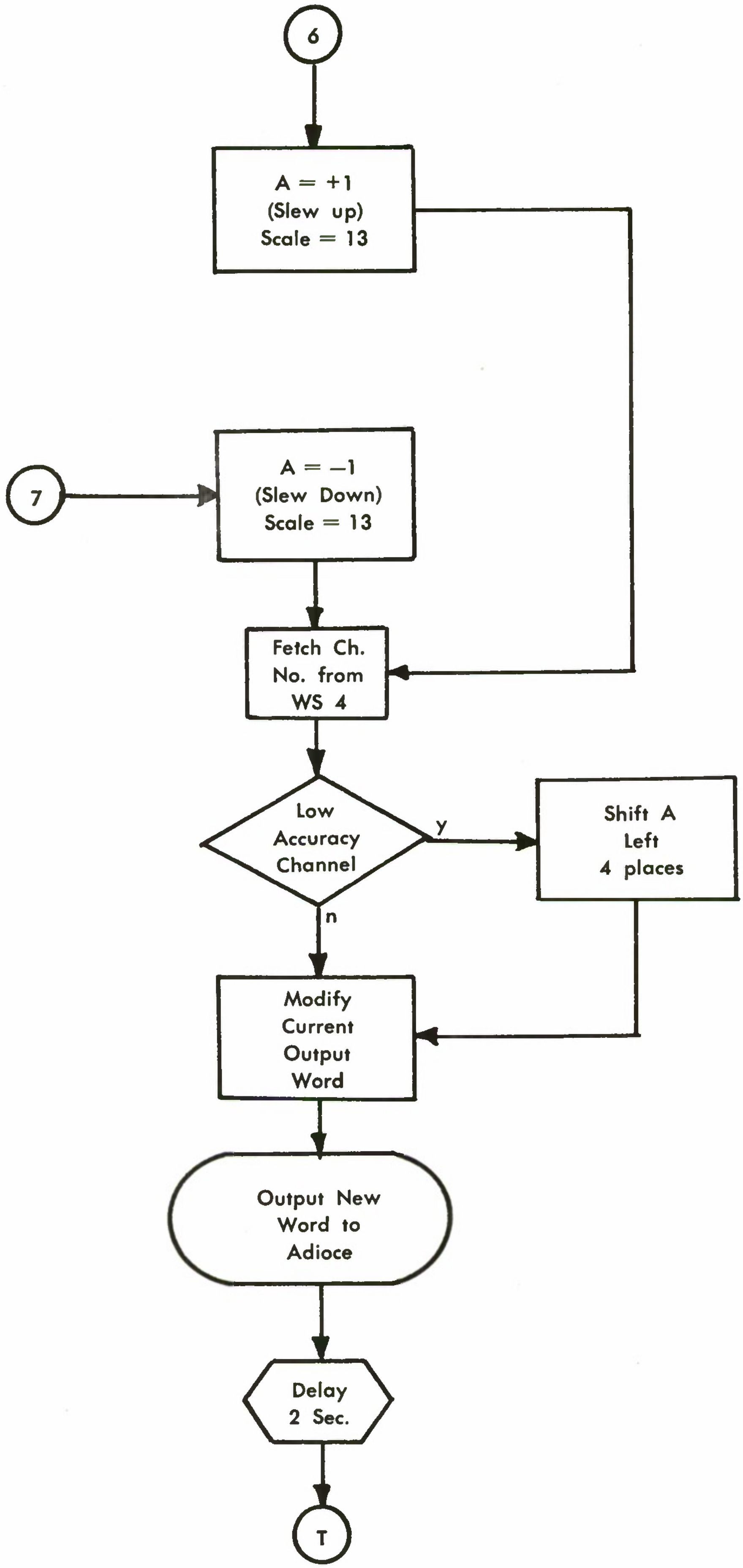

1
WS 0= 0
B
PF 6 = 0
N = 13
(scale)
Output
Word
to B
(True No. for Voltage)
WS 0 =
WS 0 + 1
Type (B)
followed
by 8
Spaces
A
PF 6 =
1
y
3
n
2


2
PF 6 = 1
N = 4
(scale)
WS 0 = WS 0
+ 1
Word to B
Type
Voltage,
8 Spaces
A


3
SW 1 = 1
n
y
WS 0 =
WS 0–2
Use WS 0 to
Fetch Current
Output Word
4


4
Fetch Ch. No. from WS 4
Form Correct Output Word in C
Select Adioce Random, Ch. 00
Lock Com
DTR C to Adioce
C to WS 1
T
SW 2 = 1 6
y
6
n
SW 3 = 1
y
7
n
SW 4 = 1
y
5
n


5
N = 13
(scale)
Type
Required
Value
Test
Completed
y
Type
End
of
Test
SW
Type
C/R and
3 spaces
n
SW 1 = 0
y
n
SW 4 = 0
y
B


6
A = +1
(Slew up)
Scale = 13
7
A = –1
(Slew Down)
Scale = 13
Fetch Ch.
No. from
WS 4
Low
Accuracy
Channel
y
n
Shift A
Left
4 places
Modify
Current
Output
Word
Output New
Word to
Adioce
Delay
2 Sec.
T

```
                        LDR          .     ANALOG OUTPUT ACCURACY TEST

                        LDR          .     7 APRIL 1966

            *           LOC @ 70100

 70100* 02700000        CTS 7 Q      .     TURN OFF ALL PROGRAM FLAGS.
                        NOP          .     INTERRUPT MASKS, AND TOGGLES

 70101* 26734573        LDI P C      .     TYPE TITLE OF TEST AND
                        EXC P C      .     SENSE SWITCH OPTIONS

 70102* 00000450        0000         .     ADDRESS OF MICRO TYPE-OUT
                        0450

 70103* 16001000        1600         .     CONTROL WORD FOR TYPE-OUT
                        1000         .     FORMAT 1

 70104* 35351477        TCF SW 5     .     LOOP UNTIL SW 5 IS ON
                        BTR    0

 70105* 26734573        LDI P C      .     TYPE REQUEST FOR
                        EXC P C      .     CHANNEL NUMBER

 70106* 00000450        0000         .     ADDRESS OF MICRO TYPE-OUT
                        0450

 70107* 01001160        0100         .     CONTROL WORD
                        1160         .     FORMAT 2

 70110* 26731233        LDI P C      .     OCTAL TYPE-IN ROUTINE
                        SEL C C

 70111* 02006100        0200         .     SELECT WORD
                        6100         .     TYPEWRITER INPUT

 70112* 65635711        COM 6 C      .     CHANNEL 3
                        XOR A A      .     CLEAR A

 70113* 07617043        CLD @ 61
                        CPF D C      .     C SET TO 61 - SLASH

 70114* 07120503        CLD @ 12     .     D = 12 (BACKSPACE)
                        LRC    3     .     N = 3

 70115* 10120000        DTR 1 B      .     DTR IN CHARACTER
                        NOP

 70116* 57243241        XOR B D
                        TZO D F      .     WAS CHAR. A BACKSPACE?

 70117* 16032141        FTR    3     .     YES - FINISHED
                        STW 4 A      .     SAVE CH. NO. IN WS 4

 70120* 66315723        SSL LOL A .        NO - PACK CHAR. INTO WORD
                        XOR B C

 70121* 32311470        TZO C F      .     WAS CHAR. A SLASH?
                        BTR 7        .     YES - BEGIN OVER

 70122* 64211470        LOR B A      .     NO
```

```
                          BTR 7

70123* 26734573           LDI P C     .    TYPE COLUMN HEADINGS
                          EXC P C

70124* 00000450           0000        .    ADDRESS OF MICRO TYPEOUT
                          0450

70125* 02301170           0230        .    CONTROL WORD
                          1170        .    FORMAT 3

70126* 21000000           STW 0 Q     .    WS0 = 0

                          NOP

70127* 34060515           STF PF 6    .    PF 6 = 0
                          LRC     13  .    N = 13 FOR SCALE

70130* 23042222           LDW 0 D     .    WS 0 TO D
                          LDS 2 B     .    WORD TO BE TYPED TO B

70131* 44442104           CIL D D
                          STW 0 D     .    WS 0 = WS 0 + 1

70132* 26754575           LDI P L     .    TYPE TRUE NUMBER
                          EXC P L

70133* 00600500           0060        .    ADDRESS OF DECIMAL
                          0500        .    TYPEOUT ROUTINE

70134* 26734573           LDI P C     .    TYPE EIGHT SPACES
                          EXC P C

70135* 00000450           0000        .    ADDRESS OF MICRO TYPEOUT
                          0450        .    TYPE 8 SPACES

70136* 00201161           0020        .    CONTROL WORD
                          1161        .    FORMAT S

70137* 37061606           TCT PF 6    .    PF 6 = 1?
                          FTR      6  .    YES

70140* 36060504           STT PF 6    .    NO - SET PF6 TRUE
                          LRC      4  .    SET SCALE TO 4

70141* 23042222           LDW 0 D     .    WS 0 TO D
                          LDS 2 B     .    WORD TO BE TYPED TO B

70142* 44442104           CIL D D
                          STW 0 D     .    WS 0 = WS 0 + 1

70143* 26754575           LDI P L     .    TYPE VOLTAGE
                          EXC P L

70144* 00100500           0010        .    ADDRESS OF DECIMAL
                          0500        .    TYPE-OUT ROUTINE

70145* 14660000           BTR      9
                          NOP

70146* 35311477           TCF SW 1    .    LOOP UNTIL SW 1 = 1
                          BTR      0
```

```
70147* 23045444    LDW 0 D   .   FETCH WS 0 TO D
                   CDL D D

70150* 54442222    CDL D D   .   D = D - 2
                   LDS 2 B   .   GET CURRENT OUTPUT

70151* 23436423    LDW 4 C   .   CH. NO. TO C
                   LOR B C   .   FORM OUTPUT WORD

70152* 26711211    LDI P A   .   SELECT ADIOCE
                   SEL A A

70153* 32001000    3200      .   SELECT WORD - ADIOCE
                   1000      .   RANDOM - CH. 00

70154* 65601023    COM 6 Q   .   LOCK COM TO 00
                   DTR 2 C   .   DTR TO ADIOCE

70155* 21120000    STW 1 B   .   OUTPUT WORD TO WS 1
                   NOP

70156* 37321623    TCT SW 2  .   SW 2 = 1?
                   FTR   19  .   YES - SLEW UP

70157* 37331624    TCT SW 3  .   SW 3 = 1?
                   FTR    20 .   YES - SLEW DOWN

70160* 35341475    TCF SW 4  .   SW 4 = 0?
                   BTR   2   .   YES - LOOP

70161* 23120515    LDW 1 B   .   NO - TYPE REQUIRED VALUE
                   LRC   13  .   SCALE = 13

70162* 26754575    LDI P L
                   EXC P L

70163* 00600500    0060      .   ADDRESS OF
                   0500      .   DECIMAL TYPEOUT

70164* 23012673    LDW 0 A   .   WS 0 TO A
                   LDI P C

70165* 77777726    7777      .   -42.0 (B23)
                   7726

70166* 55133034    ADL A C   .   WAS THIS THE LAST
                   TNZ C S   .   VALUE FOR THIS TEST?

70167* 16040000    FTR    4  .   NO
                   NOP

70170* 26734573    LDI P C   .   YES
                   EXC P C

70171* 00000450    0000      .   ADDRESS OF MICRO TYPE-OUT
                   0450

70172* 02101213    0210      .   CONTROL WORD
                   1213      .   FORMAT  4

70173* 14100000    BTR   55  .   TEST ON SW 5
```

```
                  NOP

70174* 26734573   LDI P C     .   TYPE C/R AND
                  EXC P C     .   3 SPACES

70175* 00000450   0000        .   ADDRESS OF MICRO TYPE-OUT
                  0450

70176* 00101160   0010        .   CONTROL WORD
                  1160        .   FORMAT CS

70177* 37311477   TCT SW 1    .   LOOP UNTIL
                  BTR    0    .   SW 1 AND SW 4

70200* 37341477   TCT SW 4    .   ARE BOTH OFF
                  BTR    0

70201* 14250000   BTR 42      .   JUMP TO GET NEXT
                  NOP         .   VALUE

70202* 27711603   LDM P A     .   SLEW-UP ROUTINE
                  FTR   3

70203* 00002000   0000        .   + 1 SCALED B 13
                  2000

70204* 26710000   LDI P A     .   SLEW-DOWN ROUTINE
                  NOP

70205* 77776000   7777        .   -1 SCALED B 13
                  6000

70206* 23432672   LDW 4 C     .   CH. NO. TO C
                  LDI P B

70207* 77777510   7777        .   -270
                  7510        .   FIRST HIGH ACC. CH.

70210* 55323024   ADL C B
                  TNZ B S     .   LOW ACCURACY?

70211* 05046631   LRC     4   .   YES
                  SSL LOL A   .   SHIFT A LEFT 4

70212* 23125512   LDW 1 B     .   GET CURRENT WORD
                  ADL A B     .   MODIFY IT

70213* 21126423   STW 1 B     .   RESTORE WS 1
                  LOR B C     .   FORM OUTPUT WORD

70214* 26711211   LDI P A
                  SEL A A     .   SELECT ADIOCE

70215* 32001000   3200        .   SELECT WORD - ADIOCE
                  1000        .   RANDOM - CH. 00

70216* 65601023   COM 6 Q     .   LOCK COM TO 000
                  DTR 2 C

70217* 26710000   LDI P A
                  NOP
```

```
70220* 01415177     0141        .     399.999 (B23)
                    5177

70221* 54113214     CDL A A     .     DELAY 2 SECONDS
                    TZO A S

70222* 14760000     BTR    1
                    NOP

70223* 14320000     BTR   37
                    NOP

     * 00070100     END @ 70100
```

ANALOG OUTPUT ACCURACY TEST

SW5=1 FOR A/O CH. NO. REQUEST
SW1=1 WHEN METER HAS BEEN SET TO TYPED VALUE
SW2=1 TO SLEW OUTPUT NUMBER UP
SW3=1 TO SLEW OUTPUT NUMBER DOWN
SW4=1 TO TYPE OUT SLEWED VALUE
SW1=Ø AND SW4=Ø TO TYPE OUT NEXT TEST POINT

CONNECT NULL METER TO DESIRED A/O CH. BEFORE HITTING SW5...
THEN TYPE CH. NO. IN OCTAL.

CH. NO. = 27Ø.

TRUE NO.	VOLTAGE	REQUIRED NO.
8191.	1Ø.ØØØØØ	8191.
7372.	9.ØØØ12	7372.
6553.	8.ØØØ24	6553.
5734.	7.ØØØ37	5734.
4915.	6.ØØØ49	4915.
4Ø96.	5.ØØØ61	4Ø96.
3277.	4.ØØØ73	3277.
2458.	3.ØØØ85	2458.
1639.	2.ØØØ98	1639.
82Ø.	1.ØØ11Ø	82Ø.
Ø.	Ø.ØØØØØ	Ø.
- 82Ø.	- 1.ØØØ97	- 82Ø.
- 1639.	- 2.ØØØ73	- 1639.
- 2458.	- 3.ØØØ48	- 2458.
- 3277.	- 4.ØØØ24	- 3277.
- 4Ø96.	- 5.ØØØØØ	- 4Ø96.
- 4916.	- 6.ØØØ97	- 4916.
- 5735.	- 7.ØØØ73	- 5735.
- 6554.	- 8.ØØØ48	- 6554.
- 7372.	- 9.ØØØ24	- 7372.
- 8191.	- 9.99877	- 8191.

END OF THIS TEST - HIT SW5 TO RESTART WITH NEW A/O CHANNEL

PB-440 PROGRAM ABSTRACT

PROGRAM TITLE:	ANALOG OUTPUT DYNAMIC TEST
PROGRAMMER:	P. A. KNOOP
DATE:	10 March 1965
ID:	None
FUNCTION:	The purpose of this program is to test the analog output response time for the PB-440 ADIOCE system. This is one of the ADIOCE Acceptance Test programs.
TECHNIQUE:	Given the time base (per period), magnitude, and AO channel number, this program issues a square wave response over the AO channel. The time base and magnitude may be supplied via the on-line typewriter or via analog input channels 100 and 101. If the latter mode is chosen, the routine prints the current time-base and magnitude upon instruction from the operator. Facility is included for recording occurrences of output distortion.
LOADING PROCEDURE:	Load with Binary Loader I. This program is not relocatable.
OPERATING PROCEDURES &	Hardware linkage must be established prior to execution.
LINKAGE REQUIRED:	The program will type instructions to the operator with self-explanatory notes in a conversational manner. Lower and upper limits on the time base are 100 microseconds and one second, respectively. Attached to this abstract is a table of time and magnitudes which would likely be desired as inputs for the program. Limits on the magnitude are plus and minus ten volts (full maximum output word). Except for the AO channel number, all type-ins are assumed to be decimal. If analog inputs 100 and 101 are used for supplying inputs to the program, no scaling is performed but the limitations cited above still apply and are program-initiated. If the inputs are supplied via the typewriter, time should be in seconds and magnitude should be a positive or negative integer.

PROGRAM STORAGE:

Program Segment	*Octal Locs.*	*Total*
Main Program	70100-70275	176
Micro Multiply	70040-70051	12
Comments	1000-1401	402
Micro Type	450-461	12
Decimal Output	500-621	122
Decimal Input	650-777	130
		1076_8

INTERMEDIATE STORAGE: Working Storage:

0 Storage of magnitude
1 Storage of channel number
2 Storage of time base
3 Storage of positive output word
4 Address of micro type routine
5 Timing counter
6 Storage of negative output word

SPECIAL STORAGE: None used

EXECUTION TIME: Not applicable

REGISTERS: All used

SENSE SWITCHES:

1 Mode 1
2 Mode 2
3 Enter new T, M (Mode 1)
Type out T, M (Mode 2)
4 Output distorted
5 Read new T, M (Mode 2)
6 New Channel number request

PROGRAM FLAGS:

2 On for Mode 2 test
Off for Mode 1 test

I/O DEVICES:

Typewriter
ADIOCE
Scope

PROGRAM HALTS: None

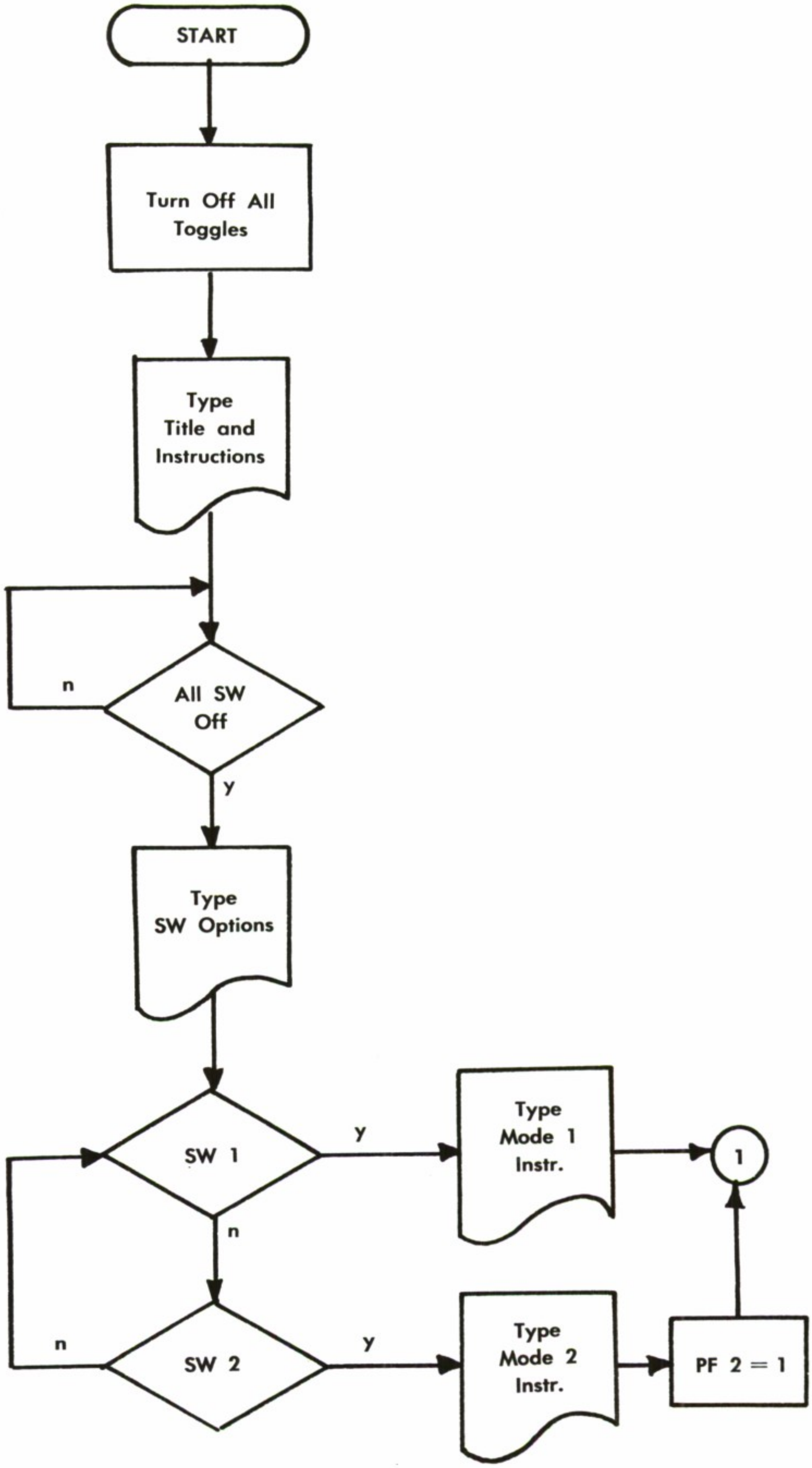
ANALOG OUTPUT DYNAMIC TEST

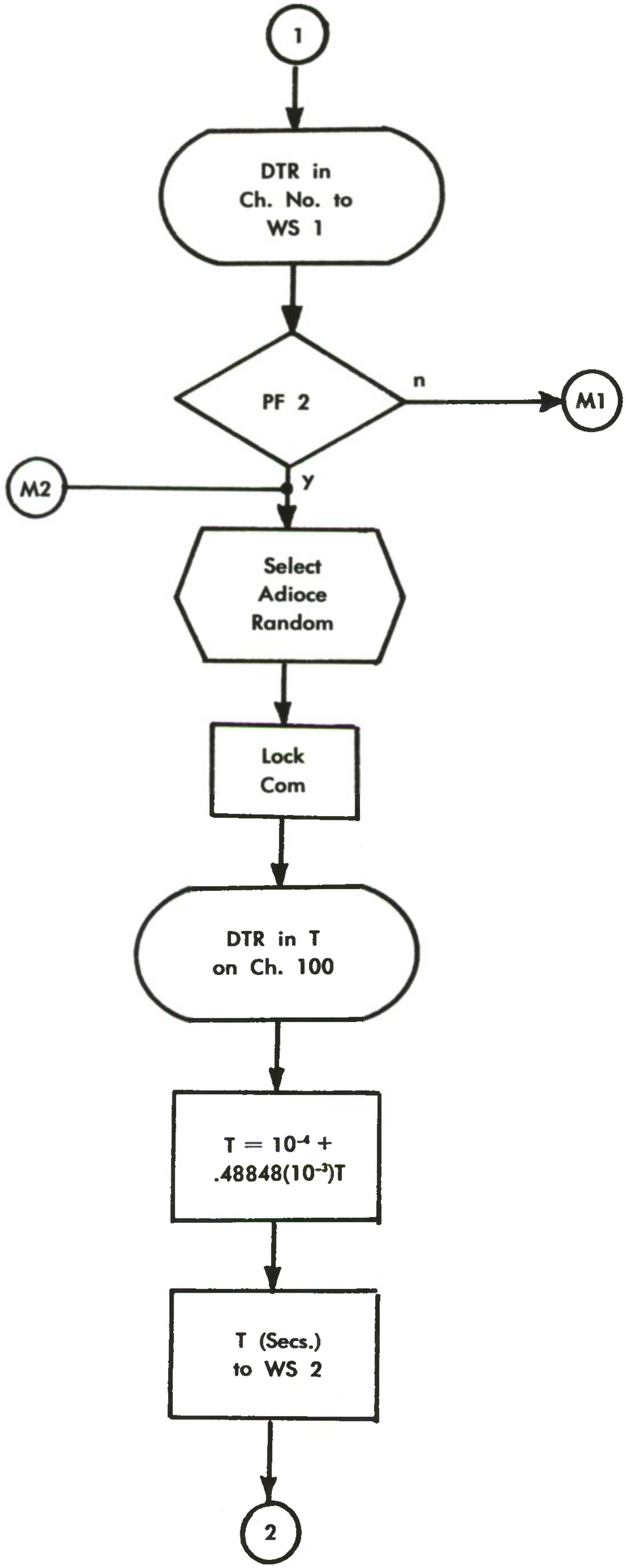
TIME-MAGNITUDE TABLE

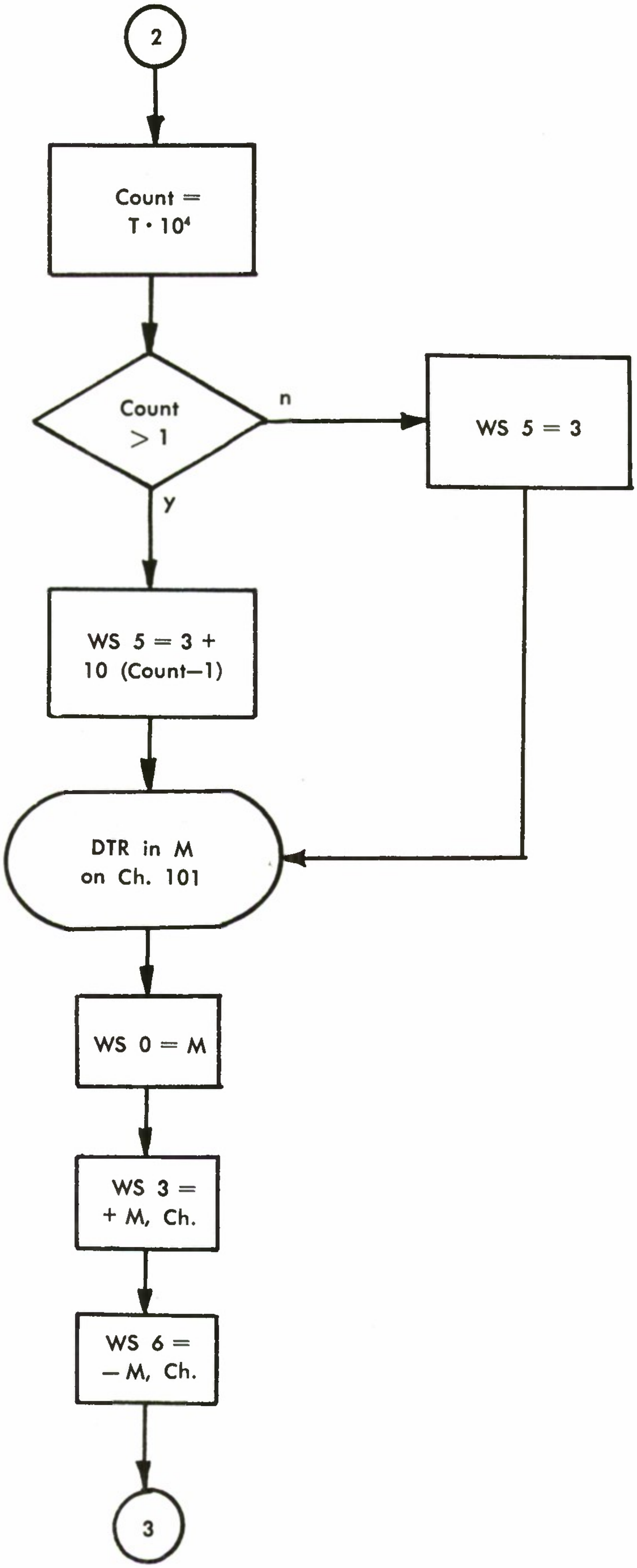
Time (sec.)	*Frequency*	*Period*	*Magnitude*	*Voltage***
.0001	10 KC	.1 MS	0	0
.0010	1 KC	1.0 MS	102	1
.0100	.1 KC	10.0 MS	205	2
.1000	.01 KC	100.0 MS	307	3
1.0000	1 CPS	1 SEC.	409	4
			512	5
			614	6
			716	7
			818	8
			921	9
			1023	10

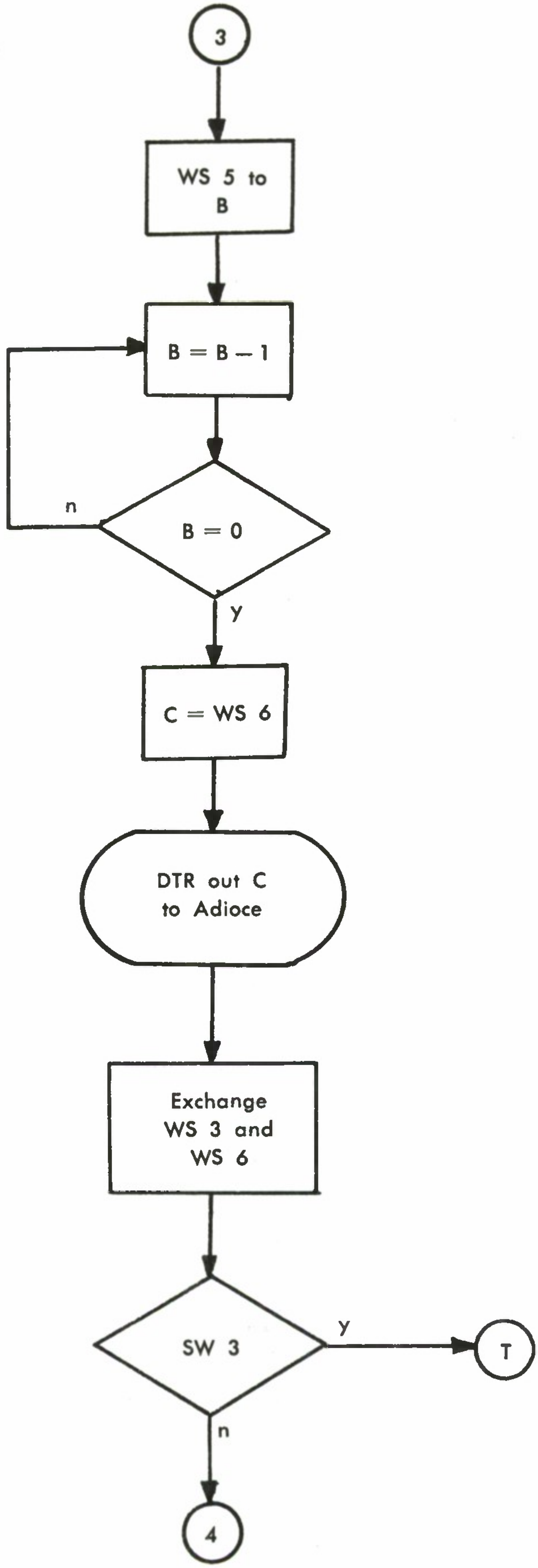
**Approximate

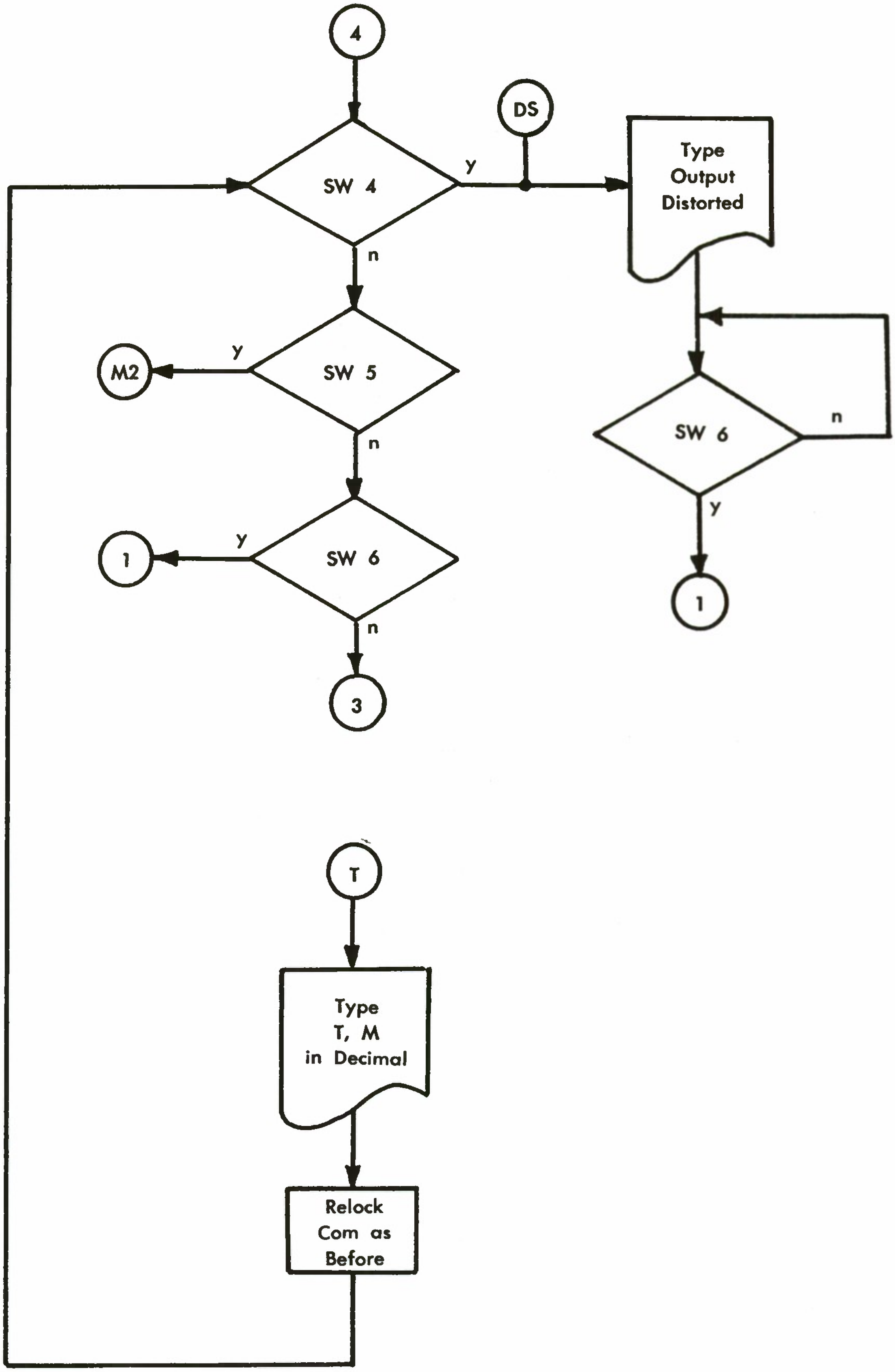
ANALOG OUTPUT DYNAMIC TEST

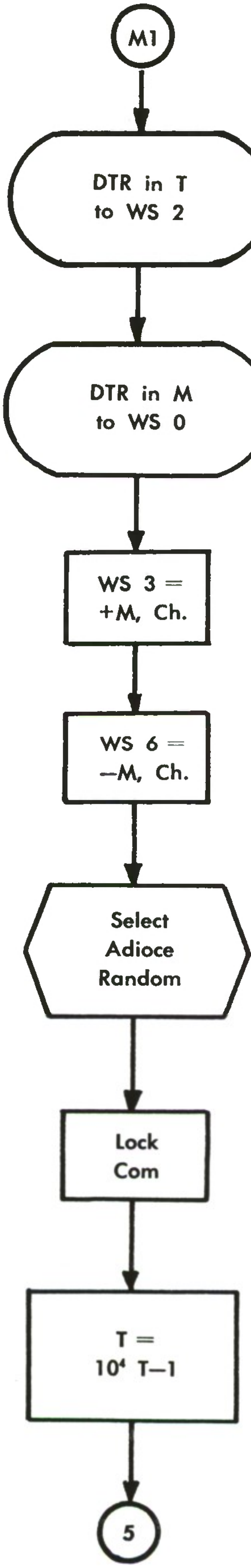



1
DTR in Ch. No. to WS 1
PF 2
n
M1
y
M2
Select Adioce Random
Lock Com
DTR in T on Ch. 100
$T = 10^{-4} + .48848(10^{-3})T$
T (Secs.) to WS 2
2

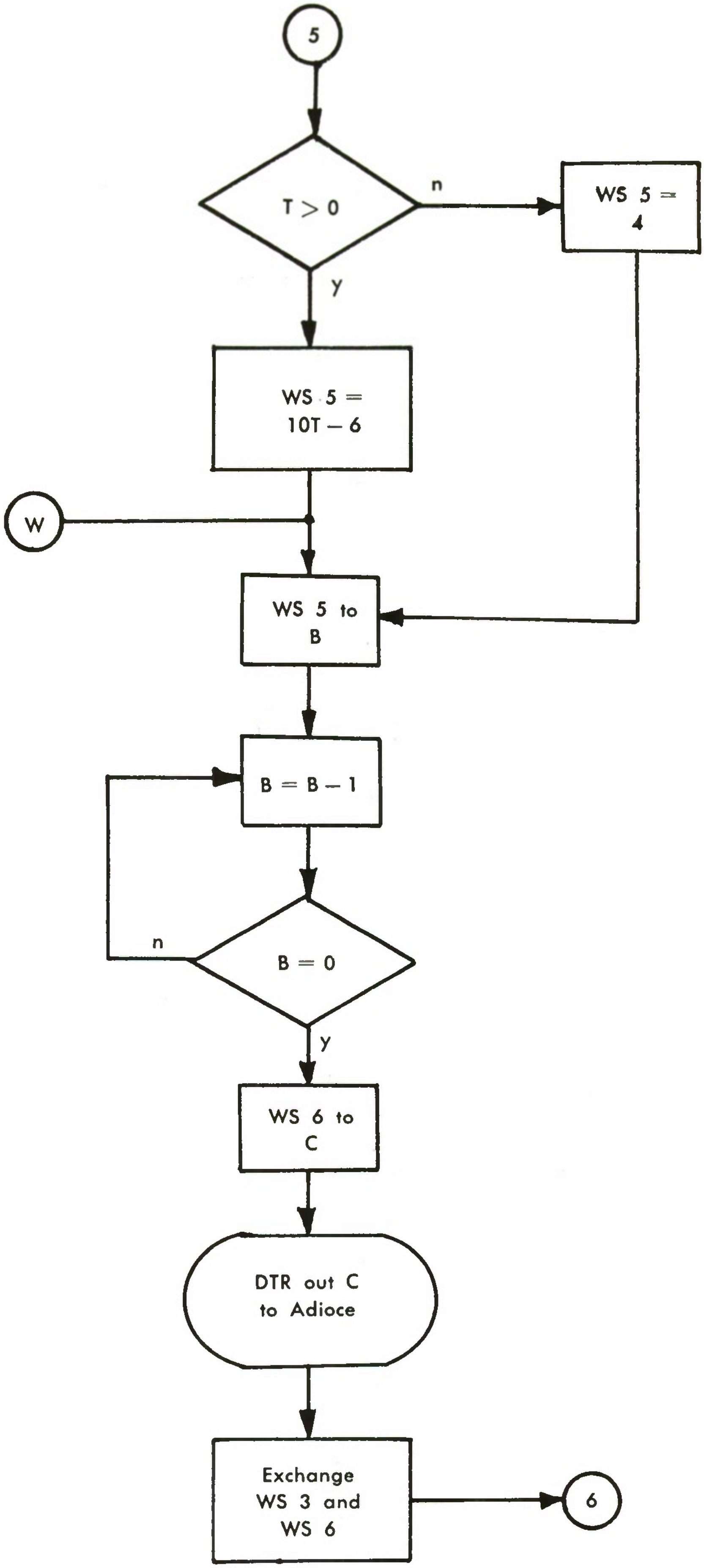

2
Count =
T · 10⁴
Count
> 1
n
y
WS 5 = 3
WS 5 = 3 +
10 (Count—1)
DTR in M
on Ch. 101
WS 0 = M
WS 3 =
+ M, Ch.
WS 6 =
— M, Ch.
3

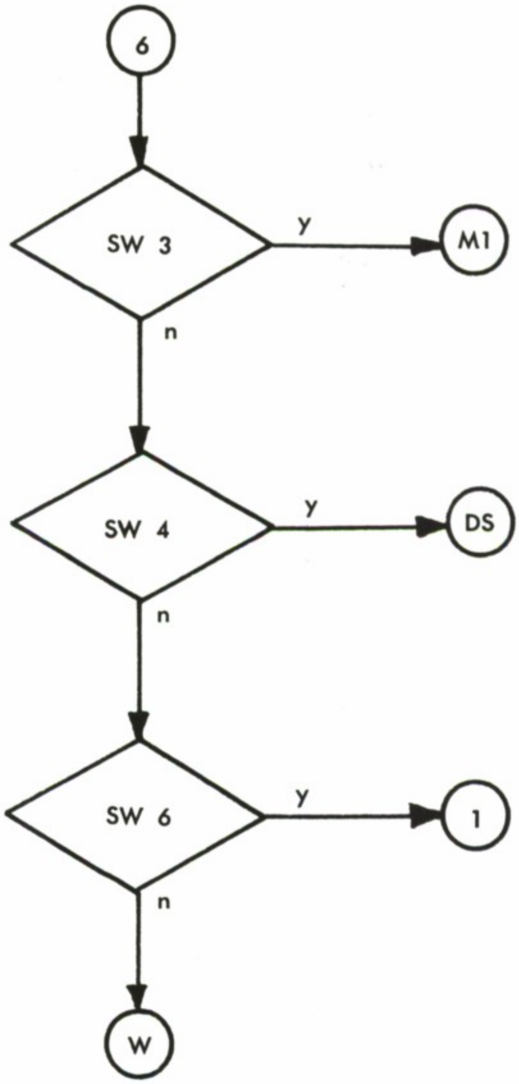

3
WS 5 to B
B = B – 1
B = 0
n
y
C = WS 6
DTR out C to Adioce
Exchange WS 3 and WS 6
SW 3
y
T
n
4


4
SW 4
DS
y
n
Type Output Distorted
y
M2
SW 5
n
SW 6
n
y
1
y
1
SW 6
n
3
1
T
Type T, M in Decimal
Relock Com as Before



M1
DTR in T
to WS 2
DTR in M
to WS 0
WS 3 =
+M, Ch.
WS 6 =
—M, Ch.
Select
Adioce
Random
Lock
Com
T =
10⁴ T—1
5


5
T > 0
n
WS 5 =
4
y
WS 5 =
10T − 6
W
WS 5 to
B
B = B − 1
n
B = 0
y
WS 6 to
C
DTR out C
to Adioce
Exchange
WS 3 and
WS 6
6


6
SW 3
y
M1
n
SW 4
y
DS
n
SW 6
y
1
n
W

```
                  LDR         .    A/0 CH. RESPONSE TEST
                  LDR         .    17 FEBRUARY 1965
                  LDR
       *          L0C 0 70100
70100* 02702673   CTS 7 Q     .    TURN 0FF ALL T0GGLES
                  LDI P C
70101* 00000450   0000        .    ADDRESS 0F MICR0-TYPE
                  0450
70102* 21434573   STW 4 C     .    ADDRESS T0 WS4
                  EXC P C     .    JUMP T0 TYPE R0UTINE
70103* 02501000   0250        .    TITLE 0F TEST
                  1000        .    F0RMAT 1
70104* 35301477   TCF SW X    .    L00P UNTIL ALL
                  BTR    0    .    SENSE SWITCHES 0FF
70105* 23434573   LDW 4 C
                  EXC P C     .    JUMP T0 TYPE R0UTINE
70106* 04401025   0440        .    SENSE SWITCH 0PTI0NS
                  1025        .    F0RMAT 2
70107* 37311604   TCT SW 1    .    IF SW 1 0N.
                  FTR    4    .    JUMP T0 M0DE 1
70110* 35321476   TCF SW 2    .    IF SW2 0N.
                  BTR    1    .    L00P
70111* 23434573   LDW 4 C     .    M0DE 2 TEST
                  EXC P C     .    JUMP T0 TYPE R0UTINE
70112* 13301204   1330        .    M0DE 2 INSTRUCTI0NS
                  1204        .    F0RMAT 4.2
70113* 36021602   STT PF 2    .    PF 2 = 1
                  FTR    2
70114* 23434573   LDW 4 C     .    M0DE 1 TEST
                  EXC P C     .    JUMP T0 TYPE R0UTINE
70115* 11301071   1130        .    M0DE 1 INSTRUCTI0NS
                  1071        .    F0RMAT 4.1
70116* 23434573   LDW 4 C
                  EXC P C     .    JUMP T0 TYPE R0UTINE
70117* 01201337   0120        .    CH. N0. REQUEST
                  1337        .    F0RMAT 5
70120* 26731233   LDI P C     .    0CTAL TYPE-IN R0UTINE
                  SEL C C     .    SELECT TYPEWRITER
70121* 02006100   0200
                  6100
```

```
70122* 65635711     C0M 6 C    .    L0CK C0M T0 03
                    X0R A A    .    A = 0

70123* 07617043     CLD 0 61
                    CPF D C    .    C = 61

70124* 07120503     CLD 0 12   .    D = 12
                    LRC    3   .    N = 03

70125* 10120000     DTR 1 B    .    DTR INT0 B
                    N0P

70126* 57243241     X0R B D
                    TZ0 D F    .    BACKSPACE?

70127* 16032111     FTR    3   .    YES - FINISHED
                    STW 1 A    .    ANS T0 WS1

70130* 66315723     SSL L0L A  .    SHIFT A LEFT 3
                    X0R B C

70131* 32311470     TZ0 C F    .    SLASH?
                    BTR    7   .    YES - BEGIN 0VER

70132* 64211470     L0R B A    .    N0 - PACK W0RD
                    BTR    7   .    DTR NEXT CHARACTER

70133* 35021670     TCF PF 2   .    PF2 = 0?
                    FTR   56   .    YES - T0 M0DE 1

70134* 26731233     LDI P C    .    M0DE 2
                    SEL C C    .    SELECT ADI0CE

70135* 32003000     3200       .    RAND0M
                    3000       .    CHANNEL 01

70136* 65610740     C0M 6 A    .    L0CK C0M T0 01
                    CLD 0 40

70137* 55441034     ADL D D    .    D = 100
                    DTR 3 D    .    DTR IN T 0N CH. 100

70140* 46432672     CPL D C    .    T T0 C
                    LDI P B    .    PICK UP C0NSTANT

70141* 10001525     1000       .    00048848 (B - 9)
                    1525

70142* 70750440     CPF P L
                    CLP 0 40   .    JUMP T0 MPY R0UTINE

70143* 26725512     LDI P B
                    ADL A B    .    GET T IN SEC0NDS

70144* 00000321     0000       .    .0001 (B2)
                    0321

70145* 21222673     STW 2 B    .    T T0 WS 2
                    LDI P C

70146* 04704000     0470       .    10000 (B16)
                    4000
```

```
70147* 70750440     CPF P L
                    CLP @ 40   .    JUMP T0 MPY R0UTINE

70150* 07376342     CLD @ 37
                    CCL D B    .    B = -1.0 (B18)

70151* 55123224     ADL A B
                    TZ0 B S    .    IS B P0SITIVE?

70152* 16022673     FTR   2    .    YES
                    LDI P C    .    20 T0 C

70153* 07032154     CLD 0 3    .    D = 3
                    STW 5 D    .    WS5 = 3

70154* 16040000     FTR   4
                    N0P

70155* 12000000     1200       .    10.0 (B5)
                    0000

70156* 70750440     CPF P L
                    CLP @ 40   .    JUMP T0 MPY R0UTINE

70157* 07035541     CLD   03   .    D = 3 (B23)
                    ADL D A

70160* 21510000     STW 5 A    .    10(10000T-1)+3
                    N0P

70161* 07405544     CLD @ 40   .    F0RM CH. N0. 101
                    ADL D D

70162* 44441034     CIL D D    .    D = 101
                    DTR 3 D    .    DTR INT0 D

70163* 21042311     STW 0 D    .    M T0 WS0
                    LDW 1 A    .    CH. N0. T0 A

70164* 64412131     L0R D A
                    STW 3 A    .    + W0RD AND CH. T0 WS3

70165* 63444444     CCL D D
                    CIL D  D   .    -M T0 D

70166* 23126442     LDW 1 B    .    CH. N0. T0 B
                    L0R D B

70167* 21620000     STW 6 B    .    -W0RD AND CH. T0 WS6
                    N0P

70170* 00000000     N0P
                    N0P

70171* 23522352     LDW 5 B    .    WS5 T0 B
                    LDW 5 B    .    DELAY

70172* 54223027     CDL B B    .    B = B-1
                    TNZ B SXF  .    B = 0?

70173* 14760000     BTR     1  .    N0 - L00P
```

```
                 NØP

70174* 23631023  LDW 6 C   .   YES
                 DTR 2 C   .   DTR ØUT M

70175* 23312161  LDW 3 A
                 STW 6 A

70176* 21333733  STW 3 C   .   EXCHANGE WS3 AND WS6
                 TCT SW 3  .   SW 3 ØN?

70177* 16110000  FTR    9  .   YES - TYPE T AND M
                 NØP

70200* 00000000  NØP
                 NØP

70201* 37341603  TCT SW 4  .   SW4 = 1?
                 FTR    3  .   YES - ØUTPUT DISTØRTED

70202* 37351431  TCT SW 5  .   SW5 = 1?
                 BTR   38  .   YES - NEW T AND M

70203* 37361412  TCT SW 6  .   SW 6 = 1?
                 BTR   53  .   YES - NEW CH. NØ.

70204* 14640000  BTR   11  .   NØ - LØØP
                 NØP

70205* 23434573  LDW 4 C   .   ØUTPUT DISTØRTED RØUTINE

                 EXC P C   .   JUMP TØ TYPE RØUTINE

70206* 00701351  0070      .   ØUTPUT DISTØRTED
                 1351      .   FØRMAT 6

70207* 35361477  TCF SW 6  .   SW6 = 0?
                 BTR    0  .   YES - LØØP

70210* 14050000  BTR   58  .   NØ - CH. NØ. REQUEST
                 NØP

70211* 23434573  LDW 4 C   .   TYPE T AND M RØUTINE
                 EXC P C   .   JUMP TØ TYPE RØUTINE

70212* 01101360  0110      .   T =
                 1360      .   FØRMAT 8

70213* 05022322  LRC    2  .   N = 2 (SCALE)
                 LDW 2  B  .   T TØ B

70214* 26754575  LDI P L
                 EXC P L   .   TYPE T IN DECIMAL

70215* 00000500  0000      .
                 0500

70216* 23434573  LDW 4 C
                 EXC P C   .   JUMP TØ TYPE RØUTINE

70217* 01101371  0110      .   M =
                 1371      .   FØRMAT 9
```

```
70220* 23020513      LDW 0 B   .     M TO B
                     LRC   11  .     N = 11 (SCALE)

70221* 26754575      LDI P L
                     EXC P L   .     TYPE M IN DECIMAL

70222* 00600500      0060
                     0500

70223* 65611455      COM 6 A   .     LOCK COM TO 01
                     BTR  18   .

70224* 23434573      LDW 4 C   .     MODE 1 TEST
                     EXC P C   .     JUMP TO TYPE ROUTINE

70225* 01101360      0110      .     T =
                     1360      .     FORMAT 8

70226* 05020000      LRC    2  .     N = 2 (SCALE)
                     NOP

70227* 26754575      LDI P L
                     EXC P L   .     JUMP TO TYPE-IN ROUTINE

70230* 00000650      0000
                     0650

70231* 21220000      STW 2 B   .     T TO WS2
                     NOP

70232* 23434573      LDW 4 C
                     EXC P C   .     JUMP TO TYPE ROUTINE

70233* 01101371      0110      .     M =
                     1371      .     FORMAT 9

70234* 05130000      LRC   11  .     N = 11 (SCALE)
                     NOP

70235* 26754575      LDI P L
                     EXC P L   .     JUMP TO TYPE-IN ROUTINE

70236* 00000650      0000
                     0650

70237* 21022311      STW 0 B   .     M TO WS0
                     LDW 1 A   .     CH. NO. TO A

70240* 64212131      LOR B A
                     STW 3 A   .     + WORD TO WS3

70241* 63224422      CCL B B
                     CIL B B   .     B = -M

70242* 23116421      LDW 1 A   .     CH. NO. TO A
                     LOR B A

70243* 21612673      STW 6 A   .     -WORD TO WS6
                     LDI P C
```

```
70244* 32003000      3200       .     RANDOM
                     3000       .     CH. 01

70245* 12336561      SEL C C    .     SELECT ADIOCE
                     COM 6 A    .     LOCK COM TO 01

70246* 23222673      LDW 2 B    .     T TO B
                     LDI P C    .     10000. TO C

70247* 04704000      0470       .     10000.(B16)
                     4000

70250* 70750440      CPF P L
                     CLP O 40   .     JUMP TO MPY ROUTINE

70251* 07376342      CLD O 37
                     CCL D B    .     -1.0 (B18) TO B

70252* 55123024      ADL A B    .     B = 10000 T-1
                     TNZ B S    .     IS B POSITIVE?

70253* 07041605      CLD 04     .     NO - D = 4
                     FTR  05

70254* 26734512      LDI P C    .     YES - C = 10
                     EXC A B

70255* 12000000      1200       .     10.0 (B5)
                     0000

70256* 70750440      CPF P L
                     CLP O 40   .     JUMP TO MPY ROUTINE

70257* 07056344      CLD O 05
                     CCL D D    .     D = -6

70260* 55140000      ADL A D
                     NOP

70261* 21540000      STW 5 D
                     NOP

70262* 00000000      NOP
                     NOP

70263* 23520000      LDW 5 B    .     WS5 TO B
                     NOP

70264* 05036631      LRC    3   .     DELAY 4 MICROSECONDS
                     SSL LOL A

70265* 54223027      CDL B B    .     B = B-1
                     TNZ B SXF  .     B = 0?

70266* 14760000      BTR      1 .     NO - LOOP
                     NOP

70267* 23631023      LDW 6 C    .     YES - M TO C
                     DTR 2 C    .     DTR OUT M

70270* 23312161      LDW 3 A
                     STW 6 A
```

```
70271* 21333733       STW 3 C    .      EXCHANGE WS3 AND WS6
                      TCT SW 3   .      SW3 = 1?

70272* 14310000       BTR    38  .      YES - NEW T AND M
                      NOP

70273* 37341411       TCT SW 4   .      NO - SW4 = 1?
                      BTR    54  .      YES - OUTPUT DISTORTED

70274* 37361413       TCT SW 6   .      SW6 = 1?
                      BTR    52  .      YES - NEW CH. REQUEST

70275* 00001465       NOP
                      BTR    10  .      NO - LOOP

                      LDR

                      LDR        .      END A/O CH. RESPONSE TEST

     * 00070100       END O 70100
```

ANALOG OUTPUT CHANNEL RESPONSE [SQUARE WAVE]

TURN OFF ALL SENSE SWITCHES.

SELECT MODE:

```
SW1    MODE 1 - TYPE IN VARIABLES
SW2    MODE 2 - SUPPLY VARIABLES VIA A/I 1ØØ AND 1Ø1
```

MODE 1 SELECTED.

AFTER SPECIFYING ANALOG OUTPUT CHANNEL IN OCTAL, TYPE IN T AND M IN DECIMAL AND OBSERVE OUTPUT. SENSE SWITCH OPTIONS ARE AS FOLLOWS:

```
SW3    ENTER NEW T AND M
SW4    OUTPUT DISTORTED
SW6    NEW CHANNEL NO. REQUEST, SAME MODE


A/O CHANNEL NUMBER      2ØØ

                  T =      1.Ø

                  M =      1Ø23.

                  T =      1.Ø

                  M =      512.

A/O CHANNEL NUMBER      2Ø1

                  T =      .5

                  M =      512.      OUTPUT DISTORTED **

A/O CHANNEL NUMBER      2Ø1

                  T =      1.Ø

                  M =      512.
```

ANALOG OUTPUT CHANNEL RESPONSE [SQUARE WAVE]

TURN OFF ALL SENSE SWITCHES.

SELECT MODE:

```
SW1     MODE 1 - TYPE IN VARIABLES
SW2     MODE 2 - SUPPLY VARIABLES VIA A/I 1ØØ AND 1Ø1
```

MODE 2 SELECTED

AFTER SPECIFYING ANALOG OUTPUT CHANNEL IN OCTAL, VARY T AND M VIA A/I 1ØØ AND A/I 1Ø1, RESPECTIVELY, AND OBSERVE OUTPUT.
SENSE SWITCH OPTIONS ARE AS FOLLOWS:

```
SW3     TYPE-OUT T AND M
SW4     OUTPUT DISTORTED
SW5     READ NEW T OR M
SW6     NEW CHANNEL NO. REQUEST, SAME MODE
```

```
A/O CHANNEL NUMBER      2ØØ

              T =   -     Ø.98321Ø

              M =        25.

A/O CHANNEL NUMBER      2Ø1

              T =   -     Ø.984187

              M =        25.       OUTPUT DISTORTED **

A/O CHANNEL NUMBER      2Ø2

              T =   -     Ø.984187

              M =        25.

              T =   -     Ø.983698

              M =        23.
```

PB-440 PROGRAM ABSTRACT

PROGRAM TITLE: COMPUTER CLOCK AND REAL-TIME CLOCK MEASUREMENTS

PROGRAMMER: D. R. GUM

DATE: 1 July 1964

ID: None

FUNCTION: The purpose of this program (part of the ADIOCE Acceptance Test package) is to measure the accuracy of the PB-440 computer clock and the ADIOCE Real-Time clock.

GENERAL DESCRIPTION OF TECHNIQUE: There are three tests that can be performed using this program. The tests are: (1) Computer Clock vs. Real-Time Test, (2) Real-Time Clock vs. Real-Time Test, and (3) Computer Clock vs. Real-Time Clock Test. These tests are selected by sense switches 1, 2, and 3, respectively. Tests 1 and 2 have two modes each; a mode using a clock with a second hand as a timing reference and a mode using a 60-cycle line input to ADIOCE as a timing reference. The program is written to essentially make timers of the PB-440 and ADIOCE which are compared with the above mentioned references. The program types the accumulated time in the clock reference mode and the accumulated time of both the reference and the device being tested and the percent error as compared to the reference. The first time typed out in this mode is the reference time.

LOADING PROCEDURE: Load with Binary Loader I. This program is not relocatable.

OPERATING PROCEDURES & LINKAGE REQUIRED: The program will type instructions to the operator as indicated on the sample test type-out sheet. The operator must provide the 60-cycle square wave reference input through discrete input channel I of Group I, which is the sign bit of the 24-bit input word. This program uses five subroutines which must be stored as follows:

PROGRAM STORAGE:	*Program Segment*	*Octal Locs.*	*Total*
	Main Program	70100-70410	311
	Interrupt Routine	70000-70013	14
	Comments	1000-1312	313
	Micro Type	450-461	12
	Decimal Output	500-621	122
	Micro Multiply	70040-70051	12
	Micro Divide	70060-70067	10
			1016_8

INTERMEDIATE STORAGE: Working Storage: 1, 2, 3, 5, and 6

SPECIAL STORAGE: Core Zero: Micro Type Address

EXECUTION TIME: The program execution time is not of importance; however, the tests should not be run for longer than the following times to prevent overflow from the timing register.

Computer Clock vs. Real-Time Test
Mode 4 – 1000 hours
(For an accuracy of .01% should run for at least 3 hours)
Mode 5 – 1 hour
(For an accuracy of .01% it should run for at least 2 minutes)

Real-Time Clock vs. Real-Time Test
Mode 4 – 1000 hours
(For an accuracy of .01% it should run for at least 3 hours)
Mode 5 – 10 hours
(For an accuracy of .01% it should run for at least 2 minutes)

Computer Clock vs. Real-Time Clock Test
Single Mode – 10 hours
(For an accuracy of .01% it should run for at least 2 minutes)

REGISTERS: All used

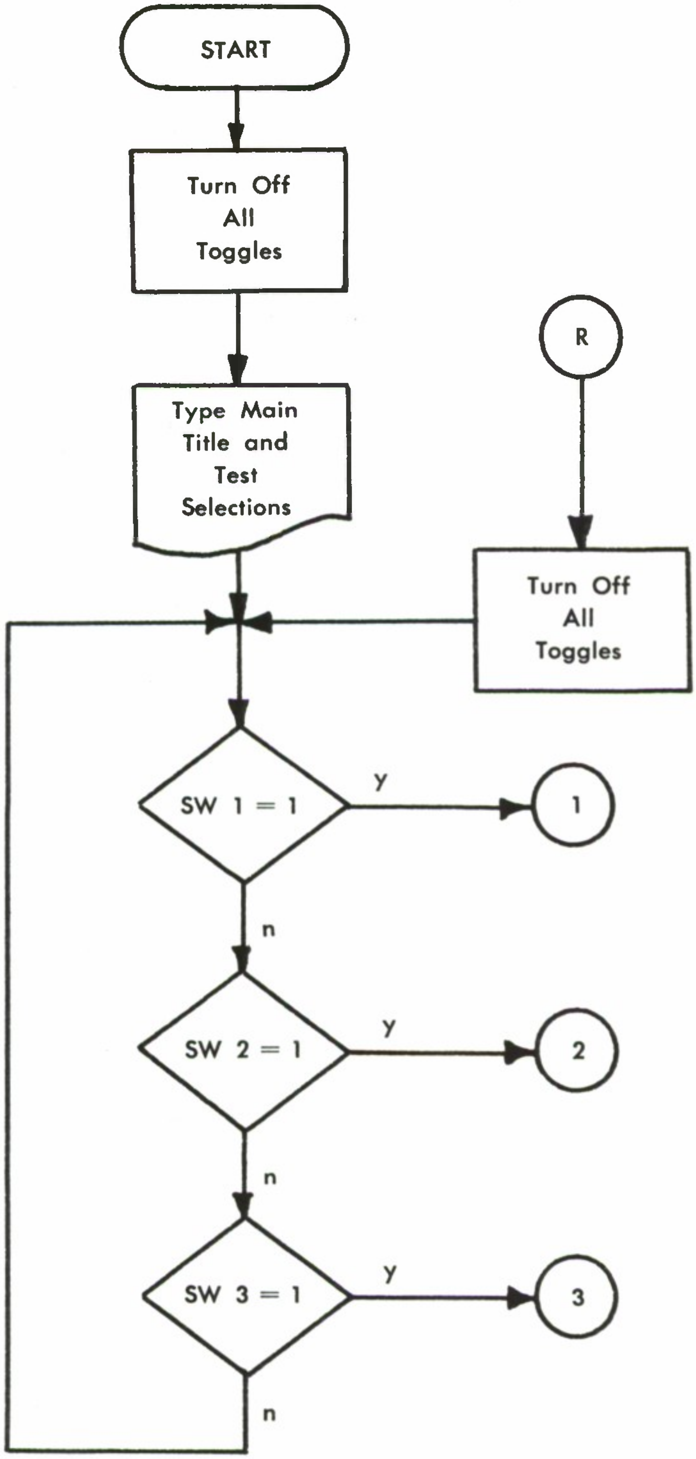
SENSE SWITCHES: As shown on sample test type-out sheet.

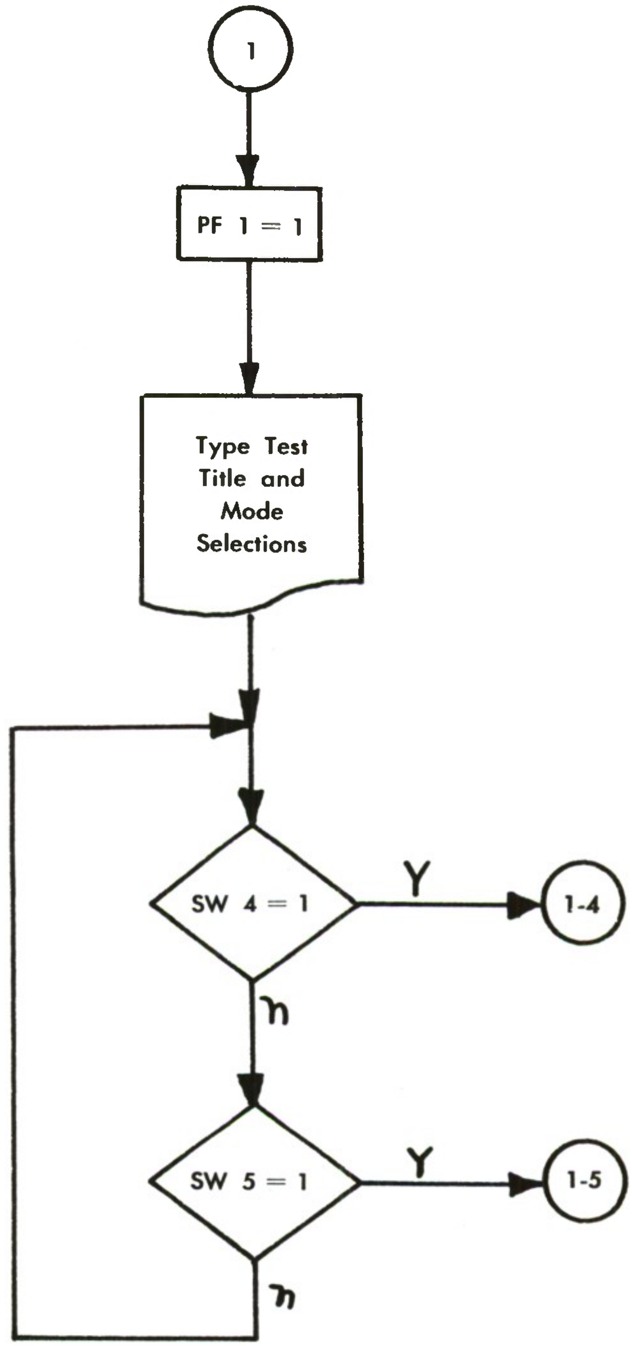
PROGRAM FLAGS: 1-5 indicating test and mode

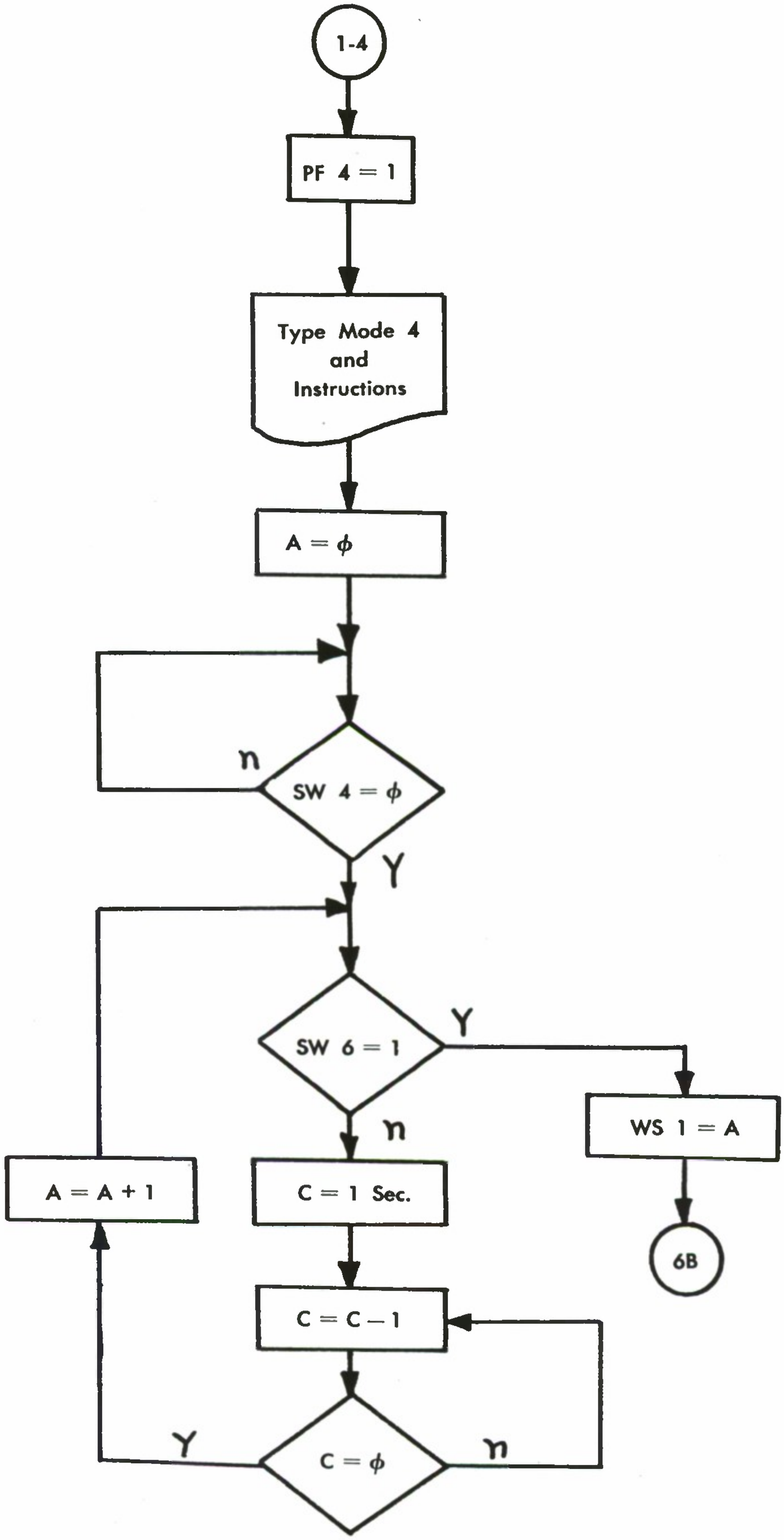
I/O DEVICES: Typewriter and ADIOCE

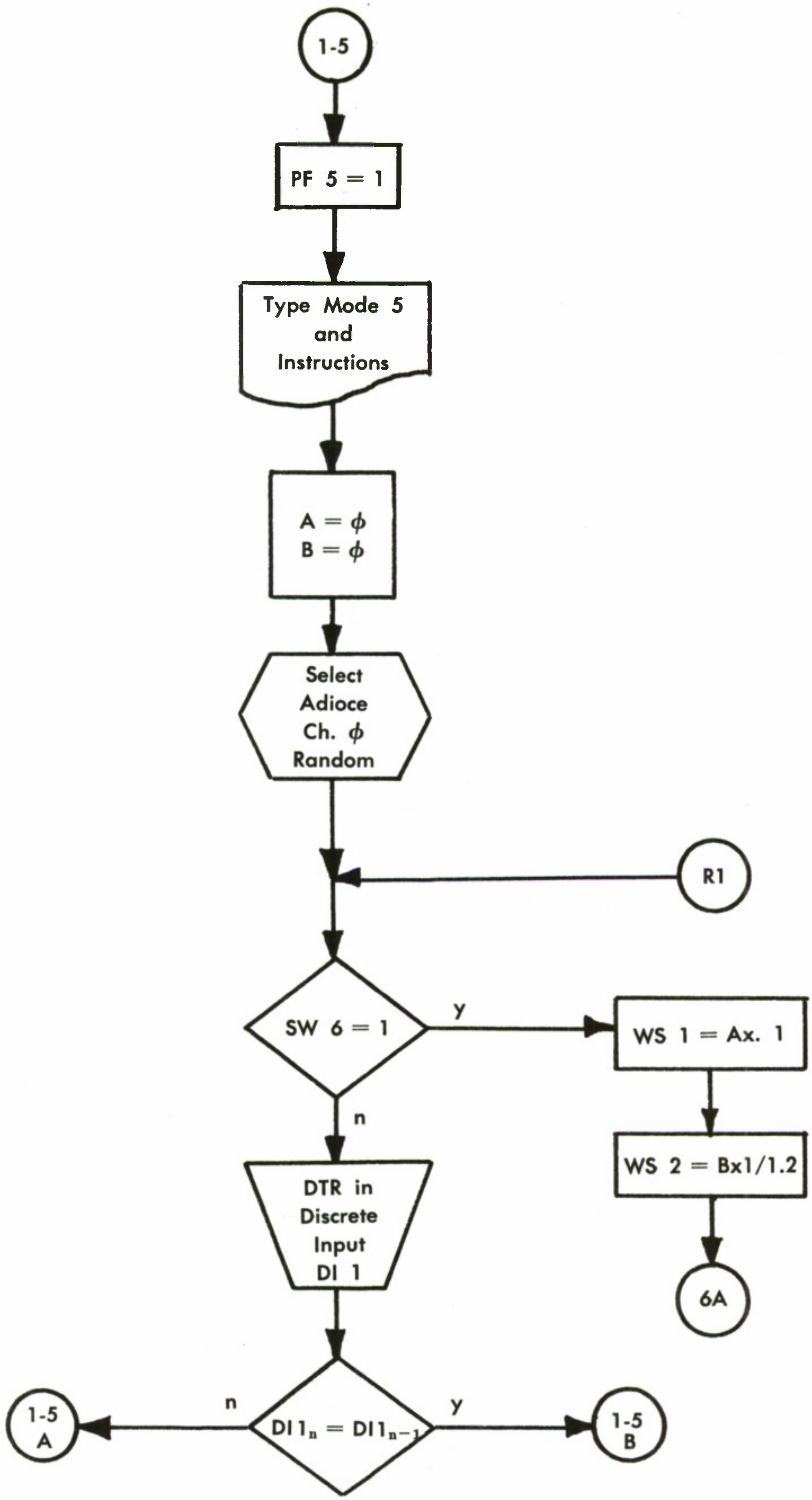
PROGRAM HALTS: None

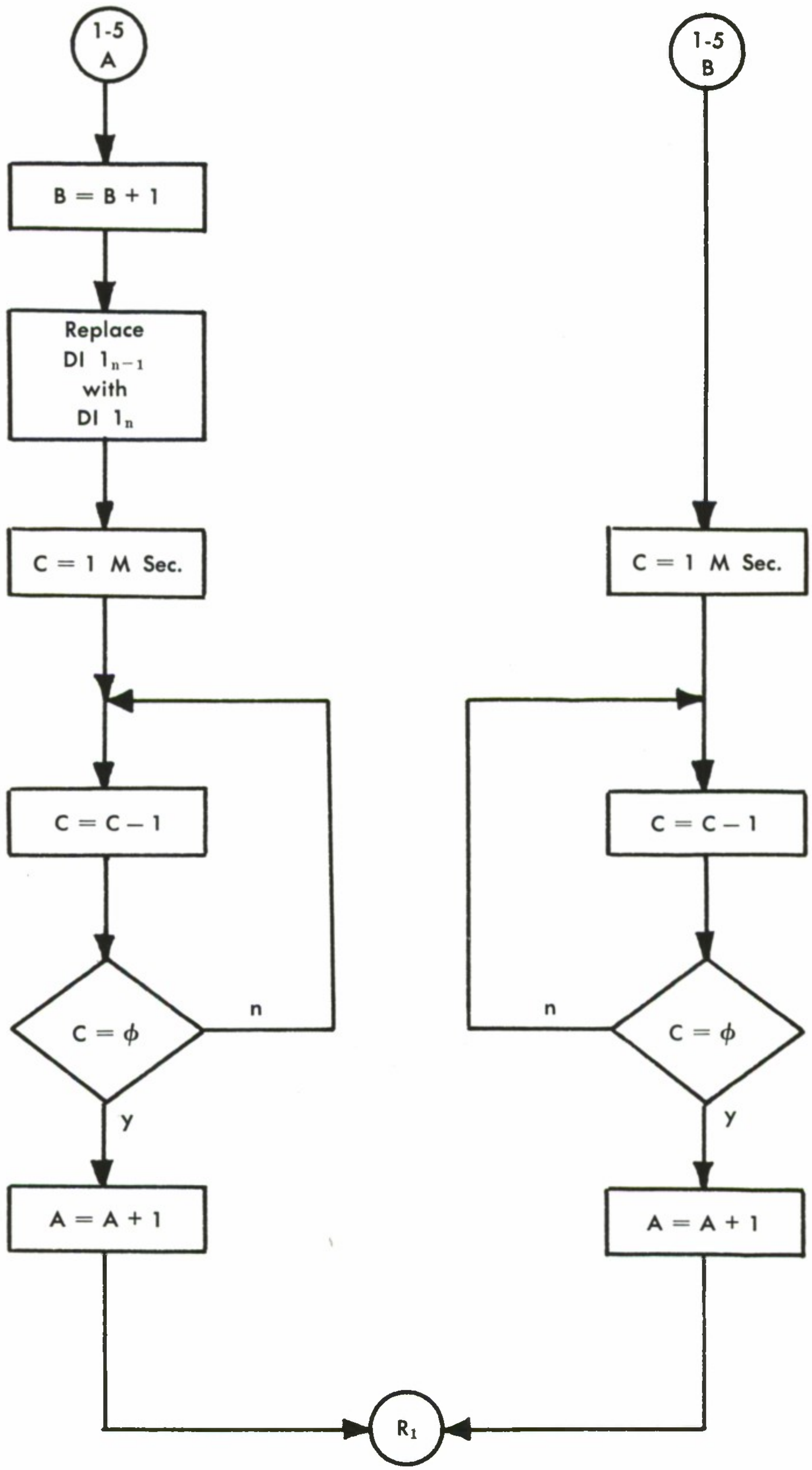
COMPUTER CLOCK AND REAL-TIME CLOCK MEASUREMENTS

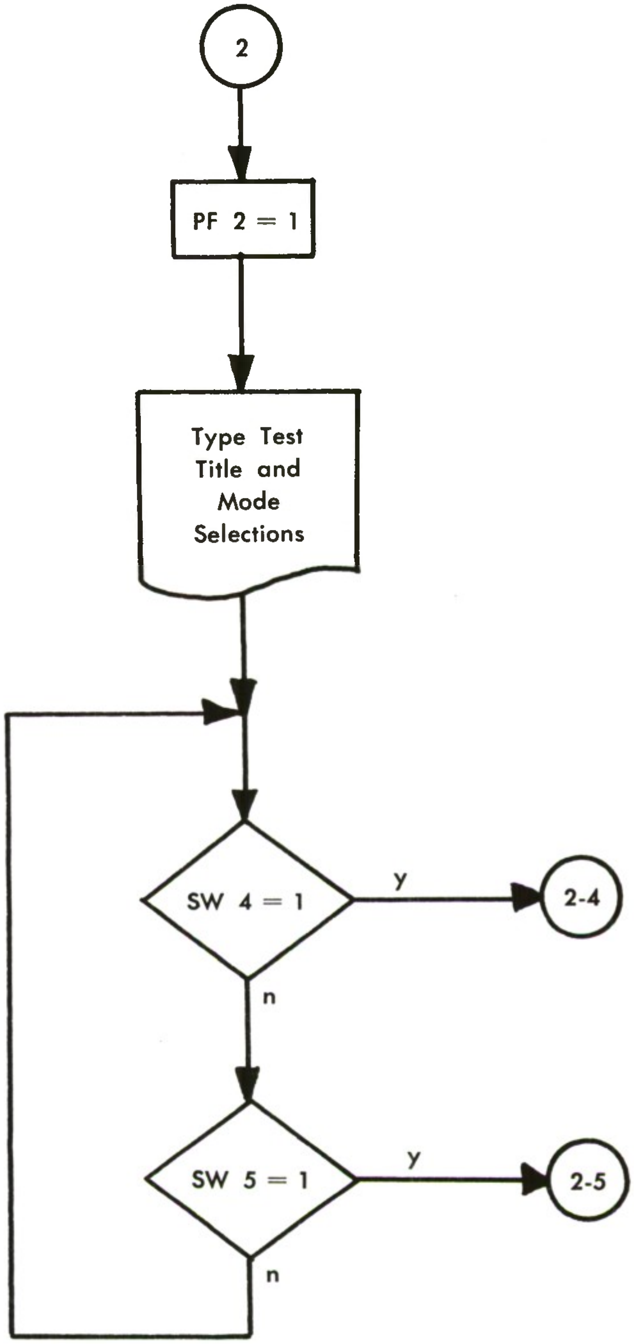


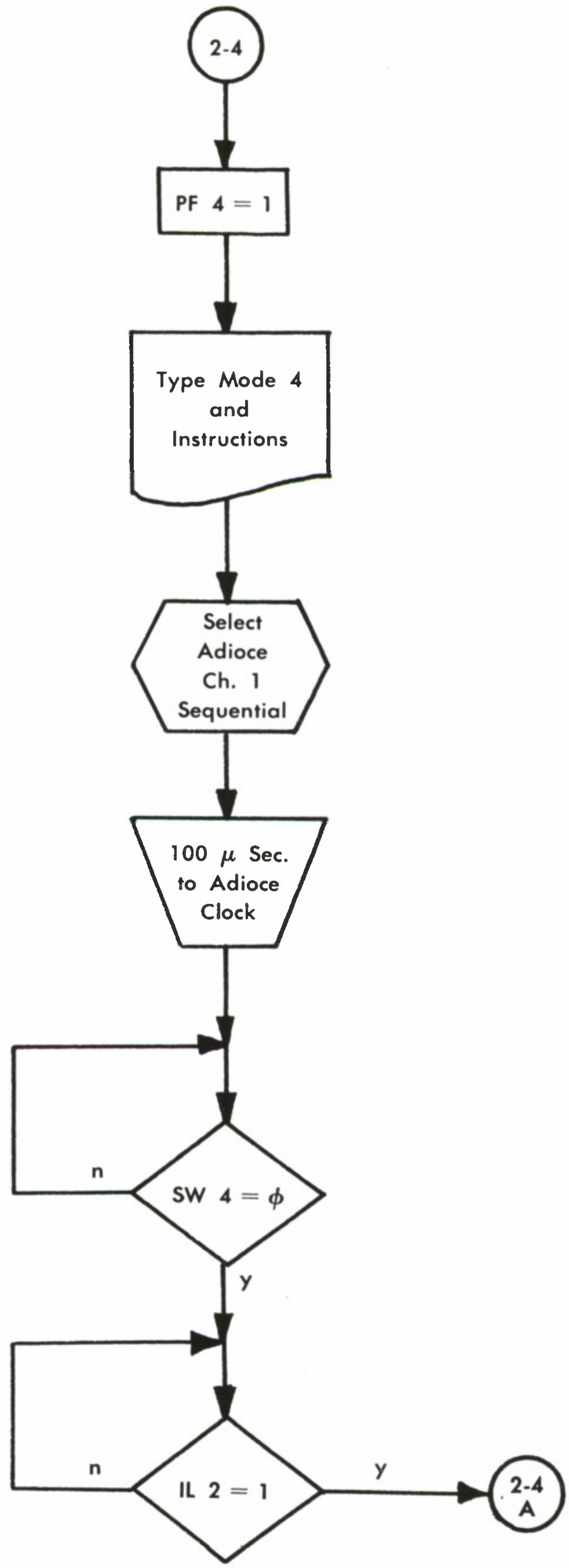

1
PF 1 = 1
Type Test Title and Mode Selections
SW 4 = 1
Y
1-4
n
SW 5 = 1
Y
1-5
n

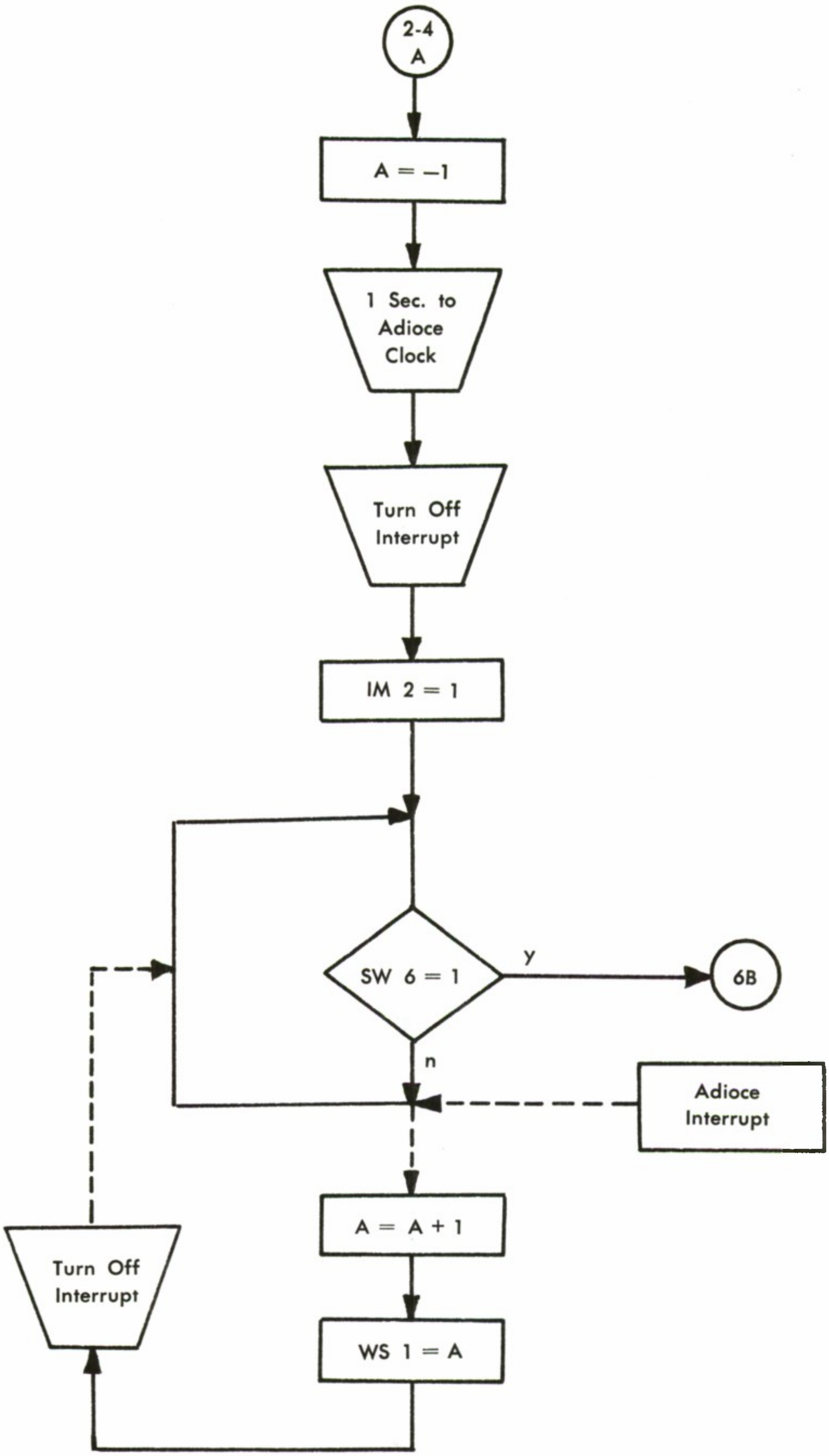

1-4
PF 4 = 1
Type Mode 4
and
Instructions
A = ϕ
n
SW 4 = ϕ
Y
SW 6 = 1
Y
WS 1 = A
6B
n
A = A + 1
C = 1 Sec.
C = C − 1
Y
C = ϕ
n


1-5
PF 5 = 1
Type Mode 5
and
Instructions
A = φ
B = φ
Select
Adioce
Ch. φ
Random
R1
SW 6 = 1
y
WS 1 = Ax. 1
WS 2 = Bx1/1.2
6A
n
DTR in
Discrete
Input
DI 1
n
DI 1n = DI 1n−1
y
1-5
A
1-5
B

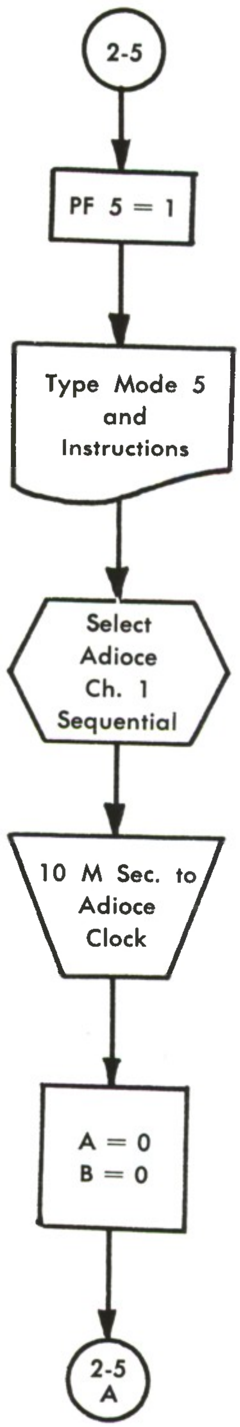

1-5
A
B = B + 1
Replace
DI 1_{n-1}
with
DI 1_n
C = 1 M Sec.
C = C − 1
C = ϕ
n
y
A = A + 1
1-5
B
C = 1 M Sec.
C = C − 1
C = ϕ
n
y
A = A + 1
R_1


2
PF 2 = 1
Type Test
Title and
Mode
Selections
SW 4 = 1
y
2-4
n
SW 5 = 1
y
2-5
n

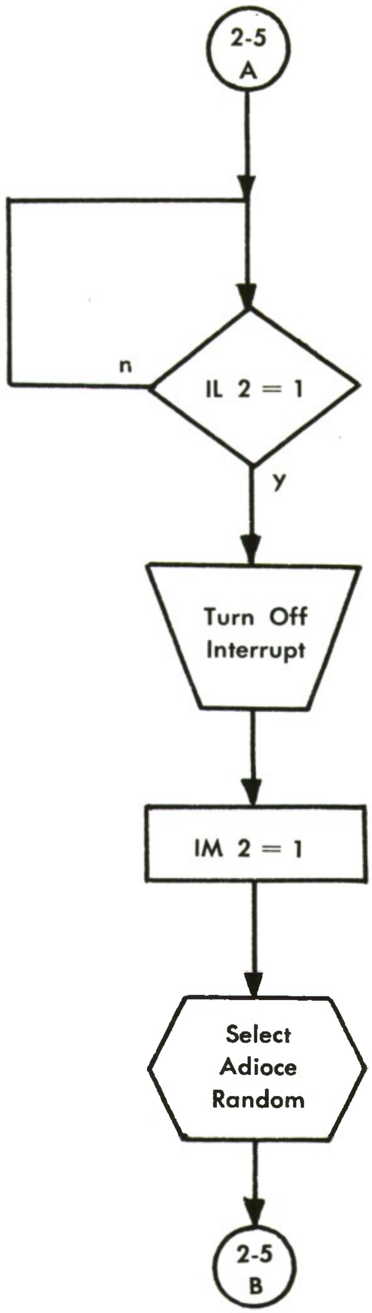

2-4
PF 4 = 1
Type Mode 4
and
Instructions
Select
Adioce
Ch. 1
Sequential
100 μ Sec.
to Adioce
Clock
n
SW 4 = φ
y
n
IL 2 = 1
y
2-4
A

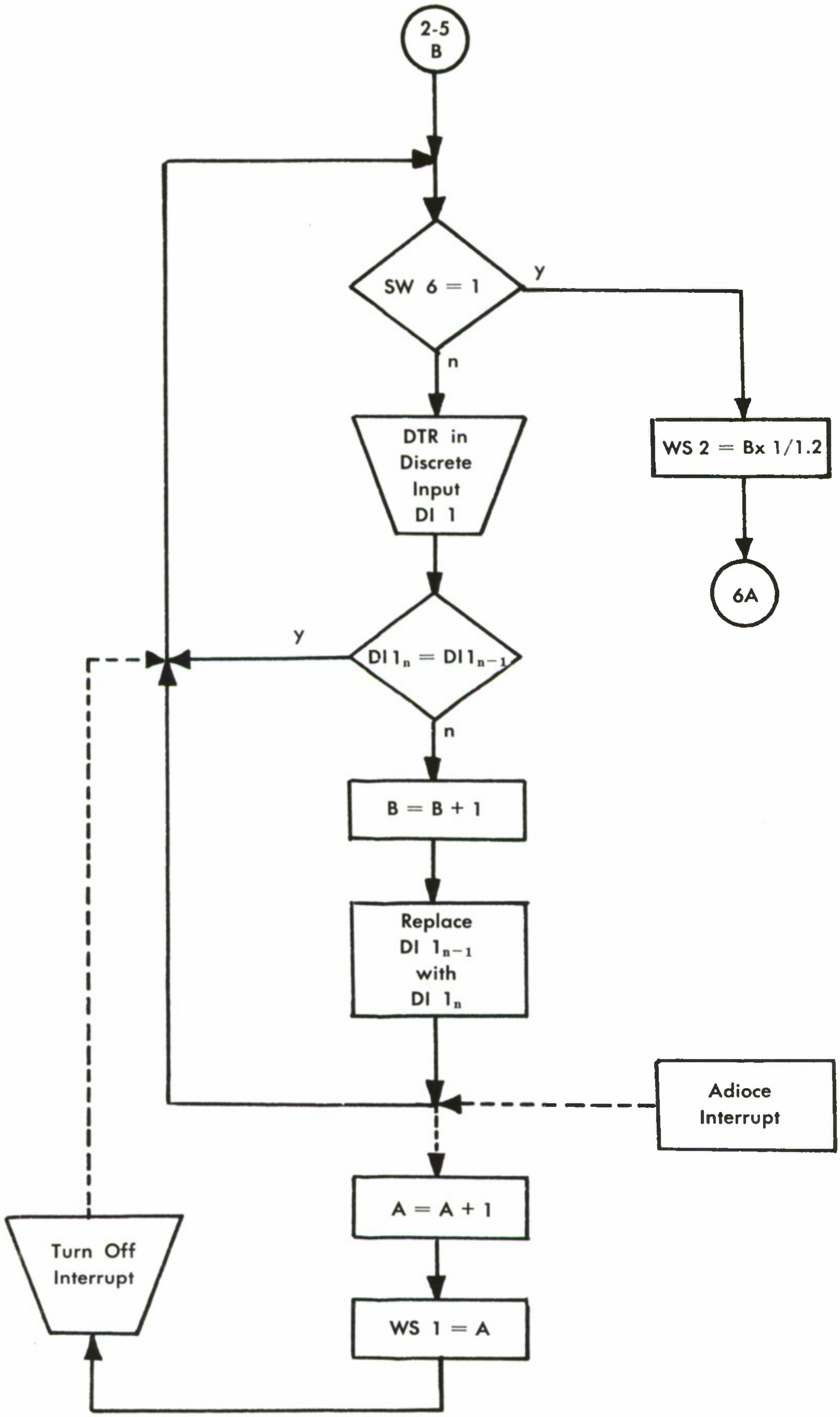


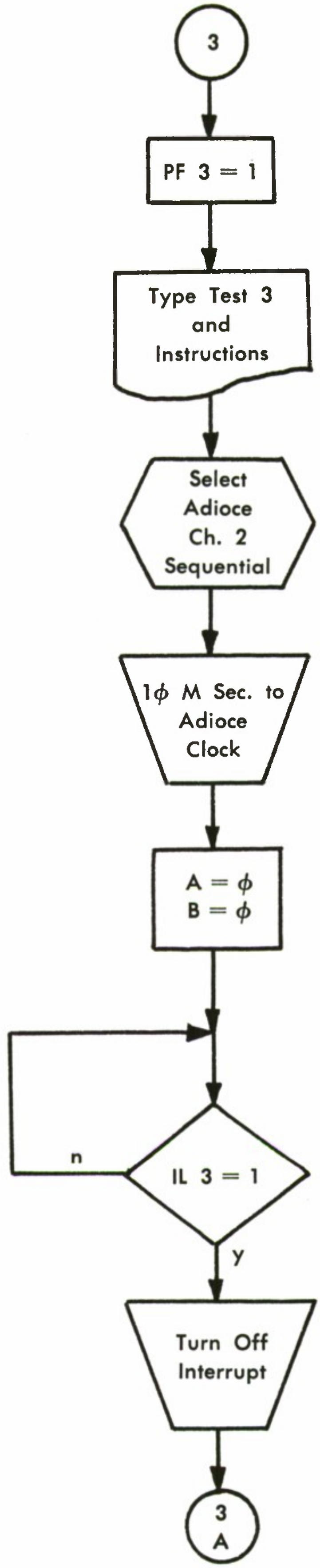
2-4
A
A = −1
1 Sec. to
Adioce
Clock
Turn Off
Interrupt
IM 2 = 1
SW 6 = 1
y
6B
n
Adioce
Interrupt
A = A + 1
WS 1 = A
Turn Off
Interrupt

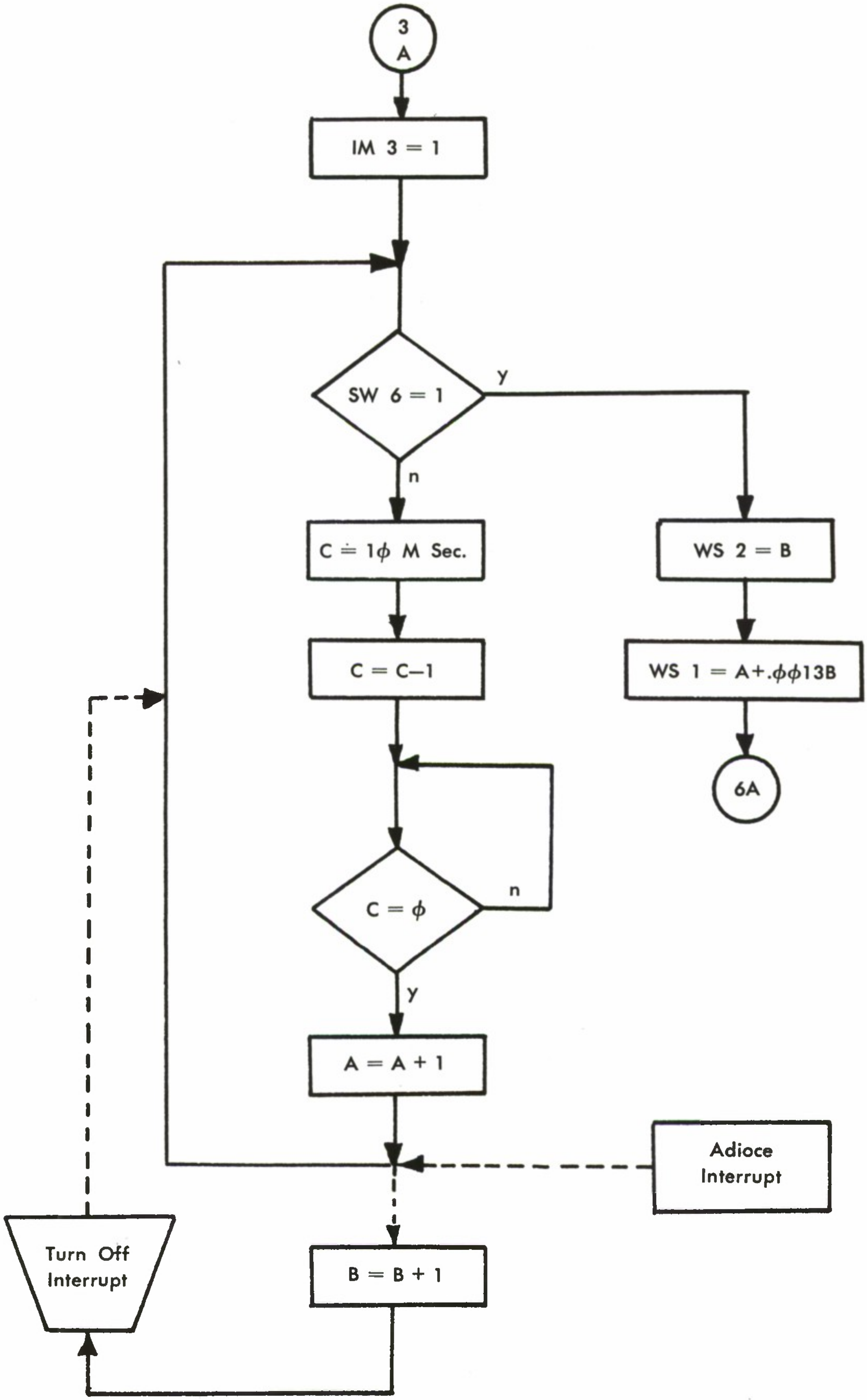


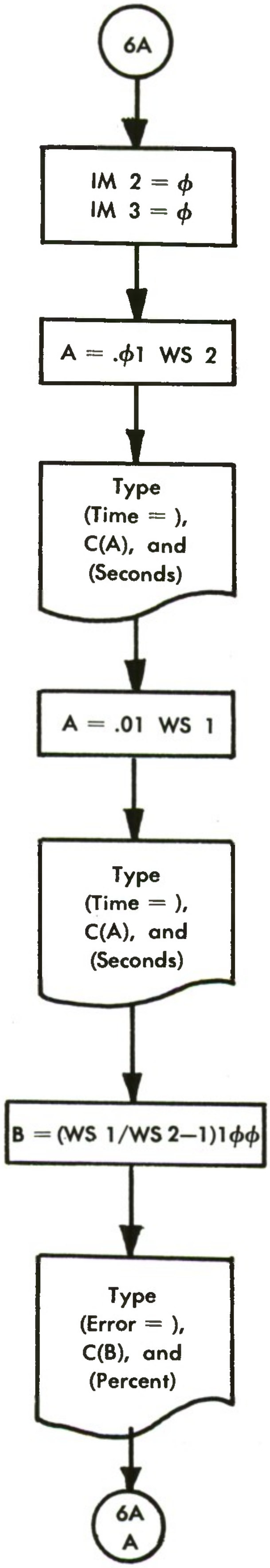
2-5
PF 5 = 1
Type Mode 5 and Instructions
Select Adioce Ch. 1 Sequential
10 M Sec. to Adioce Clock
A = 0
B = 0
2-5 A

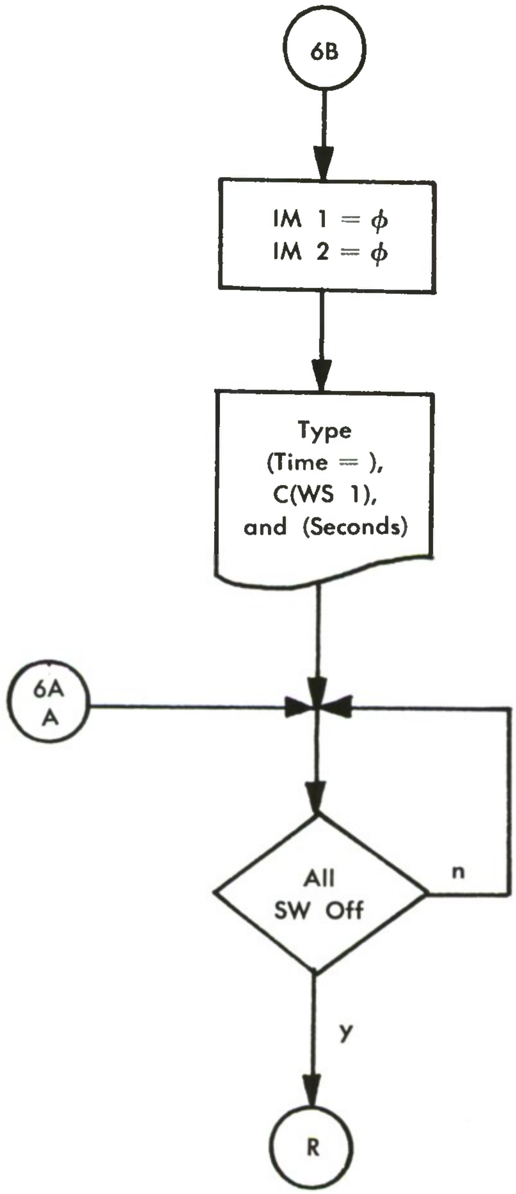

2-5
A
n
IL 2 = 1
y
Turn Off
Interrupt
IM 2 = 1
Select
Adioce
Random
2-5
B


2-5
B
SW 6 = 1
y
n
WS 2 = Bx 1/1.2
6A
DTR in
Discrete
Input
DI 1
y
DI 1_n = DI 1_{n-1}
n
B = B + 1
Replace
DI 1_{n-1}
with
DI 1_n
Adioce
Interrupt
A = A + 1
WS 1 = A
Turn Off
Interrupt


3
PF 3 = 1
Type Test 3
and
Instructions
Select
Adioce
Ch. 2
Sequential
1ϕ M Sec. to
Adioce
Clock
A = ϕ
B = ϕ
n
IL 3 = 1
y
Turn Off
Interrupt
3
A


3
A
IM 3 = 1
SW 6 = 1
y
n
C ≐ 1ϕ M Sec.
C = C–1
C = ϕ
n
y
A = A + 1
WS 2 = B
WS 1 = A+.ϕϕ13B
6A
Adioce
Interrupt
Turn Off
Interrupt
B = B + 1


6A
IM 2 = ϕ
IM 3 = ϕ
A = .ϕ1 WS 2
Type (Time =), C(A), and (Seconds)
A = .01 WS 1
Type (Time =), C(A), and (Seconds)
B = (WS 1/WS 2—1)1ϕϕ
Type (Error =), C(B), and (Percent)
6A A


6B
IM 1 = φ
IM 2 = φ
Type
(Time =),
C(WS 1),
and (Seconds)
6A
A
All
SW Off
n
y
R

```
                    LDR       COMPUTER CLOCK AND REAL-TIME CLOCK TEST

                    LDR          ;      1 APRIL 1965

        *           LOC @ 70100

70100* 02700000     CTS 7 Q      ;      0 TO ALL TOGGLES
                    NOP

70101* 26712501     LDI P A
                    STM Q A      ;      STORE MICRO TYPE

70102* 00000450     0000         ;      ADDRESS IN CORE 0
                    0450

70103* 27034573     LDM Q C      ;      TYPE OUT MAIN TITLE
                    EXC P C      ;      AND TEST SELECTIONS

70104* 07001000     0700
                    1000

70105* 02700000     CTS 7 Q      ,      0 TO ALL TOGGLES
                    NOP

70106* 37311603     TCT SW 1     ;      SW 1 = 1?
                    FTR    3     ;      YES

70107* 37321671     TCT SW 2     ;      NO, SW 2 = 1?
                    FTR @  71    ,      YES

70110* 37331667     TCT SW 3     ;      NO, SW 3 = 1?
                    FTR @  67    ;      YES

70111* 14740000     BTR    3     ;      NO, TEST AGAIN
                    NOP

70112* 36010000     STT PF 1     ;      TEST [ 1 ]
                    NOP

70113* 27034573     LDM Q C      ;      TYPE OUT TEST [1] TITLE AND
                    EXC P C      ;      MODE SELECTIONS

70114* 04701070     0470
                    1070

70115* 37341602     TCT SW 4     ;      SW 4 = 1?
                    FTR    2     ;      YES, GO TO MODE 4

70116* 37351617     TCT SW 5     ,      NO, SW 5 = 1?
                    FTR @ 17     ;      YES, GO TO MODE 5

70117* 14750000     BTR    2     ,      NO, TEST AGAIN
                    NOP

70120* 36040000     STT PF 4     ;      MODE [1-4]
                    NOP

70121* 27034573     LDM Q C      ,      TYPE OUT MODE 4 SELECTED
                    EXC P C      ;      AND INSTRUCTIONS

70122* 03201137     0320
                    1137
```

```
70123* 46010000     CPL Q A    .     CLEAR A
                    NOP

70124* 37341477     TCT SW 4   .     SW 4 = 0?
                    BTR    0   .     NO

70125* 37361606     TCT SW 6   .     SW 6 = 1?
                    FTR    6   .     YES, TYPE OUT TIME (6B)

70126* 00002673     NOP
                    LDI P C

70127* 00606476     0060       .     1 SEC INTO C
                    6476       ;     (1000000/5)-2

70130* 54333233     CDL C C    ;     C = C-1 DECREMENT COUNTER
                    TZO C XF   ;     C = 0?

70131* 16012700     FTR    1   .     YES, (10 MICROSECOND LOOP)
                    LDM Q Q

70132* 14750000     BTR    2   .     NO, (5 MICROSECOND LOOP)
                    NOP

70133* 44111471     CIL A A
                    BTR    6

70134* 21110000     STW 1 A
                    NOP        .     GO TO TYPE OUT TIME (6B)

70135* 16771631     FTR O 77
                    FTR O  31

70136* 36050000     STT PF 5   .     MODE [1-5]
                    NOP

70137* 27034573     LDM Q C    ;     TYPE OUT MODE 5 SELECTED
                    EXC P C    .     AND INSTRUCTIONS

70140* 02501171     0250
                    1171

70141* 46014602     CPL Q A    .     CLEAR A
                    CPL Q B    ;     CLEAR B

70142* 26741244     LDI P D
                    SEL D D    ;     SELECT ADIOCE CH. 0 (00)

70143* 32001000     3200
                    1000       .     (RANDOM)

70144* 37361622     TCT SW 6   .     SW 6 = 1?
                    FTR O  22  .     YES, GO TO ERROR TYPE OUT (6A)

70145* 65602774     COM 6 Q
                    LDM P D

70146* 00000021     0000
                    0021       .     GROUP 1 ADDRESS

70147* 10342333     DTR 3 D    .     DISCRETE INPUT GROUP 1
```

```
                        LDW 3 C     .    LOAD PAST DI VALUE
70150* 73433234         ADS D C
                        TZO C S     .    HAS DI 1 CHANGED?
70151* 16070000         FTR    7    .    NO
                        NOP
70152* 21344422         STW 3 D     .    YES, STORE NEW DI (LEFT LOOP)
                        CIL B B     .    B = B + 1
70153* 26730000         LDI P C
                        NOP
70154* 00000302         0000        .    (1000/5)-6
                        0302
70155* 54333233         CDL C C     .    C = C-1 DECREMENT TIMER
                        TZO C XF    .    C = 0?
70156* 00001601         NOP         .    YES
                        FTR    1
70157* 14750000         BTR    2    .    NO
                        NOP
70160* 44111463         CIL A A     .    A = A + 1
                        BTR O  14
70161* 00002673         NOP         .    (RIGHT LOOP)
                        LDI P C
70162* 00000302         0000        .    (1000/5)-6
                        0302
70163* 54333233         CDL C C     .    C = C-1
                        TZO C XF    .    C = 0?
70164* 00001601         NOP         .    YES
                        FTR    1
70165* 14750000         BTR    2    .    NO
                        NOP
70166* 44111455         CIL A A     .    A = A + 1
                        BTR O  22
70167* 21112122         STW 1 A     .    A INTO WS 1
                        STW 2 B     .    B INTO WS 2
70170* 26730000         LDI P C     .    1/1.20 INTO C
                        NOP
70171* 32525252         3252
                        5252        .    1/1.20
70172* 46750440         CPL P L     .    B X 1/1.20 INTO A
                        CLP O 40
70173* 21212312         STW 2 A     .    B X 1/1.20 INTO WS2
                        LDW 1 B
```

```
70174* 26730000     LDI P C    ;     .1 INTO C
                    NOP

70175* 03146314     0314
                    6314       ;     .1

70176* 46750440     CPL P L    ;     A X .1 INTO A
                    CLP O 40

70177* 21111665     STW 1 A
                    FTR O  65  ;     GO TO ERROR TYPE OUT (6A)

70200* 16660000     FTR O  66  ;     INTERMEDIATE TRANSFER
                    NOP        ;     TO TEST [3]

70201* 36020000     STT PF 2   ;     TEST [2]
                    NOP

70202* 27034573     LDM Q C    ;     TYPE OUT TEST [2] TITLE
                    EXC P C

70203* 01301244     0130
                    1244

70204* 27034573     LDM Q C    ;     TYPE OUT MODE SELECTIONS
                    EXC P C

70205* 03401103     0340
                    1103

70206* 37341602     TCT SW 4   ;     SW 4 = 1?
                    FTR    2   ;     YES, MODE 4

70207* 37351622     TCT SW 5   ;     NO, SW 5 = 1?
                    FTR O  22  ;     YES, MODE 5

70210* 14750000     BTR    2   ;     NO, TEST AGAIN
                    NOP

70211* 36040000     STT PF 4   ;     MODE [2-4]
                    NOP

70212* 27034573     LDM Q C    ;     TYPE OUT MODE 4 SELECTED
                    EXC P C    ;     AND INSTRUCTIONS

70213* 03201137     0320
                    1137

70214* 26732674     LDI P C
                    LDI P D

70215* 00040001     0004       ;     100 MICROSECONDS FOR TIR
                    0001       ;     MINIMUM COUNT

70216* 32003077     3200       ;     SELECT WORD (RANDOM)
                    3077       ;     CH. 1 (01)

70217* 12446561     SEL D D    ;     SELECT ADIOCE
                    COM 6 A    ;     LOCK COM TO CH. 1 (01)

70220* 10632673     DTR 6 C
                    LDI P C
```

```
70221* 00063420     0006         ;    1 SEC FØR TIR
                    3420

70222* 37341477     TCT SW 4     ;    SW4 = 0?
                    BTR    0     ;    NØ

70223* 35421477     TCF IL 2     ;    YES, IL 2 = 0?
                    BTR    0     ;    YES

70224* 54011063     CDL Q A      ;    NØ, A = -1
                    DTR 6 C      ;    1 SEC INTØ TIR

70225* 26741244     LDI P D
                    SEL D D      ;    TURN ØFF INTERRUPT

70226* 72000400     7200
                    0400

70227* 65003612     CØM 0 Q
                    STT IM 2     ;    SET IM 2 TRUE

70230* 37361635     TCT SW 6     ;    SW6 2 1?
                    FTR Ø 35     ;    YES, TYPE ØUT TIME (6B)

70231* 14760000     BTR    1     ;    NØ TEST AGAIN
                    NØP

70232* 36050000     STT PF 5     ;    MØDE [2-5]
                    NØP

70233* 27034573     LDM Q C      ;    TYPE ØUT MØDE 5 SELECTED
                    EXC P C      ;    AND INSTRUCTIØNS

70234* 02501171     0250
                    1171

70235* 26732674     LDI P C
                    LDI P D

70236* 00040144     0004         ;    10 MSEC FØR TIR
                    0144

70237* 32002077     3200         ;    SELECT WØRD (SEQ)
                    2077         ;    CH. 1 (01)

70240* 12446561     SEL D D      ;    SELECT ADIØCE
                    CØM 6 A      ;    LØCK CØM TØ CH. 1 (01)

70241* 10636500     DTR 6 C      ;    10 MSEC INTØ TIR
                    CØM 0 Q

70242* 46014602     CPL Q A      ;    CLEAR A
                    CPL Q B      ;    CLEAR B

70243* 35421477     TCF IL 2     ;    IL 2 = 1?
                    BTR    0     ;    NØ

70244* 26741244     LDI P D      ;    YES, RELEASE INTERRUPT
                    SEL D D

70245* 72000400     7200
```

```
                 0400

70246* 36120000  STT IM 2  ;   SET IM2 TRUE
                 NOP

70247* 26741244  LDI P D
                 SEL D D   ;   SELECT ADIOCE (RANDOM)

70250* 32003000  3200
                 3000

70251* 37361606  TCT SW 6  ;   SW 6 = 1?
                 FTR    6  ;   YES

70252* 07216561  CLD O  21 ;   NO, DI GROUP 1 ADDRESS
                 COM 6 A   ;   LOCK COM TO CH. 1 (01)

70253* 10346500  DTR 3 D   ;   DISCRETE INPUT GROUP 1
                 COM 0 Q

70254* 23337343  LDW 3 C   ;   LOAD PAST DI 1 VALUE
                 ADS D C

70255* 32341473  TZO C S   ;   HAS DI 1 CHANGED
                 BTR    4  ;   NO

70256* 21344422  STW 3 D   ;   YES, STORE NEW VALUE
                 CIL B B   ;   B = B + 1

70257* 14710000  BTR    6
                 NOP

70260* 21112122  STW 1 A
                 STW 2 B

70261* 26730000  LDI P C
                 NOP

70262* 32525252  3252      ;   1/1.2
                 5252

70263* 46750440  CPL P L   ;   B X 1/1.2 INTO A
                 CLP O 40

70264* 21210000  STW 2 A   ;   B X 1/1.2 INTO WS 2
                 NOP

70265* 16330000  FTR O  33 ;   TRANSFER TO TYPE OUT ERROR (6A)
                 NOP

70266* 16771607  FTR O  77 ;   TRANSFER TO TYPE OUT TIME (6B)
                 FTR    7

70267* 36030000  STT PF 3  ;   TEST [3]
                 NOP

70270* 27034573  LDM Q C   ;   TYPE OUT TEST [3]
                 EXC P C   ;   TITLE AND INSTRUCTIONS

70271* 03401257  0340
                 1257
```

```
70272* 26732674         LDI P C
                        LDI P D

70273* 00040144         0004        ;      10 MSEC FOR TIR
                        0144

70274* 32004077         3200        ;      SELECT WORD (SEQ.)
                        4077        ;      CH. 2 (10)

70275* 12446562         SEL D D     ;      SELECT ADIOCE
                        COM 6 B     ;      LOCK COM TO CH. 2 (10)

70276* 10636500         DTR 6 C     ;      10 MSEC INTO TIR
                        COM 0 Q

70277* 46014602         CPL Q A     ;      CLEAR A
                        CPL Q B     ;      CLEAR B

70300* 35431477         TCF IL 3    ;      IL 3 = 1?
                        BTR   0     ;      NO, TEST AGAIN

70301* 26741244         LDI P D     ;      YES
                        SEL D D     ;      TURN OFF INTERRUPT

70302* 72000400         7200
                        0400

70303* 36130000         STT IM 3    ;      SET IM 3 TRUE
                        NOP

70304* 37361606         TCT SW 6    ;      SW 6 = 1?
                        FTR   6     ;      YES, GO TO ERROR TYPE OUT (6A)

70305* 00002673         NOP         ;      NO, LOAD REGISTER TIMER
                        LDI P C     ;      10 MSEC INTO C

70306* 00003716         0000
                        3716        ;      (10000/5)-2

70307* 54333233         CDL C C     ;      C = C-1
                        TZO C XF    ;      C = 0?

70310* 16012700         FTR   1     ;      YES, (10 MICROSECOND LOOP)
                        LDM Q Q

70311* 14750000         BTR   2     ;      NO, (5 MICROSECOND LOOP)
                        NOP

70312* 44111471         CIL A A     ;      A = A + 1
                        BTR   6

70313* 21112122         STW 1 A     ;      A INTO WS 1
                        STW 2 B     ;      B INTO WS 2

70314* 26730000         LDI P C
                        NOP

70315* 00025231         0002        ;      .0013
                        5231

70316* 46750440         CPL P L     ;      B X .0013 INTO A
                        CLP O 40
```

```
70317* 23125521      LDW 1 B
                     ADL B A    ;      A + B (DELTA T) INTØ A

70320* 21110000      STW 1 A    ;      CØRRECTED A INTØ WS1
                     NØP        ;      GØ TØ TYPE ØUT ERRØR (6A)

70321* 34123413      STF I M 2 ;       SET IM 1 FALSE (6A)
                     STF IM 3   ;      SET IM 2 FALSE

70322* 23222673      LDW 2 B    ;      WS2 INTØ B
                     LDI P C

70323* 00243656      0024
                     3656       ;      .01

70324* 46750440      CPL P L
                     CLP Ø 40   ;      B X .01 INTØ A

70325* 05101320      LRC Ø 10
                     SDL LØM    ;      SCALE B 15

70326* 21510000      STW 5 A    ;      A INTØ WS5
                     NØP

70327* 27034537      LDM Q C
                     EXC C P    ;      TYPE ØUT (TIME =)

70330* 01001216      0100
                     1216

70331* 23520517      LDW 5 B
                     CLN Ø  17

70332* 26754557      LDI P L    ;      TYPE ØUT NUMBER
                     EXC L P

70333* 00400500      0040
                     0500

70334* 27034537      LDM Q C
                     EXC C P    ;      TYPE ØUT SECØNDS

70335* 00301226      0030
                     1226

70336* 23122673      LDW 1 B
                     LDI P C

70337* 00243656      0024
                     3656       ;      .01

70340* 46750440      CPL P L
                     CLP Ø 40   ;      B X .01 INTØ A

70341* 05101320      LRC Ø 10
                     SDL LØM    ;      SCALE B 15

70342* 21610000      STW 6 A
                     NØP

70343* 27034537      LDM Q C
```

```
                        EXC C P    ;     TYPE ØUT (TIME =)

70344* 01001216         0100
                        1216

70345* 23620517         LDW 6 B
                        CLN Ø  17

70346* 26754557         LDI P L
                        EXC L P    ;     TYPE ØUT NUMBER

70347* 00400500         0040
                        0500

70350* 27034537         LDM Q C
                        EXC C P    ;     TYPE ØUT SECØNDS

70351* 00301226         0030
                        1226

70352* 23112323         LDW 1 A
                        LDW 2 C

70353* 05016623         LRC   1
                        SSL LØM C

70354* 46750460         CPL P L
                        CLP Ø 60   ;     WS1/WS2 SCALED B1

70355* 46016101         CPL Q A
                        CCS Q A

70356* 05016671         LRC    1
                        SSL RØL A ;      1 SCALED B1

70357* 61010000         CCS Q A
                        NØP

70360* 55122673         ADL A B    ;     (WS1/WS2 - 1) SCALED B1
                        LDI P C

70361* 00000144         0000
                        0144

70362* 46750440         CPL P L
                        CLP Ø 40   ;     (WS1/WS2 -1)X100 INTØ B

70363* 05031362         LRC   3
                        SDL RØM B ;      SCALE B4

70364* 72122132         CPS A B
                        STW 3 B

70365* 27034537         LDM Q C
                        EXC C P    ;     TYPE ØUT (ERRØR = )

70366* 01001231         0100
                        1231

70367* 23320504         LDW 3 B
                        CLN   4
```

```
70370* 26754557     LDI P L
                    EXC L P   .     TYPE ØUT NUMBER

70371* 00000500     0000
                    0500

70372* 27034573     LDM Q C
                    EXC P C   .     TYPE ØUT (PERCENT)

70373* 00301241     0030
                    1241

70374* 16100000     FTR Ø 10
                    NØP

70375* 34113412     STF IM 1  .     SET IM 0 FALSE(6B)
                    STF IM 2  .     SET IM 1 FALSE

70376* 27034537     LDM Q C
                    EXC C P   .     TYPE ØUT (TIME =)

70377* 01001216     0100
                    1216

70400* 23120527     LDW 1 B   .     WS1 INTØ B
                    LRC Ø 27

70401* 26754557     LDI P L   .     ØUTPUT NUMBER
                    EXC L P

70402* 00600500     0060
                    0500

70403* 27034537     LDM Q C
                    EXC C P   .     TYPE ØUT (SECØNDS)

70404* 00301226     0030
                    1226

70405* 35301601     TCF SW X  .     ALL SW ØFF?
                    FTR    1

70406* 14760000     BTR    1  .     NØ
                    NØP

70407* 27770000     LDM P P   .     YES, RETURN FØR
                    NØP       .     NEW TEST [END]

70410* 00070105     0007
                    0105

                    LDR

                    LDR

     *              LØC Ø 70000

70000* 45750404     EXC P L
                    CLP    4

70001* 45750404     EXC P L
                    CLP    4
```

```
70002* 45750410       EXC P L
                      CLP @ 10

70003* 00000000       N@P
                      N@P

70004* 44112111       CIL A A   ,     A = A + 1 TEST [2-4 AND 5]
                      STW 1 A   .

70005* 26741244       LDI P D
                      SEL D D   ,     RELEASE INTERRUPT

70006* 72000400       7200
                      0400

70007* 45576500       EXC L P   ,     RETURN
                      C@M 0 Q

70010* 44220000       CIL B B   ,     B = B + 1 TEST [3]
                      N@P

70011* 26741244       LDI P D
                      SEL D D   ,     RELEASE INTERRUPT

70012* 72000400       7200
                      0400

70013* 65004557       C@M 0 Q
                      EXC L P   ,     RETURN

                      LDR

     * 00070100       END @ 70100
```

COMPUTER CLOCK AND REAL TIME CLOCK TESTS

SELECT TEST

SW1 - COMPUTER CLOCK VS REAL TIME

SW2 - REAL TIME CLOCK VS REAL TIME

SW3 - COMPUTER CLOCK VS REAL TIME CLOCK

COMPUTER CLOCK VS REAL TIME TEST

SELECT MODE

SW4 - CLOCK REFERENCE

SW5 - 6Ø CYCLE LINE REFERENCE

MODE 5

SW6 ON FOR TIME AND PER CENT ERROR TYPE-OUT.

TIME = 12ØØ.41 SECONDS

TIME = 12ØØ.34 SECONDS

ERROR = - Ø.ØØ5842 PER CENT

COMPUTER CLOCK AND REAL TIME CLOCK TESTS

SELECT TEST

SW1 - COMPUTER CLOCK VS REAL TIME

SW2 - REAL TIME CLOCK VS REAL TIME

SW3 - COMPUTER CLOCK VS REAL TIME CLOCK

REAL TIME CLOCK VS REAL TIME TEST

SELECT MODE

SW4 - CLOCK REFERENCE

SW5 - 6Ø CYCLE LINE REFERENCE

MODE 5

SW6 ON FOR TIME AND PER CENT ERROR TYPE-OUT.

TIME = 12ØØ.27 SECONDS

TIME = 12ØØ.21 SECONDS

ERROR = - Ø.ØØ5ØØ6 PER CENT

COMPUTER CLOCK AND REAL TIME CLOCK TESTS

SELECT TEST

SW1 - COMPUTER CLOCK VS REAL TIME

SW2 - REAL TIME CLOCK VS REAL TIME

SW3 - COMPUTER CLOCK VS REAL TIME CLOCK

COMPUTER CLOCK VS REAL TIME CLOCK TEST

SW6 ON FOR TIME AND PER CENT ERROR TYPE-OUT.

TIME = 1200.23 SECONDS

TIME = 1200.12 SECONDS

ERROR = - 0.009180 PER CENT

Appendix II.

AUTOMATED DIAGNOSTIC TEST UTILITY ROUTINES

PB-440 PROGRAM ABSTRACT

PROGRAM TITLE:	MICRO MULTIPLY
PROGRAMMER:	P. A. KNOOP
DATE:	9 June 1964
ID:	None
FUNCTION:	The purpose of this program is to serve as a micro subroutine for multiplication. This routine is part of the ADIOCE Acceptance Test package.
TECHNIQUE:	The program multiplies the contents of the B and C registers, stores the product in the coupled A-B registers, and returns control to the address provided in the L register. The calling address is 70040 in the ADIOCE Acceptance Test package.
LOADING PROCEDURE:	Load with Binary Loader I. This routine is relocatable for general use but must be stored beginning at 70040 for the ADIOCE tests.
OPERATING PROCEDURES & LINKAGE REQUIRED:	None

PROGRAM STORAGE:

Program Segment	*Octal Locs.*	*Total*
Main Program	70040-70051	12_8

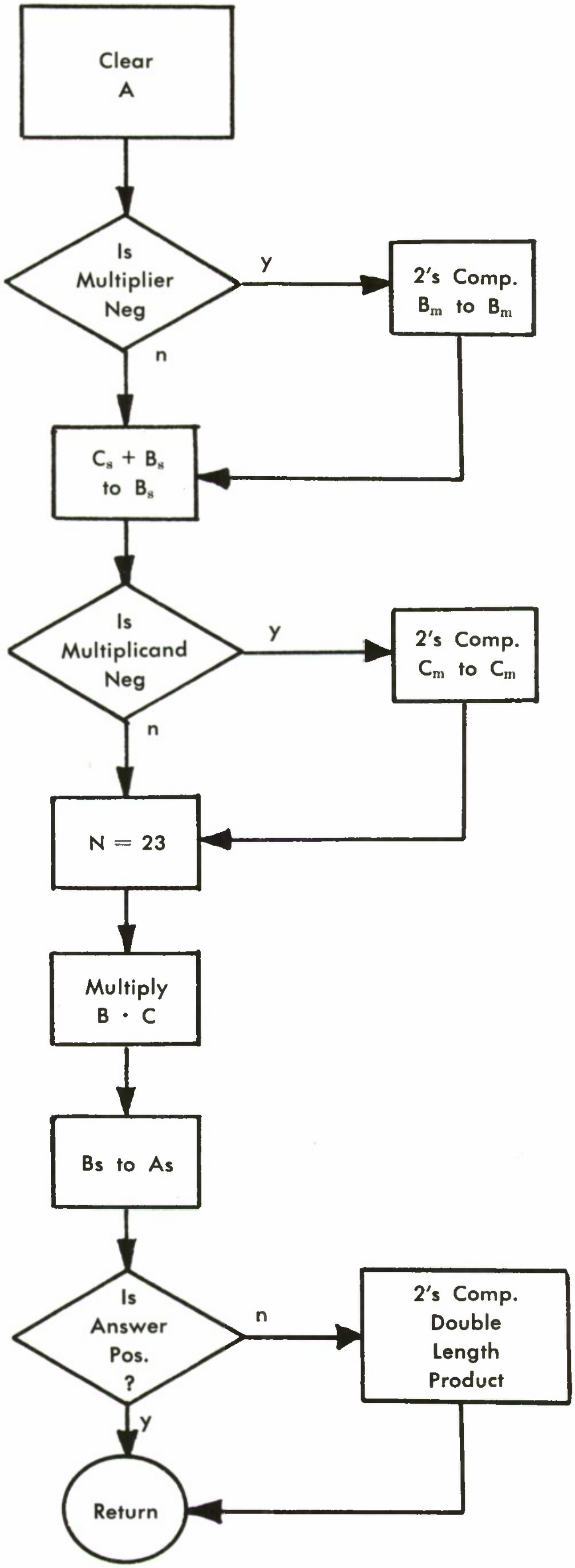
INTERMEDIATE STORAGE:	None
EXECUTION TIME:	34-42 Microseconds

REGISTERS:

A	MSB of double-length product
B	multiplicand; LSB of double-length product
C	Multiplier
D	Not used
N	Shift Counter
L	Return Location
P	Location Counter

SENSE SWITCHES:	Not used
PROGRAM FLAGS:	Not used
I/O DEVICES:	None
PROGRAM HALTS:	None

MICRO MULTIPLY



```
                        00001   LØR        .    MICRØ MULTIPLY

                        00002   LØR        .    SUBRØUTINE - ADIØCE TESTS

00001   57113024        00003   XØR A  A   .    CLEAR A
                        00004   TNZ B  S   .    B PØSITIVE???

00002   62224422        00005   CØM B  B   .    NØ - 2'S CØMP. B
                        00006   CIL B  B

00003   73323034        00007   ADS C  B   .    (C + B)S TØ B(S)
                        00008   TNZ C  S   .    C PØSITIVE???

00004   62334433        00009   CØM C  C   .    NØ - 2'S CØMP. C
                        00010   CIL C  C

00005   05270000        00011   LRC 23     .    N=23
                        00012   NØP

00006   15317221        00013   MPS C  A   .    MULTIPLY
                        00014   CPS B  A   .    SIGN TØ A

00007   32147057        00015   TZØ A  S   .    ANS PØSITIVE???
                        00016   CPF L  P   .    YES - RETURN

00010   62116222        00017   CØM A  A   .    NØ - 2'S CØMP.
                        00018   CØM B  B   .    DBL LENGTH PRØDUCT

00011   44224061        00019   CIL B  B
                        00020   AFK N  A

00012   70570000        00021   CPF L  P   .    RETURN
                        00022   NØP

        00000000        00023   END A*
```

PB-440 PROGRAM ABSTRACT

PROGRAM TITLE:	MICRO DIVIDE
PROGRAMMER:	P. A. KNOOP
DATE:	9 June 1964
ID:	None
FUNCTION:	The purpose of this program is to serve as a micro subroutine for division. This routine is part of the ADIOCE Acceptance Test package.
TECHNIQUE:	The program divides the contents of the A register by the contents of the C register and stores the quotient in the B register. It then returns control to the address in the L register. The calling address is 70060 in the ADIOCE Acceptance Test package.
LOADING PROCEDURE:	Load with Binary Loader I. This routine is relocatable for general use but must be stored beginning at 70060 for the ADIOCE tests.
OPERATING PROCEDURES & LINKAGE REQUIRED:	None

PROGRAM STORAGE:

Program Segment	*Octal Locs.*	*Total*
Main Program	70060-70067	10_8

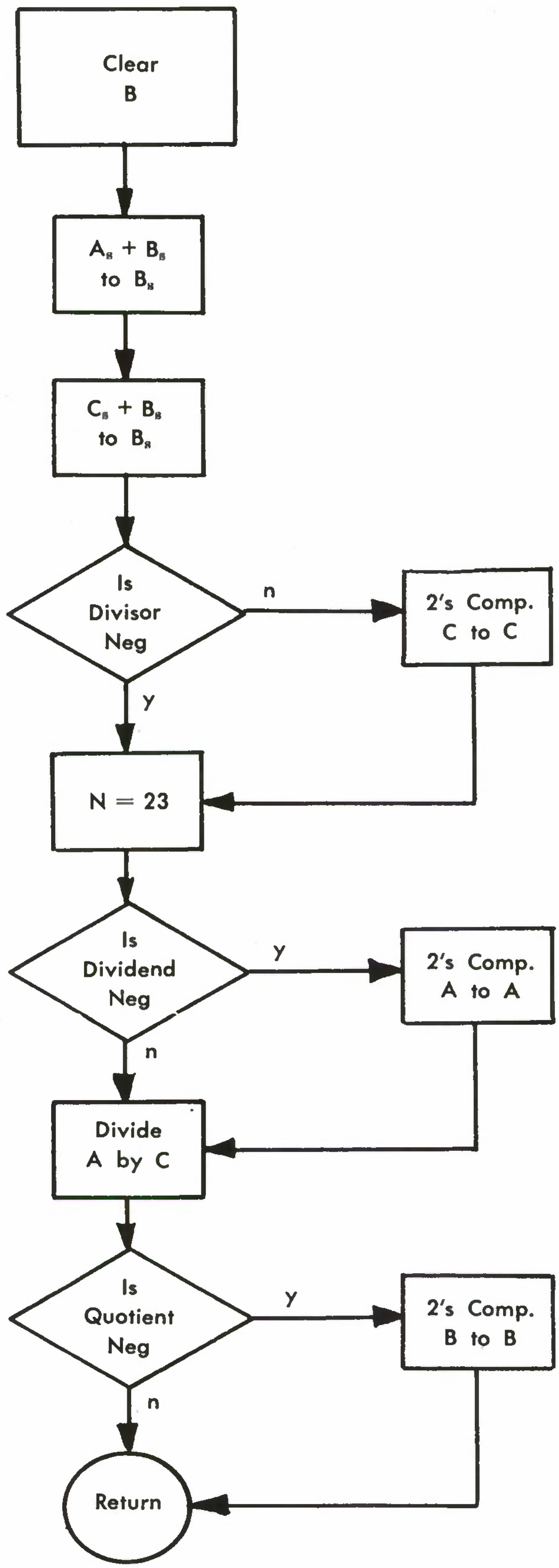
INTERMEDIATE STORAGE:	None
EXECUTION TIME:	35-39 Microseconds

REGISTERS:

A	Dividend
B	Quotient
C	Divisor
D	Not used
N	Shift Counter
L	Return Location
P	Location Counter

SENSE SWITCHES:	Not used
PROGRAM FLAGS:	Not used
I/O DEVICES:	None
PROGRAM HALTS:	None

MICRO DIVIDE



```
                          00001   LØR          .   MICRØ DIVIDE

                          00002   LØR          .   SUBRØUTINE ADIØCE TESTS

00001   46027312          00003   CPL Q B      .   CLEAR B
                          00004   ADS A B

00002   73323234          00005   ADS C B      .   FØRM SIGN ØF QUØTIENT
                          00006   TZØ C S      .   C PØSITIVE?

00003   63334433          00007   CCL C C      .   YES - 2'S CØMP. C
                          00008   CIL C C

00004   05273014          00009   LRC 23       .   N = 23
                          00010   TNZ A S      .   A PØSITIVE?

00005   63114411          00011   CCL A A      .   NØ - 2'S CØMP. A
                          00012   CIL A A

00006   17313024          00013   DVS C A      .   DIVIDE
                          00014   TNZ B S      .   ANS PØSITIVE?

00007   62224422          00015   CCM B B      .   NØ - 2'S CØMP. ANS
                          00016   CIL B B

00010   70570000          00017   CPF L P      .   RETURN
                          00018   NØP

        00000000          00019   END A*
```

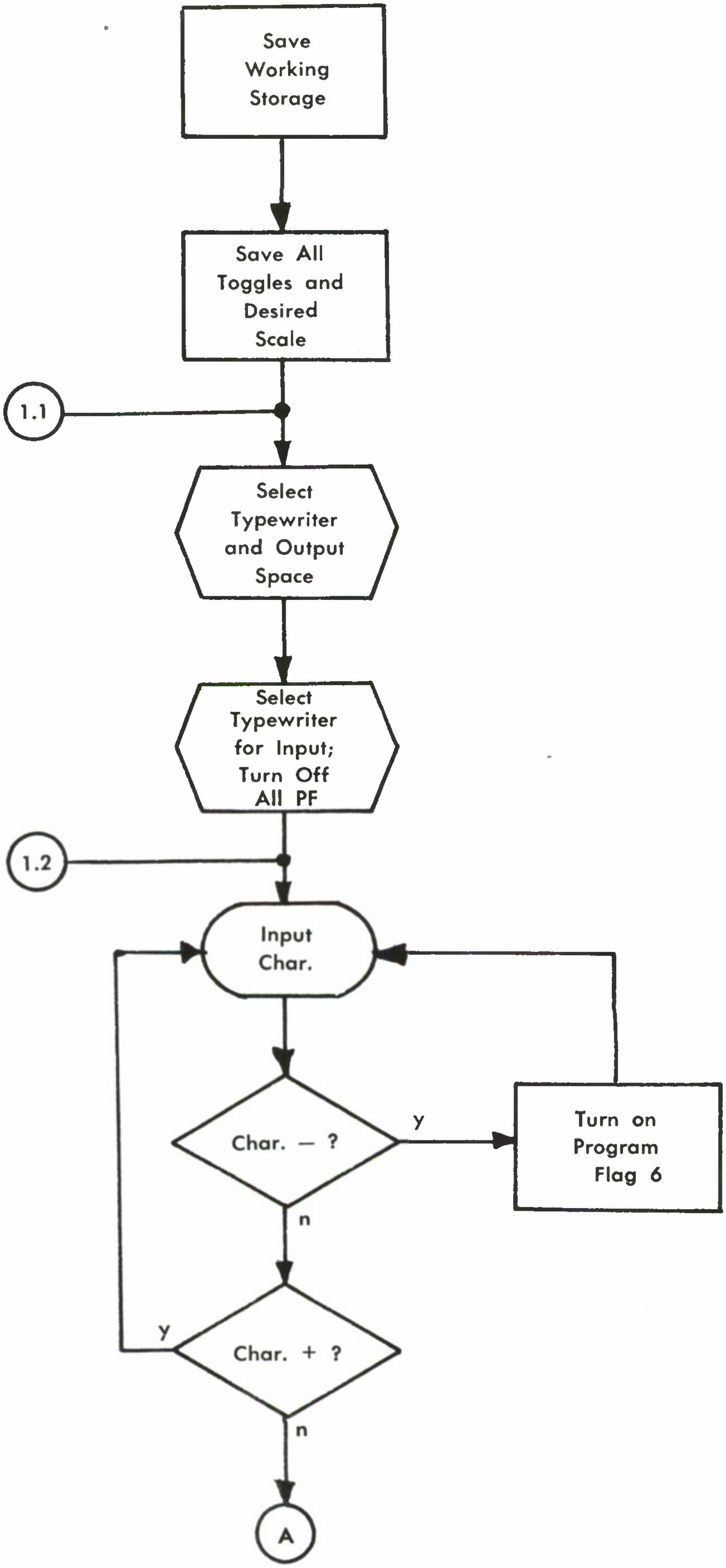
PB-440 PROGRAM ABSTRACT

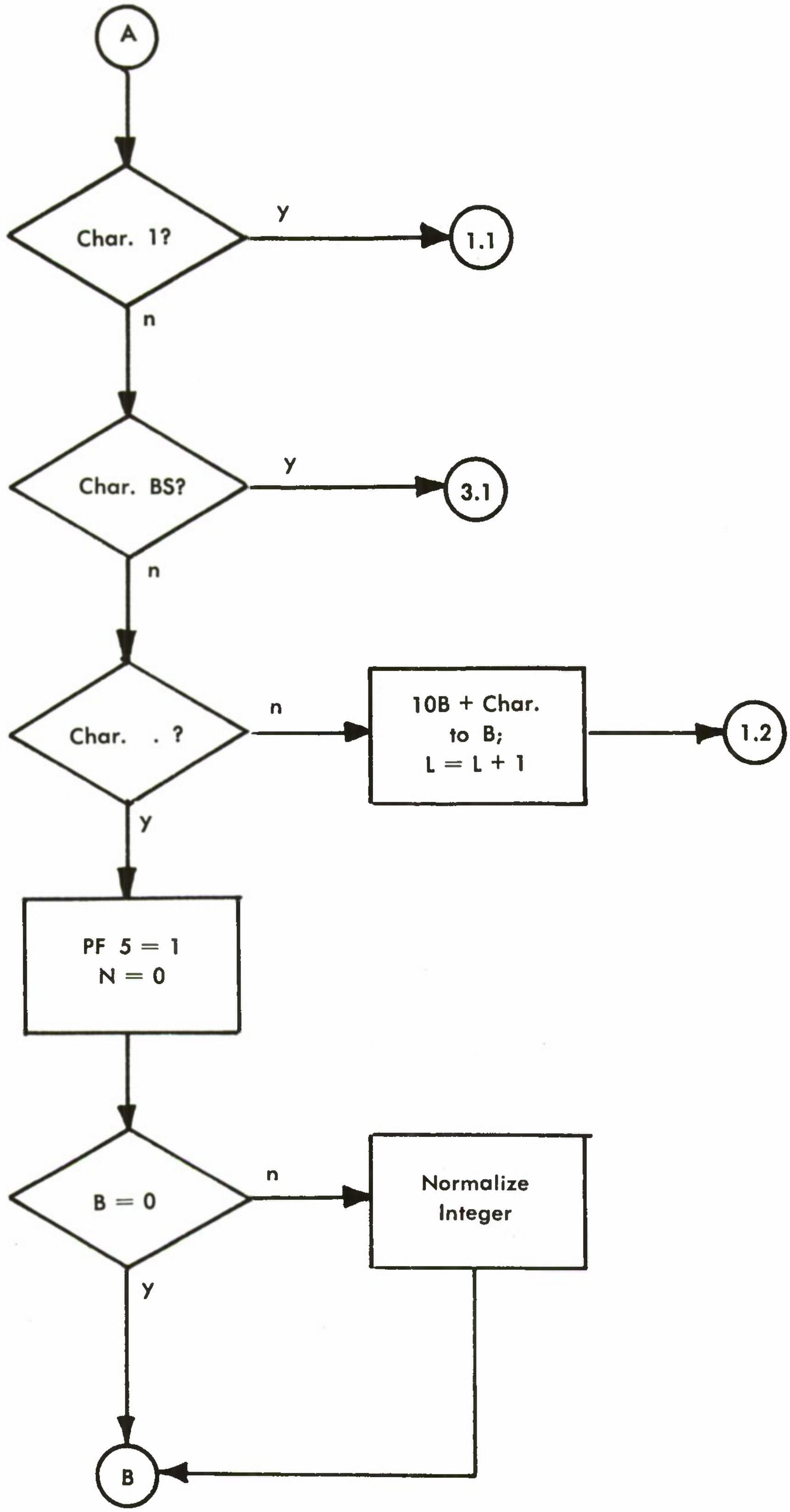
PROGRAM TITLE:	DECIMAL INPUT II (SUBROUTINE)
PROGRAMMER:	V. A. WAGNER
DATE:	30 April 1965
PURPOSE:	To input from the typewriter and convert to fixed point decimal the numbers typed. Scale (binary point position) desired by the caller is put in the N register.
METHOD:	For integer: Multiply by 10_{10} and add new digit. For fraction: Treat as integer then divide by 10^L, L being the number of digits typed behind the decimal point. The routine scales the integer B_{23} until the decimal point is typed ("."); then it normalizes the integer (i.e., shifts left until $B_1 = 1$). The fraction is scaled B_0 and shifted right normalized scale, and logically "or" d with the integer. This whole word is then shifted left or right to give the proper scale. If it needs to be shifted left the number is too large for the given scale and the routine types a space, a "?", and another space and waits for another input.
LOADING PROCEDURE:	Load as a standard BLI tape.
ENTRY CONDITIONS:	Use the following calling sequence: LDI P L EXC P L OCT 00000650
EXIT CONDITIONS:	Scale in N Number in B Typewriter disconnected Com unlocked
LINKAGE REQUIRED:	None
MEMORY REQUIREMENTS:	$650_8 - 777_8$
SPEED:	N/A
ACCURACY:	Full 23 bits for integers only. 22 bits for integers and fractions. Last bit may be incorrect.
SPECIAL TOGGLES USED:	PF 6 — negative number PF 5 — "." has been input CT All normal arithmetic charges These are reset at end of program.
REFERENCES:	None
REGISTERS USED:	All

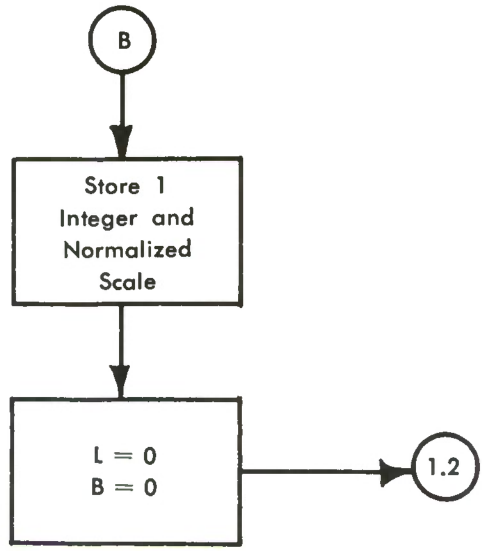
SENSE SWITCH OPTIONS:	None
HALTS:	None
I/O USAGE:	Typewriter
I/O CHANNEL ASSIGNMENT	
ALTERATIONS:	Typewriter connected then disconnected from Channel 3.
NOTES:	It is possible to use this routine with the photo reader by selecting the photo reader on Channel 3 before calling this routine. This routine can be called by SCS by using the following calling sequence:

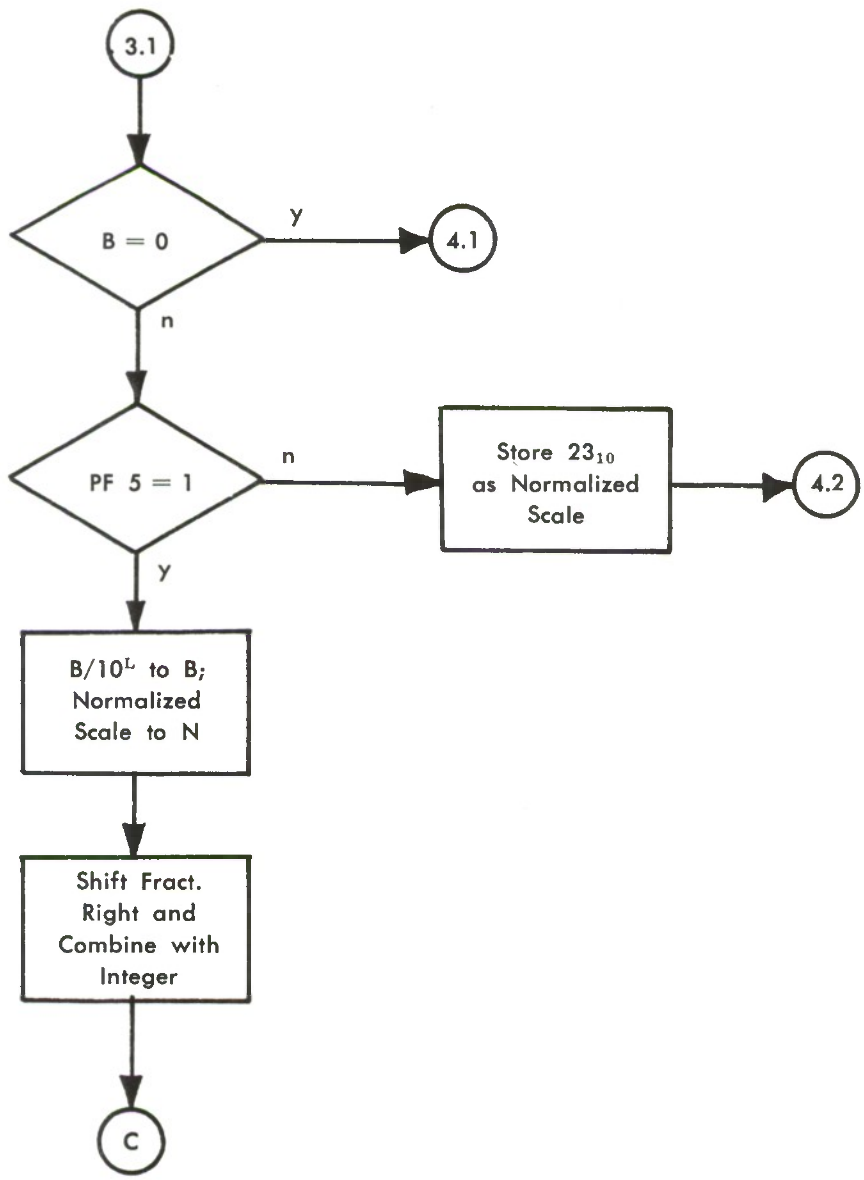
```
ETC x      EXC L P
LDI P L
EXC P L
00000650
EXC L P
NOP
Next Macro
```

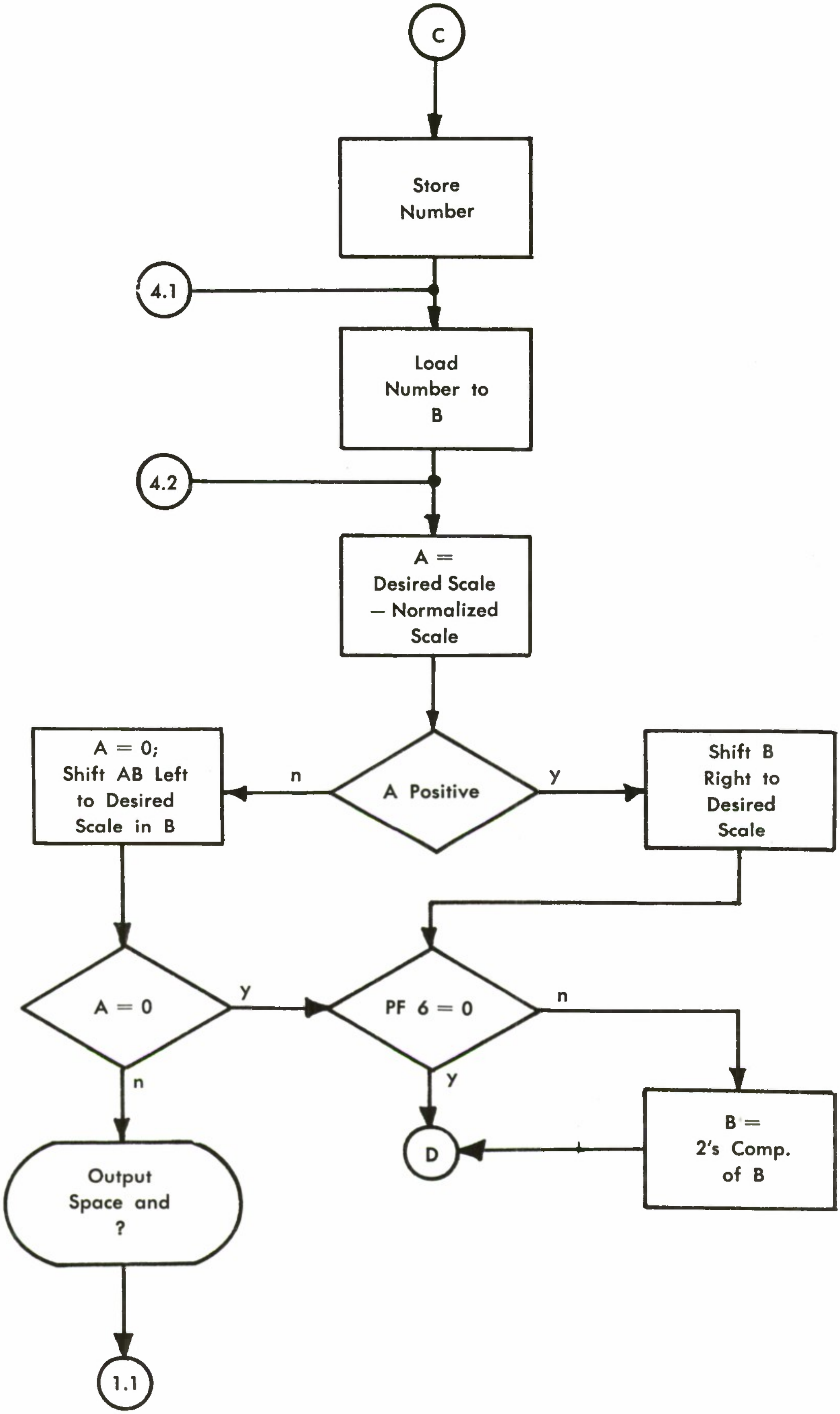
DECIMAL INPUT II (SUBROUTINE)

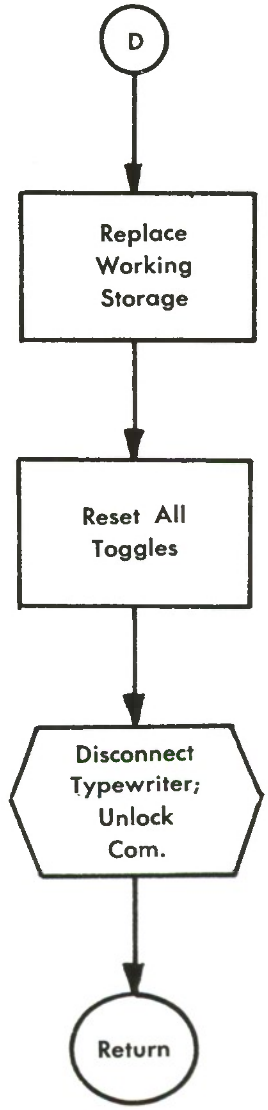



A
Char. 1?
y
1.1
n
Char. BS?
y
3.1
n
Char. . ?
n
10B + Char.
to B;
L = L + 1
1.2
y
PF 5 = 1
N = 0
B = 0
n
Normalize
Integer
y
B


B
Store 1
Integer and
Normalized
Scale
L = 0
B = 0
1.2


3.1
B = 0
y
4.1
n
PF 5 = 1
n
Store 23₁₀
as Normalized
Scale
4.2
y
B/10^L to B;
Normalized
Scale to N
Shift Fract.
Right and
Combine with
Integer
C


C
Store Number
4.1
Load Number to B
4.2
A = Desired Scale − Normalized Scale
A Positive
n
y
A = 0; Shift AB Left to Desired Scale in B
Shift B Right to Desired Scale
A = 0
y
n
PF 6 = 0
n
y
Output Space and ?
D
B = 2's Comp. of B
1.1


D
Replace Working Storage
Reset All Toggles
Disconnect Typewriter; Unlock Com.
Return

```
                    LDR\*******************************
                    LDR\D E C I M A L   I N P U T   II
                    LDR\V.  W A G N E R      27 SEPT 1965
                    LDR\*******************************
                    L0C\0 650
00650   46741610    CPL P D\1ST L0CATI0N 0F *ST0RAGE* T0 D
                    FTR 0 10\SKIP 0VER *ST0RAGE*
00651   00000000    0000\*****      ST0RAGE      *****
                    0000\**
00652   00000000    0000\**
                    0000\**
00653   00000000    0000\**
                    0000\**
00654   00000000    0000\**
                    0000\**
00655   00000000    0000\**
                    0000\**
00656   00000000    0000\**
                    0000\**
00657   00000000    0000\**
                    0000\**
00660   00000000    0000\**
                    0000\*****      ST0RAGE      *****
00661   23022104    LDW 0 B\WS 0  T0 B
                    STW 0 D\1ST L0CATI0N 0F *ST0RAGE* T0 WS0
00662   24422312    STI D B\WS0 T0 1ST L0CATI0N F0 *ST0RAGE*
                    LDW 1 B\WS 1  T0  B
00663   24422115    STI D B\WS1 T0 NEXT L0CATI0N 0F *ST0RAGE*
                    STW 1 L\RETURN ADDRESS T0 WS 1
00664   46452674    CPL D L\*****      +++++      *****
                    LDI P D
00665   23132453    2313
                    2453\M0VE THE REST 0F
00666   52440604    CIX D D\WS T0 *ST0RAGE*
                    E P   D
00667   31771476    T F 7 7
                    BTR M 01\*****      +++++      *****
00670   77732123    CFS 7 C
                    STW 2 C\SAVE ALL T0GGLES IN WS 2
00671   21366563    STW 3 N\ST0RE DESIRED SCALE IN WS 3
```

```
                    CM  6 C\LMCK CM  UTATMR TM CHANNEL 3

00672   26731203    LDI P C\SELECT TYPEWRITER FOR OUTPUT
                    SEL Q C\ON CHANNEL  3

00673   02006040    0200
                    6040

00674   02700760    CTS 7 Q\CLEAR ALL TOGGLES
                    CLD M 60\(SP)  TO  D

00675   10240000    DTR 2 D\OUTPUT SPACE
                    NOP

00676   07404143    CLD O 40
                    ADF D C\SELECT TYPEWRITER FOR INPUT

00677   12034602    SEL Q C\ON CHANNEL  3
                    CPL Q B\CLEAR B

00700   10130000    DTR 1 C\INPUT CHARACTER
                    NMP

00701   07405734    CLD O 40\(-)  TO  D
                    XMR C D

00702   46013241    CPL Q A\CLEAR  A
                    TZO D F\WAS CHARACTER (-) ?

00703   14743606    BTR O 03\YES, GO BACK PICK UP NEXT CHARACTER
                    STT PF 6\(MINUS INDICATOR)

00704   07205734    CLD O 20\(+)  TO  D
                    XOR C D

00705   32411472    TZO D F\WAS CHARACTER (+) ?
                    BTR O 05\YES, GO BACK FOR NEXT CHARACTER

00706   07125734    CLD O 12\(BS)  TO  D
                    XOR C D

00707   32411616    TZO D F\WAS CHARACTER (BS) ?
                    FTR O 16\YES, SKIP

00710   07615734    CLD O 61\(/)  TO  D
                    XOR C D

00711   32411460    TZO D F\WAS CHARACTER (/) ?
                    BTR O 17\YES, GO BACK AND RESTART

00712   07335734    CLD O 33\(.)  TO  D
                    XOR C D

00713   32411603    TZO D F\WAS CHARACTER (.) ?
                    FTR O 03\YES, SKIP OVER MULTIPLY

00714   07120527    CLD O 12\10 (DEC)  TO D
                    LRC O 27\LOAD REPEAT COUNTER FOR MULTIPLY

00715   15414332    MPS D A\10B  TO  B
                    ADM C B\10B + B  TO  B
```

```
00716  14614455    BTR 0 16\GO BACK FOR NEW CHARACTER
                   CIL L L\INCREMENT L

00717  36054606    STT PF 5\(DECIMAL POINT INDICATOR)
                   CPL Q N\CLEAR N

00720  32271603    TZO BSXF\DOES  B = 0 ?
                   FTR 0 03\YES, GO DIRECTLY TO STORE

00721  46214602    CPL B A\B  TO A  FOR NORMALIZATION
                   CPL Q B\CLEAR B

00722  03215063    SLC 2 A\NORMALIZE INTEGER
                   CPX N C\N TO C

00723  05275336    LRC 0 27
                   ADX C N\NUMBER SHIFTED (ACTUAL SCALE)

00724  21512166    STW 5 A\STORE INTEGER
                   STW 6 N\STORE (ACTUAL SCALE)

00725  14524605    BTR 0 25\GO BACK FOR ANOTHER CHARACTER
                   CPL Q L\CLEAR  L

00726  32231615    TZO B XF\FRACTION = 0 ?
                   FTR 0 15\YES, SKIP

00727  05273505    LRC 0 27\LOAD REPEAT COUNTER FOR DIVIDE
                   TCF PF 5\IS THERE A FRACTION ?

00730  16142166    FTR 0 14\NO, SKIP
                   STW 6 N\STORE (ACTUAL SCALE)

00731  41752753    ADF P L\LOCATION OF 10**L  TO L
                   LD  L C\10**L  TO  C

00732  45121606    EXC A B\B  TO  A  FOR DIVIDE
                   FTR 0 06\SKIP OVER TABLE

00733  77777766    7777
                   7766\10**1

00734  77777634    7777
                   7634\10**2

00735  77776030    7777
                   6030\10**3

00736  77754360    7775
                   4360\10**4

00737  77474540    7747
                   4540\10**5

00740  74136700    7413
                   6700\10**6

00741  17312366    DVS C A\AB/10(DEC) TO  B  REMAINDER TO  A
                   LDW 6 N\ACTUAL SCALE TO N

00742  66622351    SSL ROM B\SHIFT B  ROM (ACTUAL SCALE)
                   LDW 5 A\INTEGER TO A
```

```
00743  43122152    ADM A B\COMBINE INTEGER AND FRACTION
                   STW 5 B

00744  23520000    LDW 5 B\LOAD NUMBER INTO  B
                   NMP

00745  23615411    LDW 6 A\ACTUAL SCALE TO  A
                   CDL A A\**

00746  23336311    LDW 3 C\DESIRED SCALE TO  C
                   CCL A A\**2S COMPLIMENT OF A  TO  A

00747  55313751    ADL C A\DESIRED SCALE-ACTUAL SCALE TO  A
                   TCT A 1\IS DESIRED SCALE-ACT SCALE POSITIVE ?

00750  16025411    FTR O 02\NO, SKIP TO SHIFT LEFT
                   CDL A A\DECREMENT  A

00751  46166662    CPL A N\COPY  A  TO  N
                   SSL ROM B\SHIFT  B  ROM  N PLACES

00752  16122336    FTR O 12\GO TO POSITIVE NEGTIVE TEST
                   LDW 3 N\DESIRED SCALE TO  N

00753  60164601    CCX A N\ABSOLUTE VALUE OF SCALE TO N
                   CPL Q A\CLEAR A

00754  13312336    SDL LOL A\SHIFT  AB  LEFT
                   LDW 3 N\DESIRED SCALE TO N

00755  32171607    TZO A SXF\DOES  A = 0 ?
                   FTR M 07\YES, TO PMSITIVE NEGATIVE TEST

00756  26741244    LDI P D\NO,
                   SEL D D\*****      +++++      *****

00757  02006040    0200
                   6040

00760  07604643    CLD O 60
                   CPL D C

00761  07320000    CLD O 32\TYPE (SP)  AND (?)
                   NOP

00762  10230000    DTR 2 C
                   NOP

00763  10240000    DTR 2 D
                   NOP\*****      +++++      *****

00764  14040000    BTR O 73\GO BACK TO START
                   NOP

00765  00003706    NOP
                   TCT PF 6\IS NU BER PMSITIVE ?

00766  54226322    CDL B B\NO,
                   CCL B B\2S COMPLIMENT OF NUMBER TO  B

00767  23142174    LDW 1 D
```

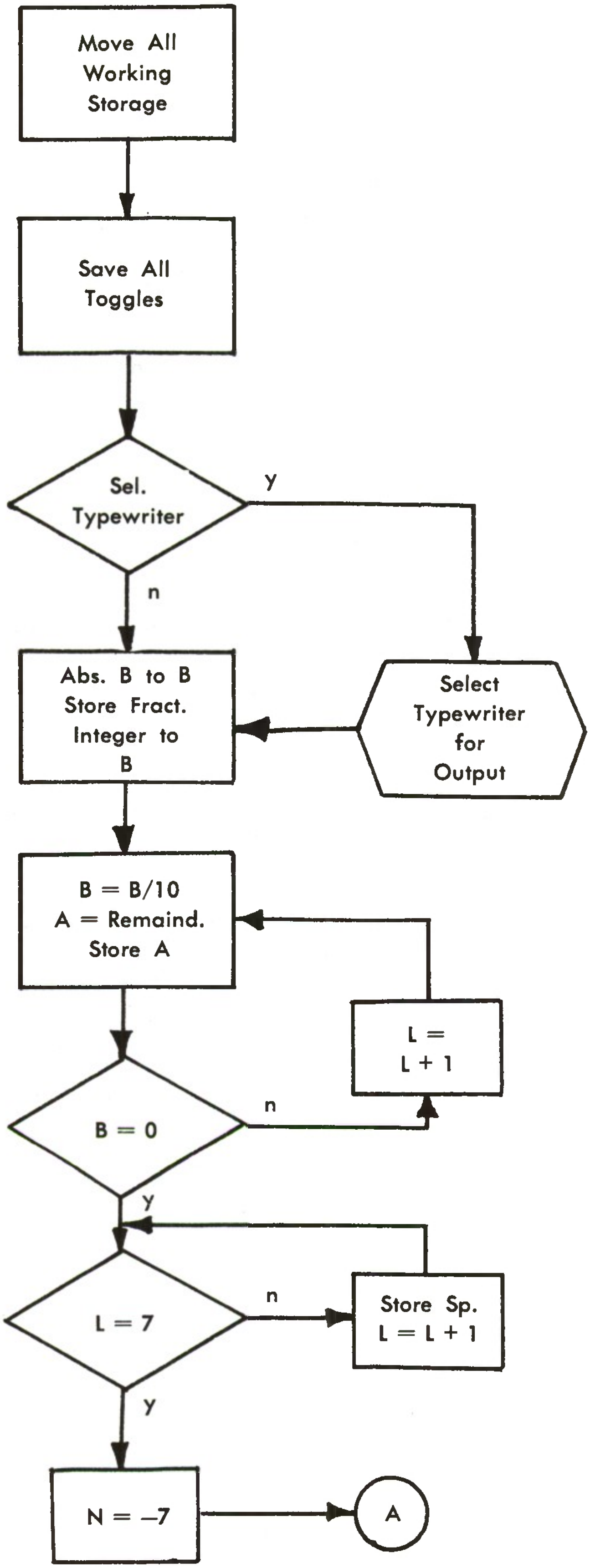
```
                    STW 7 D\MAIN PROGRAM RETURN ADDRESS TO WS 7

00770   23052323    LDWO L\1ST LOCATION OF *STORAGE* TO L
                    LDW 2 C\ORIGINAL TOGGLES TO  C

00771   26742651    LDI P D\*******      ******      ******
                    LDI L A

00772   20712651    2071
                    2651\MOVE WORKING STORAGE

00773   52440604    CIX D D\BACK TO WORKING STORAGE
                    EMP   D

00774   31661476    TMF 6 6
                    BTR 0 01\******      ******      ******

00775   23752171    LDW 7 L\RETURN ADDRESS TO  L
                    STW 7 A\WS7  TO WS7

00776   10006500    DTR 0 Q\DISCONNECT TYPEWRITER
                    COM 0 Q\UNLOCK COMMUTATOR

00777   70570273    CPF L P\RETURN ADDRESS TO  P
                    CTS 7 C\RESET ORIGINAL TOGGLES

        00000000    END A*
```

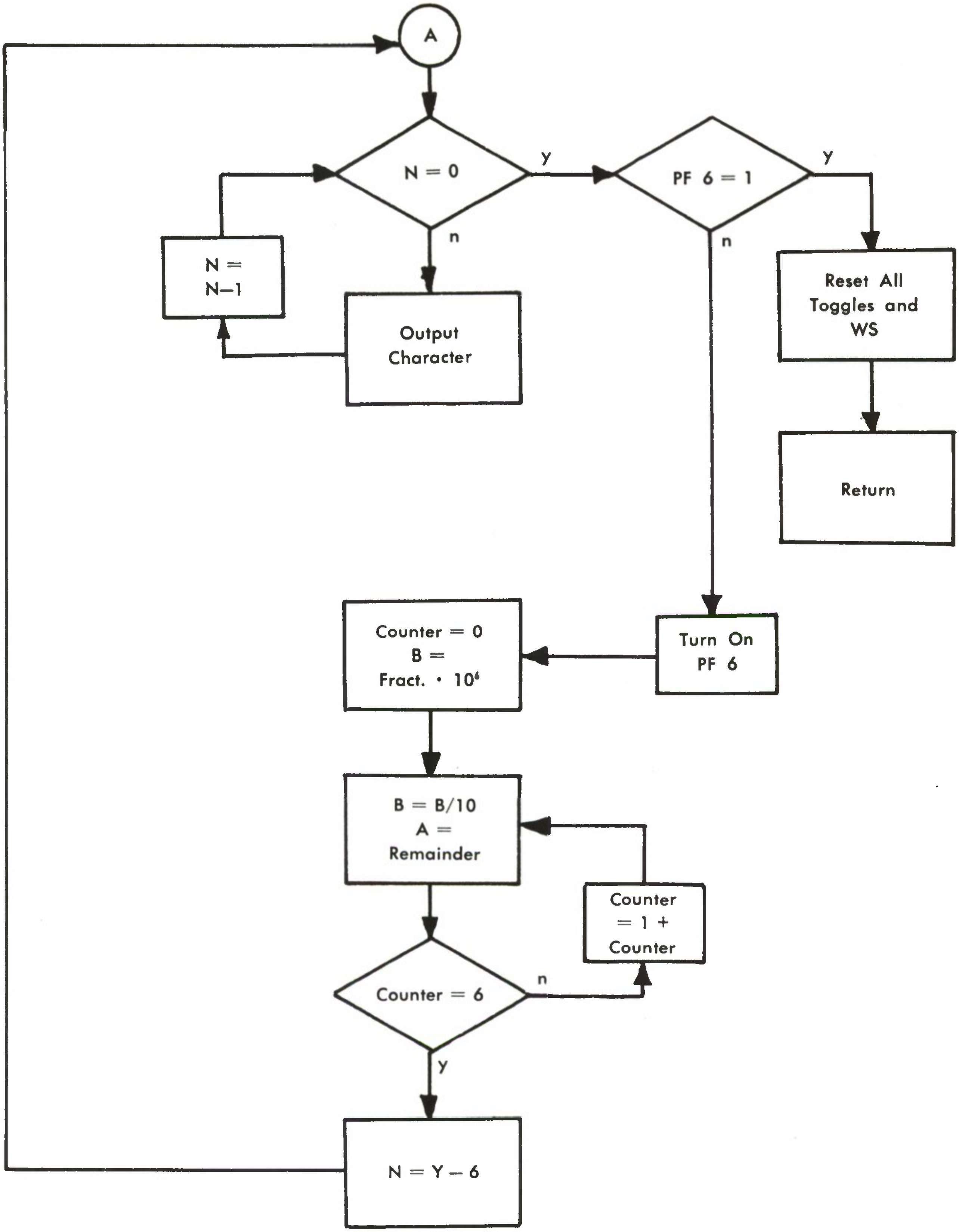
PB-440 PROGRAM ABSTRACT

PROGRAM TITLE:	DECIMAL OUT II (SUBROUTINE)
PROGRAMMER:	V. A. WAGNER
DATE:	27 March 1965
FUNCTION:	To take a number in the B register (scale factor in the N register) in 2's complement format and output it in decimal form.
DESCRIPTION:	The micro coded Decimal Out II is located from 500 to 621 octal. All storage used is contained in these locations. Output device is optional, the operator may choose the typewriter or any other device on line by a coded command word in the calling sequence. (SEE BELOW.)
OPERATING PROCEDURE:	Decimal Out II is called using the following calling sequence: LDI P L EXC P L OCT X0Y00500 X equals either 0 or 4. If X equals 4, the routine does not select any device or lock the commutator; this must be done by the programmer before the routine is called. If X equals 0, the routine will select the typewriter for output on channel 3 and will output its information on the typewriter. Y equals 0 through 7 octal. For a listing of what effect this has, see attached page.
REGISTERS:	Decimal Out II uses all the registers and in general destroys their contents or makes them meaningless.
FLAGS:	Effectively none; however, uses PF 6 to determine if finished or not.
SENSE SWITCHES:	None used
PROGRAM HALTS:	None
COMMUTATOR:	Unlocked at the end of this routine. If typewriter was selected, it is still selected at the end of this routine.

Y EQUALS	OUTPUT
0	nnnnnnn.nnnnnn
1	nnnnnnn.nnnnn
2	nnnnnnn.nnnn
3	nnnnnnn.nnn
4	nnnnnnn.nn
5	nnnnnnn.n
6	nnnnnnn.
7	nnnnnnn

DECIMAL OUT II (SUBROUTINE)




A
N = 0
y
n
PF 6 = 1
y
n
N =
N—1
Output
Character
Reset All
Toggles and
WS
Return
Counter = 0
B =
Fract. · 10⁶
Turn On
PF 6
B = B/10
A =
Remainder
Counter
= 1 +
Counter
Counter = 6
n
y
N = Y – 6

```
                          LOC\O 500

                          LDR\********************

                          LDR\DECIMAL OUTPUT II

                          LDR\V. WAGNER

                          LDR\********************

00500    46741610         CPL P D\1ST LOCATION OF WSTORAGE TO D
                          FTR O 10\SKIP OVER WSTORAGE

00501    00000000         0000\*****      WSTORAGE      *****
                          0000

00502    00000000         0000
                          0000

00503    00000000         0000
                          0000

00504    00000000         0000
                          0000

00505    00000000         0000
                          0000

00506    00000000         0000
                          0000

00507    00000000         0000
                          0000

00510    00000000         0000
                          0000\*****      WSTORAGE      *****

00511    23032104         LDW O C\WSO TO C
                          STW O D\1ST LOC OF WSTORAGE TO WSO

00512    24432313         STI D C\WSO TO 1ST LOC OF WSTORAGE
                          LDW 1 C\WS1 TO C

00513    24432115         STI D C\WS1 TO NEXT LOC OF WSTORGE
                          STW 1 L\RETURN ADDRESS TO WS1

00514    46452674         CPL D L\*** --- ***
                          LDI P D

00515    23132453         2313
                          2453\MOVE THE REST OF WS

00516    52440604         CIX D D\TO WSTORAGE
                          EMP   D

00517    31771476         TMF 7 7
                          BTR   01\*** --- ***

00520    77732123         CFS 7 C
                          STW 2 C\SAVE ALL TOGGLES IN WS2

00521    21312142         STW 3 A\SAVE A IN WS3
```

```
                        STW 4 B\SAVE B IN WS4

00522   23155455        LDW 1 L
                        CDL L L

00523   27540270        LDM L D\CALL AND CONTROL WORD TO D
                        CTS 7 Q\CLEAR ALL PF, TM AND CT

00524   33773606        TMT 7 7\INTEGER ONLY?
                        STT PF 6\YES, SET PF6 TRUE

00525   30441603        TNZ D S\SELECT TW FOR OUTPUT
                        FTR   03\NO, SKIP OVER SELECT

00526   26741244        LDI P D\TW SELECT WORD TO D
                        SEL D D\SELECT TW

00527   02006040        0200\TW SELECT WORD
                        6040

00530   65633402        COM 6 C\LOCK COM TO CHANNEL 3
                        STF PF 2\SET PF2 TRUE

00531   32241602        TZO B S\IS NUMBER POSITIVE?
                        FTR   02\YES, SKIP COMPLIMENT

00532   54226322        CDL B B
                        CCL B B\2'S COMPLIMENT OF B TO B

00533   36010000        STT PF 1\SET PF1 TRUE
                        NOP

00534   46011321        CPL Q A\CLEAR A
                        SDL 2 A\SEPARATE INTEGER AND FRACTION

00535   21620711        STW 6 B\STORE FRACTION
                        CLD 0 11\CLEAR D EXPONENT

00536   63434612        CCL D C\2'S COMPLIMENT OF 10 (DEC.) TO C
                        CPL A B\INTEGER TO B

00537   46751610        CPL P L\1ST LOC OF NSTORAGE TO L
                        FTR 0 10\SKIP OVER NSTORAGE

00540   00000000        0000\*****     NSTORAGE     *****
                        0000

00541   00000000        0000
                        0000

00542   00000000        0000
                        0000

00543   00000000        0000
                        0000

00544   00000000        0000
                        0000

00545   00000000        0000
                        0000
```

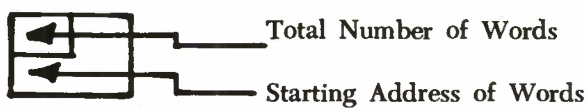
```
00546  00000000     0000
                    0000

00547  00000000     0000
                    0000\*****      NSTØRAGE      *****

00550  05274601     LRC Ø 27\LRC FØR DIVIDE
                    CPL Q A\CLEAR A

00551  17312451     DVS C A\AB/10 TØ B REMAINDER TØ A
                    STI L A\STØRE REMAINDER IN NSTØRAGE

00552  52443023     CIX D D\INCREMENT MØDE
                    TNZ B XF\B =0?

00553  14740000     BTR   03\NØ, GØ BACK TØ DIVIDE AGAIN
                    NØP

00554  45430760     EXC D C\SAVE MØDE
                    CLD Ø 60\SPACE TØ D

00555  37010750     TCT PF 1\WAS NUMBER NEG?
                    CLD 0 40\YES, + TØ D

00556  24540760     STI L D\STØRE SIGN IN NSTØRAGE
                    CLD M 60\SPACE TØ D

00557  45430000     EXC D C\SPACE TØ C MØDE BACK TØ D
                    NØP

00560  33771602     TMT 7 7\MØDE = 7?
                    FTR   02\YES, SKIP SPACE FILL

00561  24535244     STI L C\STØRE SPACE IN NSTØRAGE
                    CIX D D\INCREMENT MØDE

00562  14750000     BTR   02\LØØP
                    NØP

00563  05066366     LRC     06
                    CCL N N\-7 TØ N

00564  54552754     CDL L L\LAST LØC ØF NSTØRAGE TØ L
                    LDM L D\LAST LØC ØF NSTØRAGE TØ D

00565  10240000     DTR 2 D\ØUTPUT NSTØRAGE
                    NMP

00566  32621601     TZØ N X\N =0?
                    FTR   01\YES SKIP

00567  14745266     BTR   03\LØØP
                    CIX N N\INCREMENT N

00570  37061612     TCT PF 6\INTEGER ØNLY?
                    FTR Ø 12\YES, SKIP FRACTIØN CØMPUTATIØN

00571  23150733     LDW 1 L\*** 1
                    CLD Ø 33\(.) TØ D

00572  10240000     DTR 2 D\ØUTPUT (.)
                    NØP
```

```
00573   54550505      CDL L L\*** 1
                      LRC   05\*** 2

00574   27536066      LDM L C\CONTROL WORD TO C
                      CCX N N\-6 TO N

00575   23620712      LDW 6 B\FRACTION TO B
                      CLD 0 12\10 (DEC.) TO D

00576   53630000      ADX N C\CONTROL WORD-6 TO C
                      NOP

00577   32321603      TZO C X\DONE?
                      FTR   03\YES, SKIP

00600   05274601      LRC 0 27\LRC FOR MULTIPLY
                      CPL Q A\CLEAR A

00601   15415233      MPS D A\10B TO AB
                      CIX C C\INCREMENT C

00602   14731021      BTR    04\LOOP
                      DTR 2 A\OUTPUT A

00603   37021000      TCT PF 2\DID THIS ROUTINE SELECT TW?
                      DTR 0 Q\YES, DISCONNECT TW

00604   23142174      LDW 1 D\**
                      STW 7 D\RETURN ADDRESS TO WS7

00605   23052323      LDW 0 L\1ST LOC OF WSTORAGE TO L
                      LDW 2 C\**

00606   02732331      CTS 7 C\RESET ALL IM, PF, AND CT
                      LDW 3 A\RESET A

00607   23420000      LDW 4 B\RESET B
                      NOP

00610   26742653      LDI P D\*** --- ***
                      LDI L C

00611   20732653      2073
                      2653\MOVE WSTORAGE 0-6

00612   52440604      CIX D D\BACK TO WS 0-6
                      E P D

00613   31661476      TMF 6 6
                      BTR   C1\*** --- ***

00614   23752173      LDW 7 L\RETURN ADDRESS TO L
                      STW 7 C\WSTORAGE 7 TO WS 7

00615   65004657      COM 0 Q\UNLOCK COM
                      CPL L P\RETURN

        00000000      END A*
```

PB-440 PROGRAM ABSTRACT

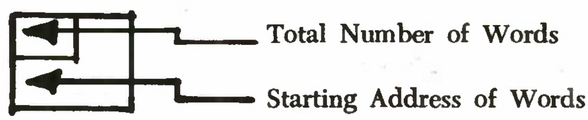
TYPE OF PROGRAM:	MICRO SUBROUTINE
PROGRAM TITLE:	MICRO TYPE
PROGRAMMER:	D. R. GUM
DATE:	1 February 1965
ID:	None
FUNCTION:	The purpose of this program is to provide an efficient means of outputting program comments via the typewriter.
GENERAL DESCRIPTION:	This program is a micro coded subroutine for use with micro or SCS programs. The program types out characters which are stored sequentially in memory four characters per word. The program requires the starting location of the characters in memory and the total number of words to be typed.
LOADING PROCEDURE:	Load with Binary Loader I. This program is relocatable.
OPERATING PROCEDURE & LINKAGE REQUIRED:	The program operates as a subroutine of another program. A typical micro calling sequence is shown below.

```
LDI P C
EXC P C
0000
0450                    Micro Type Address
```



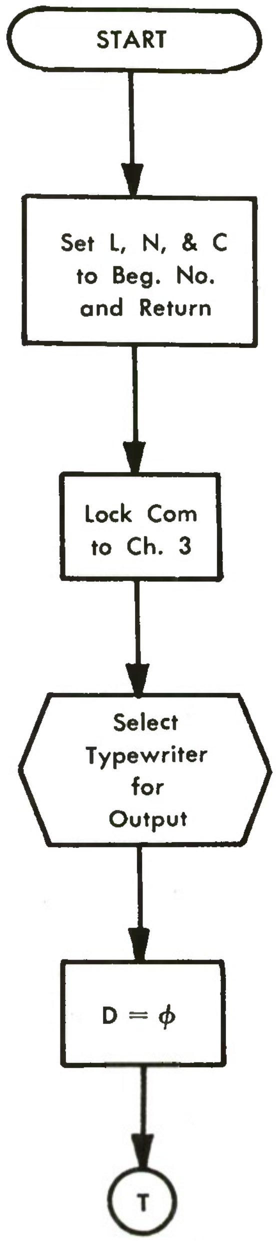
The micro type address may be stored in working storage and the routine called as follows.

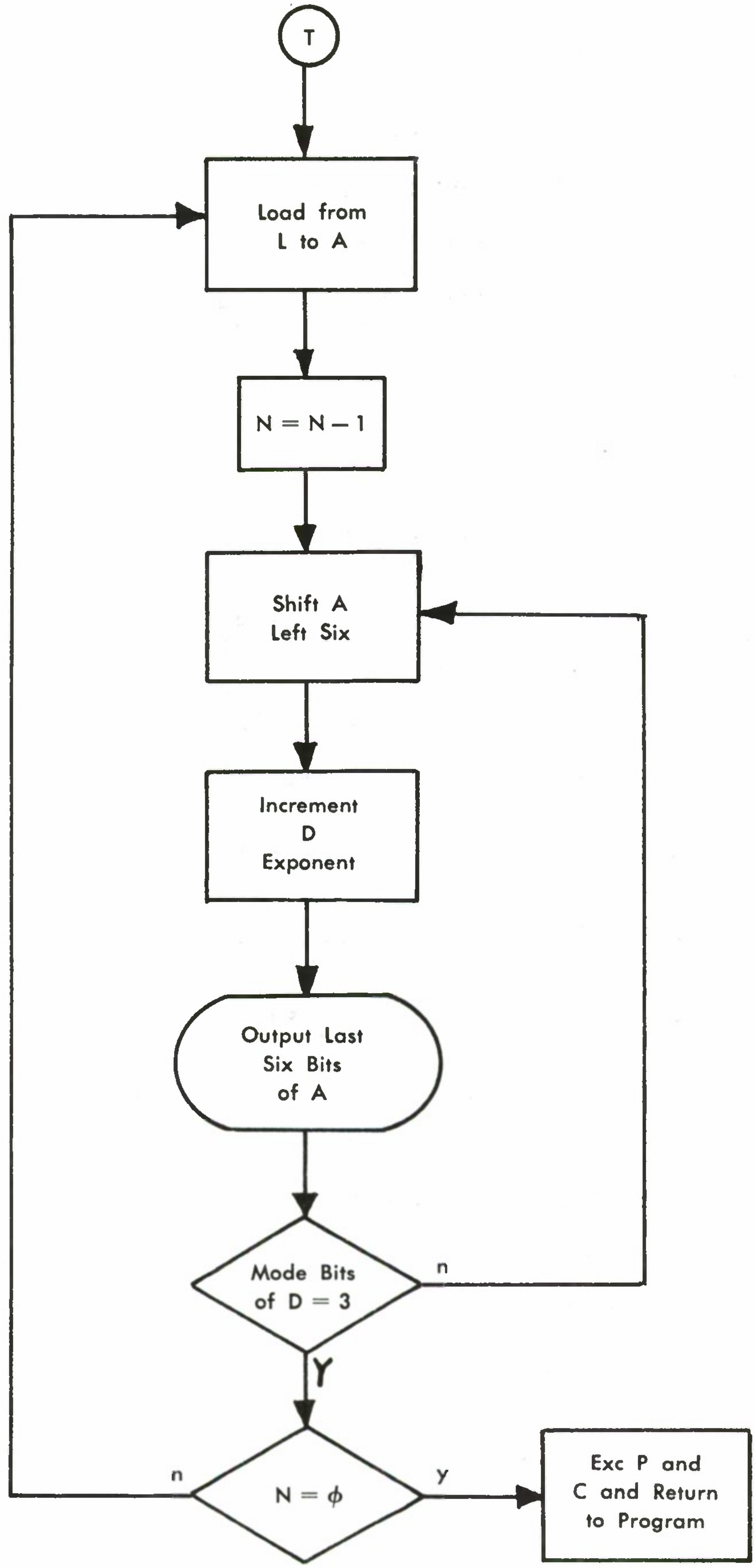
```
LDW O C
EXC P C
```



PROGRAM STORAGE:	*Program Segment*	*Octal Locs.*	*Total*
Core	Micro Type	450-461	12_8
Biax	None		
INTERMEDIATE STORAGE:	None		
EXECUTION TIME:	N/A		
REGISTERS:	All except B		
SENSE SWITCHES:	None		
PROGRAM FLAGS:	None		

MICRO TYPE


START
Set L, N, & C to Beg. No. and Return
Lock Com to Ch. 3
Select Typewriter for Output
D = ϕ
T

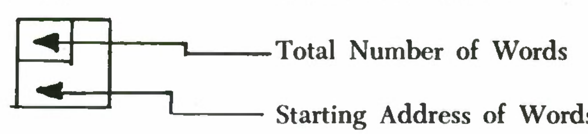

T
Load from L to A
N = N − 1
Shift A Left Six
Increment D Exponent
Output Last Six Bits of A
Mode Bits of D = 3
n
Y
N = ϕ
n
y
Exc P and C and Return to Program

```
                         LDR\MICRO TYPE

                         LDR\1 FEB 1965

                         LOC O 450

00450   27352636         LDM C L\BEGINNING ADDRESS INTO L
                         LDI C N\NUMBER OF WORDS INTO N

00451   65632671         COM 6 C\LOCK COM
                         LDI P A

00452   02006040         0200\SELECT WORD
                         6040

00453   12114604         SEL A A\SELECT FOR TYPE OUT
                         CPL Q D\D * 0

00454   26515466         LDI L A\LOAD FROM L TO A
                         CDL N N\N * N Δ 1

00455   67115244         SLS A A\SHIFT LEFT SIX
                         CIX D D\INCREMENT D EXPONENT

00456   10210000         DTR 2 A\OUTPUT LAST SIX BITS OF A
                         NOP

00457   31031475         TMF 0 3\MODE BITS OF D = 3?
                         BTR   2\NO

00460   30621473         TNZ N X\YES, N = 0?
                         BTR   4\NO, PICK UP NEW WORDS

00461   65014537         COM   0\ A*YES, UNLOCK COM
                         EXC C P\RETURN TO PROGRAM

                         LDR

                         LDR

        00000450         END O 450
```

PB-440 PROGRAM ABSTRACT

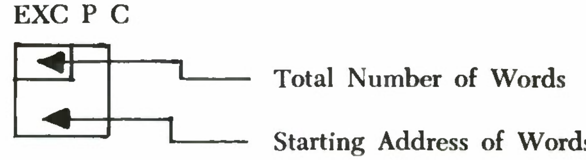
TYPE OF PROGRAM:	MICRO SUBROUTINE
PROGRAM TITLE:	MICRO PRINT
PROGRAMMER:	D. R. GUM
DATE:	1 February 1965
ID:	None
FUNCTION:	The purpose of this program is to provide an efficient means of outputting program comments via the Datamark printer.
GENERAL DESCRIPTION:	This program is a micro coded subroutine for use with micro or SCS programs. The program types out characters which are stored sequentially in memory four characters per word. The program requires the starting location of the characters in memory and the total number of words to be printed.
LOADING PROCEDURE:	Load with Binary Loader I. This program is relocatable.
OPERATING PROCEDURE &	The program operates as a subroutine of another program.
LINKAGE REQUIRED:	A typical micro calling sequence is shown below.

```
LDI P C
EXC P C
0000
0400                    Micro Print Address
```



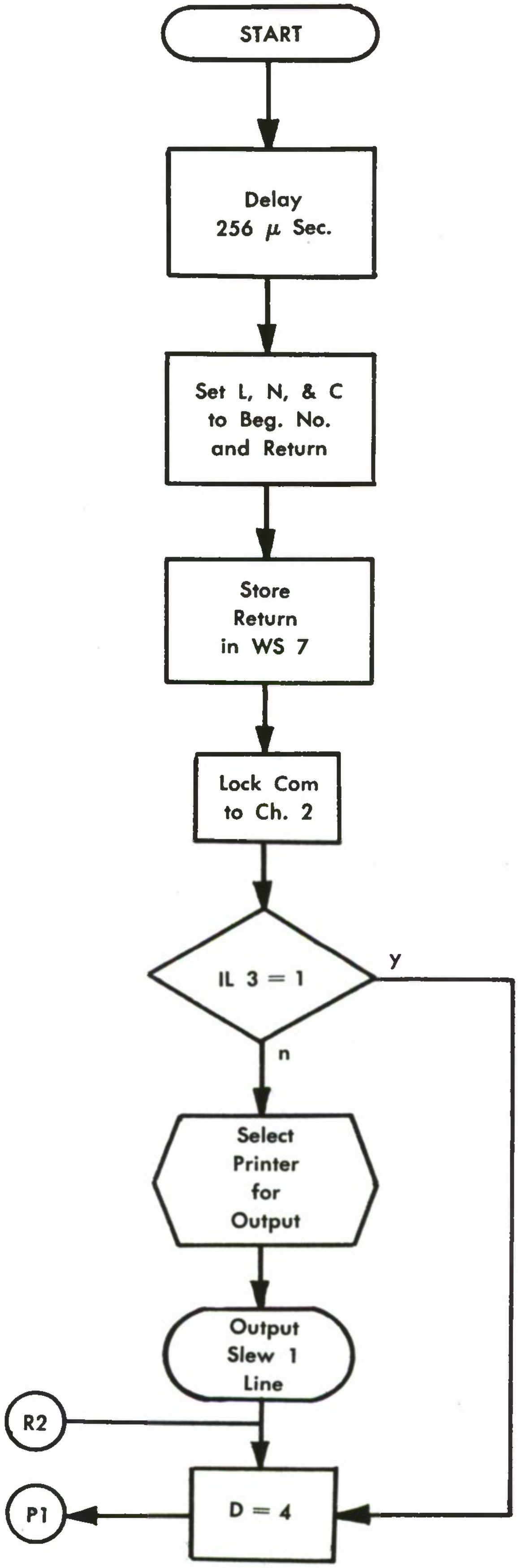
The micro print address may be stored in working storage and the routine called as follows.

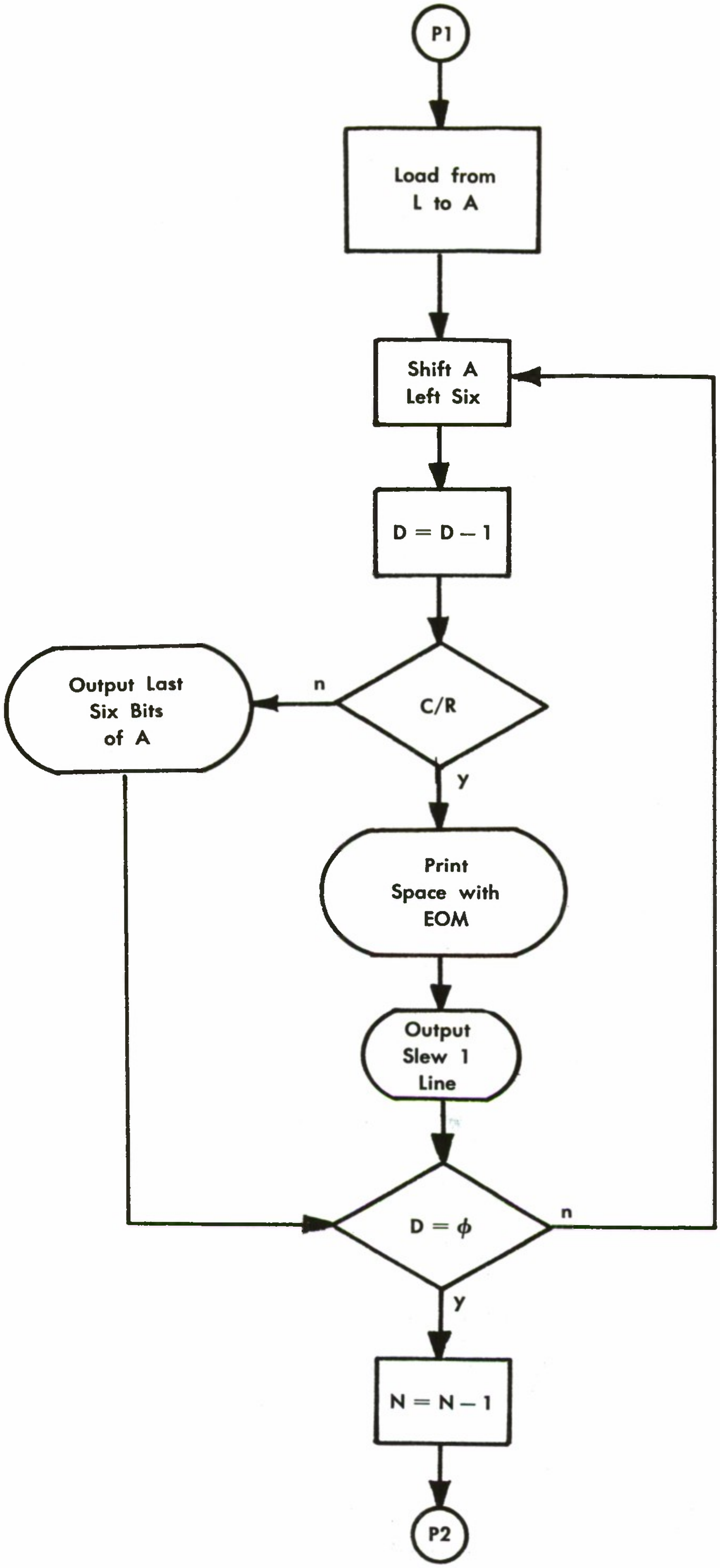
```
LDW O C
EXC P C
```

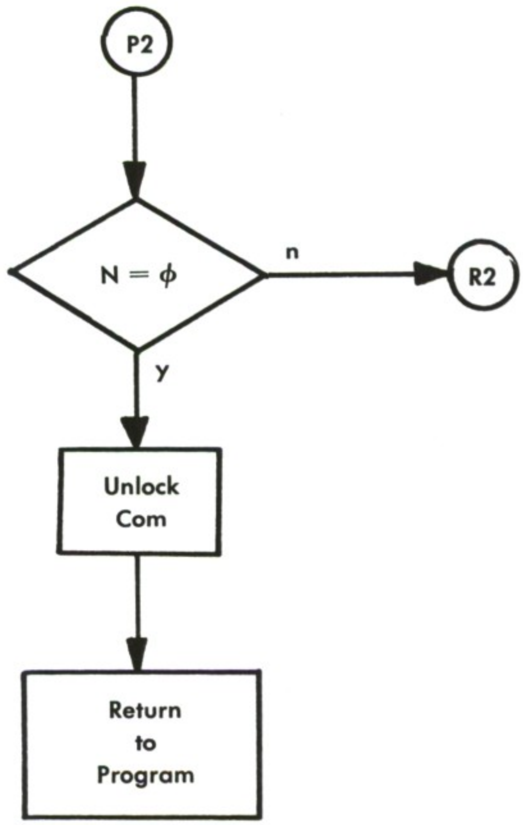


PROGRAM STORAGE:	*Program Segment*	*Octal Locs.*	*Total*
Core	Micro Print	400-426	27_8
Biax	None		
INTERMEDIATE STORAGE:	None		
EXECUTION TIME:	N/A		
REGISTERS:	All		
SENSE SWITCHES:	None		
PROGRAM FLAGS:	None		

MICRO PRINT


START
Delay
256 μ Sec.
Set L, N, & C
to Beg. No.
and Return
Store
Return
in WS 7
Lock Com
to Ch. 2
IL 3 = 1
y
n
Select
Printer
for
Output
Output
Slew 1
Line
R2
D = 4
P1


P1
Load from L to A
Shift A Left Six
D = D – 1
C/R
n
Output Last Six Bits of A
y
Print Space with EOM
Output Slew 1 Line
D = ϕ
n
y
N = N – 1
P2


P2
N = ϕ
n
R2
y
Unlock
Com
Return
to
Program

```
                  LDR         ,    MICRØ PRINT

                  LDR         ,    1 FEB 1965

                  LØC Ø 400

00400  60066600   CCX Q N     ,    256 MICRØSECØND DELAY
                  SSL 0 Q

00401  27352636   LDM C L     ,    BEGINNING ADDRESS INTØ L
                  LDI C N     ,    NUMBER ØF WØRDS INTØ N

00402  21736562   STW 7 C     ,    STØRE RETURN
                  CØM 6 B     ,    LØCK CØM

00403  37431603   TCT IL 3    ,    TEST INTERRUPT LINE 3
                  FTR   3

00404  26711211   LDI P A
                  SEL A A     ,    SELECT ØN CH. 2

00405  22004000   2200        ,    SELECT WØRD
                  4000

00406  10210000   DTR 2 A     ,    ØUTPUT SLEW CHARACTER
                  NØP

00407  07042651   CLD   4     ,    D = 4
                  LDI L A     ,    LØAD FRØM L TØ A

00410  67115444   SLS A A     ,    SHIFT LEFT SIX
                  CDL D D     ,    D = D - 1

00411  26725612   LDI P B
                  AND A B     ,    MASK LAST SIX BITS ØF A

00412  00000077   0000
                  0077

00413  26735723   LDI P C
                  XØR B C     ,    XØR WITH CR CØDE

00414  00000052   0000
                  0052

00415  30311603   TNZ C F     ,    CARRIAGE RETURN?
                  FTR   3     ,    NØ

00416  27721062   LDM P B     ,    YES
                  DTR 6 B     ,    PRINT SPACE WITH EØM

00417  00000060   0000
                  0060

00420  44031023   CIL Q C
                  DTR 2 C     ,    ØUTPUT SLEW CHARACTER

00421  10210000   DTR 2 A     ,    ØUTPUT CHARACTER
                  NØP

00422  30411465   TNZ D F     ,    D = 0?
                  BTR Ø 12    ,    NØ
```

```
00423  54663062    CDL N N    ;      YES, N = N-1
                   TNZ N X    ;      N = 0?

00424  14620000    BTR @ 15   ;      NO, PICK UP NEW WORD
                   NOP

00425  65010000    COM   0    ; A*      UNLOCK COM
                   NOP

00426  23734537    LDW 7 C
                   EXC C P    ;      RETURN TO PROGRAM

                   LDR

                   LDR

       00000400    END @ 400
```

Appendix III.

RAYTHEON 440 MICRO COMMAND LIST

MNEMONIC	*OCTAL*	*MEANING*
ADF	41	Add fractions
ADL	55	Add logical
ADM	43	Add magnitudes
ADS	73	Add signs
ADX	53	Add exponents
AFK	40	Add fractions with carry
ALC	51	Add logical for carry
AMK	42	Add magnitudes with carry
AND	56	Logical product
BTR	14	Backward transfer relative
CCF	71	Copy complement fraction
CCL	63	Copy complement logical
CCM	62	Copy complement magnitude
CCS	61	Copy complement sign
CCX	60	Copy complement exponent
CDL	54	Copy decrement logical
CFS	77	Copy from special storage
CIL	44	Copy increment logical
CIX	52	Copy increment exponent
CLD	07	Copy literal to D-register
CLP	04	Copy literal to P-register
COM	65	Commutator control (I/O)
CPF	70	Copy fraction
CPL	46	Copy logical
CPM	47	Copy magnitude
CPS	72	Copy sign
CPX	50	Copy exponent
CTS	02	Copy to special storage
DTR	10	Data transfer (I/O)
DVS	17	Divide step
EMP	06	Execute micro pair

MNEMONIC	*OCTAL*	*MEANING*
EXC	45	Exchange
FTR	16	Forward transfer
HLT	01	Halt
LDI	26	Load and increment
LDM	27	Load from memory
LDS	22	Load from special storage
LDW	23	Load from working storage
LOR	64	Logical "OR"
LRC	05	Load repeat count (N Register)
MPS	15	Multiply step
NOP	00	No operation
SDL	13	Shift double length
SEL	12	Select (an I/O device)
SFR	11	Shift floating right
SL6	67	Shift left six
SLC	03	Shift left and count
SSL	66	Shift single length
STI	24	Store and increment
STM	25	Store into memory
STF	34	Set toggle false
STS	20	Store into special storage
STT	36	Set toggle true
STW	21	Store into working storage
TCF	35	Test condition false
TCT	37	Test condition true
TMF	31	Test mode bits (of D register) false
TMT	33	Test mode bits (of D register) true
TNZ	30	Test non-zero
TZO	32	Test zero
XOR	57	Exclusive "OR"

Appendix IV.
RAYTHEON 440 SYSTEMS COMMAND SET LIST

1. DATA TRANSMISSIONS

MNEMONIC	*MEANING*
ENA	Enter A-register
ENB	Enter B-register
LAC	Load A-register with complement
LBC	Load B-register with complement
LDA	Load A-register
LBD	Load B-register
MOV	Move (A block of data)
PDQ	Push down QUEUE
SAA	Store address field of A-register into memory
SAB	Store address field of B-register into memory
STA	Store A-register into memory
STB	Store B-register into memory
STZ	Store zero into memory
XAB	Exchange A and B registers
ZTS	Zeros to memory

2. ARITHMETIC

ADA	Add memory to A-register
ADB	Add memory to B-register
CLA	Clear A-register
CLB	Clear B-register
DIV	Divide AB registers by memory
DMO	Decrement memory by one
IMO	Increment memory by one
INA	Increment A-register
INB	Increment B-register
MPY	Multiply B-register by memory
RAD	Replace—Add A-register and memory
RSB	Replace—Subtract A-register form memory
SBA	Subtract memory from A-register
SBB	Subtract memory from B-register

3. TRANSFERS

MNEMONIC	*MEANING*
RET	Return (indirect jump)
TAP	Transfer if A-register positive
TAZ	Transfer if A-register zero
TBP	Transfer if B-register positive
TBZ	Transfer if B-register zero
TOV	Transfer if overflow is indicated
TRA	Unconditional transfer
TSR	Unconditional transfer and set return

4. COMPARES AND SKIPS

CAE	Skip next command if A-register equals memory
CAG	Skip next command if A-register greater than memory
CAL	Skip next command if A-register less than memory
CAM	Skip next two commands if A-register greater than memory; skip next command if A-register less than memory
CBE	Skip next command if B-register equals memory
CBG	Skip next command if B-register greater than memory
CBL	Skip next command if B-register less than memory
CME	Skip next command if A-register equals memory masked by B-register
SMP	Skip next command if memory is positive
SMZ	Skip next command if memory equals zero
TLU	Table look-up

5. SHIFTS and LOGICAL

AND	Logical product of memory and A-register
CMA	Complement A-register
CMB	Complement B-register
LOR	Logical sum of memory and A-register
RLA	Shift A-register left circular
RLB	Shift B-register left circular
RLC	Shift AB-registers left circular
SLA	Shift A-register left open

5. SHIFTS and LOGICAL — (continued)

MNEMONIC	*MEANING*
SLB	Shift B-register left open
SLC	Shift AB-registers left open
SRA	Shift A-register right open
SRB	Shift B-register right open
SRC	Shift AB-registers right open
SSU	Selective substitute of bits in A-register and memory
XOR	Exclusive "OR" of memory and A-register

6. INDEXING

ATX	A-register to index register
BTX	B-register to index register
DXT	Decrement index register and transfer if non-zero
ENX	Enter index registers
INX	Increment index register
IXS	Increment index register by one and skip next command if index register equals specified literal
LDX	Load index register
STX	Store index register
TSX	Transfer and set index register to address of next command
XTA	Index register to A-register
XTB	Index register to B-register

7. FLOATING POINT (16, 24, or 39 bit mantissa)

FAD	Floating add
FDV	Floating divide
FIX	Fix (a floating point number)
FLD	Floating load
FLT	Float (a fixed point number)
FMP	Floating multiply
FSB	Floating subtract
FST	Floating store
FTO	Floating transfer on overflow

8. SPECIAL

MNEMONIC	*MEANING*
EMP	Execute micro pair
NOP	No operation
HLT	Halt and transfer
MRC	Micro subroutine call
DML	Descend to micro level
CLM	Compare limits
SCS	Set control sequence

References

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2. Illinois Institute of Technology, *ADIOCE Calibration/Diagnostic Program for Real-Time Training Simulation Research System*, Chicago, Illinois, October 1964. (Unpublished technical manual compiled under contract AF 33(657)-11007 for Wright-Patterson Air Force Base, Ohio.)

3. Illinois Institute of Technology, *An Introduction to Programming ADIOCE*, Chicago, Illinois, October 1964. (Unpublished technical manual compiled under contract AF 33(657)-11007 for Wright-Patterson Air Force Base, Ohio.)

4. Packard Bell Computer, *An Introduction to PB-440 Micro Programming*, Santa Ana, California, 1962.

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7. Sylvania Electric Products, Inc., *The UDOFT Flight Simulation System*, AMRL-TDR-63-133 (AD 431 205), Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, December 1963.

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13. ABSTRACT

This report describes a library of automated diagnostic test-programs for the real-time input/output section of a digital training simulation research system. The application of such automated test to simulation-system acceptance testing is explored. Included is a description of real-time simulation as a training technique and the Real-Time Simulation Research Systems (RTSRS) for which the test-programs were prepared. Detailed program listings, flow charts, and abstracts of each test and of utility subroutines are also provided.

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Security Classification

Security Classification

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