What is the MTR System?

MTR is a Maintenance Test Routine system designed for the L2000 which is capable of detecting the existence of all failures and rapidly diagnosing a high percentage (98%) of all failures to some modular level. The operator of the system does not require a high degree of intelligence or require extensive training, or an oscilloscope. The small percentage of failures which are not diagnosable by the MTR system will be handled by a second echelon of maintenance which does not have the above restrictions.

The objectives of MTR are:

The MTR system is designed to detect all repeatable failures and to diagnose 98% of all failures. The average time to repair for any failures is 2.66 hours which allows 45 minutes for diagnosis. The remaining time is for repair and verification of repair. Included in the 2% of failures which are not diagnosable by the MTR system are the following:

a. Random backplane shorts or opens.

b. Connector shorts or opens.

c. Analog type failures which do not become repeatable.

d. Failures which were neglected because of inaccurate assumptions or errors in predicting failure modes.

e. Failures which were neglected in the failure analysis because of a very low expected rate of occurence. (An economical MTR system is rarely capable of diagnosing all failures.)

The MTR system is capable of diagnosing only single repeatable failures. Multiple failures are corrected by diagnosing for a single failure, repairing the failure and then diagnosing for another single failure. In order to guarantee diagnosis, failures must have a high degree of repeatability during the execution of the procedures.

No detailed diagnosis is done in the mechanical area. The MTR system determines whether the failure is mechanical, electrical or logic. If the failure is diagnosed as mechanical, it is isolated to a mechanism or part of a mechanism. Electronic or logic failures are isolated to a card or a group of cards. In the case of electronic failures in areas such as the power supply, the failure is isolated to the smallest replaceable subunit of the machine.

The primary purpose of the MTR system is to provide a systematic approach for the rapid diagnosis of failures. The user of the system does not require extensive training either on the use of complex test equipment or in the design of the machine. The MTR system permits the ~~un~~trained user to quickly diagnose failures by providing him with the necessary documentation and tools. The documentation is organized in such a manner that it removes the requirement of deductive reasoning from the man. The tools available for use in diagnosing failures with the MTR system consists of the following:

a. MTR manual which is a set of decision tables which guide the user through formalized diagnostic procedures.

b. A set of test tapes which are used in conjunction with the decision tables.

c. An MTR meter to make measurements as specified in the decision tables.

d. Two logic cards for enabling the machine maintenance modes.

e. A set of backplane jumper wires.

The MTR system is designed to detect and diagnose failures based on their probable rate of occurrence, i.e. the areas of the machine which have the highest probability of failure are tested first.

Park Royal Branch (G.B.) is a good example of the MTR system which is used throughout the Subsidiary.

All L men are MTR trained only.

They are currently fixing 95% of the calls that they attend. One particular installation consists of 85 TC500's, which is handled very successfully by 1 1/2 men.

"Calls show a ratio of 9 mechanical to 1 electronic. MTTR has ranged from 2.1 hours to 6.3 hours per attention per week." (Report from Barclays).

The L and TC are a series of highly sophisticated general purpose digital computers using microprogramming concepts and integrated circuit technology.

Some of the features of the series are:

a. Completely modular in design.

b. Logic packaged with maintainability in mind. 90% IC

c. Ceramic memory disk with 1024 words of storage.

d. Hardware controlled by firmware. Firmware controlled by software.

e. No mechanical ties between input and output sections.

1. Indicator - used to indicate that the signal probe is connected to the backplane and that the signal being measured is within the electrical specifications for the circuits.
2. Reset push button - This push button is used to extinguish the indicator if the signal being measured is within electrical specifications.

   0V - .5V, 3.0V - 5.0V, 0.5V - 3.0V for more than 2 microseconds.

   Low high leading edge
3. Clock push button - used to change leading edge tolerance to .2 microseconds.
4. Duty cycle push button - depressing this push button will cause the meter to read the percent duty cycle of the signal under test.
5. 10X push button - depressing this push button simultaneously with the duty cycle push button expands the lower range of the meter by a factor of 10. Thus, a full scale reading corresponds to a duty cycle of 10%.
6. Invert push button - depressing this button simultaneously with the duty cycle push button logically inverts the signal being measured prior to applying it to the normal meter measurement circuit. A full scale deflection corresponds to a 0% duty cycle while a reading of 0% corresponds to an input waveform having a 100% duty cycle.
7. If the invert, 10X and duty cycle push buttons are depressed simultaneously, the upper range of the normal scale is expanded by a factor of 10. Thus, it is possible to achieve a very accurate reading for signals in the range of 90% - 100%.

The MTR system utilizes two circuit cards that are primarily Field Engineering tools. They are the FE1 and FE2 circuit cards.

The FE1 circuit card enables the L and TC to be operated in two additional modes other than normal. They are: Tape to Q and KBD to Q. These different modes of operation are selected by placing the FE1 card in the appropriate card slot and then jumpering the appropriate pads.

The FE2 circuit card is used whenever running a Tape to Q program tape. Its main purpose is to detect a keyboard failure or parity error during the running of the program tape. Such an error will be indicated by the illuminating of the error light; also, the clock will be frozen.

The FE2 circuit card must be removed when running the manual procedure of the MTR system.

In Tape to Q mode all codes on the tape are loaded directly into the Q register where they are interpreted and executed as microinstructions. That is, the program is not loaded into memory but is executed directly from the tape.

The format of tapes used in the Tape to Q mode is thus necessarily different than the format of tapes loaded into memory using the load routine.

In KBD to Q mode the keyboard is enabled to allow entry of microinstructions directly in the Q register. This is the only difference between Tape to Q and KBD to Q modes. KBD to Q mode is used extensively during the manual procedure portion of the MTR system. Generally microinstructions will be entered and cyclic functions set up to aid MTR meter readings.

A total of 26 different procedures are used in the MTR system and these procedures can be broadly classified under the following headings:

a) Macroprogram

b) Microprogram

c) Tape to Q Procedures

d) Manual Procedures

Macroprograms - There are four procedures in the MTR system which are written in the GP-300 language.

a) Standard Performance Tests

b) Punch Memory Routine

c) Print Memory Routine

d) Memory Loader Test

The first of these procedures is used to completely test the L2000 machine to determine if a failure exists. The next two procedures are used as service routines to permit the user to punch or print the contents of selected portions of memory. These three procedures are loaded from tape into memory using conventional memory load and then executed from memory. The fourth procedure deviates from this philosophy by loading two macroinstructions from keyboard into memory using the conventional memory load routine.

Microprograms - The dynamic excercisers are special microprograms which are loaded into memory from tape using the conventional memory load routine. Since the microprogram is executed at disk speeds, lengthy test algorithms can be used to rapidly exercise various areas of the machine. They are designed primarily to test mechanisms under special conditions or to operate the mechanism at its rated speed. In this way, failures which apparently have a low repetition rate under macroprogram control may manifest themselves as highly repeatable failures under microprogram control. There are five dynamic exercisers designed for the L2000 MTR system. They are as follows:

a) Forms

b) Logic

c) Printer

d) Memory

e) Carrier

Tape to Q Procedures - These procedures consist of a tape, which is executed in the Tape to Q mode, and a set of error detection charts which are compared with the results of the test. The primary purpose of these procedures is to rapidly locate the failure area and to eliminate the areas which are functioning normally. There are three primary Tape to Q procedures:

a) Mechanism Test

b) Logic Test

c) Conditional jump logic test

Manual Procedures - The procedures are designed for three distinctively different areas of the machine: power, mechanisms and logic. Various techniques are used within the manual procedures to achieve diagnosis. In the power section AC and DC voltage measurements are taken with a Voltohmmeter.

In the mechanism area the MTR meter, Voltohmmeter, are used to measure logic and non-logic signals respectively. The KBD to Q mode is commonly used, also specific visual observations are required.

In most logic manual procedures the machine is put in the KBD to Q repeat mode to enable cyclic patterns in the logic such that the duty cycle of the signal can be measured. The MTR meter is the measurement device whenever logic levels (0 to 5 Volts) are measured. The common logic manual procedure generally cannot use the KBD to Q mode since failures in this area will cause all microinstructions to fail. Hence, measurement points have been selected which inherently are of a cyclic nature.

Standard Performance Test is a program written in the GP-300 language. The purpose of this procedure is to perform an exhaustive test of the L2000 hardware and the GP-300 firmware. The basic assumption is that if a failure is detected during the execution of the customer's program, the Standard Performance Test will detect the failure also. The test is divided functionally into five subtests as follows:

a) Printer test

b) Carrier test

c) Forms test

d) Logic test

e) Keyboard test

Additionally, the loading of the program tape into memory constitutes a test of the memory load capability of the machine. In general, diagnosis cannot be made from the printout of the Standard Performance Test. Instead, the test is primarily used to detect the existence of failures. If a static failure is detected, the user is directed to the Tape to Q procedures; whereas, if the failure is dynamic, the user is directed to the dynamic exercisers. The choice of the dynamic exercisers depends upon the subtest which failed. This criterion is altered whenever a carrier positioning failure is detected. For this case, the Carrier Dynamic Exerciser is entered directly independent of the mode of failure.

These procedures are special microprograms which are loaded into memory from tape using the conventional memory load routine. The purpose of each of these programs is to increase the repeatability of a failure in a particular area of the machine (forms, printer, carrier, logic, or memory). This is done by exercising the area of the machine, which the program was designed to test under micro control. This allows the machine to be tested under worst case conditions which cannot be generated under macro control. If a dynamic failure is detected by the Standard Performance Test, it will become more repeatable under control of the dynamic exercisers.

Each dynamic exerciser consists of an executive routine and several subtests. The executive routine indicates that the program was loaded and entered correctly. An F prints for forms, L for logic, etc. The subtests are selected by certain numeric keys. All dynamic exercisers are loaded into the macro portion of memory, block 0. Depressing the numeric 0 key will terminate any exercise and return the machine to the ready mode.

One of the basic tools of the L2000 MTR system is the MTR manual. This manual consists of four different sections. They are as follows:

Decision Tables

The primary advantage of decision tables is that the user does not require the power of deductive reasoning to diagnose failures; i.e., the conditions for each test and all possible outcomes are determined beforehand so that the decision making process is reduced to a selection process based on the results of the test. The user performs a test and is guided to his next action depending upon the outcome of the test.

Error Detection Dictionary

Its primary purpose is to describe the results of a test other than a measured value. For example, often the results of a subtest for a micro of macroprogram is a printed message which requires detailed inspection to determine if the test passed or failed. If a visual inspection is required in a procedure, a sketch of the assembly to be inspected is contained on this format.

Failure Dictionary

Its primary purpose is to provide a numerical list of all possible failure conditions. Whenever diagnosis is achieved, the failure dictionary is referenced. For the case of logic card failures, a list (by card location) of primary and secondary suspects is given for each failure mode. The primary suspect is generally considered to be the failed source and the secondary suspects are the loads on the source. Mechanical failures are also identified as primary and secondary suspects. In this case, however, a written description of the component or assembly is given.

Description

This section contains a short explanation of the MTR system and the FE1 and FE2 circuit cards. It explains how the different modes of operation are selected on the FE1 card. A description of each of the MTR tapes, the expected results, as well as their modes of operation is also contained in this section.

Date M.T.R. Evaluation Sheet Of

Fault Location

✓ Agree

X Disagree

Diagnosis

Rule

Page No.	1	2	3	4	5	6	7	8

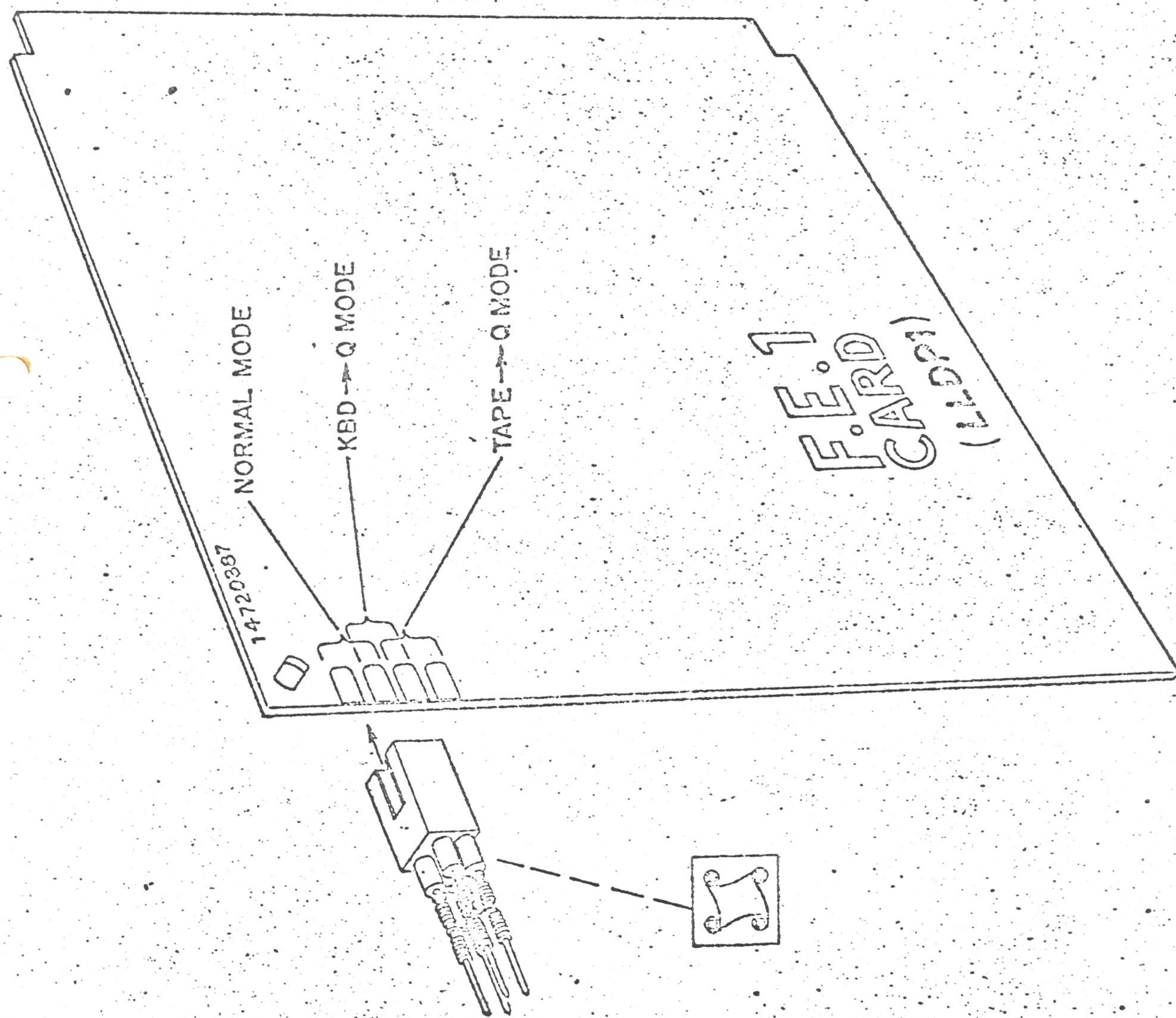


FIGURE A.3.1 Maintenance Modes on Field Engineering Card #1

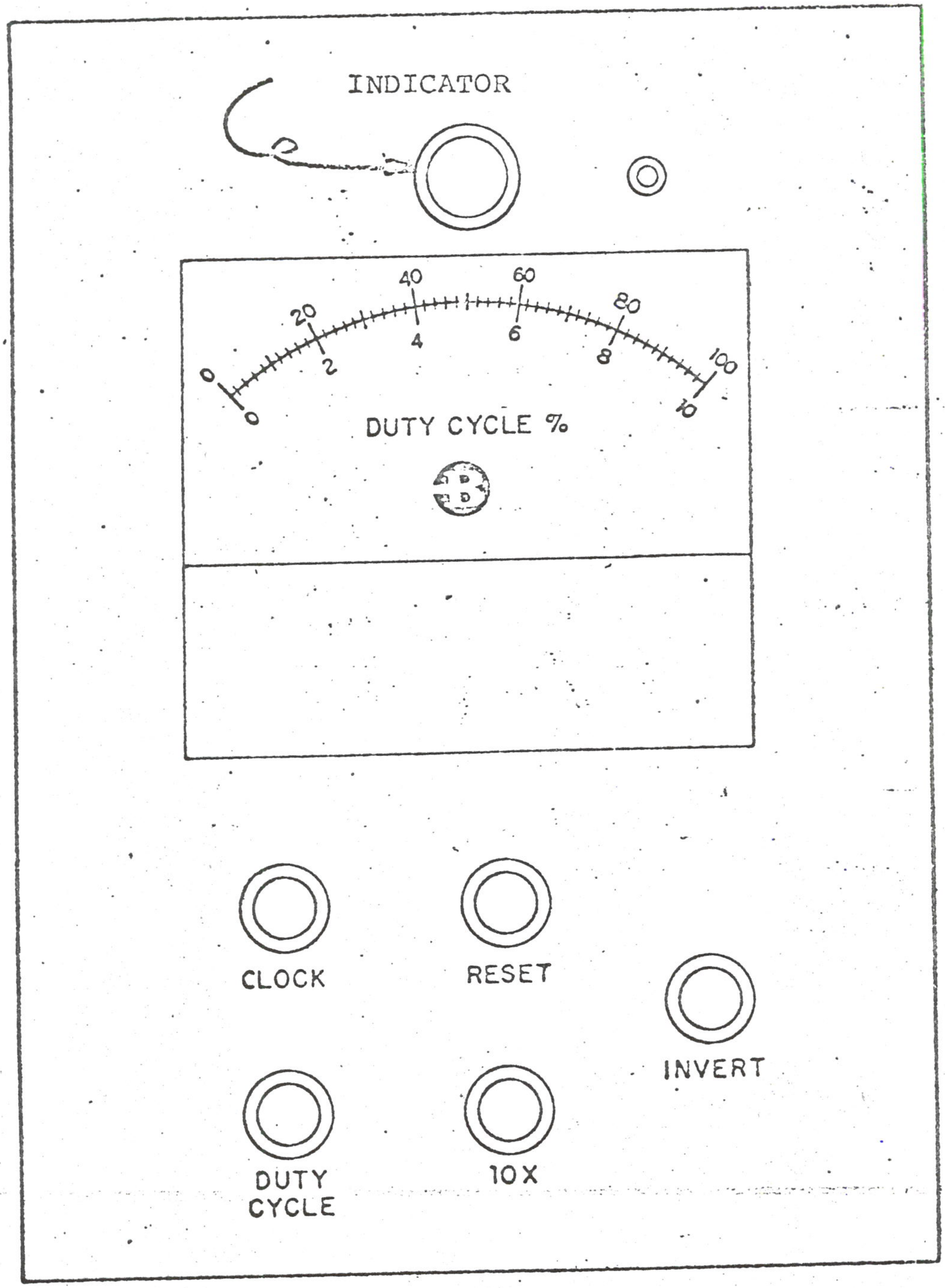


FIGURE B.2 MTR METER

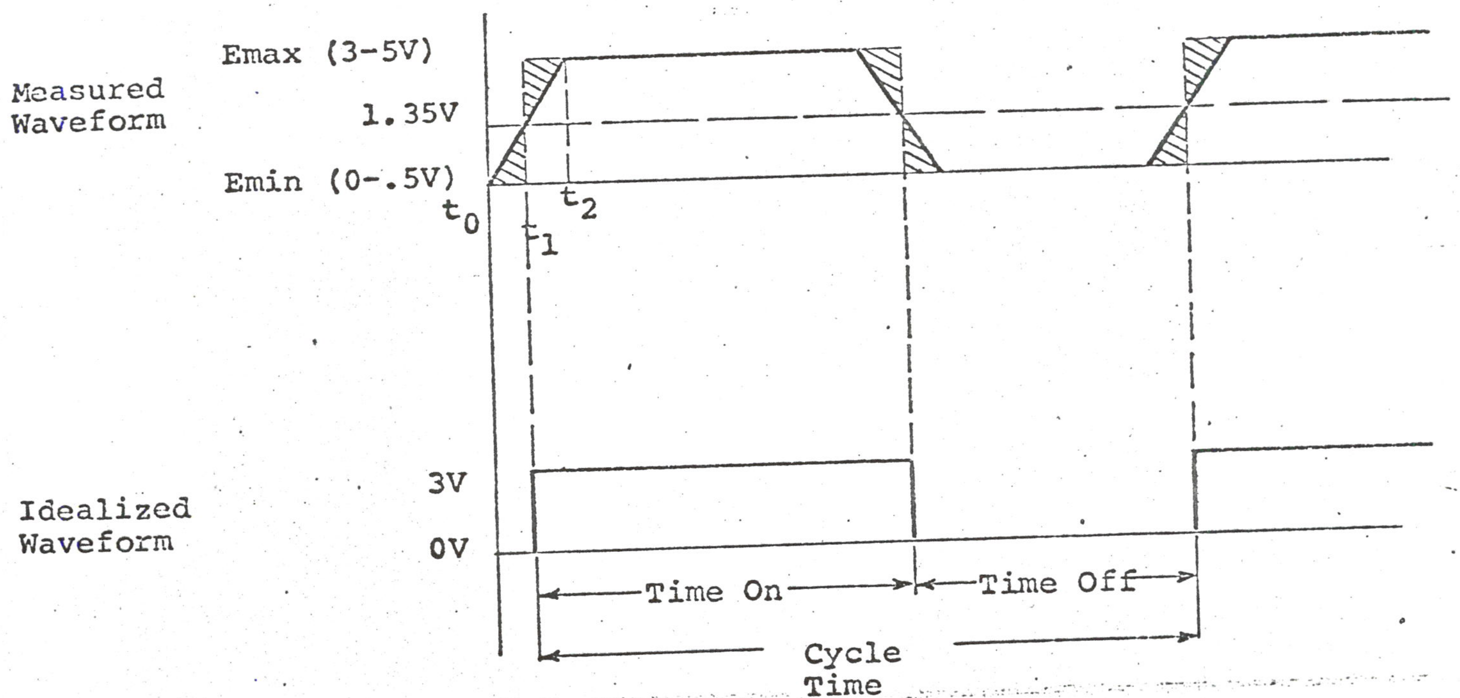
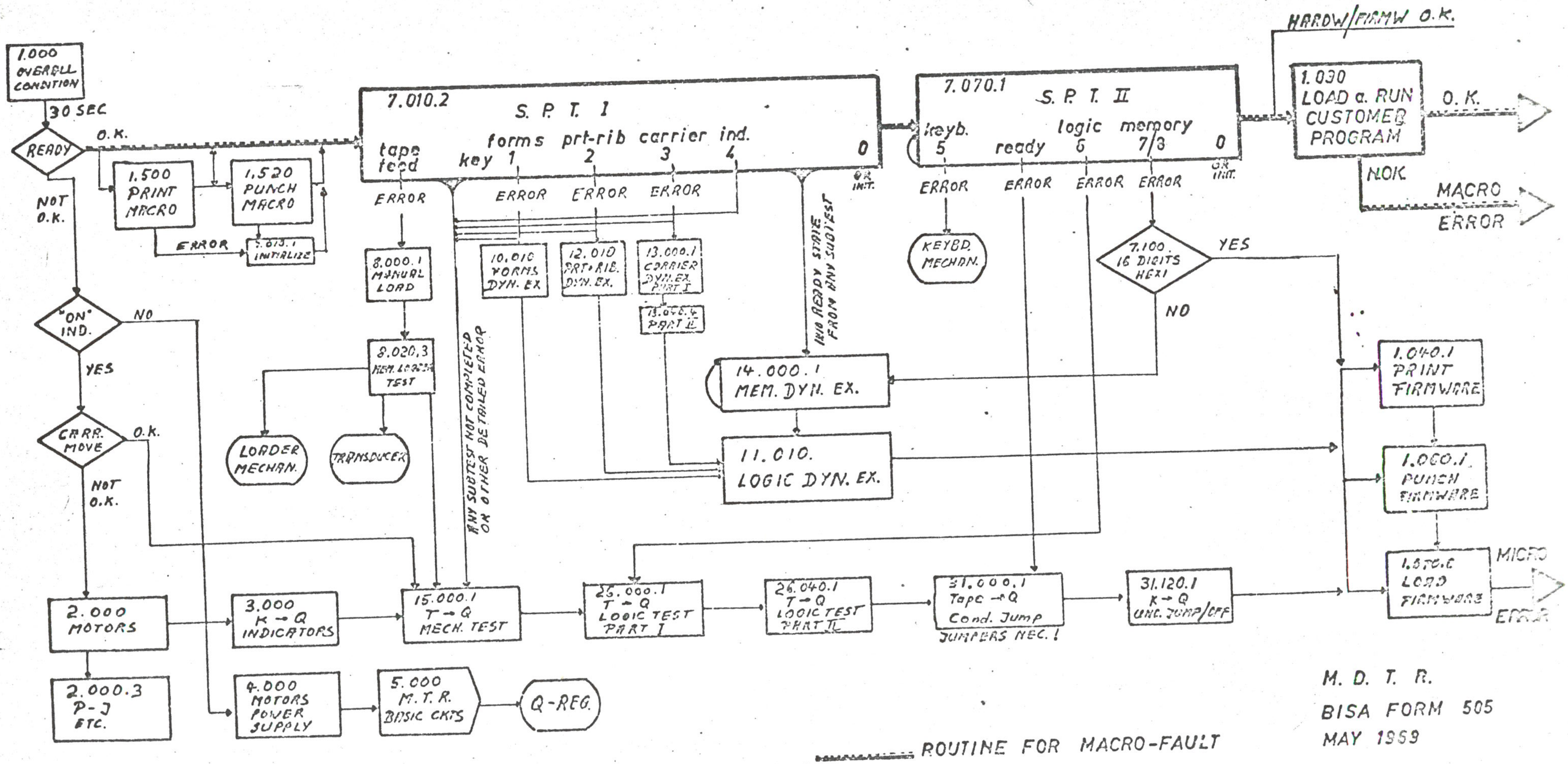


Figure B.1 Generation of Idealized Waveform



M. D. T. R.

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