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SUBJECT: TESTING OF INDIVIDUAL CORES IN MTC MEMORY PLANES

To: N. H. Taylor

From: A. D. Hughes

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Abstract: The 32 x 32 magnetic-core memory planes for MTC were constructed from cores tested and sorted on a production basis. To obviate the possibility of defective cores, each core was retested after it had been wired into a memory plane. A device was constructed to enable the operator to send current pulses through each core in a plane and observe the output. The necessary test equipment was arranged to provide the pulses and allow measurement of the outputs.

No defective cores were found. The test showed that the limits of output voltage at the sensing time used were ±17%. Five cores with outputs outside of these limits were replaced. Taking into account that the variable factors inherent in testing and equipment are ±5%, the cores in each plane are within approximately ±20% limits.

Definition of Terms

The magnetic memory for MTC consists of 17 memory planes. Each plane has 1024 magnetic cores wired at the intersections of 32 pairs of vertical wires and 32 pairs of horizontal wires (see Memorandum M-2225, "The Construction of Memory Planes for MTC Memory," E. A. Guditz, June 10, 1953). These vertical and horizontal wires are called the x and y windings, respectively. The completed plane also includes both a sense winding and a Z-plane winding, each of which passes through each core.

The tester being described is called the plane tester. The tester used to select cores for the planes is called the production tester.

Reason for Test

Lest completed planes mistakenly include defective cores rejected by the production tester or cores damaged in construction, it was decided to retest the individual cores in each memory plane after completion of the x and y windings.

Defective cores could then easily be replaced before the Z-plane and sense windings were added. A retest also gave the limits of the ONE-disturbed output voltages or the percent difference between the highest and lowest cores in the plane. (An incidental result here was a correlation of plane-tester outputs with those of the production tester.)

Actual testing of the planes showed three common errors in construction of the x and y windings:

1. Any cores out of proper 90° angle with their neighbors;

2. Failure of any x or y wire to go through any core;

3. Improper connection of the pair of x or y windings to the correct terminals.

Such errors were easily corrected before addition of the Z-plane or sense windings.

Method of Test (see Fig. 1)

Testing each core in the array was accomplished by using the x windings for driving and the y windings for sensing. One y winding was connected to a scope so that the ONE-disturbed output of any of the 32 cores on that winding could be observed. The driving current was then connected to all the x windings in succession, until each of the 32 cores on the y winding had been tested. The sensing connection was then moved to the next y winding, and the procedure repeated until the output of every core in the array had been measured. Only one of the pair of x windings need be used for the driving current since the current drivers supply both negative and positive pulses over the same wire. Using only one of the x windings for the driving current considerably speeds the testing procedure, since a rig was devised which makes it very easy for an operator to shift the driving current quickly from one x wire to the next. The device (Fig.1) provides a spring wire which can be moved to make contact with any of the x windings on one set of terminals. The other connection at the opposite side of the plane is a common wire connecting all of the x terminals. The movable spring-wire connection and the common wire are connected to the source of driving current. The sensing or output connection merely connects the ends of one given y winding into a coaxial cable, which is fed into the scope. The device provides a means of testing the plane using one of the pairs of x windings and one of the pairs of y windings which pass through each core. So that the others of the pairs of x and y wires may be used, the test device is reversed and the plane retested. Although one test is sufficient to detect a bad core, the second test gives a double check and completes a test of all the x and y wires of the plane for possible construction errors. The entire test can be completed in about 2 hours.

Test Setup (see Fig. 2)

To drive the cores, a train of pulses which simulates actual operating conditions is used. The positive pulses are provided by two Mod. VI core drivers and the negative pulses by two Mod. V drivers. The logic used to drive the system is the same physically as that used with the production tester. (An Engineering Note by J. W. Schallerer which will describe the Production Tester is being written.) Calibration of the current amplitude is provided by a 60-cycle a-c/d-c chopper calibrator mounted with the test setup. The current which drives the cores goes through a 1%, 10-ohm resistor. The voltage across the resistor is then fed to the current calibrator. Calibration of the scope for reading the output voltage is provided by the same calibrator used with the production tester, which gives a continuous 200-millivolt, 400-cycle, square wave. Fig. 2 shows two cables on input 1 at the scope, one for voltage calibration and the other for current calibration. Actually, either one or the other is connected, but not both. Since the scope is easily calibrated, the test operator can read the output of each core directly from the scope face, which is marked off with the proper division lines.

Also included with the test setup is a delay-line panel which provides a pulse to intensify the output disturbed-ONE pulse at the desired read time. The d-c voltage for the test setup is provided by a regulated power supply. This is to insure, in particular, no drift of the current drivers.

Driving Current

Most of the test was designed to be consistent with the production tests, since, in effect, it was desired to show that no really bad cores had been passed by the production tester. However, since the production tester uses a semi-infinite current-pulse length, it was decided that a pulse length closer to the one MTC would use would give a better test. The read and write driving currents used, including the disturb pulses, were 1.5 microseconds in length, measured from 10% of the maximum at the rise to 10% of the maximum at the fall. At the beginning of the test it was not known exactly what pulse length would be used for MTC. It was decided, however, that a 1.5-microsecond pulse length was probably the minimum that could be used. Since then, a 2-microsecond pulse length was decided on for MTC, but the tests were continued at 1.5 microseconds, for consistency. The current rise time used for the tests was the same as that used for the production tester, 0.2 microseconds.

The current amplitude used was the same that was used with the production tester, 920 milliamps for read and write pulses and 460 milliamps for half-selecting pulses. This seemed to be optimum driving current and gave consistent results.

Output

The output for each core in the plane was displayed on the scope. Five important traces were observed, disturbed ONE, disturbed ZERO, write ONE, half-selected ONE, and half-selected ZERO. The traces which were significant for the tests were the disturbed ONE and disturbed ZERO. The disturbed ZERO was found to have decayed to zero at sensing time for all cores tested. The disturbed-ONE output was measured at the same sensing time for all cores. The sensing time was determined by taking the average peak time for a large sample of cores. This turned out to be 0.52 microseconds after the read driving current pulse had reached 10% of its full value. The delay-line panel mentioned above was used to intensify the disturbed-ONE trace on the scope at 0.52 microseconds for easy reading.

Results

It was found early in the tests that the variation between the lowest and the highest disturbed-ONE output for a given plane was about 34% at its minimum. It was decided that ±17% would comprise the basis for acceptance of cores in a given plane. That is, any cores whose output at sensing time was outside of the limits prescribed were considered bad cores. The average output per core was 0.115 volts. The acceptable limits, then, were 0.095 volts and 0.135 volts. Cores replaced were as follows:

Plane	Core Output	Next Closest Core in Plane
6	0.093 volts	0.097 volts
9	0.092	0.097
10	0.138	0.135
10	0.093	0.098
10	0.096	0.098

The 0.096-volt core in Plane 10 was replaced since it happened to be on the same x winding as the 0.093-volt core.

It should be emphasized that there were no cores in all 17 planes tested which were actually bad cores, mistakenly placed in the planes. Those cores which were replaced, were found to be satisfactory, although marginal, when retested on the production tester. As mentioned above, important results of the tests were the detection of errors of construction in building the arrays. About one third of the planes tested had such a construction error.

The production tester accepted cores between 0.105 volts and 0.125 volts whereas the plane tester found the range to be 0.095 volts to 0.135 volts. The difference was probably due to several factors, one of which was the difference in driving-current pulse lengths. Another was a difference in sensing time (0.67 microseconds for the production tester, 0.52 microseconds for the plane tester).

A third factor was the noise in the plane being tested and general difference in physical setups between the plane tester and production tester.

Validity of Results

Each plane was considered as a separate unit. Core outputs in any given plane were tested for spread for that plane alone. Since MTC has a separate sensing amplifier with variable gain for each plane, considering each plane separately seemed to be a valid criterion. Differences in core outputs throughout a given plane, regardless of distribution, were disregarded, providing the outputs fell within the desired limits. The time and effort involved and the variation in availability of large numbers of cores prevented the construction of planes with an even distribution of core outputs or putting cores of closest outputs in the same planes.

Control of parameters involved in driving current was as close as practicable. However, variations in results were inevitable due to such variations in parameters. The greatest cause of error resulted from variations in amplitude of driving current. A 5% change in driving-current amplitude will produce approximately a 25% change in output. Considering all the parameters, i.e., rise time, pulse width, and amplitude of driving current, plus variations in the oscilloscope and the calibrators, the worst variation in core outputs in any given plane would be approximately ±20%.

Conclusions

1. The most distinct advantage of testing a plane before Z-plane and sense windings are added is in incovering construction errors when correcting such errors is simple.

2. It is believed that the test will definitely show any cores which are bad.

3. The quality of the present core-selection system was good enough so that no bad cores were found in 17 planes, of 17,408 cores selected as good.

4. The cores in each memory plane at the driving currents used for the tests have a worst-output variation of approximately ±20%.

5. The plane tester performed the function for which it was designed. Further improvements and tests would overlap core production tests and tests given the planes before their use in MTC.

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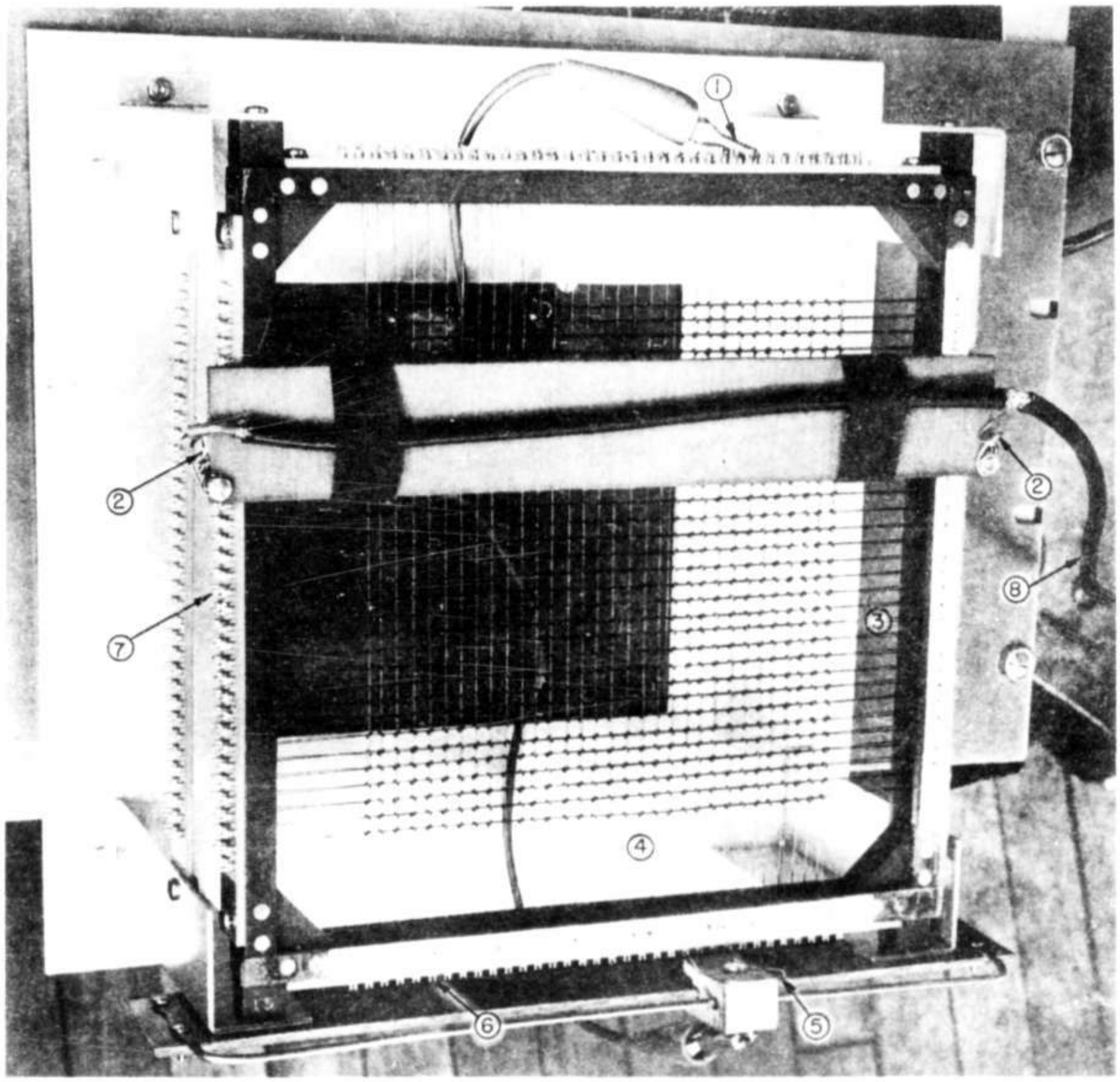
Attached drawings: A-55166
A-55167

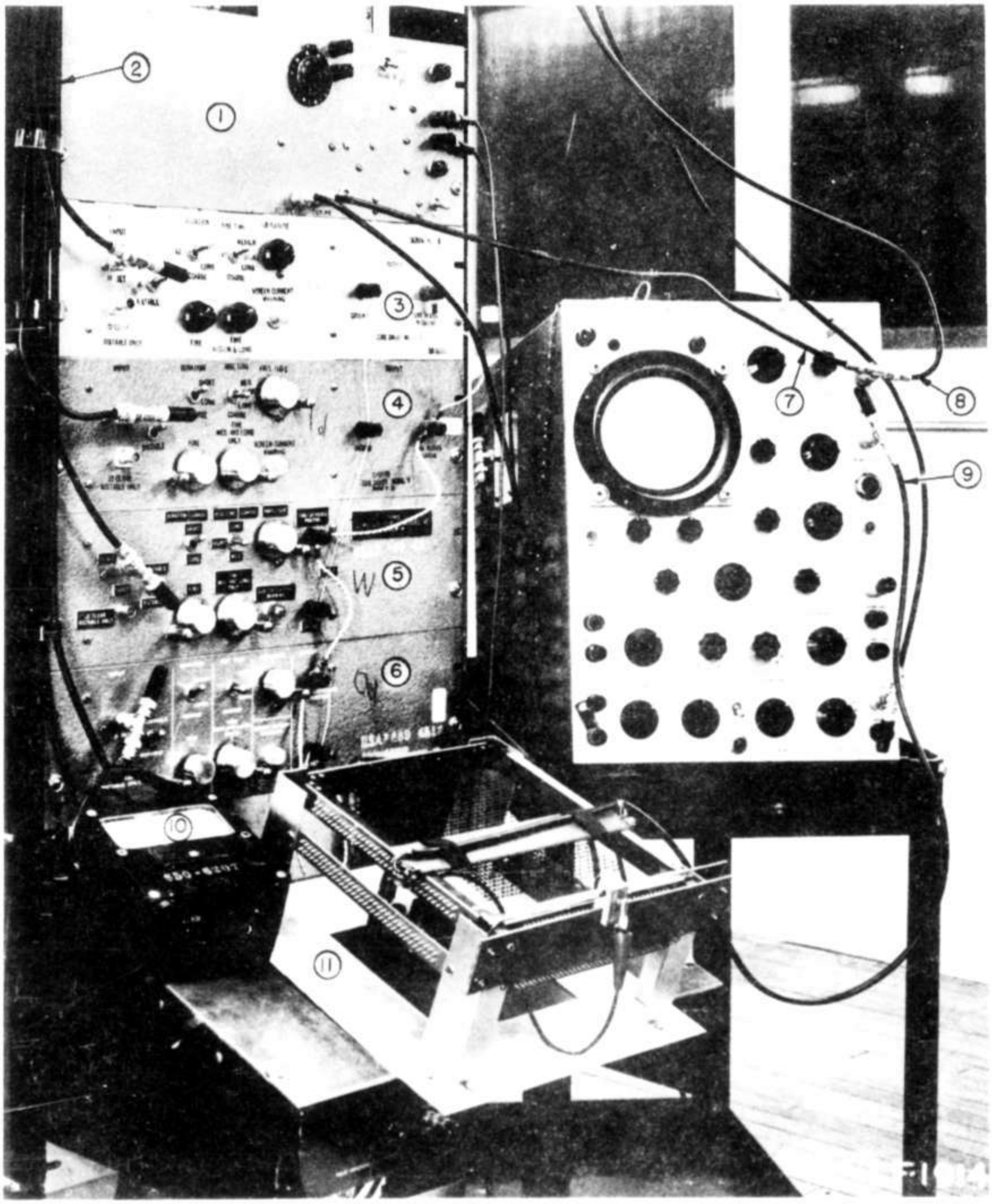


①	DRIVING CURRENT CONNECTION TO COMMON OF X WINDING TERMINALS	⑤	MOVABLE SPRING WIRE FOR X WINDING DRIVING CURRENT
②	SENSING CONNECTIONS TO Y WINDINGS	⑥	X WINDING TERMINALS
③	Y WINDINGS	⑦	Y WINDING TERMINALS
④	X WINDINGS	⑧	TO SCOPE FOR OUTPUT MEASUREMENT

FIG. I

M.T.C. PLANE ON TEST DEVICE

A-55166
F-1915



① CURRENT CALIBRATOR
② CABLES FROM PRODUCTION TESTER LOGIC
③ READ CURRENT DRIVER
④ HALF AMPLITUDE READ CURRENT DRIVER
⑤ WRITE CURRENT DRIVER
⑥ HALF AMPLITUDE WRITE CURRENT DRIVER
⑦ CURRENT CALIBRATION SIGNAL
⑧ VOLTAGE CALIBRATION SIGNAL
⑨ OUTPUT SIGNAL
⑩ VOLTMETER FOR CURRENT CALIBRATION
⑪ MEMORY PLANE ON TEST DEVICE

FIG. 2
M.T.C. MEMORY PLANE TEST SETUP

A-55167