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SUBJECT: IMPROVED MEMORY CORES PRODUCED IN LINCOLN LABORATORY

To: Group 63 Staff

From: F. E. Vinal

Date: 13 April 1955

Approved: [signature]

D. R. Brown

Abstract: Recent memory core production in the Lincoln Laboratory pilot plant has offered an improved variety of cores for experimental project use. Typical characteristics are shown for these cores and the principal advantages to be derived from their use are discussed. A comparison of characteristics is made between our cores and those commercially available. The basis of selection of superior cores is described and the extent of production capacity for our pilot plant is given. Methods which may be employed to improve further the characteristics of memory cores of this type are suggested, and, to some extent, the degree of further improvement which may reasonably be expected is noted.

Introduction

For some months, the Chemistry Section of Group 63 has been producing for project use a variety of memory cores improved over those obtainable commercially. The properties which have been improved, as well as the degree of improvement, have been the subject of considerable discussion, leading in some instances to misunderstandings about our cores, their properties and their use. It is the purpose of this memorandum to present enough data about our cores to enable engineers to make "educated guesses" about their performance in various applications, and to make clear that although considerable progress has been made with memory cores, there is plenty of room for further improvement and the development of special adaptations.

Performance

The "proof of the pudding" for our memory cores will, of course, be their performance in the coincident-current-memory application. All test data has been taken with this application in mind, and, thus far, only one set of operating conditions has been intended, namely, the use of the

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cores at a driving current of 820 ma. and in a matrix using a 2:1 ratio of currents for selecting and disturbing pulses. The performance of our present production under these conditions is summarized in Figure 1.

Since these cores have been reduced in cylindrical height to about 0.022" to provide output voltages more comparable to commercially available cores, one might not see at once that the cores represent an improvement over commercial cores. While offering an adequate output signal voltage, these cores also exhibit excellent discriminating signal ratios between the dV1 peak voltage and the dVz at strobing time. In addition, the decreased half-selected output signals of the smaller cores offers a considerably reduced back voltage on the driving circuits, permitting larger matrices. In combination with the above advantages, the switching time of the cores also has been shortened by about 0.15 microsecond at 820 ma. driving current, to a practical operating value of 0.98 microsecond.

In order to compare the properties of the current core production here with commercial cores, the data on our cores have been normalized by preparing some in a cylindrical height of 0.025", the size commercially available. Performance data for these cores are compared in Figure 2 with data taken from published advertising literature of the General Ceramics Corporation.

Testing and Yields

The current IBM core specifications used to purchase cores for the FSQ-7 machines stipulate as principal performance requirements that the cores intended for use at 820 ma. driving current and 2:1 selection ratio shall each pass tests for

(1) 75mv. minimum signal for uV1 voltage at a current drive of 740 ma. and a strobing time of 0.55 microsecond.
(2) 45mv maximum signal for the peak dVz voltage when examined with disturbing pulses of 470 ma. (2:1.15 selection ratio).

The cores must, therefore, qualify under test conditions more severe than the subsequent matrix operation (2:1 selection ratio).

Because of low values of the dVz signals from cores made here (this might be restated to say because of the high squareness ratio ($R_{s\ max}$ = 0.865) over the 740 ma. to 940 ma. range of the above qualification tests) it has been possible to select or test cores for our use on an even more stringent basis. For our own use, cores are qualified only if they meet a minimum output signal of 80mv for the uV1 voltage and are rejected if the dVz signal rises above 28 or 29mv.

On this restricted test basis, batch yields are consistently 95% or better. A 99% yield is not unusual. Occasional batches fail, but when they do, they fail miserably (yields of 25%), and in each case the cause of failure has been traced to faulty equipment or human error. The manufacturing process is now apparently a stabilized and reliable method and will consistently produce high quality cores if permitted to do so by equipment and operators.

Production Facilities

Combining the interest of this laboratory in maintaining an emergency source of supply position for the FSQ-7 machines with our production for local advance development work, facilities for production at a maximum rate of 250,000 cores per week will soon be available. Currently, the maximum rate is approximately 120,000 per week. The increased production will be achieved simply, through better furnace loading techniques and more adequate core pressing facilities, capable of pressing cores much more rapidly than our present equipment. Core testing facilities can handle, approximately, the current output of cores in normal working hours. Much could be gained in an emergency by operating this automatic testing equipment on a broader schedule.

Further Work

Because of the emphasis on memory access time for the Lincoln Laboratory's interests, continued effort will be made to reduce further the switching time of the cores without sacrificing driving currents or other factors. From the examination of Figure 1, one can realize that the current core production is probably providing an unnecessarily large operating margin at the high driving current ranges. It seems obvious, therefore, that the entire set of curves may be shifted slightly to the left. Such a procedure should further decrease the switching time at 820 ma. operating current by about 0.1 microsecond. Likewise output voltage for the uV1 would be increased substantially (possibly 25mv.) which could be used as such or used to decrease again the core height and gain further on the advantages which would accrue. Less obvious improvements are likely by tampering with the chemical composition and processing techniques. Experimental work of this character will be carried on along with other experimental work to produce materials for special adaptations. Large scale production of cores resulting from this experimental work will not be available for some time, and for the present, memory core production from our pilot plant will be stabilized for the production of the cores for which typical characteristics are illustrated in Figure 1.

Signed: F. E. Vinal

FEV:fm

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Drawings Attached: Figure 1 A-62423
Figure 2 A-62424

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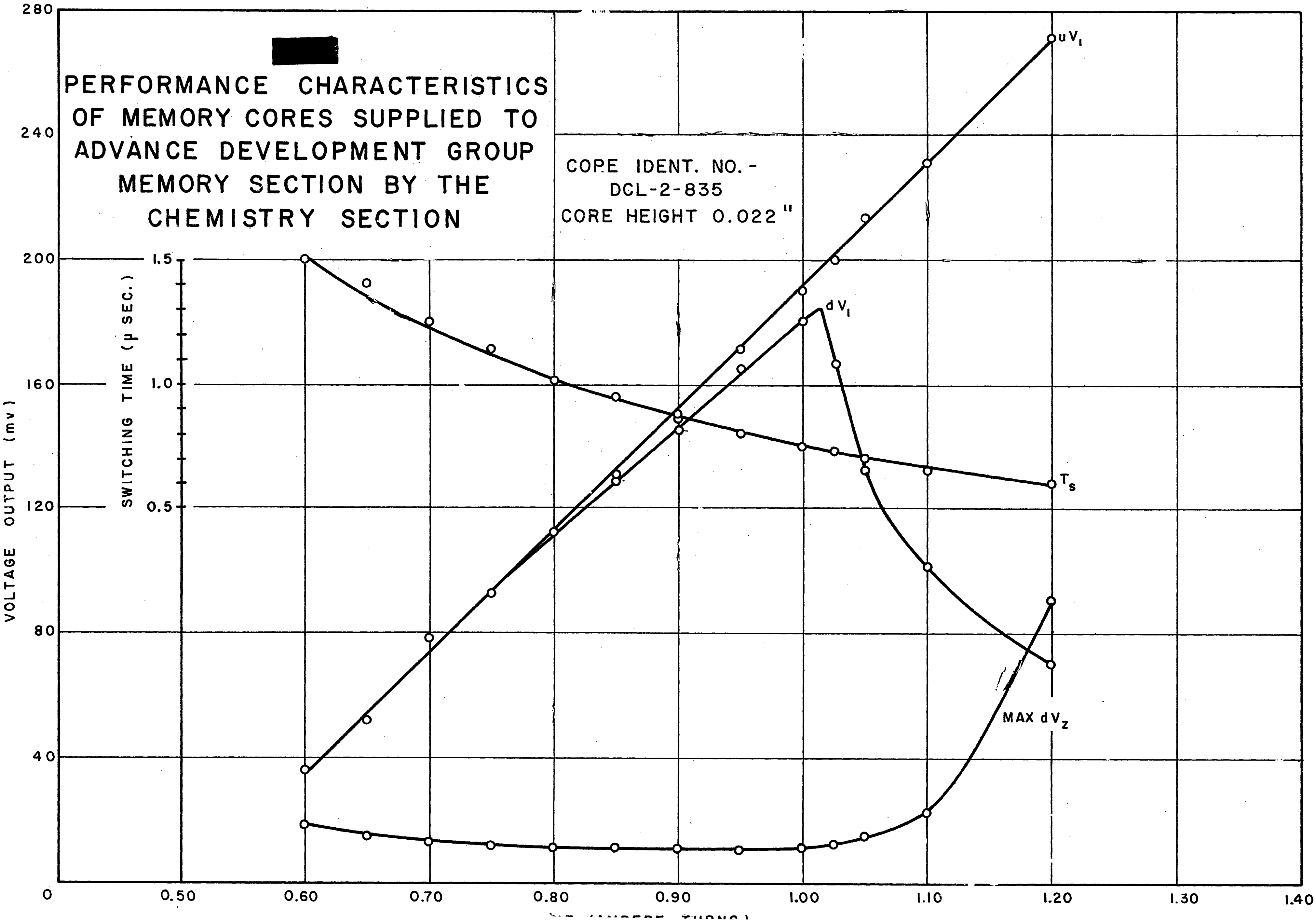
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PERFORMANCE CHARACTERISTICS OF MEMORY CORES SUPPLIED TO ADVANCE DEVELOPMENT GROUP MEMORY SECTION BY THE CHEMISTRY SECTION
CORE IDENT. NO. - DCL-2-835
CORE HEIGHT 0.022"
VOLTAGE OUTPUT (mv)
SWITCHING TIME (μ SEC.)
uV1
dV1
Ts
MAX dVz
280
240
200
160
120
80
40
0
1.5
1.0
0.5
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40

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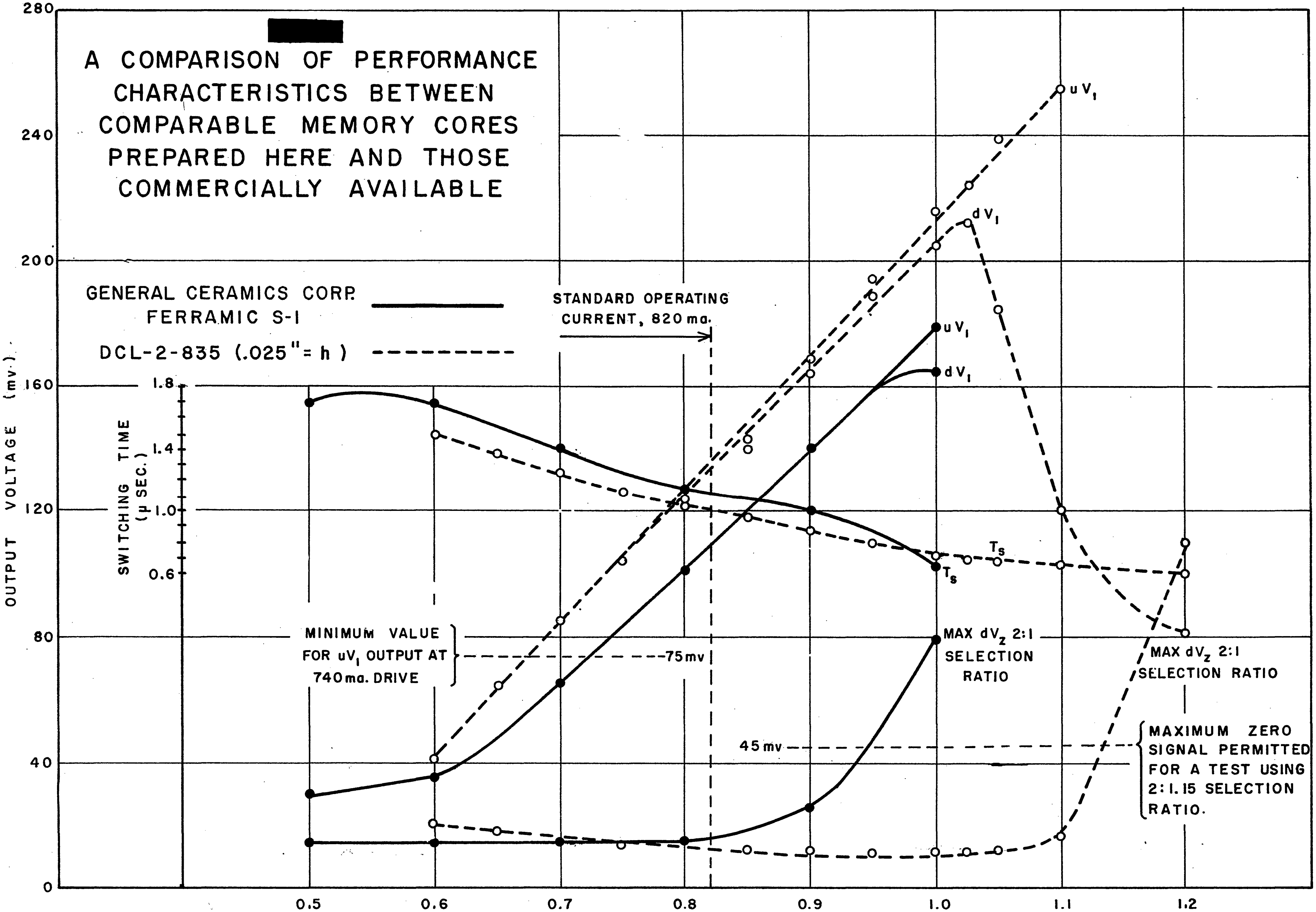
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A COMPARISON OF PERFORMANCE CHARACTERISTICS BETWEEN COMPARABLE MEMORY CORES PREPARED HERE AND THOSE COMMERCIALLY AVAILABLE
GENERAL CERAMICS CORP. FERRAMIC S-1
DCL-2-835 (.025" = h)
STANDARD OPERATING CURRENT, 820 ma.
OUTPUT VOLTAGE (mv)
SWITCHING TIME (μ SEC.)
0
40
80
120
160
200
240
280
0.6
1.0
1.4
1.8
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
uV1
dV1
uV1
dV1
Ts
Ts
MINIMUM VALUE FOR uV1 OUTPUT AT 740 ma. DRIVE
75 mv
MAX dVz 2:1 SELECTION RATIO
MAX dVz 2:1 SELECTION RATIO
45 mv
MAXIMUM ZERO SIGNAL PERMITTED FOR A TEST USING 2:1.15 SELECTION RATIO.