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SUBJECT: BIWEEKLY REPORT FOR 22 APRIL 1955

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From: Division 6 Staff

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I - SYSTEM TEST & PLANNING

1.1 Air Defense

1.1.1 Test Program

(D. R. Israel) (CONFIDENTIAL)

Progress on the 1954 Cape Cod Test Program continues at an accelerated pace. Large-scale testing will definitely be under way by mid-May and is now scheduled through November of this year. An important factor in the satisfactory progress over the past few weeks has been the generous cooperation and assistance of Henry Frachtman and Jack Nolan.

A good deal of the initial planning for the test program for the Experimental Subsector (XD-1) has been completed. These plans have been prepared as proposals for the SAGE Test Committee; the Committee may later issue this material in M-note form.

The research reported in this document was supported jointly by the Department of the Army, the Department of the Navy, and the Department of the Air Force under Air Force Contract No. AF 19(604)-455.

2.6 Vacuum Tubes

2.6.1 Activities of Group 65

(P. Youtz) (UNCLASSIFIED)

I spent the week of 11 April on the west coast with the newly formed IBM-MIT Display-Tube Committee and M. J. Raffensperger. This Committee was set up by IBM to study thoroughly the present status of display tubes with respect to tube specification and production and compatibility of tube specifications with system and circuit requirements.

At Hughes three of their personnel were members of the Committee. A. V. Haeff acted as chairman concerning Typotron study and problems.

At Convair three of their personnel were members of the Committee with G. T. Gerlach acting as chairman on the study of the Charactron problem. Minutes of these meetings will be issued on a company-confidential basis.

I have been asked by the Committee to return the week of 25 April 1955 to Convair with F. H. Caswell and J. S. Palermo. We will work with the Convair Quality-Control Group and Tube Plant Group until all Charactron Manufacturing Processing Specifications are issued and signed by Convair. Henceforth, Charactrons will be manufactured to these specifications except when IBM releases a change in specification on request from Convair.

2.6.2 Tube Research and Development

(D. C. Lynch, J. S. Palermo) (UNCLASSIFIED)

During the past biweekly period we prepared 2-inch bulbs for cathode studies, 7-inch bulbs for A. Zacharias' phosphor evaluation, and 19-inch bulbs for C. L. Corderman.

Groups of 7AK7 and 2420 tubes were polycast for the dimensional-analysis-study program.

We studied and checked the Convair Manufacturing Process Specifications and the Lincoln Tube Process Specifications.

(S. Twicken) (UNCLASSIFIED)

I attended a meeting at Kingston with Hazeltine and the IBM Tube Group to discuss Hazeltine's suggestion of changing the Charactron deflection driver from the triode 6161 to the tetrode 4X150A. Hazeltine had felt that the settling-time specification could not be met with the triode 6161 and present circuitry. The circuit groups involved at MIT and Endicott feel that the 6161 is adequate, and until such time as inadequacy can be shown, the matter of approval of the 4X150A is closed.

A suggested specification for the 3002420, based on a statistical analysis of the lot-evaluation program, has been received from Sylvania and will be compared with the IBM-MIT Tube Group analysis currently under way.

Data taken on the 3002420 dimensional-analysis program to date is being collated and studied.

A meeting is scheduled with IBM for the week of 25 April to coordinate and intensify the program to determine the physical cause of the 0528 (Z-2177) difficulties.

(T. F. Clough) (UNCLASSIFIED)

I spent the majority of the past biweekly period writing the Lincoln Tube Process Specification for the 19-inch display tube.

(P. C. Tandy) (UNCLASSIFIED)

Ten 19-inch Charactrons, CHT-61, CHT-62-1, CHT-68-1, CHT-72-2, CHT-73, CHT-75, CHT-80, Convair 14-1, 0082, and 0083, have completed from 487 to 4085 hours on life test. The status of these ten tubes and the five Convair tubes, 14-5, 0117, 0123, 0124, and 0127, which failed since the last report is shown in Table I.

Table I

Tube No.	Before Last Biweekly		After Tube Cutoff for 12 Hours		A_2 Changed from 200 to 50 volts	
	Hours	Pulse 0-Bias I_{Matrix}	Hours	Pulse 0-Bias I_{Matrix}	Hours	Pulse 0-Bias I_{Matrix}
CHT-61	3527	134 μa	3768	91 μa	4064	130 μa
CHT-62-2	3411	190 μa	3654	123 μa	3955	88 μa
CHT-68-1	827	100 μa	1067	73 μa	1369	135 μa
CHT-72-2	831	340 μa	1071	200 μa	1373	195 μa
CHT-73	742	220 μa	982	225 μa	1285	195 μa
CHT-75	2166	150 μa	2406	122 μa	2707	149 μa
CHT-80	2015	320 μa	2255	310 μa	2556	275 μa
14-1	0	190 μa	288	150 μa	590	110 μa
14-5	4	460 μa	264	40 μa		
0082	583	460 μa	824	245 μa	1121	245 μa
0083	4	590 μa	261	320 μa	475	360 μa
0117	4	520 μa	265	8.7 μa		
0123	5	400 μa	262	35.5 μa		
0124	5	82 μa	267	15.5 μa		
0127	5	280 μa	267	270 μa	475	0 μa

All the tubes have gold-plated G_1 apertures except Convair 0117, 0123, and 0124.

A power-supply failure caused the tubes to operate for about 12 hours cut off (grids not pulsed on). The first group of transfer characteristics since the last report was made shortly after this 12-hour period. The pulse zero-bias-matrix current of 12 of the 15 tubes dropped off from the previous test. Four of the 12 tubes failed to meet the 50-μa-matrix-current requirement and were rejected. The zero-bias-matrix current of three of the remaining eight tubes, which had dropped after the 12-hour cutoff, had recovered to its precutoff condition at the last testing period. Convair 0127 did not drop appreciably after being cut off for 12 hours, but no emission was observed at 475 hours, and the tube was rejected.

The reliability of the Charactron life test is being threatened by the approach to the limit of power available from the laboratory power supplies. A power-supply failure will cause the tubes to be operated at a cutoff condition unless it is noted and the life test shut down. The capacity of the laboratory power supplies should be increased as soon as possible to alleviate this condition.

Work on expansion of the Charactron life test from 15 to 20 positions is continuing. Convergence-coil drivers are completed, and tube control boxes have been started. The major holdup appears to be delivery of 6.195.3 filament transformers.

(L. B. Martin) (UNCLASSIFIED)

Difficulty with the lab power supplies has impeded work on the Typotrons. At one time there were 22 volts of 60 cycle on the -150-v line; at last measurement there were 6 volts. This ripple caused marginal operation in almost all the equipment including the line-driver amplifiers and was particulary objectionable in the writing-gate generators. Accurate current measurements are impossible for high net-bias conditions when taking pulse-transfer data. The +250 supply is running at or slightly above rated capacity when maximum load is on. There have been several interruptions of this supply during the last month. D. Mach has started using a small motor-generator for additional +250-v current as a stop-gap measure.

Typotron 268 has been continuously monitored for flood-gun grid-cathode leakage with flood-gun heaters energized. The leakage (or emission) has been constant at 9 microamperes. The test will be discontinued.

Hot and cold grid-cathode leakage tests were made on 9 Typotrons for both guns. In each case the grid was held 500 volts below the cathode. The results appear below.

Tube	Flood Gun		Writing Gun	
	Cold	Hot	Cold	Hot
12242	0.2 μa	5.3 μa	0 μa	0.03 μa
12522	0.7 μa	12.3 μa	0 μa	0.005 μa
12461	0.07 μa	5.5 μa	0 μa	0.1 μa
12622	0.17 μa	4.5 μa	0 μa	0 μa
12523	0.001 μa	0.08 μa	0.39 μa	shorted
12221	0.005 μa	0.01 μa	2.6 μa	7.5 μa
12641	0.22 μa	12.6 μa	0 μa	0.009 μa
11981	0.005 μa	0.03 μa	0 μa	0 μa
12122	0.005 μa	shorted	0 μa	0 μa

The two shorts listed above were cleared by discharging a capacitor into the short. C. L. Corderman has reduced the hot-leakage test voltage to 150 volts on the writing gun but retained the flood-gun voltage at 500 volts. A 1.2-megohm series resistor was used in these tests. Hot and cold leakage tests will be made on other tubes that have been in the old life test.

Tube 280 is now considered marginal after 7799.2 hours because of low-beam current. The falloff of beam current has been gradual, and this decision to call it marginal is rather arbitrary. Perhaps a minimum of writing time at zero net bias should be agreed upon for a marginal tube. I suggest 50 microseconds minimum writing time as the dividing line.

Work continues on the automatic-curve tracer but at a low priority. Most likely it will not be finished before June.

The following is a list of tubes, their condition, and total hours on the eight-position life test:

Tube	Total Hours	Condition
265	8617.2	marginal
280	7799.2	marginal
389	6196.6	satisfactory
390	6280.4	satisfactory
392	6280.4	satisfactory
394	5498.3	marginal
11601	1593.0	satisfactory
11521	1348.5	satisfactory

The following tubes have been on the 16-position life test for 776.9 hours and are satisfactory: 11981, 12122, 12523, 12622, and 12641.

(A. Zacharias) (UNCLASSIFIED)

Investigations of CRT cathodes were continued during this period. As a result of evidence presented in the literature and experimental results, it can be easily shown that the simple observation of beam current, "activation" current, or any ratio will not allow one to determine even moderate differences in cathode condition between guns of similar-type construction. Variation in "activation" current (diode current) will be more strongly dependent on G_1-K spacing than on cathode work factor for most conditions. Beam current (IA_3) is dependent upon cutoff (G_1-K spacing) and gun geometry in general (aperturing) more than on cathode condition in most cases concerned with on initial life. The ratio of IA_3 to cathode current or A_2 current is dependent upon the geometry of the gun. The only way in which cathode condition will affect these is on life where changes can be found. From tube to tube, cathode condition will only show up if poisoning and saturated emission are present. Neither life nor saturated emission at initial life was deemed useful enough for determining cathode condition.

However, an analysis of beam production in the gun was made which determined that only the central portion of the cathode should contribute to beam current, aperturing being done as a "field stop" much more than an "aperture stop." Since the central portion of the cathode is at highest-current density due to maximum penetration of the G_2 field, the beam is produced from a more saturated portion of the cathode than IA_2 is drawn. Hence, reducing cathode temperature should reduce IA_3 a greater proportion than IA_2. A procedure for determining the condition of a cathode would be to take the ratio IA_2/IA_3 at fixed E_{c_1} and then reduce cathode temperature. The increase in this ratio will give an indication of the nearness of the current density of the axial portion of the cathode to temperature limiting.

These points were brought out by experiment and the theory deduced from the data. The deductions were then verified by the information found in the literature.

There are a number of assumptions which must be verified before a procedure can be set for testing the cathode emission in a given gun. The first is the variation of cutoff with cathode temperature due to thermal expansion changing the G_1-K spacing. The field at the cathode is principally affected by grid drive, i.e., $E_{c_1}-E_{c_o}$ where E_{c_o} is cutoff voltage. The value of current density at the cathode center due to geometry will remain fixed for a given gun if the drive is maintained constant. However, it would be laborious to determine the value of E_{c_o} at all cathode temperatures before testing. If a plot is made of IA_2/IA_3 vs. E_{c_1} at fixed temperature (1100 K), then in all tubes a "plateau" is reached in ratio for E_{c_1} from -30 volts to -10 volts in almost all cases. If the cathode temperature is reduced, E_{c_o} is (in magnitude) decreased, and E_{c_1} held constant, the value of the drive (E_d) is reduced with temperature. However, if E_{c_1} is held at -10 volts, the value of drive is reduced through the "plateau." Even though the drive changes with temperature the geometric value of IA_2/IA_3 will not change. An increase in the ratio must then be due to (to first order) temperature limiting of the cathodes.

A value of ratio increase from E_H = 7.0 volts to E_H = 5.0 volts at E_{c_1} = -10 volts is reduced to percent based on the 7.0-v ratio. This percentage is termed η'. For the RCA 5C guns η' = 4% initially, in the Superior 5C guns η' = 15 to 25%, and the same for the Sylvania 5C guns. These cathodes were processed by the vacuum-tube laboratory at Barta to various schedules, which indicated the variation of the schedule made no difference in initial characteristics.

In order to compare the η' of various geometries, the loading at the cathode axis for each geometry must be found. Using an empirical equation found in the literature, values of ρc were found for the three types of guns in question. The RCA 5C has ρc = 10.7 ma/mm^2 at E_{c_1} = 0 volts; Superior 5C, ρc = 12.2 ma/mm^2 at E_{c_1} = 0 volts; Sylvania 5C, ρc = 12.4 ma/mm^2 at E_{c_1} = 0 volts. These figures are based on average cutoffs for the guns. RCA, E_{c_o} = -62 volts; Superior, E_{c_o} = -62 volts; Sylvania, E_{c_o} = -77 volts. These values are averages taken from the guns whose η' had been taken. Saturated emission (d-c) of an oxide cathode at 1100 K is of the order of 10 ma/mm^2 so that all guns are not to be operated for any life at zero bias. However, as far as the comparison of η' for the various guns is concerned, the only possibilities that exist are that either the RCA cathodes are better, or that the cathode-temperature-heater-voltage characteristic is different. This latter possibility cannot be simply determined at present, so that the trial of life testing must be the only method of comparison at the moment.