WILLIAMS TUBES SELECTION PROGRAM

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INTRODUCTION:

Probably the most critical component in the Williams Memory System is the storage tube itself. It was originally supposed that ordinary cathode ray tubes, designed for use in oscilloscopes, would suffice for the storage element in this type of electrostatic memory but it soon became apparent that these tubes had two serious defects. First, they had impurities on the storage surface, and, second, the focus of the electron beam was not sharp enough to allow repetitive consultation of one storage location without disturbing the surrounding information.

These defects are opposite in nature so that the circuit parameter change that improves one of these conditions, aggravates the other. Thus, if the acceleration voltage is increased, the focus improves but the impurities become more troublesome.

The most obvious solution to the problem is the development of a special cathode ray tube which will have sharp focus and a clean storage surface. This task was undertaken recently by RCA at their Lancaster, Pa., plant. As part of the tube selection program for the Oak Ridge computer, the ORACLE, most of the design samples of these tubes were tested at our laboratory with a full raster testing technique. Several types of commercial cathode ray tubes were also tested in this manner.

We prefer this testing technique over some of the more fundamental methods of evaluation as it takes into account any subtle effects which might prevent extrapolation of the results of less elaborate tests. The effects of beam focus, deflection defocusing, gentle electron rain, adjacent spot interference, etc., are all noted at once. Thus, an indication of how the tube will perform in a computer is obtained by determining the maximum number of repetitive consultations a tube will tolerate under favorable operating conditions. We call this the RC number and use it as an approximate figure of merit for the tube.

Emphasis was placed on the repetitive consultation problem during our tests, as we plan to use in the ORACLE a double tube system (see paper on Oak Ridge Computer by J. C. Chu in this publication) to cancel effects of screen impurities. However, we believe that the impurities of the screen can be eliminated by extreme cleanliness in the manufacturing process. RCA is equipped to make all of the necessary studies. Some time will necessarily elapse, however, before considerably improved tubes can be obtained readily. We have devoted ourselves to devising methods for the selection of usable tubes from those now available.

TESTING SYSTEM:

Each type of cathode ray tube performs best with a certain set of circuit parameters. During these tests, an attempt was made to find the optimum operating conditions for each type tube.

In our experience, the double-dot and dot-dash systems give about the same number of repetitive consultations and are superior to other systems in this respect

The defocus-focus method has been suggested to minimize the effects of screen impurities but the number of repetitive consultations possible for a given tube is considerably reduced under these conditions.

The circle-dot system shows promise on single-tube set-ups but does not appear practical for a multistage memory because of the technical difficulty and expense of distributing the deflection signals that produce the circle to many stages simultaneously.

The double-dot system was used for these repetitive consultation tests.

SELECTION OF PARAMETERS:

Experiments have shown that, in general, lower beam currents give higher RC numbers, limited, of course, by the noise of the system. Most of this noise originates in the input circuit of the video amplifier. This amplifier must have a band pass of 3-megacycle frequency to pass the sharp leading edge of the "one" signal. An input resistor of about 15,000 ohms is as small as can be used without seriously attenuating the signal at the pick-up plate of the storage tube.

The thermal noise of such a system requires a signal at the pick-up plate of about 2/3 millivolt for a 10-to-1 signal to noise ratio. As a signal of twenty volts was required to operate the gating circuits, an amplifier gain of approximately 30,000 was used.

It is possible that some of the tubes had a phosphor with high secondary emission ratio and, therefore, gave the required 2/3 m. v. at lower beam current than did the other tubes. However, the RC number reported would reflect any improved operation resulting from this. It appears, then, that the absolute value of the beam current required of a certain tube to produce useful output is not as important as the RC number obtainable from the tube when used with that beam.

DISCRIMINATION LEVEL:

With the double-dot system, the wave forms of the signals from the video amplifier are shown on Figure 1. The positive going or "one" signal is the result of the double-dot. Similar waveforms are obtained with the dot-dash system.

When a storage location near a "zero" is consulted a number of times before the "zero" is regenerated, the output waveform from that "zero" becomes more positive so that there is no longer the great difference between the two states that this figure indicates.

The next figure - No. 2 - shows a typical "zero" as it is refilled. The greater the number of times a location in the vicinity is consulted before regenerating the "zero", the more positive the "zero" becomes. Thus, if we are to obtain the most reliable operation, the recognition level for a "one" must be set as positive as possible, which is just below the smallest "one" we wish to accept. The setting used for these tests was about 75% of the average "one" amplitude.

It will also be seen from this figure that the refilled "zeros" do not attain their maximum amplitude as rapidly as the "ones". For this reason, the first portion only of the signal is gated into the recognition circuit to further reduce the possibility of mistaking a "zero" for a "one".

PATTERN CONFIGURATION:

The time that the beam is on is greater for a "one" than it is for a "zero", and, therefore, repeated consultation of a "one" has the most detrimental effect upon surrounding information. It is obvious that the "zeros" are the most sensitive to this refilling. To simulate the worst case of computer operation then, it is desirable to arrange a pattern of alternate "ones" and "zeros", and to consult the "ones" a number of times while observing the "zeros".

The pattern used consisted of 1024 storage locations arranged in a 32 x 32 raster. Its size was adjusted to cover the useful storage area of the tube. The second or rewrite dot was twitched to the right in odd columns and to the left in even columns. The next figure, No. 3, gives an idea of the pattern used.

OTHER OPERATING CONDITIONS:

Other factors which affect the performance of the Williams' tube, such as beam-on time for dot 1 and dot 2, twitch distance, acceleration and astigmatism voltage, etc., were adjusted to give the best performance experimentally.

TESTING PROCEDURE:

After the circuit parameters were adjusted for a tube, the procedure for determining the RC number was as follows:

(1) The pattern of alternate "zeros" and "ones" was written into the tube.

(2) The first "one" in the raster was read N times, and the complete pattern was regenerated.

(3) The second "one" was read N times and the pattern again regenerated.

(4) This process continued until all the "ones" were read N times, then repeated.

(5) N was increased gradually until some of the refilled "zeros" changed to "ones".

This value of N was recorded as the maximum number of repetitive consultations for that tube. This is the RC number.

RESULTS:

The results of these tests are shown on the next figure, No. 4. The experimental RCA tubes are plotted together with some of the commercial tubes which have been used for electrostatic storage.

The ordinate of this graph is the percentage of these tubes tested that gave the RC number indicated on the abscissa. For example, from curve 4, about 70% of the 3JP1's tested gave 1000 repetitive consultations. Clearly, the tubes whose curves are on the right are more desirable for memory use.

The acceleration voltage used for the tubes was 2500 volts, as this was the highest recommended by the manufacturer. In every case of the tubes plotted, the performance was poorer at lower voltage. However, the RCA experimental tubes were still considerably better than conventional tubes, even at low acceleration voltage.

Many more RCA 3" and 5" experimental storage tubes were tested than the graph shows but these were earlier design samples without a sufficient number of any one type to plot. However, they were usually inferior to the 3", 3611 series which is shown.

The RCA samples were also checked by another laboratory and the results of the independent tests agreed closely. A larger sample of these 3" tubes of final design has been made by RCA and will be tested in the near future. It is hoped that these tubes which will be in use presently will be superior to those now in use.

On the basis of these tests, it was decided to build the memory for the ORACLE with 3JP1 storage tubes but to make provision so that the new RCA tubes could be used when they are available.

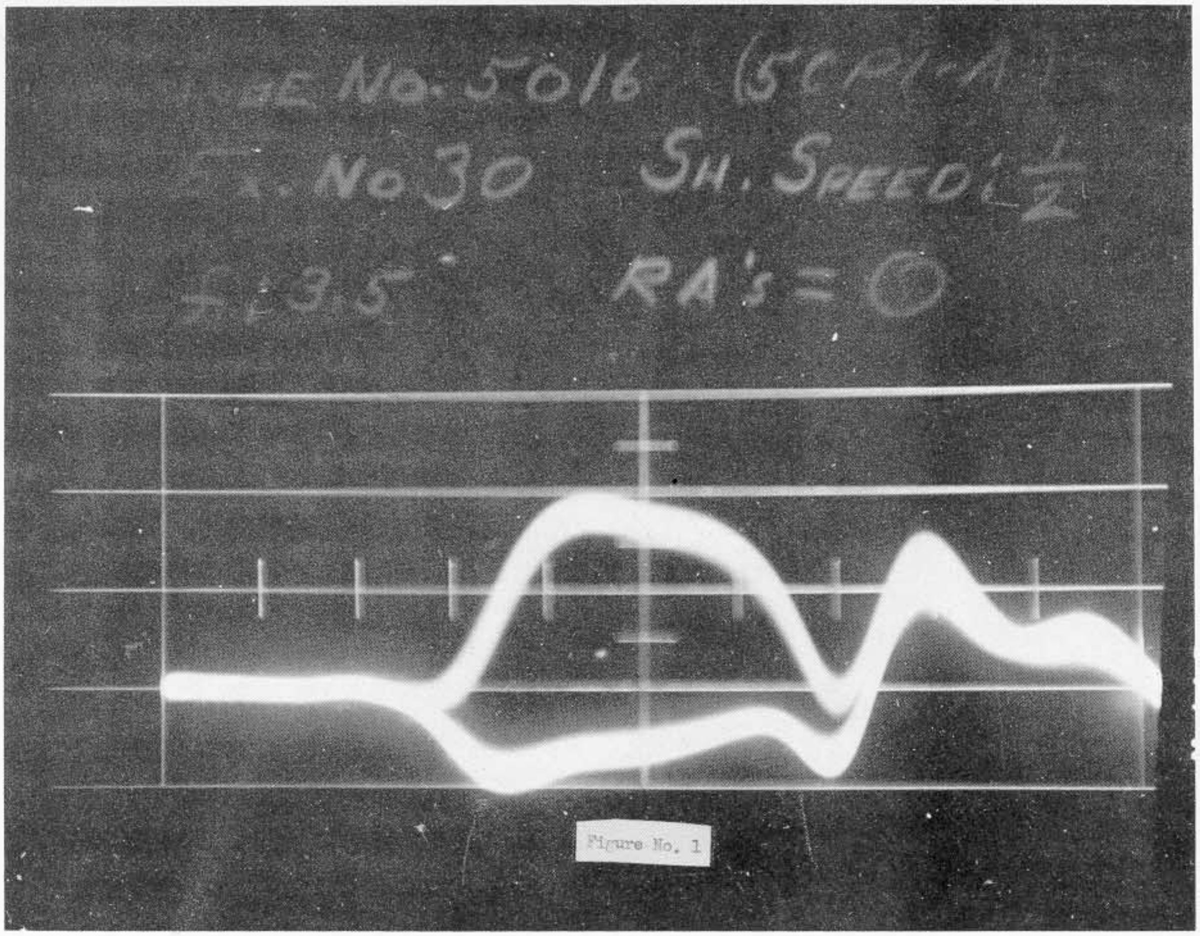

Figure No. 1

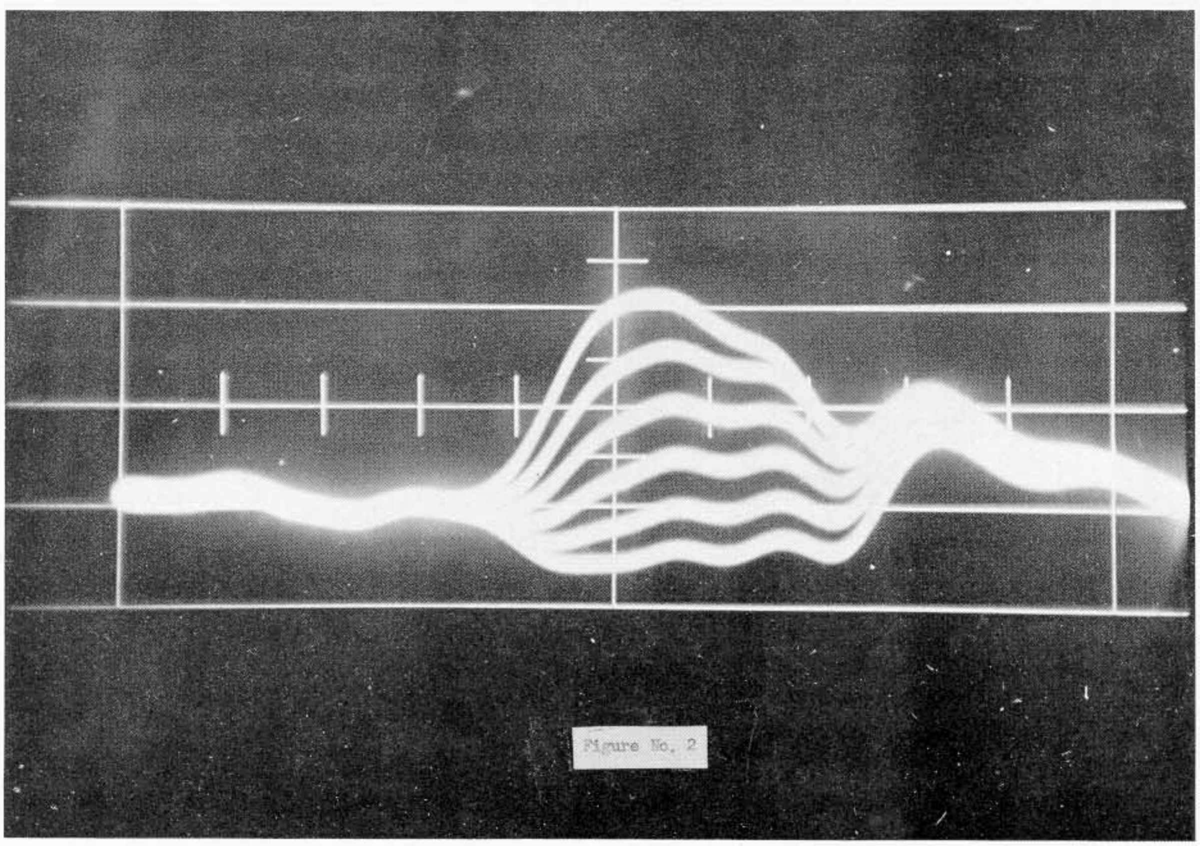

Figure No. 2

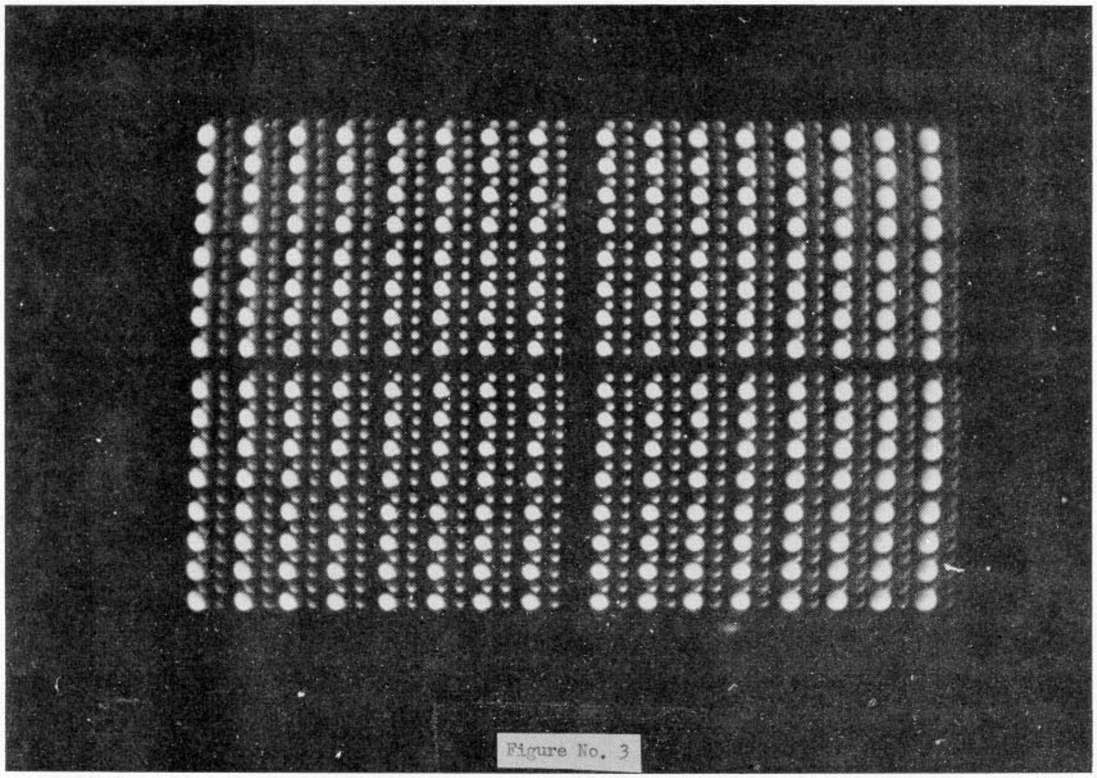

Figure No. 3

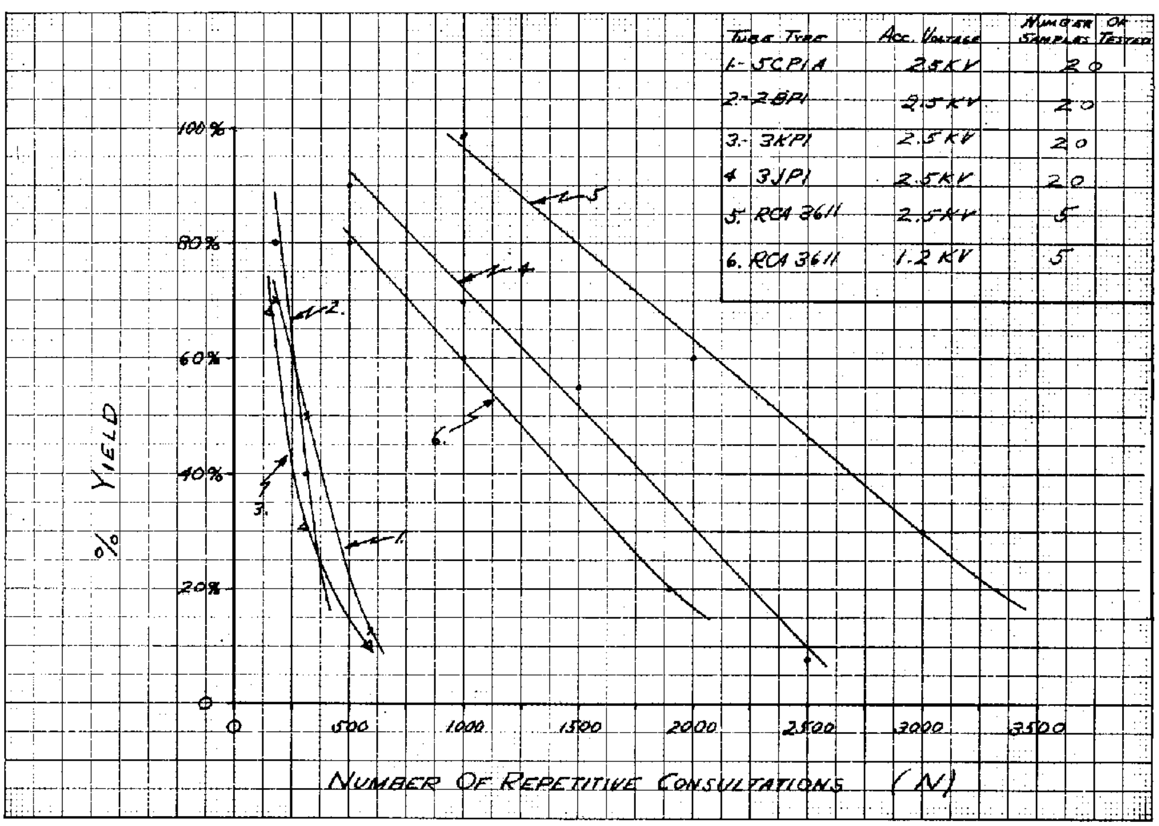

Figure No. 4