d. High density Williams storage.

Introduction. One great drawback of the Williams storage system is the read-around, or redistribution, trouble when used as a random access memory. It is well known that read-around can be improved by increasing the spacing between bits. In view of this fact, it can also be argued that if read-around can be restricted by using special modes of operation, packing can be increased. The inquiries were divided into roughly the following lines:

1) Most operating Williams storage systems assign two neighboring locations to store one bit of information. These locations each occupy about one spot diameter of the beam. If only one position was bombarded, this position will contain a positive charge due to the release of more secondary electrons than primary electrons arriving. If the two positions are bombarded in succession, then the first position will be charged negative due to the deposition of secondary electrons when the second position is bombarded. Thus two kinds of signals can be stored in the first position. The second position really does not store any information. If this second position can be shared between two neighboring bits, some improvement in packing should result.

2) The read-around and packing density trade is investigated by using the techniques of an operating Williams memory. The packing is increased until the Williams tube fails to store a prescribed sequence of ones and zeros.

3) The geometry of the cathode ray tube is also briefly investi-

gated. For a given size beam spot diameter, obviously the larger the screen size, more will be the number of bits that can be stored on a single Williams tube. Experiments were carried out by using different sizes of cathode ray tubes.

4) Long term stability was not included in the investigations because this calls for significantly more elaborate equipment. Most experiments described in this paper were done on an exploratory basis and used a minimum amount of equipment, their details are therefore omitted.

It was envisioned that with increased packing, and employed in a role similar to the magnetic drum, the Williams system should be more flexible and may even be competitive in cost. An example of such usage is provided by a hypothetical machine organization.

Experiments and results. Using the double-dot system and circuitry similar to that in the IAS machine, it was found possible to store successfully a mixed pattern of 64 x 64 on the 3" RCA C73621 cathode ray tubes (believed to be the prototype of 6571 storage tube).

A mixed pattern is a random mixture of ones and zeros. This is done by briefly introducing some noise into the system by mechanically tapping the signal amplifier. Furthermore, the rasters can be shrunk to occupy an area approximately 1.5" x 1.5". Five samples were tested and are all capable of storing the mixed pattern, observed with a long persistent oscilloscope with no visible change of the patterns over many regeneration cycles.

Williams and Kilburn stated that a spot diameter is sufficient to isolate neighboring bits. On this basis, a three-dot system is therefore tried. Figure 1' shows a comparison between the two systems. The shaded areas denote the positions at which the beam is turned on. Clearly, the three-dot system may offer an increase of 50% or more in packing.

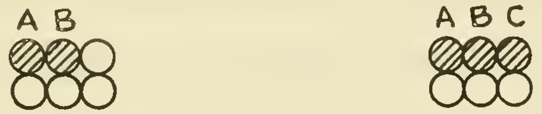


Figure 1'

Relative areas needed by the two-dot system (left) and the three-dot system (right).

In the three-dot system, A and C each contain one bit of information. The positions are inspected by turning the beam on at A and then C, with their contents recorded in two flip-flops. Figure 2' shows the amplied output signals through the four possible combinations. The contents of A and C are destroyed after the inspection pulses. The beam is

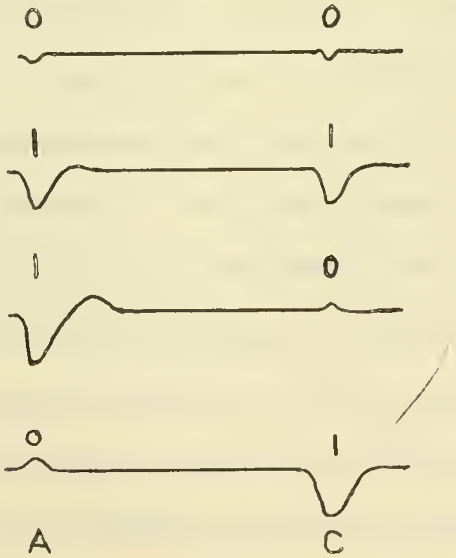


Figure 2'. Output signals with the 3-dot system.

then turned on at B to make both A and C to contain 1's. The beam is again turned on at position A to produce a zero at position A if A originally contains a zero and similarly for position C. For reasons of expediency, a 16 x 64 raster of this fashion successfully stores the four combinations of contents of A and C. There is room for two more such rasters on the face of the C73621 cathode-ray tube. Therefore it is believed that a 48 x 64 raster of this sort is possible.

The remaining series of experiments explores the packing density per tube by using various sizes of cathode ray tubes. Using the two-dot system throughout, one each of 5CP1A, 7VP1 and 17BP4A were tested. Both the 5CP1A and the 7VP1 can barely store the 64 x 64 raster when the rasters occupy the maximum permissible sizes. Since there is no obvious advantage to use the two types as far as packing is concerned, They are not considered any further.

A mixed pattern on a 16 x 128 raster was stored on a 17BP4A. This raster can be moved to store on different portions of the tube surface, with the necessary readjustment in focus. By careful manipulation, this raster can be made to occupy a space of 9/16" x 6" if it is placed in the center. By assuming each bit to occupy a space of six spot diameter squared, the spot diameter of the 17BP4A tested can be interpreted as approximately 1.7 times larger than that of the 3" storage tube. Obviously, the increase in screen diameter is many times that amount and therefore the increase in packing per tube should be greater with the 17BP4A or even larger tubes. Deflection defocusing of the big tube is quite severe, although methods of correction are straight-forward. Without focus correction, an attempt to store a 128 x 128 raster showed that no one focus adjustment is satisfactory for the entire raster. This point is not pursued further because the focus correction circuit is external to the cathode ray tube and is not the subject of this inquiry.

To investigate the usefulness of a non-random access Williams storage system, the following example is offered.

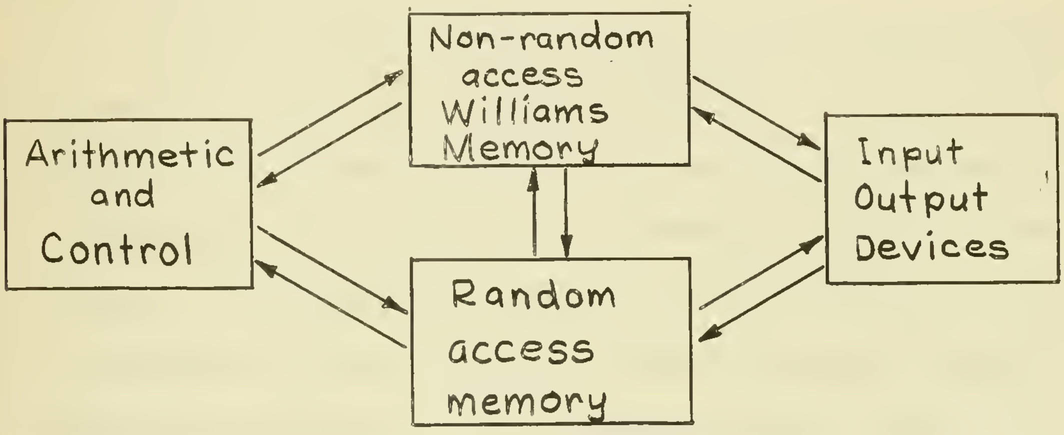


Figure 3'

An example of a machine organization using a non-random access Williams Memory System.

It is necessary, of course, to have a random access memory for any serious computation. The organization diagram of figure 3' indicates that the non-random access Williams memory communicates with three different units. Basically, the Williams memory regenerates its contents in a sequential manner. It is intended that the information exchange between the Williams memory and the other three units be limited to sufficiently long sequences. The faster the rate of occurrence, the longer the sequences should be in order that regeneration can be insured. Input-output units such as punched cards or tape have relatively low slow rates. In these cases, it is only necessary to interrupt the regeneration routine whenever a word is to be communicated between the Williams memory and the input-output devices. Most input-output routines consult the addresses of the Williams memory in sequence at a low slow rate, it is therefore possible to interlace the input-output routine with other routines imposed on the Williams memory without interference with each other.

If the communication between the Williams memory and the random-access memory is limited to blocks of information, it is practical to allow a jump in the regeneration routine to the starting address of the block. This then also becomes the new regeneration routine. A time delay equal to one regeneration cycle time is set in motion such that this time delay must expire before any further jump can be made, thus insuring a low read-around. This limitation actually is not too important if one recognizes the fact that usually after such a transfer, some time is devoted to arithmetic operations on the transferred words. Orders or data are quite often referred to in a sequential fashion. These references, however, usually occur at a much higher time rate and may equal or even exceed the speed of the Williams memory. It is permissible to interrupt but not alter the regeneration routine. A counter is needed to keep track of the work sequences. A similar time delay is set in motion so as to insure low read-around.

The foregoing example does show that Williams memory when operated in the manner described is more flexible than a magnetic drum. It is also possible to eliminate some of the access time normally unavoidable on the drum unless serious coding requirements are imposed.

Conclusion. A packing density of 4096 bits on a 3" storage tube appears to be achievable without using radically different circuits. Access time can be reduced without impairing read-around by suitable logical organization. The use of the three-dot system and the use of television tubes as storage tubes must await developments in circuitry in order to achieve reliability, but are certainly within the realm of possibility.

e. The design of standard chassis for experimental work.

Rapid advances in printed circuit techniques and Tinker-Toy type of waver assemblies have provided the electronic equipment manufacturer with a cheap and reliable means of producing repetitive circuits in large quantities. Unfortunately, no such panacea exists for the equipment designer faced with the necessity of producing small quantities of assemblies or families of units that can be basically similar but must be individually flexible. This situation is particularly true in the research and development field where the initial cursory examination would seem to indicate that each assembly must be special and unique.

Obviosuly, the construction of chassis tailored to suit individual circuits is a costly procedure; one that can produce sub and major assemblies that are neither functional nor aesthetic. In addition, the time consumed in designing and producing such individual units is frequently a source of minor irritation to the circuit engineer who naturally prefers to test his ideas while the spirit moves him.

In the interests of reducing costs and minimizing construction time it behooves the equipment designer to examine the circuit requirements of the group that he services. While a perfunctory investigation