RESEARCH REPORT
1946

Prepared for use by engineers and executives
of RCA divisions and companies in
planning the development of
products and services

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION
PRINCETON N.J.

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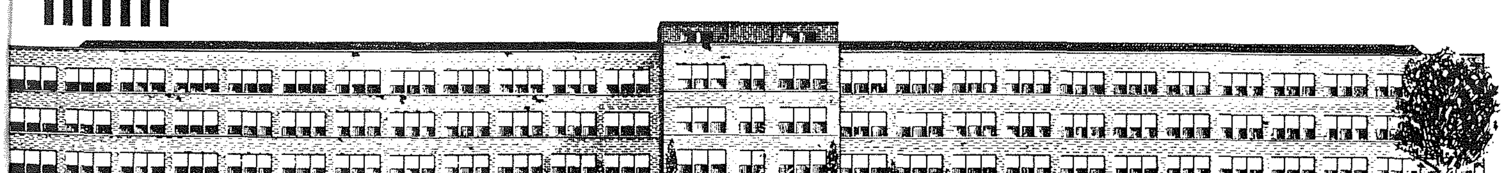

Research Report

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The period during 1945 following the end of direct war action was one in RCA Laboratories of conversion from a program with all-out emphasis on military research to one pointed toward the interests of RCA and the radio-industry. The year 1946 was a period during which these peacetime programs were reshaped and re-emphasized in proportion to their new importance. For example, broadcast-radio-receiver research was re-established following several years of inactivity during the war, research on records and phonographs was built-up, and television research took a prominent place, with the attainment of exceptionally fine results in both black-and-white and color television.

While much has been accomplished, more activity is scheduled along these lines. Additional emphasis is to be placed on broadcast-receiver research and on our radio-tube research program. This will call for some expansion of laboratory facilities and personnel and for the rescheduling of present facilities and personnel.

With emphasis as indicated on research applied to RCA's present fields of operation, appropriate attention will be given to long-term research which will serve us in the future and which will add knowledge of a basic nature upon which we can continue to build. Consideration has been given and will continue to be given to participation by RCA in work related to nuclear physics. A senior member of our technical staff is now assigned to the Oak Ridge Laboratory for a year of research and training.

Work done for the military services under contract has been stabilized at a level which is expected to continue for several years. One contract now under way calls for an extension of laboratory facilities.

This report does not include any item on which a military-secrecy classification continues in effect. Excluding such items was decided upon in the interest of making the report of greatest usefulness.

While the material presented here is not classified in a military sense, it is highly confidential in an RCA sense; the report and the material contained in it should be so treated.

To assist the technical people of RCA who read this report, there are included at the close of each item, references to pertinent documents, technical reports and publications. Also, the names are given of the research people to whom technical questions should be directed if further information is needed. As a general rule, where two or more names are given, the first is that of the supervisor in general charge of the research, while the others are those of men most familiar with the details of the work. The names given are not intended to be a list of those to whom credit is due for the progress reported.

While many members of the technical staff had a part in the preparation of this Research Report for 1946, special credit goes to C. M. Burrill and E. T. Dickey who compiled the material and handled the editorial work.

Princeton, New Jersey
February 1, 1947

E. W. Engstrom

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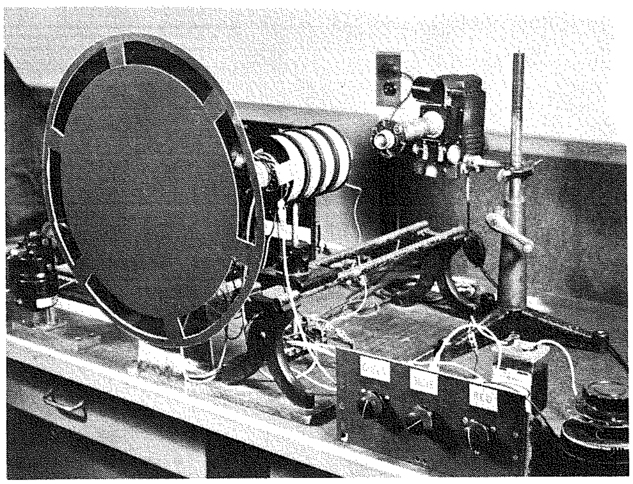
electrons having greater than a given initial velocity may be transmitted to the final image. Thus, in a three-color picture, blue, blue + green, blue + green + red may be selected by applying the appropriate potential to the selector grid. The brightness of the image is reduced by a factor of approximately 10 in this process due to the rather broad velocity distribution of photoelectrons for each of the primary colors.



Bench set-up to demonstrate color-selector image tube.

Although the blue portion of a picture may be separated out directly with this tube, additional circuits and storage tubes would be required to permit complete color separation of the red and green portions. However, it was found possible to reproduce a simple three-color pattern to a fair approximation simply by using a commutator to control the selector grid potential in synchronism with a color wheel through which the fluorescent image was reviewed. Because of its inherent inefficiency, it appears doubtful that this tube will be a satisfactory means for color television pickup. Nevertheless, the device represents a novel means of color discrimination using purely electronic methods.

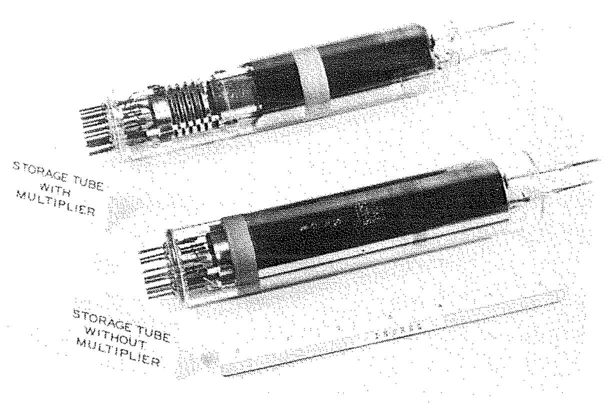
For further information refer to:

G. L. Krieger

5- 5 Storage Tubes

Our storage-tube research project has been very active during the past year and promises to become increasingly so. The most highly developed type of storage tube is the barrier-grid tube used in a moving-target-indication (MTI) type of radar equipment. In the operation of this device, the signal received from one radar scan is stored in the tube and compared with that from the next scan, the tube cancelling all unchanged signals from fixed targets and passing signals from moving targets. About one hundred fifty of this type of tube were delivered to the Signal Corps.

Another type of storage tube, which we designate a picture-storage tube, is designed to effect the storage of a complete picture with high definition for observation at a later time. There are a number of immediate applications for such a device when completed. One of these is in the Teleran System, where it would be used to convert radar (PPI) signals to television signals for transmission to planes in the air, and possibly for the storage of information in the plane to allow time-sharing of transmitting equipment between planes at different altitudes. A promising line of work is now being followed which makes use of a high-capacitance insulated target scanned by two beams. The "writing" beam operates at a high voltage such that the secondary emission ratio of the surface is less than unity. Thus electrons are deposited on the surface as this beam scans the target. The second or "reading" beam strikes the surface at lower velocity where the ratio is greater than unity. Charges



Storage tubes developed for moving-target-indication (MTI) radar applications.

left by the high-velocity beam are removed as the reading beam returns the surface to equilibrium. The target current during this removal constitutes the signal. If the capacitance of the target is high it may take many scans by the reading beam to discharge the surface, giving the desired long storage tune. Several materials having the necessary characteristics are being studied. Among these are films of silica and similar substances, and also composite layers exhibiting a trapping action on secondary electrons. Ample storage time has been obtained, with detail resolution which approaches a usable value.

Another type of storage tube applicable to Teleran consists of a special orthicon tube with a high-capacity target. Such a tube has been made with an extremely thin target, by depositing a very thin layer of silica on a transparent signal plate. When the image of the radar indicator (PPI scope) is focused on its target, this tube can be made to re-transmit several hundred copies of the picture over an extended period of time. Tests of this tube under Teleran operating conditions indicate that it will meet the requirements of the Teleran System. Plans are under way to carry out the first demonstration of Teleran using this storage tube.

References: *PTR-27C, "Storage Delay Tube SDT-5", by R.L. Snyder, Jr., December 12, 1945.*

PTR-49 "Ground Clutter Reduction Using the Storage Tube", by J. P. Smith and M. H. Mesner, July 15, 1946.

PEM-41 "Storage Tube Circuits", by J. P. Smith and M. H. Mesner, July 10, 1946.

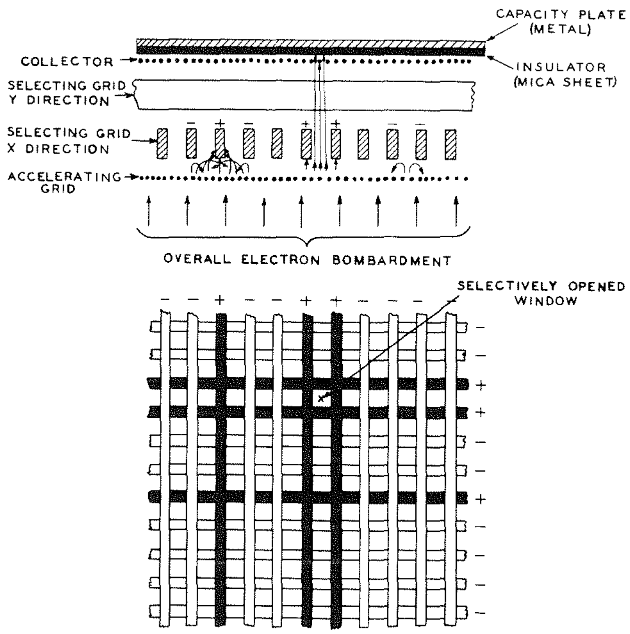
For further information refer to:

L. E. Flory, H. B. Law, or S. Forgue

5-6 The Selectron

The selectron is a new type of selective electrostatic storage tube which in the present design is capable of registering 4096 on-off signals. The writing (recording) requires no previous erasing and is effected in a fewmicroseconds per element. The storage time is indefinitely long. The reading (reproduction) requires no scanning of unwanted elements, can be accomplished on a few microsecond's notice, and can be repeated indefinitely. This tube has been developed to meet the need for such storage or memory devices in high-speed electronic digital computing machines.

With electronic computer circuits developed at RCA Laboratories and elsewhere during the war, the actual computation can be accomplished with great speed. However, high speed of computation is not enough; information must be supplied to and received from the computing circuits at rates comparable with the computation speed. Clearly, a memory organ is necessary in which the digits of the numbers can be stored and extracted at high speeds.



Sketch illustrating the operating principles of the Selectron. A window is open only when the selecting grid conductors on all four sides are positive.

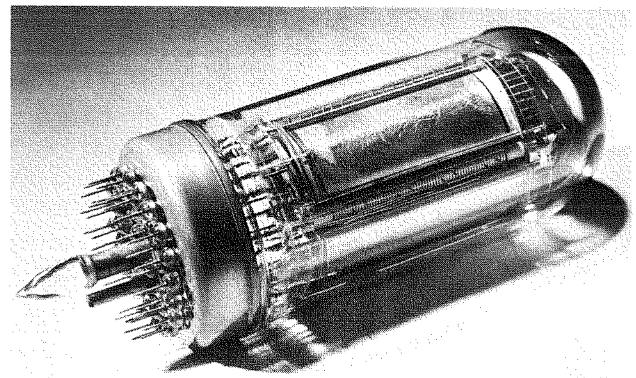
The first successful large-scale electronic digital computing machine, the Eniac built by the University of Pennsylvania, uses 23,000 tubes of which several thousand connected in pairs of "flip flop" circuits provide the memory function. The memory of the Eniac is inadequate for many problems, such as partial differential equations or the analysis of empirical data, and it would be impractical to provide the larger storage merely by increasing the number of tubes.

In the larger electronic digital computer to be built in Princeton, it is proposed to use 40 selectrons to register 40-digit numbers on a binary arithmetical system (digits related to powers of 2 instead of powers of 10 as in the decimal system). This will be equivalent to several hundred thousand conventional tubes. This computing-machine development is a joint project of RCA Laboratories and a group at the Institute for Advanced Study under the direction of Professor John von Neumann.

In the selectron, electrons from an extended source are intercepted by two orthagonal sets of spaced parallel conducting bars, creating a checker board of windows looking on an extended recording surface. These bars are internally connected in such combinations that by applying on-off voltages to a relatively small number of sealed-in leads, the flow of electrons stops through all the windows except through a positively selected one. This selection is made for writing and reading from the memory. During storage periods, electrons pass through all the windows and maintain the isolated areas of the insulated recording surface beneath each window at either one or the other of two naturally stable potentials.

The writing consists of selecting the proper one of these equilibrium potentials by applying a sufficiently powerful pulse of voltage to the conducting plate which backs up the insulated recording surface. A negative pulse establishes the lower of the two equilibrium conditions and a positive pulse the higher equilibrium condition.

Reading from the memory involves a determination of which of the two stable potentials the recording surface beneath a particular window has assumed. A simple method for doing this involves coating the recording surface with a material which emits light when bombarded by electrons. When this surface is at the lower equilibrium potential, approximately that of the electron-emitting cathode, it will not be reached by the bombarding electrons directed to it and therefore will not glow. However it will become luminous if at the higher equilibrium potential, approximately that of the collector electrode, for then the bombarding electrons will reach it with substantial energy. Thus reading a particular element involves closing all the windows except the corresponding one, so that that element is the only one subjected to electron bombardment, and then observing with a photo cell the presence or absence of fluorescent light.



The selectron tube.

In addition to the construction and test of simplified tubes to investigate basic functioning, several full-scale selectrons have been built. These have had satisfactory selecting properties, but some practical difficulties have been experienced with the storage. However, we expect that entirely satisfactory selectrons will be obtained shortly. We plan to make a sufficient number for the Princeton computing machine and a reasonable number for replacements.

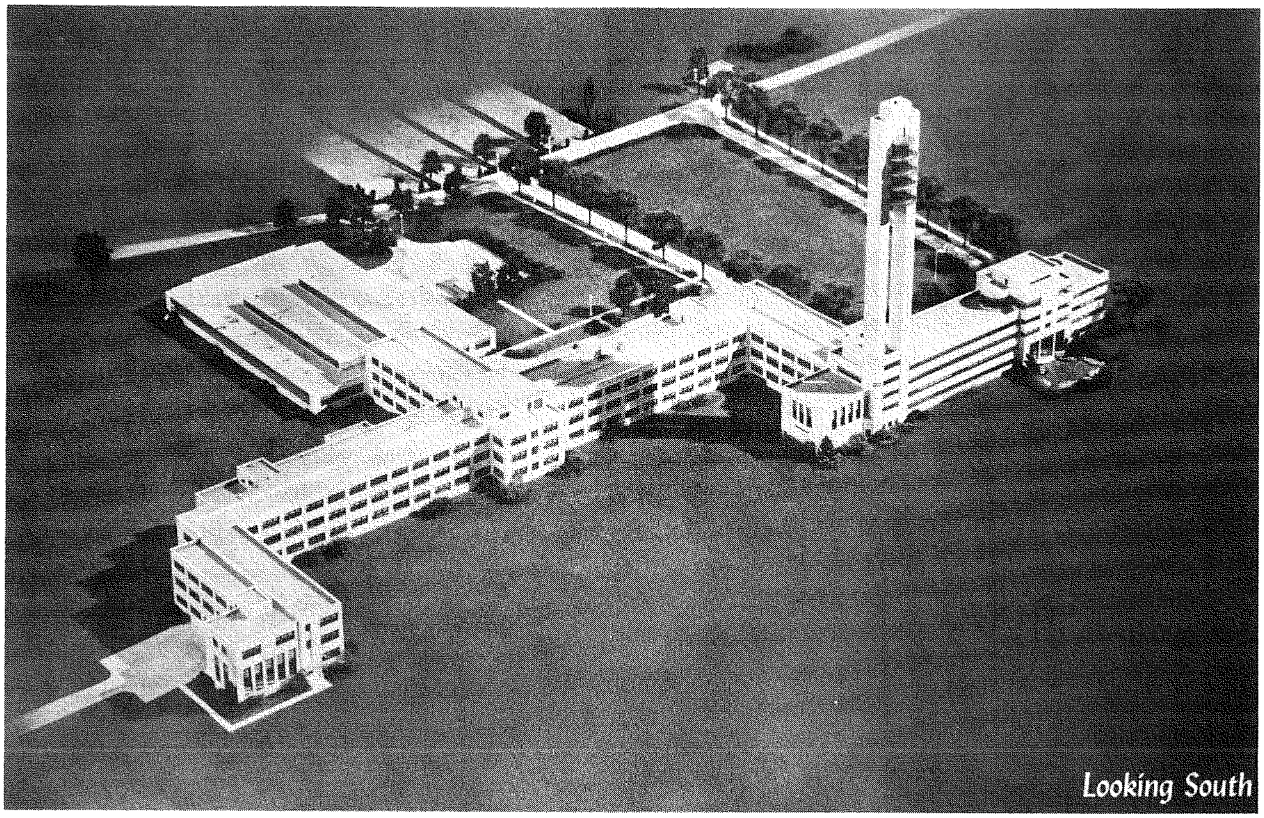
These selectrons have 64 selecting bars in each direction, providing 4,096 windows corresponding to an equal number of memory elements. To control this number of elements only 32 external control leads are required. In order to obtain this economy of leads four control leads are simultaneously energized in each selection.

For further information refer to:

J. Rajchman

5- 7 Electron Microscope

The major part of 1946 has been devoted to the improvement of the electron-microscope objective lens and the attainment of a complete understanding of its operation near its calculated limit of resolving power.



During 1946 we completed an architectural study based upon facilities requirements at RCA Laboratories and in keeping with the original concept of the Princeton development. The results of this study are now available for use at such time as a discussion of the program of facilities extension becomes appropriate. The photograph shows a model built during the course of the architectural study, representing the extent of completed facilities after the next period of construction.