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SECTION 2 OF DIVISION D

DIARY OF CHAIRMAN

Monday, December 22, 1941 - Camden, New Jersey

Visit at RCA Laboratories. Present: Dr. V. K. Zworykin, Mr. A. W. Vance, Mr. R. L. Snyder, Dr. J. A. Ragchman, Dr. C. A. Morton, from RCA; Dr. A. W. Tyler and Dr. S. M. MacNeille from Kodak; Lt. Hazeltine from Frankford Arsenal; and WW.

RCA has been working for about one year on the general problem of electronic computing techniques applicable to directors. When they realized the magnitude of the problem they refused any contracts for producing any equipment; but three months ago they accepted a new contract from the Army for study and report. Then the Navy approached them, and they set up a similar contract which runs to April 20. About three-fourths of Zworykin's crowd are on this work.

They have a block diagram of a complete director. They have restricted themselves to the exclusive use of purely electrical methods, - no mechanical motions of any sort. They realize that their scheme is fantastically complicated, - Z. says that television is child's play by comparison. Z. wants to explain their present ideas; and hopes that there can later follow, preferably after some intervisiting, a conference at which there will be a complete pooling of all ideas on electrical directors and a decision (Z. more or less infers by the NDRC) as to what should be dropped, what pushed, and by whom. Z. hopes this could be participated in by the RCA, Eastman Kodak, National Cash Register, and MIT. WW urges the desirability of including representation of the combined electro-mechanical approaches, such as Lovell, Bode, Wiener, Atanasoff, etc. (Incidentally, the next day WW inquires from M. Kelly whether the BTL would be willing to send delegates to such a conference, authorized to pool any information. K. says of course, and suggests Lovell and Bode to attend to cover construction and theoretical aspects) It seems clear to WW that D-2 should take the initiative in this matter. The next step should probably be a visit to NCR. (Later WW talks with Tuttle on the phone, and Kodak would be glad to attend such a conference.)

The RCA group has concentrated on two systems, although Z. says they had ideas on several more. These two are an impulse binary system and a frequency modulation system.

It is neither feasible nor necessary to describe the impulse binary system in detail. They have concentrated on two units, - a multiplier and an "arbitrary function unit." The multiplier is similar to one of the E.K. schemes, except that they use separate signals for the carry system and the transfer system, and thus eliminate certain delays inherent in the E.K. scheme. The counters operate at 100,000 per sec. They have a multiplier built and operating (about 12-14 places - rather hard to test very realistically without a great deal more ultra-high-speed equipment).

To handle "arbitrary functions" (ballistic data) they use a two-dimensional grid with fifteen divisions on a side and, at each grid point, tubes which count up to the values (in the binary system) which the function and its derivatives with respect to x and y assume at this particular point.

Intermediate values are obtained by a fifteen-step interpolation between the grid points. Each such grid requires some 500 or more tubes! In fact the entire director would require some 2,000 to 5,000 tubes! This grid scheme was adopted after trying several other schemes. For example, a screen with variable density only yielded 1% accuracy. Then they tried a screen with lines ruled in such a way that the number of lines crossed in going from O to X is proportional to f(x). This scheme could be developed to give 0.1%.

The director uses a memory system for giving finite difference average rates. The whole director operates on a system of cycles determined (in absolute speed) by the value of range. That is to say, the cycle time varies roughly proportionally to the time of flight. During the successive steps of a cycle the various interlocked computation processes are carried out in a definite order, - data accepted and coded in binary system, resolved into Cartesians, stored in memory device, etc., etc., etc.

A report on this system is just going to Colonel Taylor, and Z. suggests we request a copy.

The frequency modulation system has been developed chiefly by Vance, who is the chief RCA expert on circuit design. The mechanical signals set pots which resolve and furnish A.C. amplitudes proportional to the Cartesian coordinates. An A.C. network differentiator gives rates. Vance is considering filter circuits to smooth x, y, and z before differentiating, and also to smooth the resulting derivatives. The rates are multiplied by time of flight in a variable gain amplifier, the gain determined by the D.C. input proportional to time of flight. The future coordinates, as A.C. amplitudes, enter a freq. mod. circuit, the frequency of the output being proportional to the future coordinates. Vance does this because of the fact that he can construct filters whose frequency characteristics are practically anything. This is his method of handling the ballistic data. He subtracts out the square law (the main dependence) in the relation between height and time of flight; and then constructs a filter to handle what is left. He has to use a bank of some fifty such filters, depending on the value of future horizontal range; and he expects to use some sort of interpolation scheme so that he will actually use the three filters which come nearest (and next nearest on each side) to being constructed for the right horizontal range; and then combine the three outputs so as effectively to interpolate. Vance thinks the individual units can be constructed to operate with an accuracy of 0.1%. He has constructed the differentiating network, the freq. mod., and one or two typical filters. This scheme has a purely electrical feed-back of time of flight, with no servos. Vance is not far enough along to have any idea of the time constants of his feed-back, but it will obviously be very fast as compared with a mechanical or electro-mechanical method. The other crowd, incidentally, had apparently never stopped to think of the problem of converging on the correct solution, all their thinking being about the steady state.

We came away with two very strong impressions. One: They have some clever ideas, but the schemes as a whole are utterly impractical.
Two: Lt. Hazeltine is a violently unpleasant little ass.