M-830

Richard F. Markel
May 13, 1947

MASTER'S THESIS RESEARCH PROPOSAL

1. Title

High-Speed Gas Discharge Gaps for Data Storage in Electronic Computers.

2. Brief Statement of the Problem

It is desired to determine if low-pressure gas discharge gaps can be used as elements in three-dimensional data storage devices with short response times.

3. History of the Problem

One of the basic components of a numerical computer is a data storage device, or memory. The necessity for storing operating instructions and numerical data in large-scale computers requires a device which will store large quantities of data in a small volume and at the same time make this data instantly available when needed. The lack of a data-storage means which fulfills these requirements has in the past made very large computers impractical. Magnetic recording, for example, meets the first requirement, but the data is not instantly accessible. Electronic storage methods such as flip-flop circuits, image storage tubes, and the electrostatic tube developed at M.I.T. are high-speed devices but they fail to make effective use of the large amount of space required. Electronic-type volume data storage appears to be one answer to this difficulty.

Volume data storage would consist essentially of a three-dimensional array of elements which may be triggered from one stable operating point to another.[1] Low-pressure gas discharge gaps which have the static volt-ampere curve shown in Figure 1, have this characteristic. Transition from the dark discharge to the abnormal glow discharge region, a process equivalent to the storage of a binary digit, may be accomplished by voltage pulses. This characteristic of gas discharge gaps is well known, but it is equally important that their dynamic characteristics be determined since the device must not introduce excessive time delays into the computing operation.

Time lags in gas discharges have been studied fairly extensively in the last two decades. The time lags associated with spark breakdown are divided into two types: statistical time lags, caused by the chance occurances necessary for the initiation of a spark; and the formative lag required for the discharge to become self-maintaining after initiation. Lags of the first type were first studied by Zuber and Laue[2] in 1925, and the latter, more important, type of time lag was investigated by Steenbeck[3] in 1930 and Schade[4] in 1937. Fairly accurate mathematical analyses have been made of these time lags, based on Thomson's[5] classical theory, and the results are of the order of magnitude of the time required for positive ions to cross the gap at low pressures. Deionization times have been investigated

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1. J. W. Forrester, M.I.T., Servo. Lab., Memorandum M-70, (April 29, 1947).
2. K. Zuber, Ann. d. Physik, 76, 231, (1925); M. V. Laue, ibid, 76, 261, (1925).
3. M. Steenbeck, Wissen. Veröffent. a. d. Siemens-Werken, 9, pt. 1, 42,
4. R. Schade, Zeits. f. Physik, 104, 487, (1937).
5. J. J. Thomson, "Conduction of Electricity Through Gases", Vol. 2, (1933).

for thyratrons by Nottingham[1] and Snoddy[2] whose results have given an insight into the mechanism of this process. From the results of these workers it appears likely that gas discharge gaps can be developed which will have response times within the limits imposed by high-speed electronic computers.

4. Proposed Procedure

1. Preliminary Analysis and Design:

The first phase of the project will consist of developing mathematical relationships through which the various design variables will be determined. Use will be made of published data on this subject in the preliminary analysis with particular importence being attached to the achievement of short time lags. The following requirements will also be considered:

a. The physical size of the gap must be small.

b. Power dissipation must be very low.

c. Voltage ranges in which breakdown or extinction will or will not occur must be fairly sharply defined.

The variables to be considered in the design of gaps which will meet these requirements will be:

a. Type of gas and its pressure.

b. Type, area, and configuration of electrodes.

2. Experimental Procedure:

Determination of the performance of the gaps suggested by the above analysis will require both static and dynamic tests, including:

1. W. B. Nottingham, Franklin Inst. J., 211, 271, (1931).
2. L. B. Snoddy, Physics, 4, 366, (1933).

a. Variation of current with voltage under steady-state conditions, with gas pressure as the parameter.

b. Variation of breakdown time with overvoltage for various steady-state voltages, at pressures which fulfill the static requirements.

c. Variation of extinction time with undervoltage for the above conditions.

d. Statistical survey of the probability of firing and extinguishing for various pulse magnitudes, lengths, and repetition rates.

The equipment for these tests will be provided by DIC 6345, under whose direction this project is being carried out. The vacuum system shown in Figure 2, to be installed in the Servomechanisms Laboratory will permit tests with different types of gases and pressures without requiring the use of sealed envelopes. The various pressure gauges enable the pressure to be accurately measured over wide limits.

The electrical characteristics of the gaps will be determined by means of the electrical circuit shown in Figure 3. It is expected that standard laboratory components will be used. Static volt-ampere characteristics will be determined using only the variable-voltage power supply and the series resistor. The pulsing circuit will be used to investigate the dynamic characteristics. The components are designed so that each firing pulse will be followed by an extinguishing pulse to return the tube to its original non-conducting state. The sequence may be reversed when extinction characteristics are being considered. Provision is made for varying the pulse magnitudes and lengths, and both manual and periodic triggering are available. Measurements will be made with the oscilloscope.

Analysis of the results obtained from the above tests will serve to indicate the suitability of the gaps for service as data storage elements and will also verify or invalidate the predictions of the preliminary analysis.

5. Estimated Division of Time

(a)	Preparation of proposal......................	75 hours
(b)	Further study of the literature..............	25 "
(c)	Experimental work and analysis..............	125 "
(d)	Correlation of results.....................	25 "
(e)	Preparation of report......................	50 "
(f)	TOTAL.......................................	300 hours

6. Signature and Date

Richard F. Markel
May 13, 1947

7. Supervision Agreement

I certify that the above problem seems to me adequate for a Master's research, and that I am willing to supervise the project and evaluate the thesis.

Jay W. Forrester

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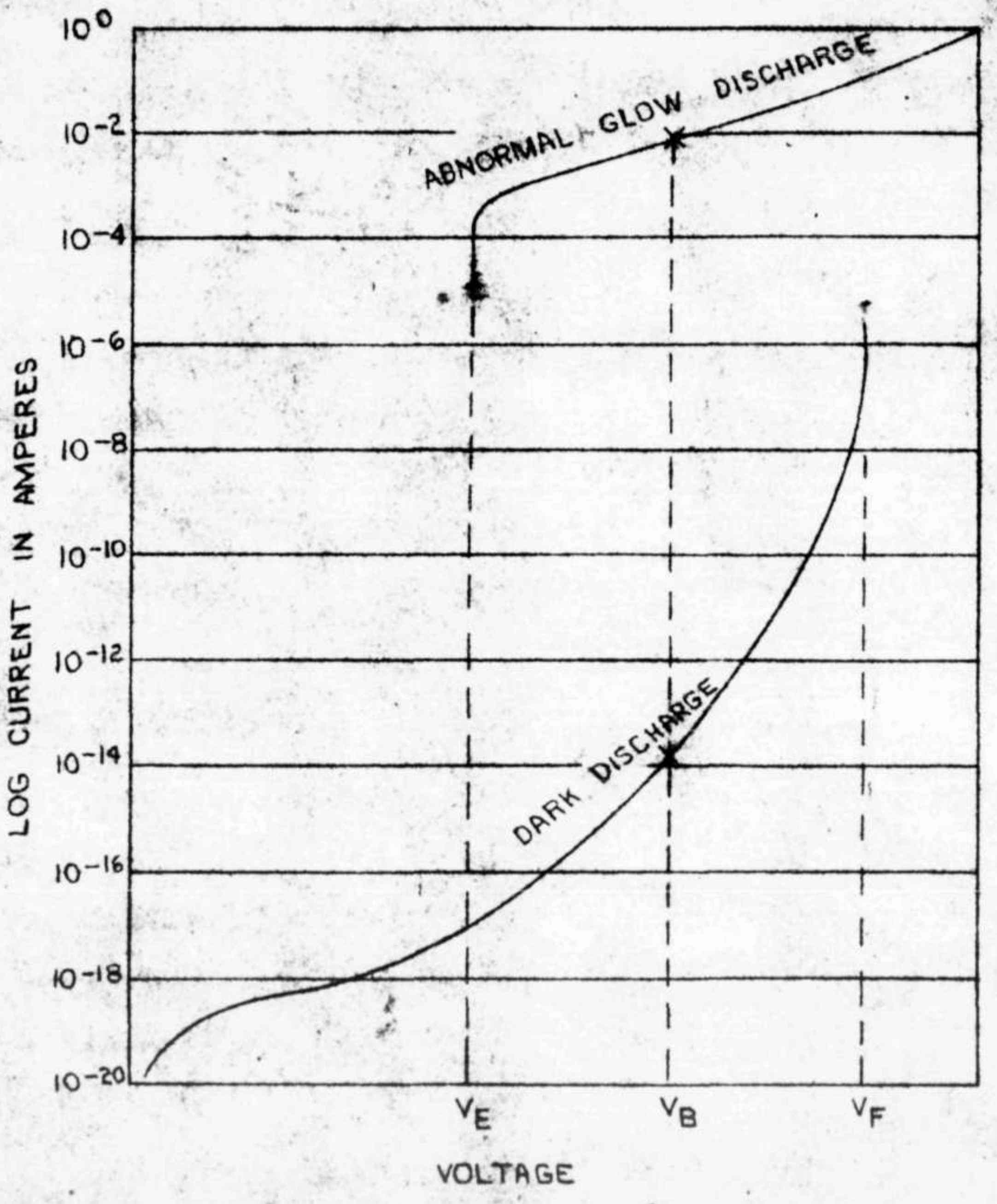

FIGURE 1. STATIC VOLT-AMPERE CHARACTERISTIC OF A TYPICAL GLOW DISCHARGE GUN.

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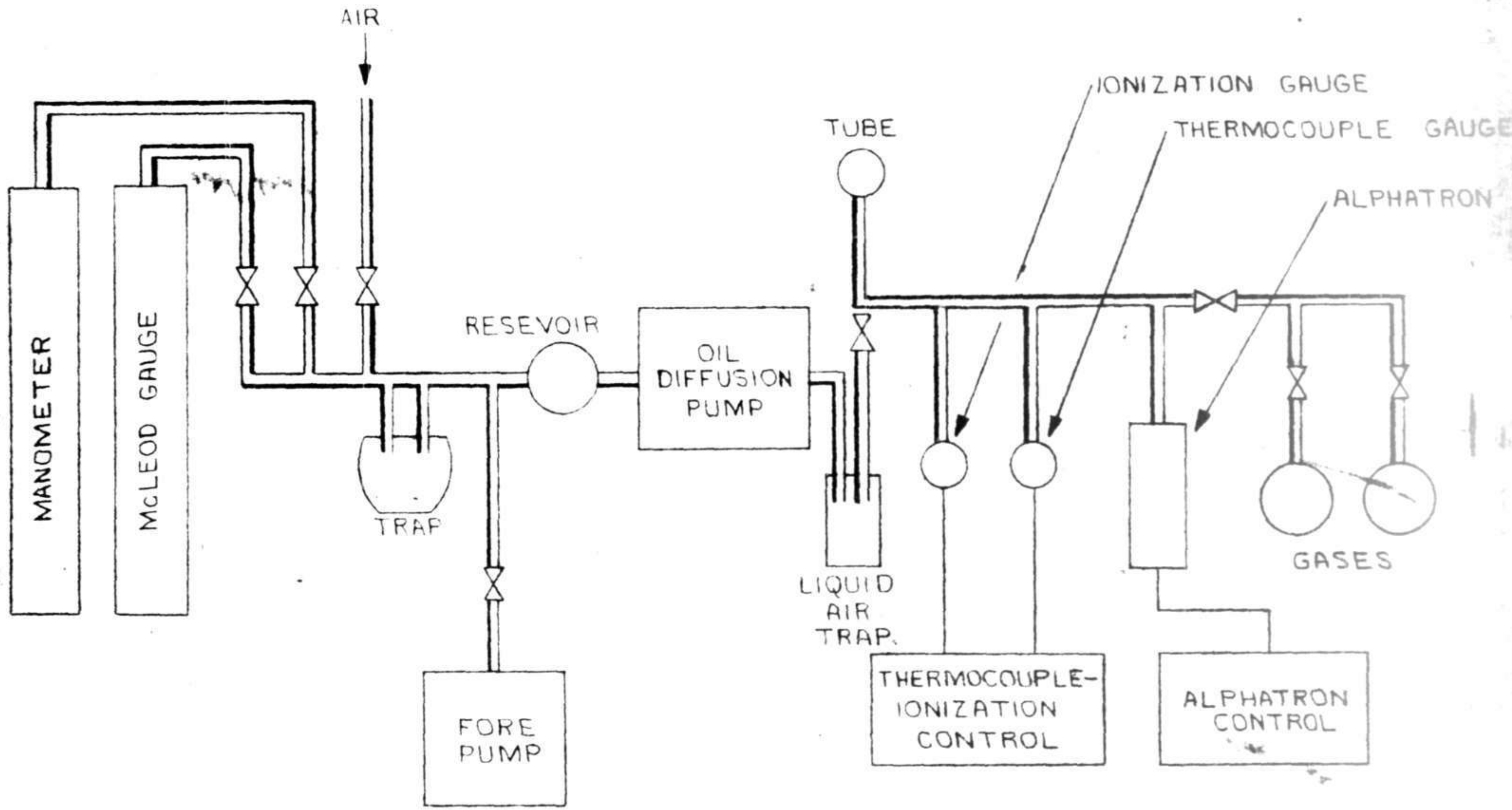

FIGURE 2. VACUUM SYSTEM

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY

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