CAPACITOR FAILURE RATE DETERMINATION TEST

by

W. C. Dysart

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 3-7623

WYLE LABORATORIES
Testing Division

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QUARTERLY PROGRESS REPORT

for period

Contract Initiation to December 1965

BY

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

December 15, 1965

CONTRACT NAS 3-7623

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Cleveland, Ohio
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ABSTRACT

The object of this test program is to evaluate and obtain accurate reliability predictions, to establish safe operating limits of a. c. voltages on state-of-the-art polycarbonate and polycarbonate foil capacitors for use in long life aerospace applications. Test specimens will be subjected to selected temperature and voltage levels over a 5, 000 hour life test period. The applied voltages will consist of both a. c. and commutated wave forms.

Capacitor manufacturers have been solicitated for information and an analysis made of submitted data. Initial design of test circuitry has been completed. The finalization of test circuits and test temperatures is awaiting the results of preliminary tests.

TABLE OF CONTENTS

SUMMARY

This report covers the period of contract initiation to 15 December 1965. During this time considerable effort has been expended in the investigation of polycarbonate and polycarbonate foil capacitors. Capacitor manufacturers have been solicited for information, the results of which have been analyzed by Wyle Laboratories. Design has continued on both the alternating and commutating test circuits. The finalization of circuit design parameters, the fabrication of test equipment, and the test temperature requirements are pending the results of preliminary tests. These preliminary tests will be conducted after additional solicitation of capacitor manufacturers for detailed specification and test information. A manufacturer's letter requesting this information has been prepared and submitted to NASA-Lewis for approval. It is anticipated that approval of this letter will be received shortly and that analysis of submitted data will begin.

INTRODUCTION

The lack of adequate alternating current characteristics has caused considerable difficulty for equipment designers in the selection of polycarbonate capacitors for use in aerospace static converters and inverters.

The purpose of this test program is to obtain data from which safe operating characteristics may be established. These characteristics will be obtained by subjecting 524 metallized and 204 film-foil polycarbonate specimens to a 5,000 life test period. The potentials applied to the specimens will consist of both alternating and commutated wave forms. The magnitude of these voltages and the temperatures to which the specimens will be subjected are designed to induce failures as a function of time.

It is anticipated that the results of this test will provide accurate reliability predicitions which the designer may use in the selection of these components for use in the above mentioned applications.

1.0 TECHNICAL PROGRESS

The following is a description of the technical progress made to date on NASA Contract NAS 3-7623.

1.1 Capacitor Evaluation

A technical evaluation was conducted by Wyle Laboratories to determine those capacitor manufacturers qualified to supply samples for test. The investigation was first initiated in June, 1965, by reviewing the Thomas Register to determine those companies that manufacture capacitors. The first review indicated that 41 companies were listed. Each of the 41 listed capacitor manufacturers were requested to provide technical information on 1 microfarad and 3 microfarad polycarbonate film-foil and metallized polycarbonate capacitors. Of those 41 companies solicitated, 14 did not acknowledge receipt of the letter. Twenty companies returned letters stating that the requested information was not in their product line. Seven companies responded to the request and were technically evaluated based on their response. The technical information which was submitted was reviewed on the basis of physical size, capacitance, dissipation factor, and insulation resistance with special emphasis on derating characteristics with respect to voltage and temperature.

During this reporting period NASA-Lewis representatives suggested that further screening of capacitor manufacturers be conducted prior to test initiation. At their request Wyle Laboratories prepared a second manufacturer's letter encompassing the parameters and space environments which may be encountered in the application of these capacitors. In addition, this letter requests the manufacturer to supply not only detailed test parameter information but manufacturing processes as well. This letter has been submitted to NASA-Lewis for approval prior to transmittal to the manufacturers.

1.2 Preliminary Tests

Preliminary tests were conducted on a small sample of capacitors to determine their thermal characteristics and to attempt to anticipate temperature-voltage time to failure data. These tests indicate, and preliminary discussion with dielectric manufacturers confirms, that a high infant mortality can be expected when in excess of 140 c. This information was transmitted to NASA-Lewis in a meeting in Cleveland, Ohio. The preliminary conclusions were that the dielectric shrinkage would cause such a high failure rate in the

1.0 TECHNICAL PROGRESS

1.2 Preliminary Tests (Continued)

preliminary stages of the program that adequate data would not be obtained from which analysis of capacitor performance could be made.

After a design review and a number of discussions and meetings with NASA-Lewis Representatives, it became apparent that considerable changes would be required in regard to test voltage and temperature requirements. At this time Wyle Laboratories suggested that additional preliminary tests be performed to establish voltage and temperature parameters which would result in a proper distribution of induced failures over the 5,000 hour life test period. Figure 6 depicts the apportionment of test samples to each temperature and voltage condition. The values of voltage and temperature shown are for information purposes only, the exact values are pending the results of preliminary tests.

1.3 Design

During this period considerable effort has been expended on the design of alternating and commutating voltage circuitry. The alternating voltages will be obtained from a 400 cycle generator with center taped transformers designed for the particular voltage applied to each group of capacitors. A typical a. c. circuit is depicted in Figure 1.

The commutating circuits are being designed utilizing breadboard switching circuits and silicon controlled rectifiers. The waveform obtained is to resemble the wave shapes applied to the commutating capacitor in a parallel type SCR, d. c. to a. c. inverter circuit. The rise and fall time requirements for the waveshapes of these voltages was not to exceed 25 microseconds with the oscillatory ringing portion of the waveshape to equal or exceed 5 kilocycles. After a design analysis, this requirement was later changed to be equal or less than 100 microseconds with an oscillatory ringing of 5 kc or greater, the major problem in achieving the desired rise-time is in reducing the total circuit resistance to a value such that the circuit RC time constant is short relative to the rise-time requirement. The RC time is naturally proportional to the number of capacitors which are tested simultaneously. Since it is desired to test all capacitors concurrently under identical temperature-voltage conditions, total circuit resistance on the order of 1/4 ohm or less are necessary. This total resistance includes the individual series

1.3 Design (Continued)

resistance of the following:

(a) Wiring from power supply, through chamber wall to capacitor and return
(b) All connections
(c) Silicon controlled rectifier
(d) Saturable reactor
(e) 5 kc choke
(f) Slo-Blo fuse
(g) Internal impedance of power supply

Figures 2 through 5 depict the basic design concept of the commutating circuit which will be used for test.

2.0 PROBLEM AREAS

The following items are to be accomplished:

(1) NASA approval of second capacitor manufacturer's letter.
(2) NASA approval for conducting preliminary tests prior to initiation of the 5,000 hour life test.
(3) The finalization of voltage and temperature requirements are pending the results of preliminary tests. The completion of circuitry design will depend on the voltage requirements established after preliminary tests.

3.0 FORECASTED PROGRESS

(1) NASA approval of second capacitor manufacturer's letter.
(2) Transmit letter to capacitor manufacturers.
(3) Evaluation of manufacturer's submitted data.
(4) NASA approval of manufacturer's evaluation.
(5) NASA approval for conducting preliminary tests.
(6) Conduct preliminary tests and submit results to NASA for approval.
(7) Finalization of test voltages and temperatures.
(8) Finalization of test procedure and design of test circuits.
(9) Initiate fabrication of both alternating and commutating test circuitry.

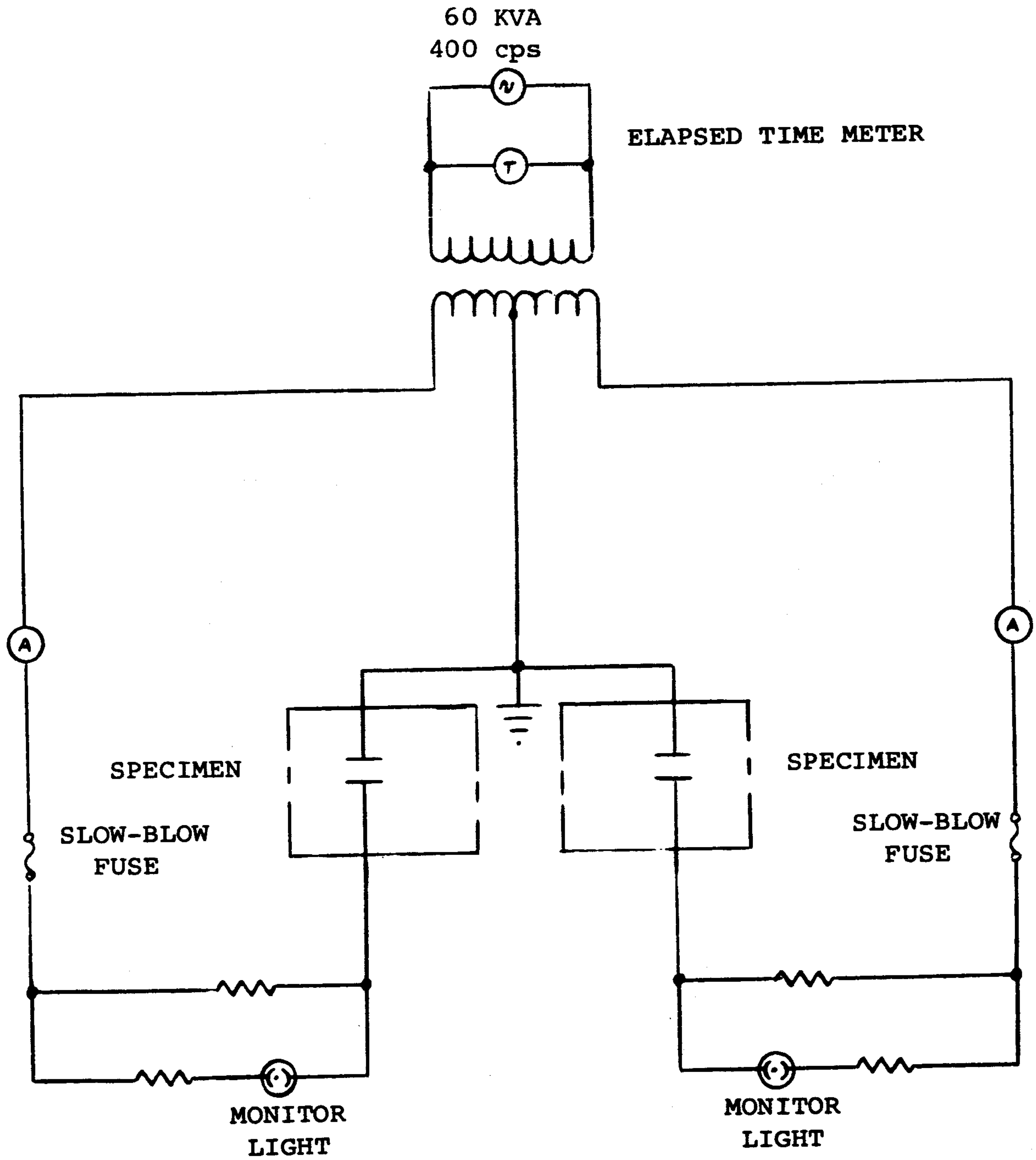


FIGURE 1

TYPICAL SINEWAVE EXCITATION CIRCUIT

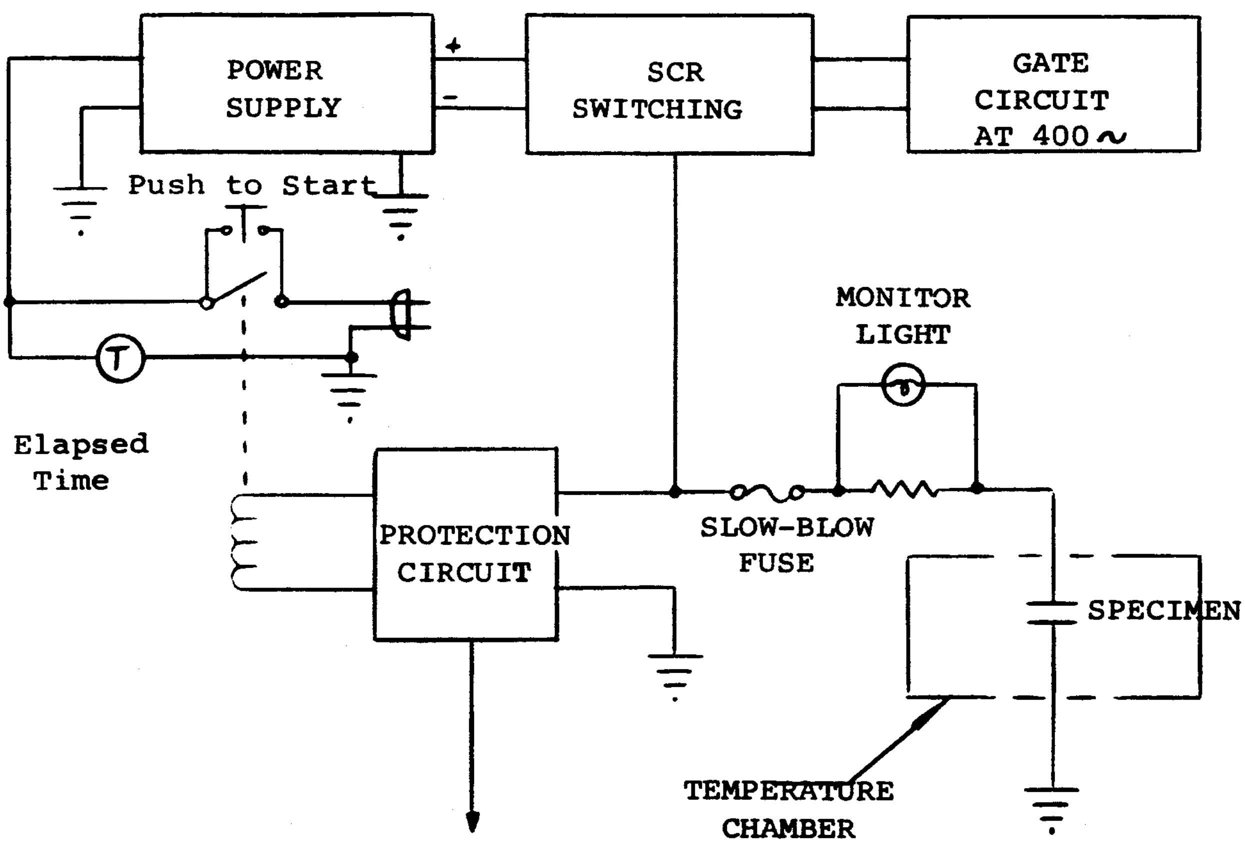


FIGURE 2

BLOCK DIAGRAM

FIGURE 3
TYPICAL SCR SWITCHING CIRCUIT

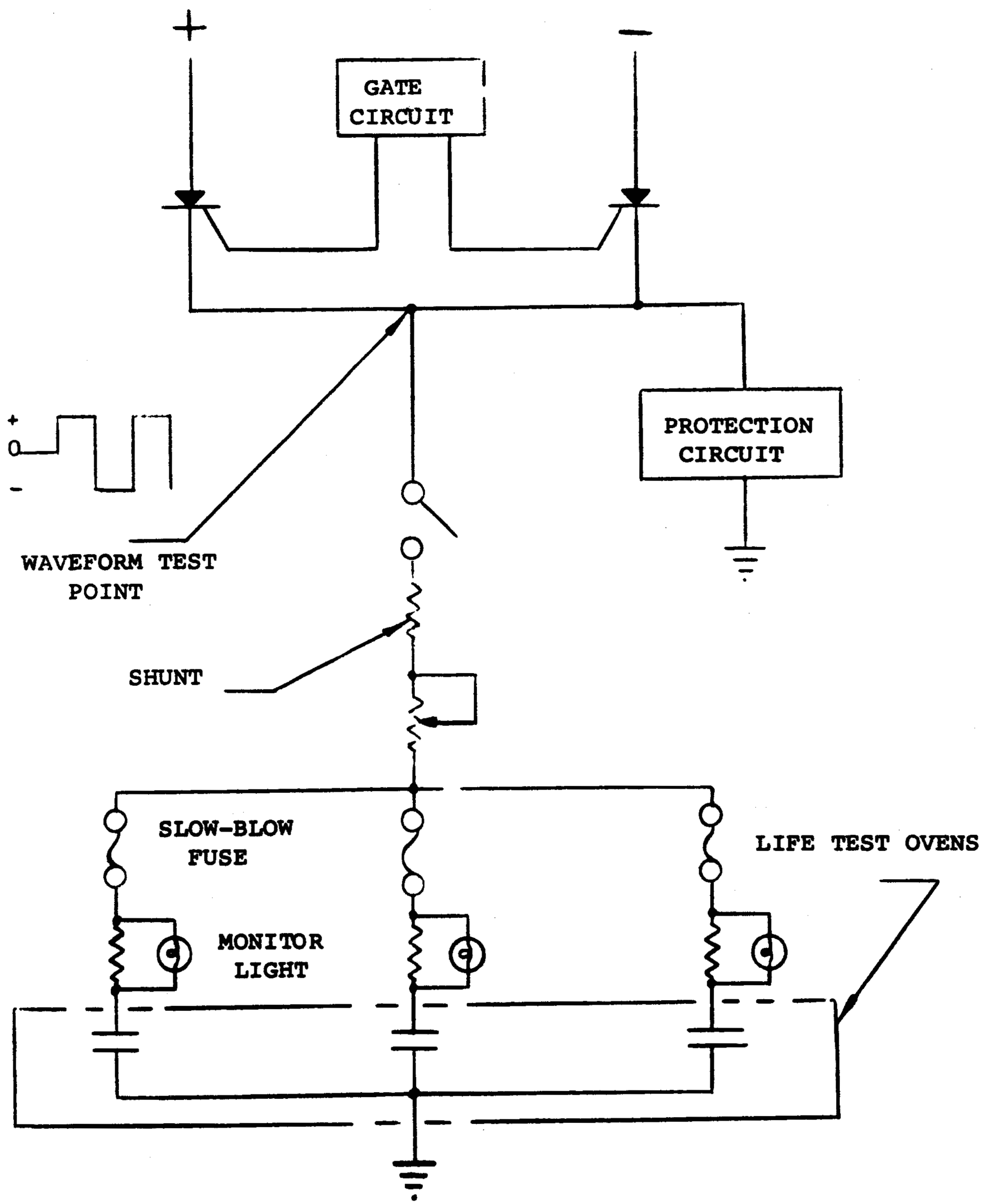
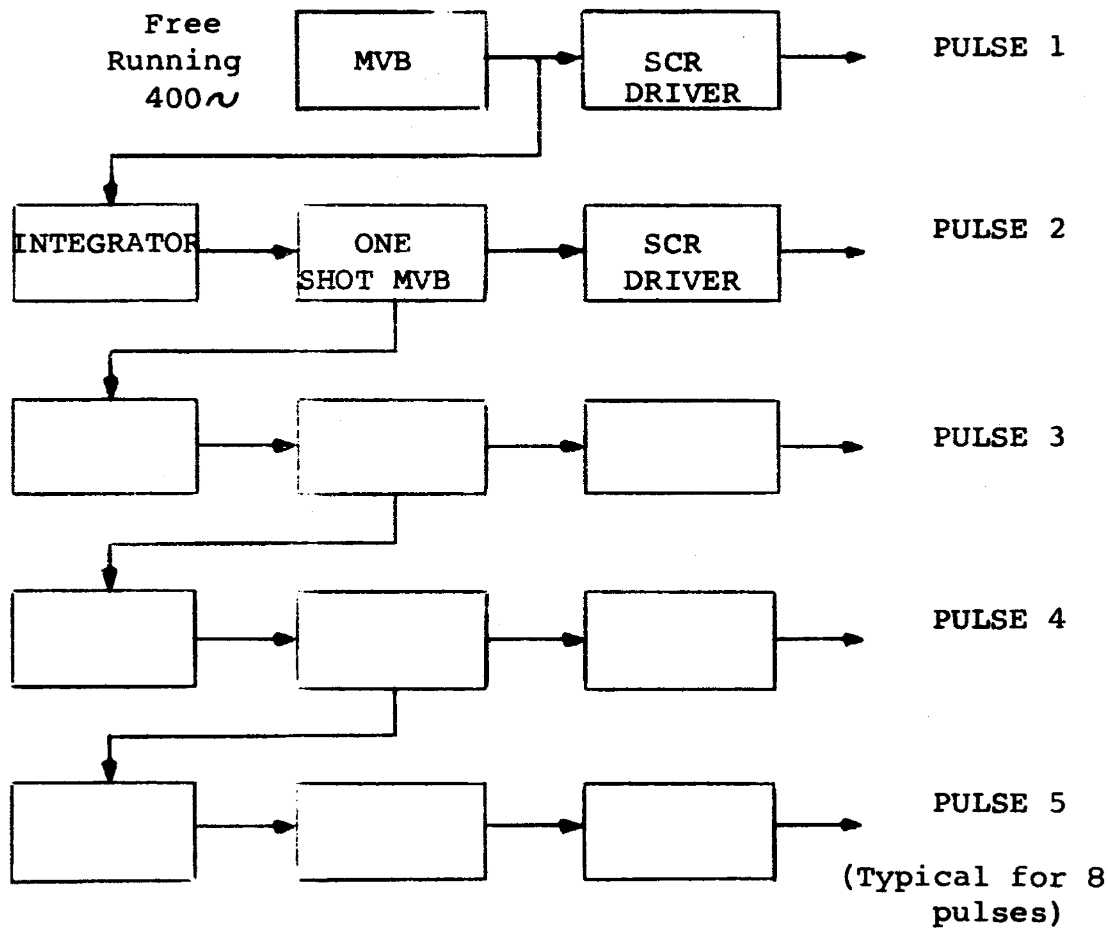
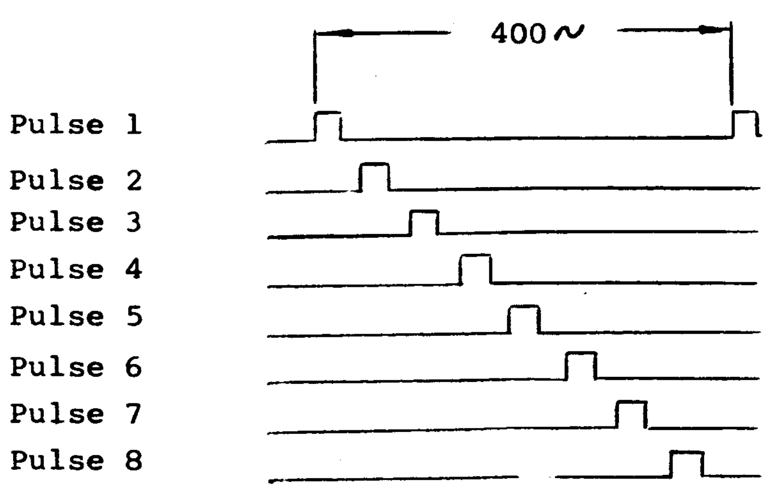


FIGURE 4
GATE PULSE SEQUENCING





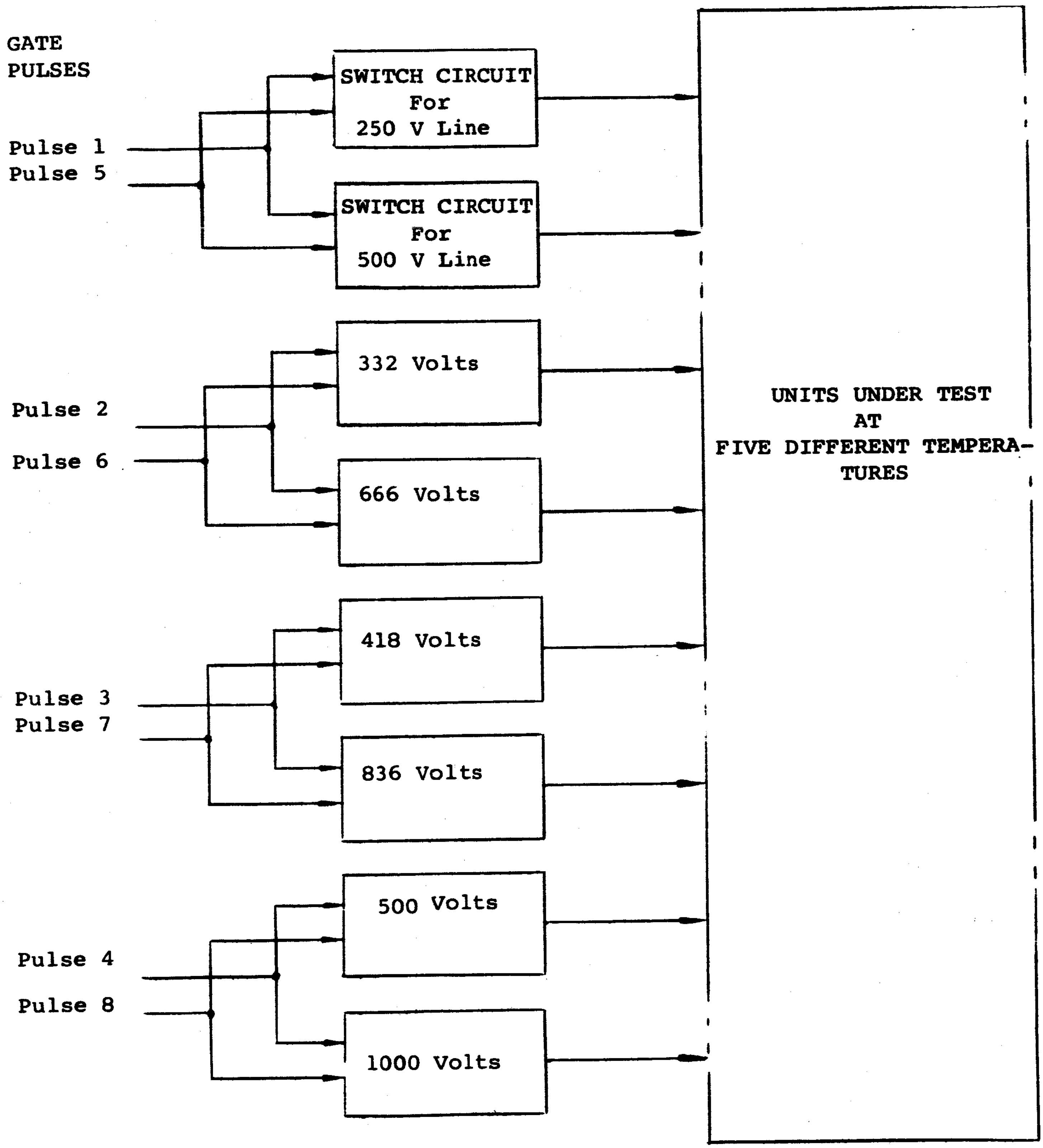
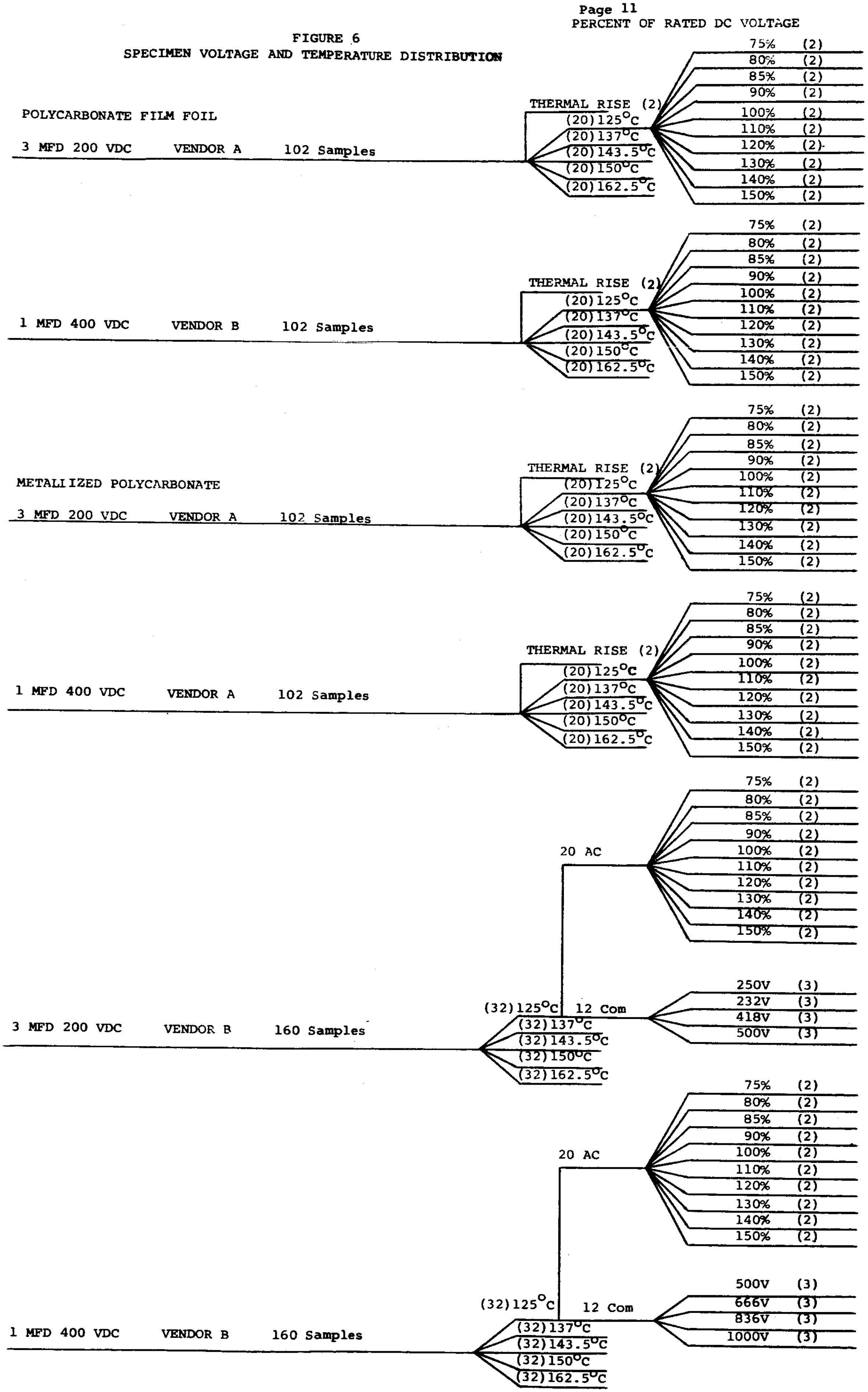


FIGURE 5
GATE PULSE DISTRIBUTION

FIGURE 6
SPECIMEN VOLTAGE AND TEMPERATURE DISTRIBUTION



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