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FINAL REPORT
ON
PHASE II
FOUR-INCH ROCKET

1210-E-1

Contract No. RD-45
Research Order No. 13

[redacted]

50X1

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TABLE OF CONTENTS

SECRET

I. INTRODUCTION

The transfer of the Four-Inch Rocket project [redacted] 50X1
[redacted] also marked the transition from Phase I to Phase II. 50X1
At the close of Phase I, the internal ballistics study was established and the basic component material study was well advanced. Immediately following the transfer, the spin stabilized rocket was redesigned in an effort to eliminate failures due to limitations in the strength of plastic materials.

New personnel were acquainted with the past history of the project and trained in rocket fundamentals and the fabrication of plastic parts.

A proposed flight test area was investigated at another site. The general conclusion of the groups involved was that while it was possible to use the area, it was rather unsuitable from the standpoint of safety and the extensive precautions required such as road blocks and aerial guards. An inspection trip was made to another area situated at
[redacted] This seemed sufficiently suitable to all 50X1
concerned and plans were made for its use.

II. STATIC TESTING

To facilitate static testing of rocket motors, a reinforced concrete slab was poured in the test area and a braced steel test stand was constructed and erected on the slab (as may be seen in Plate 1). A 300 foot cable connected the equipment at the test stand to an oscilloscope which was especially modified for use on the project. Following the transfer of the propellant powder to [redacted] static tests were made on a single tube steel motor to test the instrumentation and familiarize personnel with firing procedures.

During this period, the multitube motor was completely redesigned and many static tests were made to study the strength of construction and internal ballistics of a single plastic tube motor which was an integral part of the design. After this method of tube construction had been proven, many tests were made of the new three tube design, testing the strength of head block materials. Additional static testing was done to develop the best possible bonding resin for use in bonding the nozzle and plug inside the motor tube. All of the components of the proposed model were successfully static tested and construction was started on flight test models.

III. FLIGHT TESTING

As stated in Section I, an inspection of a flight test area at another site indicated that it was, on the whole, unsuitable for our purposes. An area was selected at [redacted] 50X1 [redacted] that was satisfactory to all concerned. 50X1 This area is approximately 300 by 4500 feet, fairly clear and level. Recently, approval was given to extend this area to approximately 7000 feet by conducting flight tests which would cross a public road that would require intermittent blocking.

A. Spin Stabilized Rockets

A spinner type rocket attains its stability by spinning longitudinally at a rate of approximately 600 rpm. One method of achieving this spin is to divert a portion of the rearward thrust so that its line of action misses the center of gravity, thus producing a torque. In the case of the multi-tube rocket, this was done by canting each nozzle at an angle to its lever arm, somewhat as in the fashion of a pinwheel. In the redesigned model of this rocket an attempt was made to obviate the failures of previous models by making the tube assembly able to withstand the pressure within itself thus reducing the stress in the interconnecting head section.

Basically, the design consisted of a four-inch diameter motor with three or six tubes, each employing a canted nozzle. Each tube was plugged at the head end and a connecting hole was bored in the plug through the side wall of the tube, as illustrated in Plate 2. The tubes were oriented in the motor head so that the bored holes connected to a central cavity and were bonded in place with epoxy resin. The pressure in the central cavity was contained by a hollowed plug sealed with O-rings, as may be seen in Plate 3, along with a bored head into which has been laminated a central reinforced core. The payload compartment was a length of spiral wound paper tubing, capped by a polyester ogive, which may be seen in Plate 4 as the completely assembled rocket.

This motor possesses several advantages from a design standpoint, since the head can be made smaller and lighter. This would require less fuel and smaller stresses in takeoff. The main benefits of the design are that the principle effect of the pressure is confined within the tube and, in addition, since the pressurized area of the head is quite small, the stresses within the head are greatly reduced. By the utilization of either three or six tubes, the attainment of two ranges is facilitated.

Considerable time and effort was spent on the development of this type rocket, since it was compact and permitted easy utilization of the proposed time delay. It was felt by all concerned, that it was desirable to develop this design if at all possible because of its many advantages. In practice, however, the factors that made the design suitable from a pressure standpoint were undesirable due to restriction of gas flow. In order to reduce the pressurized areas in the head, the crossport size had been reduced to a 3/8" drilled hole, with the result that pressure equalization through this port did not take place rapidly enough, with resultant instability in flight. The crossport area was increased considerably through evolution of several revised head blocks, such as shown in Plate 3, and although increased stability resulted, the flights were still not considered satisfactory. Another rocket was constructed with an aluminum head with crossports considerably larger than before, which materially increased its stability. The area of these ports, however, was too large to be made safely in plastic. Thus, it became increasingly evident that the problem of sufficient pressure equalization area versus the limited strength of plastics was incapable of solution within the project's limitations in either time or money.

B. Fin Stabilized Rockets

As mentioned earlier, although the problems involved in a spinner rocket are not incapable of solution, the remaining four months allotted to Phase II in the project were insufficient to produce another new design concept which could overcome the limitations of the two previous designs. The design of a finned rocket, however, is much simpler in that fewer components are required and the operating principles are more fully developed, especially in the case of the low powered miniature rocket in which we are interested. Basically, the stability of finned rockets is achieved by providing sufficient lateral fin area as rearward as possible from the center of gravity, a task much easier than providing a balanced spin rate. The biggest advantage from the standpoint of time and money is that the internal gas pressure is completely contained in a single motor tube whose operation had been repeatedly demonstrated previously.

The design consists of a finned motor tube which is glued into the base socket of the cargo compartment. To provide sufficient stability a delta fin was evolved whose over-all width was three times that of the rocket body. A launcher was designed with four internal ribs, the rocket fins lying between the ribs and the rocket body guiding on the ribs or rails. Success was met almost immediately, with several 1,000 meter shot groups landing within circles 70 - 80 meters in diameter. The equivalent payload capacity of this model was 22 ounces, simulated by an appropriately shaped block of wood, as may be seen in Plate 5.

During this time, another model was evolved whose design was better suited to production. Since more propellant would be required for a longer range, the motor tube size was increased to accomodate three sticks of propellant side by side. By this means, the length of a single stick of propellant can be shortened. A long length of propellant tends to split due to internal pressure build up. The fins were made of a smoother material to provide less drag. The head or payload section consisted of a 9" length of 3" O.D. paper tubing capped by an ogive at the front and a base cap at the rear, which also had a recess to receive the motor tube. The payload tube held 660 grams of leaflets packed in three sections. Flights were made with this style rocket to determine the propellant ratio required to produce a range of 1,000 meters at burst point. A group of four rockets with the proper weight and propellant ratio landed within a circle of 50 meters in diameter at an average distance of 1,080 meters on the ground, which corresponds to a distance of 1,020 meters at burst point. The complete rocket, which is essentially a production prototype, may be seen in Plate 6.

A system of bursting was devised which would eject the payload as in the fashion of a mortar. This system possesses the advantage of separating the leaflet section from the motor section before the motor section is destroyed by a larger blast; therefore, resulting in less leaflet damage. The time fuse for the unit is under development at this time, as is the system for destroying the motor section of the rocket.

By increasing the length of the motor tube, sufficient propellant can be carried for a range of 3,000 meters. Following the static test of three ten inch grains in such a motor, rockets were test fired into an earth covered hillside at a distance of 125 feet. Although some trouble was encountered in these models, one unit apparently reached full acceleration, burying itself deeply into the hillside. No damage to the unit was observed which could be attributed to acceleration effects. An approval to extend our present range has been granted so that longer flight tests can be accomodated.

IV, SUMMARY

The work in Phase II has established the design of a finned rocket capable of carrying a 22 ounce payload 1,000 meters with a probable dispersion of 50 - 60 mils. Sufficient static and flight tests have been made to establish the reliability and functioning of the design.

Each component has had a design aimed at production although it is anticipated that minor changes will be required to facilitate a production model.

Tests have been made establishing the basis for a 3,000 meter model, although it is anticipated that completion of this model may take longer than was first anticipated.

V. FINANCIAL STATEMENT

Total Amount of Contract (Phase II)

Total Obligations to June 30, 1956

Balance of Contract (Phase II)

[redacted]

50X1

PLATE 1

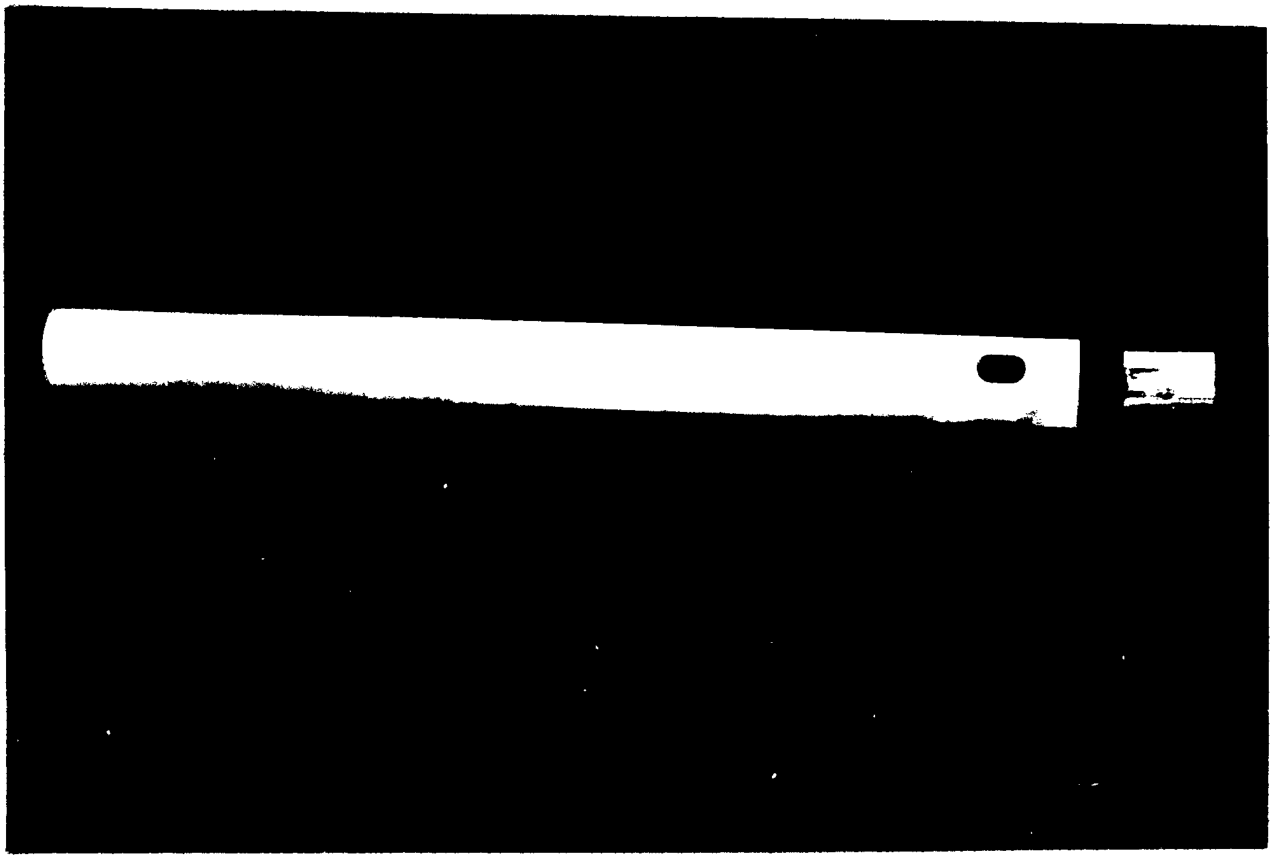

PLATE 2

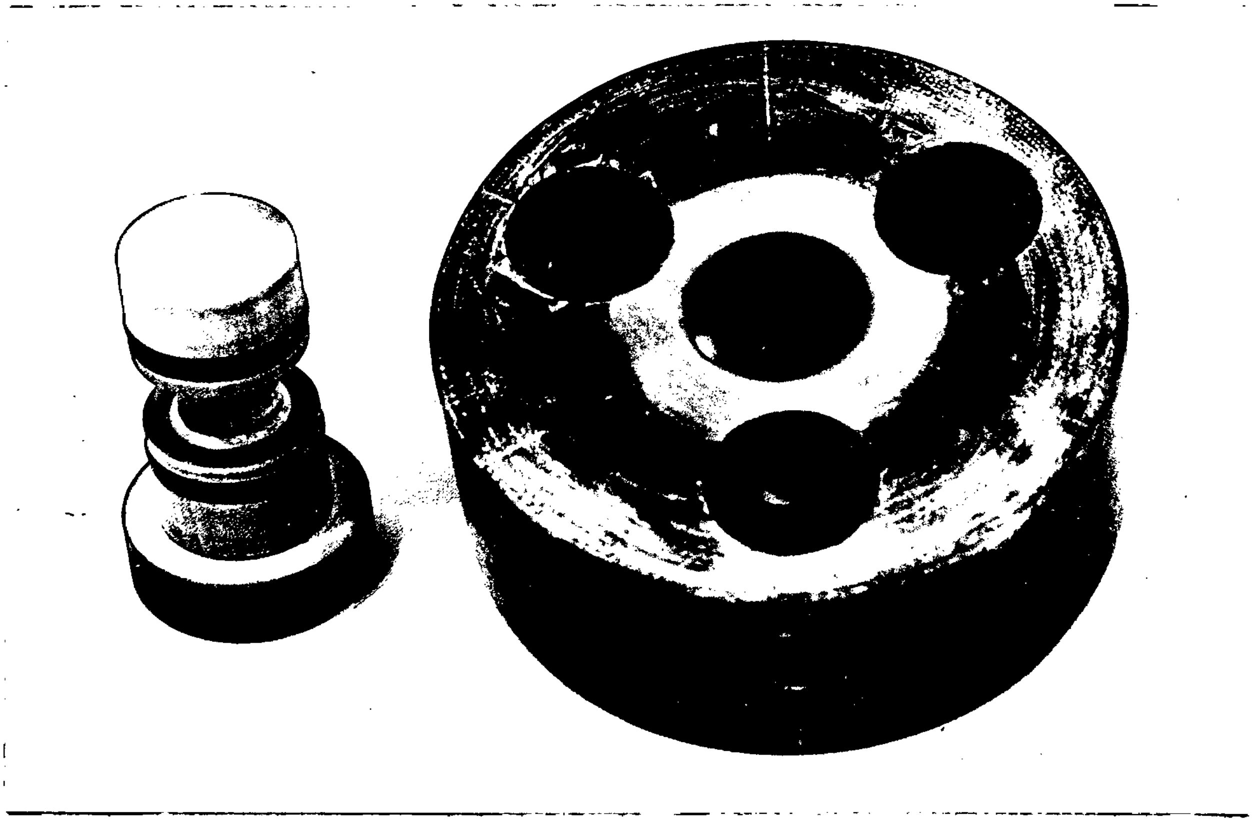

PLATE 3

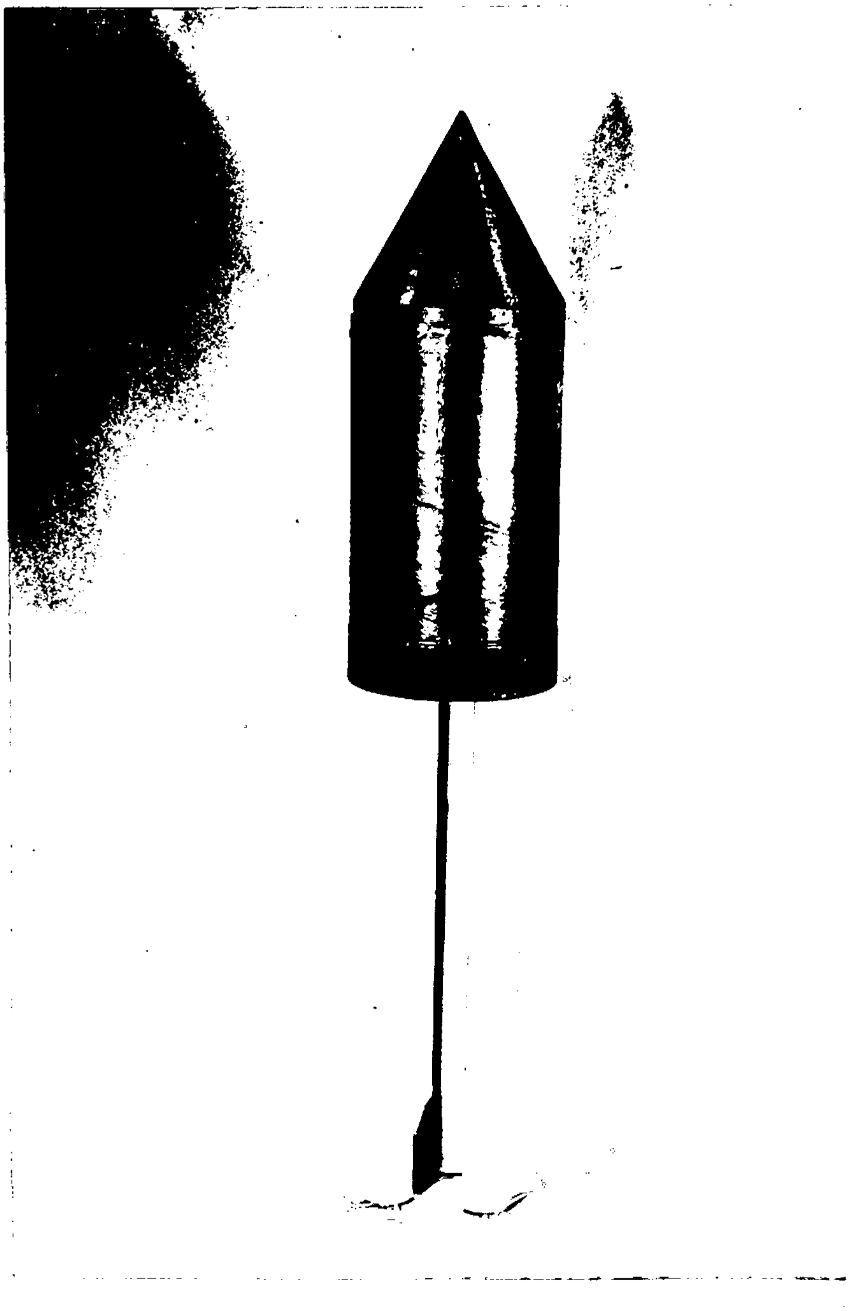

PLATE 4

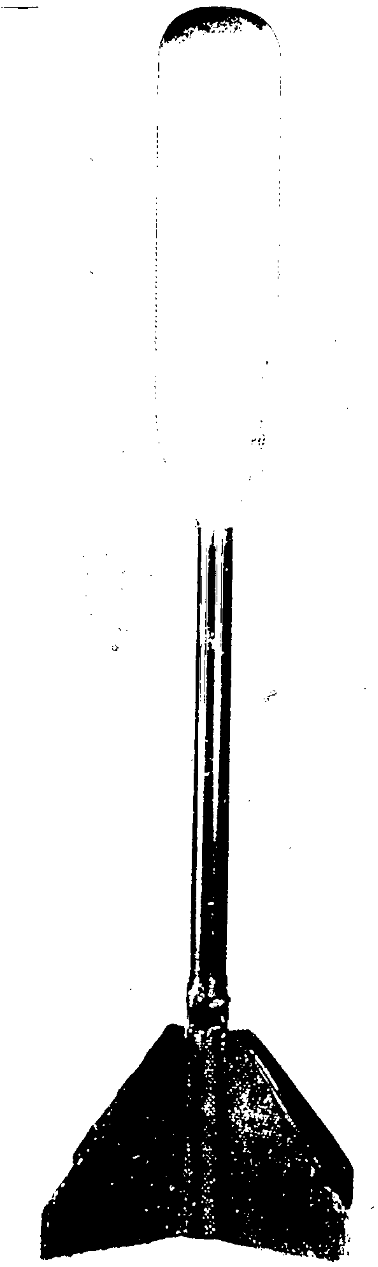

PLATE 5

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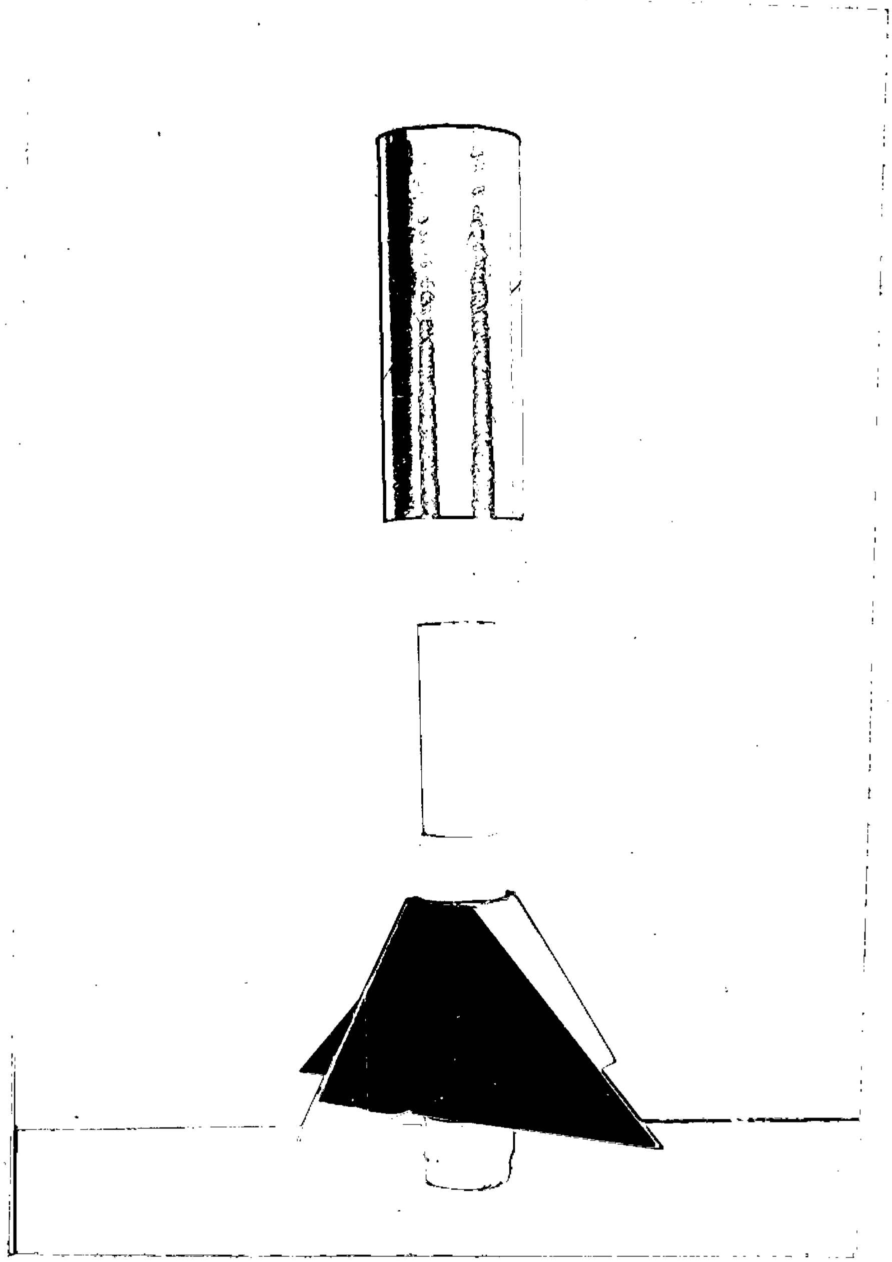

PLATE 6

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