SC 1004-A (3-55)

000056

UNCLASSIFIED

~~SECRET~~

Ref. Sym: 7223 (380)

[redacted]

UNIQUE DOCUMENT #SAC200119840000

INVENTORIED

THIS MEMORANDUM IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS WRITTEN PERMISSION OF SANDIA CORPORATION.

INVENTORIED MAR 1 1966

INVENTORIED MAR 1 1966

MAR 1965 3428-3

3427-1

3428-3

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
DETERMINATION [CIRCLE NUMBERS]
1. CLASSIFICATION RETAINED
2. CLASSIFICATION CHANGED TO:
3. CONTAINS NO DOE CLASSIFIED INFO
4. COORDINATE WITH:
5. CLASSIFICATION CANCELED
6. CLASSIFIED INFO BRACKETED
7. OTHER (SPECIFY):

9-57-14

A PROPOSED ZIPPER SYSTEM FOR SMALL WEAPONS (U)

B. J. Carr - 1423

INVENTORIED AUG 1 1962

ABSTRACT

DOE b(3)

The unit should be no larger than 100 cubic inches in volume and should weigh about 10 pounds. Two units, in a dual system, could be placed in an 11-1/2-inch-OD space only 3-1/2 inches thick.

DOE b(3)

Power and trigger can be supplied from an X-unit, or other 28-volt DC input supplies such as rotary choppers and transverters can be used.

A look into other possible future Zipper units of considerably smaller dimensions is discussed.

Work performed under AEC Contract AT-(29-1)-789.

Inventoried September 1960

RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmittal or the disclosure of its contents in any manner to an unauthorized person is prohibited.

THIS DOCUMENT CONSISTS OF 23 PAGE(S)
NO. 13 OF 37 COPIES, SERIES A

[redacted]

Case No. 755.00

INVENTORIED MAY 22 1957 BY ORG. 2743

April 12, 1957

~~SECRET~~

UNCLASSIFIED

DISTRIBUTION:

1/37A - N. E. Bradbury, LASL, DO
2/37A - J. H. Hall, LASL, ADO
3/37A - D. P. MacDougall LASL, GMX-DO
4/37A - M. F. Roy, LASL, W-DO
5/37A - J. E. Dougherty, LASL, W-3
~~6/37A - R. T. Wagner, LASL, W-3~~
7/37A - A. R. Sayer, LASL, W-4
8/37A - R. Canada, LASL, W-4
9/37A - R. L. Spaulding, LASL, GMX-7
10/37A - J. H. McQueen, LASL, GMX-7
11/37A - E. L. Peterson, LASL, GMX-4
12/37A - J. W. McRae, 1
13/37A - G. A. Fowler, 5000
14/37A - R. W. Henderson, 1200
15/37A - L. A. Hopkins, Jr., 1400
16/37A - W. J. Howard, 1800
17/37A - S. C. Hight, 5100
18/37A - R. A. Bice, 5200
19/37A - W. C. Scrivner, 1210
20/37A - J. P. Cody, 1220
21/37A - E. H. Draper, 1240
22/37A - L. D. Smith, 1260
Attn: J. J. Marron, 1263-1
23/37A - T. S. Church, 1410
24/37A - E. L. Deeter, 1440
25/37A - L. E. Hollingsworth, 1820
26/37A - W. R. James, 2310
27/37A - J. W. Jones, 1225
28/37A - R. T. DePew, 1411
29/37A - J. P. Shoup, 1413
30/37A - J. McMinn, 1832-3
31/37A - R. K. Smeltzer, 7221-3
32-37/37A - A. D. Pepmueller, 7223

A PROPOSED ZIPPER SYSTEM FOR SMALL WEAPONS

INTRODUCTION

With the realization of the desires for smaller nuclear warhead systems, it has become necessary to consider smaller Zipper units.

DOE b(3)

A Zipper system which shows promise for these applications is described herein.

DOE b(3)

The time delay is included in the system which is small and rugged; depending upon the power supply and timer unit selected, the system is capable of being relatively radiation-resistant.

REQUIREMENTS

A summary of the controlling requirements for this system analysis follows:

Applications

This Zipper is intended for use in 10- to 12-inch-small warheads used in guided missiles (NIKE AJAX, TERRIER, and possibly air-to-air missiles), a ballistic missile (LITTLE JOHN), a (high-g) rocket-assisted depth bomb (ASROC), and an atomic demolition munition (C-ADM).

DOE b(3)

The criteria listed below include present information as to the extreme requirements which will be imposed on the Zipper by the above applications. Development of a miniaturized version of the XMC-825 with choice of power supplies such as a rotary-chopper converter, transverter or X-unit voltage supply may prove satisfactory.

Performance Requirements

Electrical. -- Zipper units should be capable of accepting a 28±4-volt DC, 1-ampere or less per channel power input, or X-unit voltages of 1800 to 2600 volts DC so that it will operate in 4 seconds after application of this power by triggering from an X-unit or other suitable signal. [redacted]. Actual neutron requirements are not firm and will be obtained from the nuclear laboratories when they have been definitely determined. [redacted]

DOE b(3)

DOE b(3)

Environmental. -- The Zipper should be environmentally compatible with SCS-7 with the addition of the ability to withstand the following criteria.

[redacted] -- Operate after the following weapon environments:

Linear Accelerations - 2000 g's for 0.1 ms,
1000 g's for 2 ms.
650 g's for 0.5 sec.
500-g shock in any direction.

[redacted] -- Operate after the following weapon environments:

Linear Accelerations - 2000 g's for 0.1 ms.
1500 g's for 2 ms.
500-g shock in any direction.

[redacted] -- Operate after the following weapon environments:

Linear Accelerations - 75 g's for 4.5 sec.
Angular Acceleration - 2000 rad/sec/sec for 0.01 sec.

Angular Velocity - 50 rad/sec for 100 sec.

Altitude - Operation at 90,000 feet altitude is required.

DOE b(3)

If extreme difficulty is encountered in development due to the acceleration, radiation insensitivity, and size and weight requirements, two separate Zipper developments might best be considered with less restrictive radiation, weight and size requirements on the high-g unit.

Reliability. -- Failure probability of a single-channel system not to exceed 1/100.

Dimensional Requirements

Size and Shape. -- Dual-channel unit allowable volume appears to be approximately 200 cubic inches. Actual size and packaging configuration should be coordinated with the applicable 1200 or 1800 project group, and appropriate form factors will have to be negotiated as design progresses.

Weight. -- Because of warhead application requirements, the weight of a dual-channel Zipper should be limited to 20 pounds including potting, with a lower weight preferred.

Additional information which may be of aid during the development stages of the Zipper unit follows:

Time Scales

Weapon Operational Availability. --

DOE b(3)

October 1959 (Other Applications)

Component CDR Desired

June 1958 (Other Applications)

Development Models Required

September 1957 (Other Applications)

Cognizant 1000 Organizations

Systems	Project
1261	1225
1261	1222
1261	1810
1261	1810

SYSTEMS

Figure 1

The basic system considered herein is shown in block diagram form in Figure 1. The pulsed neutron source is the same small pulsed linear accelerator which has been developed for other weapon applications.

Energy for these pulses is stored in a capacitor similar to those being developed for X-units. The energy is switched to the transformer by a switch which is triggered by the output of the timer unit. The timer itself may be electronic or explosive in nature. The input to the timer may be obtained from several points in the weapon system as may be found most adequate, such as the

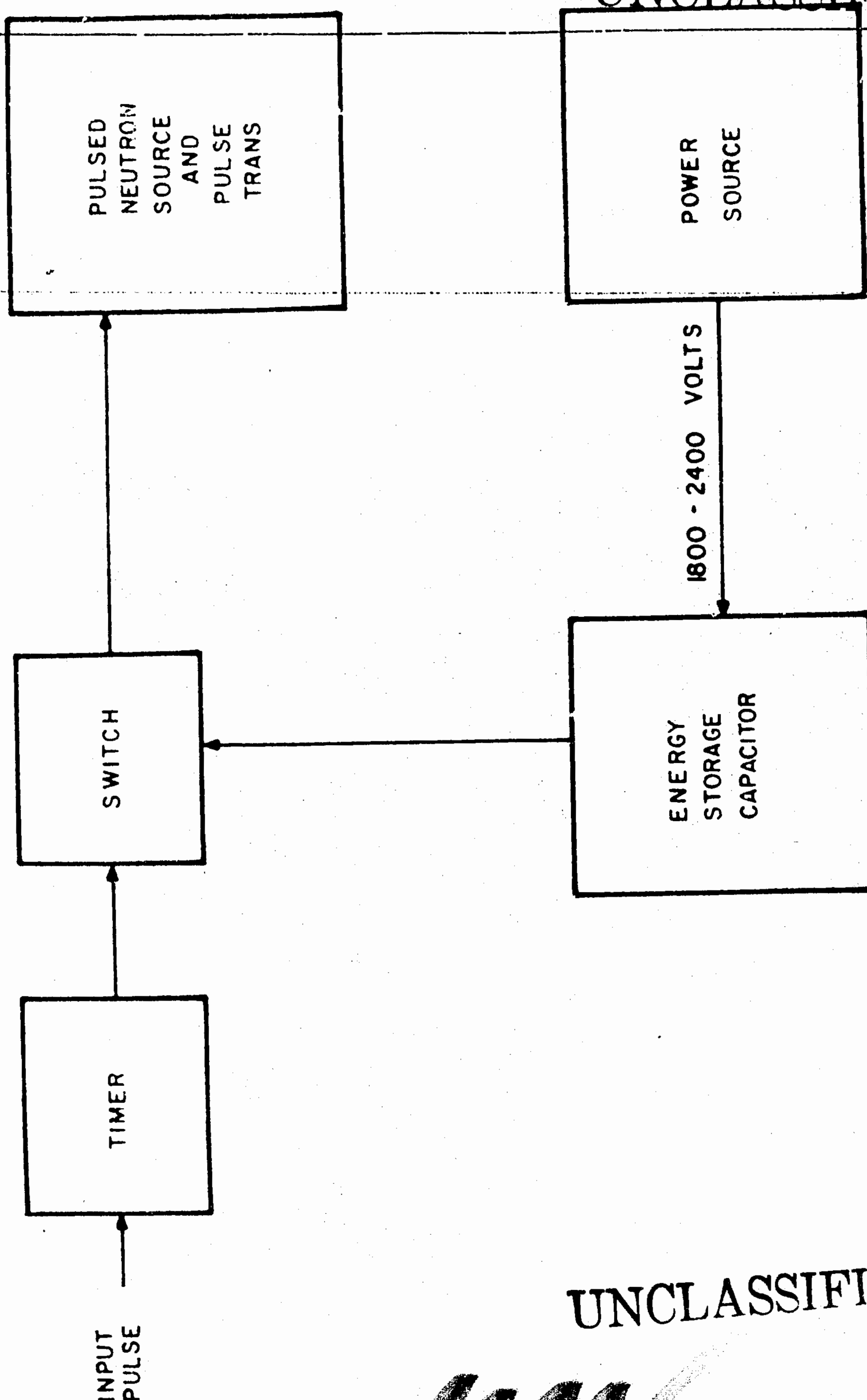


FIG. I NEUTRON SOURCE SYSTEM BLOCK DIAGRAM

X-unit load plate, X-unit capacitor plate, an X-unit fired detonator or a crystal signal derived from the exploding HE of the nuclear system.

Power to charge the energy storage capacitor may be chosen for each specific application as desired, but the primary requirement is that the energy storage capacitor be charged to from 1800 to 2600 volts DC. Investigations will be carried out to determine if the 1800-volt minimum is realistic if its occurrence is small. Since the electronic timer delay circuit can be made so that the time delay is a function of the input voltage, there are several advantages to using voltages equal to that on the X-unit capacitor for the Zipper-operating voltage. In the case of an explosive timer, this advantage is small, and where an electronic timer with a crystal input is used, the advantages and disadvantages are not clear.

Three possible circuits for the Zipper system are shown in Figures 2, 3, and 4. The similarity of each of these circuits is that the energy storage, pulse transformer for accelerating potentials, and the neutron source tube are identical. The timers and high-voltage switch are different. Both the circuits in Figure 2 and Figure 3 are capable of several tests with no appreciable degradation to the system. The circuit in Figure 4 is a one-shot device, but special laboratory equipment can be devised which would permit the pulsed neutron portion of the unit to be tested. This unit is probably the most reliable circuit shown because it essentially precludes any field tests which might degrade its operation.

Figure 2

The time delay unit shown in Figure 2 uses an electronic timer. The time delay circuit input signal is derived from the X-unit capacitor plate.

b(3)

FIG. 2 AN XR CIRCUIT TO OPERATE FROM AN X - UNIT CAPACITOR BANK

DOE b(3)

Figure 3

With a separate tube at the input of the timer circuit, it is practical to trigger the timer from a $B_aT_iO_3$ or PZT crystal which is glued to the HE of the nuclear system or to the face of a 1E15 or similar detonator.

DOE b(3)

SECRET

- 11 -

UNCLASSIFIED

Ref. Sym: 7325 (360)

UNCLASSIFIED

SECRET

Figure 4

DOE
b(3)

Reliability

DOE
b(3)

FIG. 4

DOE b(3)

DOE b(3)

The electronic timers developed to date of Zipper applications have exhibited timing variations as a function of (a) input B+ voltage, (b) trigger signal shape, (c) temperature, and (d) selection of circuit parameters. These variations have accounted for about ±0.2 microsecond in laboratory and early prototype timing circuits. The temperature effects are, of course, not random. In addition, it is believed that unless considerable circuit complexity is incorporated with possible reliability losses such timers would, in production, be somewhat less accurate, perhaps ±0.4 to ±0.5 microsecond total variations. It is desirable not to make a timer more complex than the proposed circuit so the neutron pulse should be wide enough to account for ±0.5 microsecond timer variations.

Figure 5 illustrates neutron pulse requirements for a Zipper system.

The three circuits shown should exhibit similar reliabilities in the pulsed neutron portion of the unit. However, the remaining parts are different and can be analyzed on a "guess" basis, and a comparative reliability should be indicated.

For the circuit in Figure 2, the number of parts used is 17. The circuit in Figure 3 uses 22. The circuit in Figure 4 uses only 9 parts. Assuming equal failure rates in the various parts, this indicates that the unit using explosive time delay techniques is advantageous from the reliability standpoint. Whatever power supply is used would be again common for this comparison and only reflects in the actual reliability analysis.

By suitable development, the average part reliability should be so that failures occur at a 1 in 2000 rate or less. From this approximation, the best system, not including the power supply, should fail about 1 in 200 times or less and the poorest system about 1 in 98 or less. This compares favorably with the XMC-757 early analysis of a 1 in 50 to 70 failure rate where a large number of transistors used lowers the reliability considerably. One can conclude that the reliability in a dual system of any one of the three circuits, if used with an X-unit power source, should exhibit failure rates not in excess of 10^{-4} as is required in these systems.

UNCLASSIFIED

FIG.5 TIMING AND NEUTRON REQUIREMENTS

DOE
b(3)

Package

Preliminary unit layouts for possible applications in 11- and 12-inch-diameter weapons are shown in Figures 6 and 7.

DOE b(3)

In order to accommodate for a gas-boosting bottle, a hole about 4 inches OD was provided in the package.

Unit volumes are:

Figure 6	110 cubic inches
Figure 7	124 cubic inches
(XW-35 only)	

Unit weights are:

Figure 6	10.5 pounds
Figure 7	13 pounds

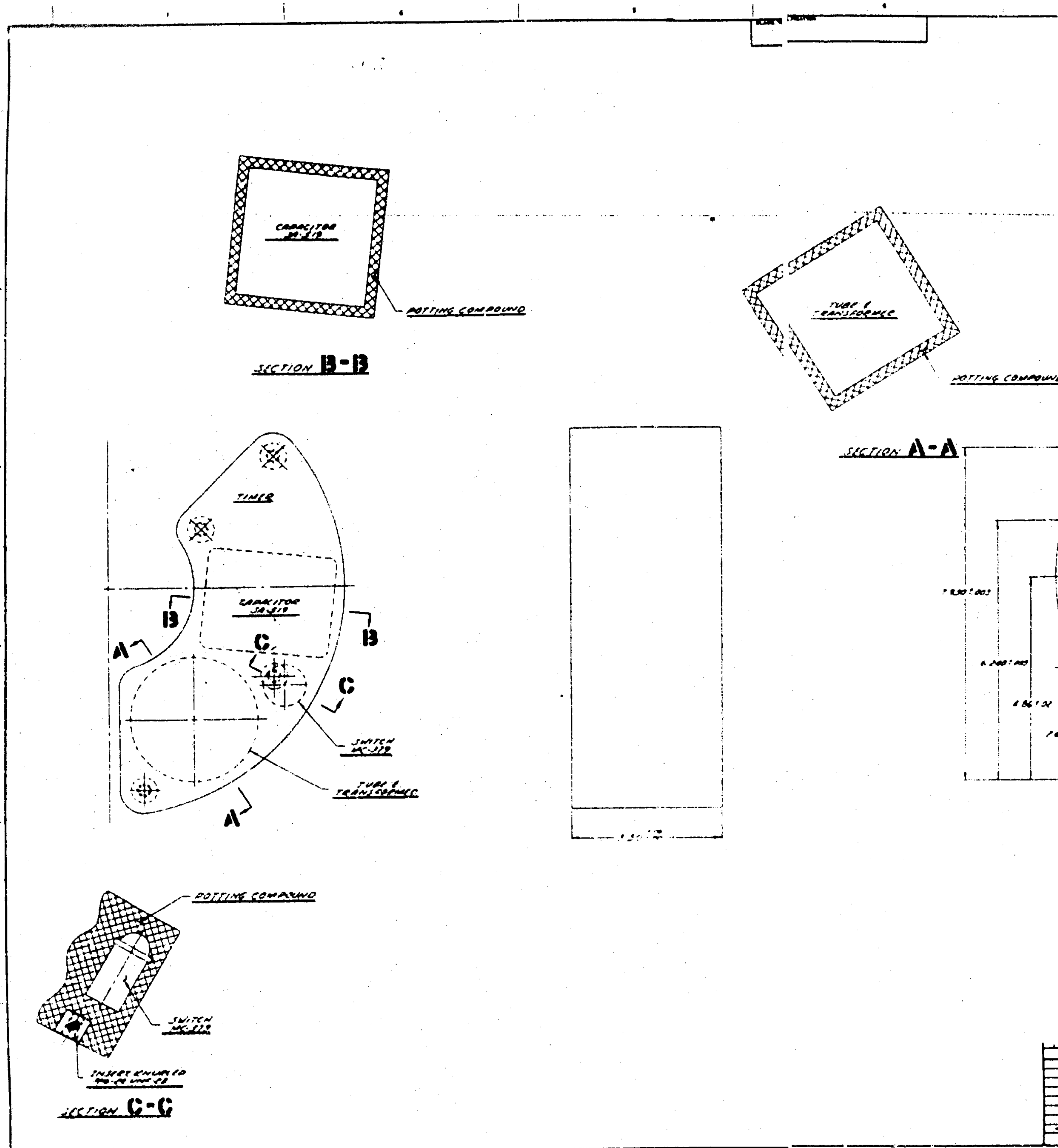
If the explosive timer is used in either case, the volumes reduce to

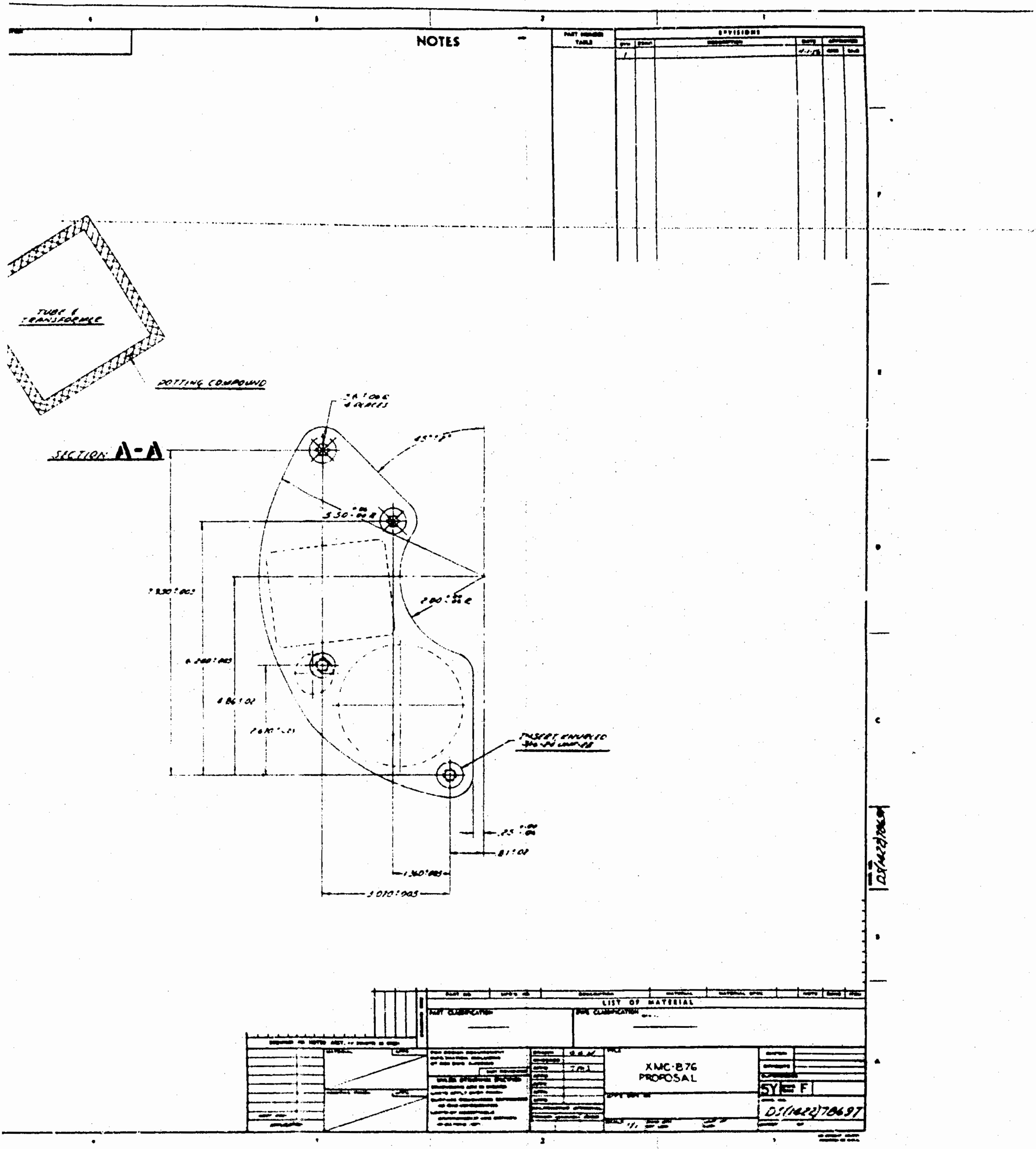
Figure 6	100 cubic inches
Figure 7	90 cubic inches

and the weights drop accordingly. (Figure 5 to 9.5 pounds.)

An all-encapsulated package is proposed. The package could probably be reduced to a thickness of 2-3/8 inches and a diameter of 11 inches with two bumps 3-1/2 inches OD protruding only 1 inch from the nominal 2-3/8-inch thickness. This could best be done with two units in a single package, but other techniques need to be investigated to determine what minimum package is possible.

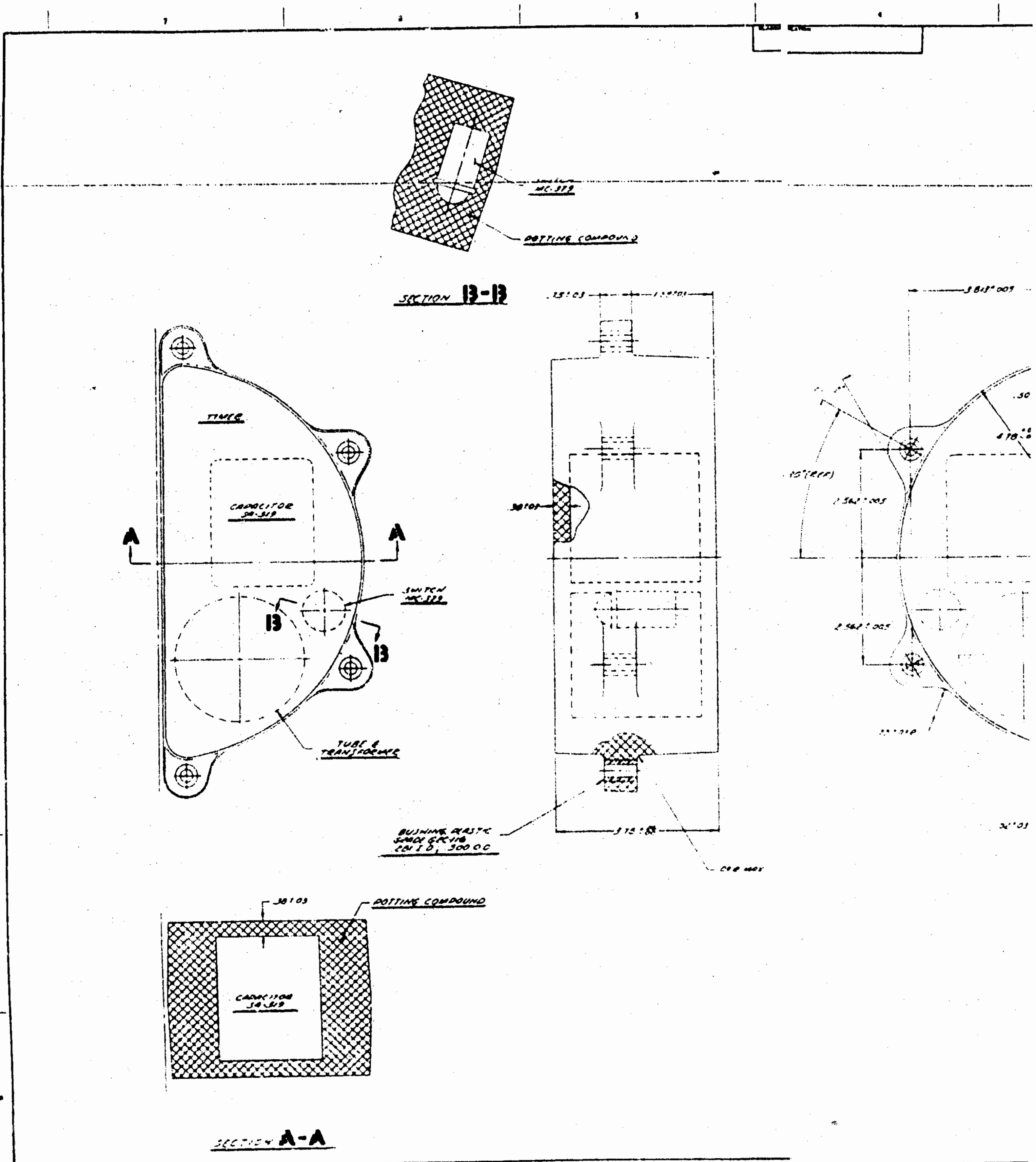
UNCLASSIFIED





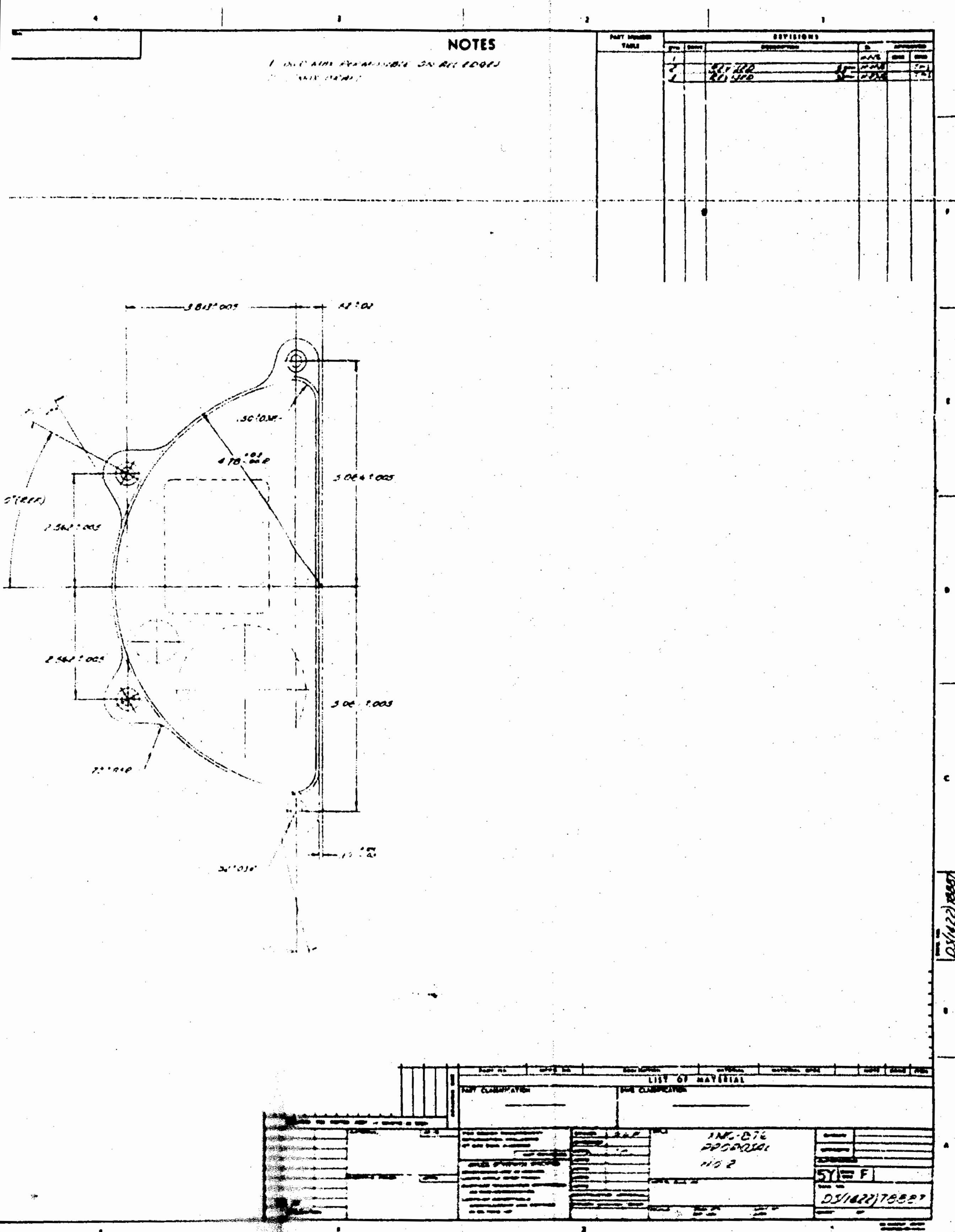
UNCLASSIFIED

UNCLASSIFIED



000674

Ref. Sym: 7223 (380)



UNCLASSIFIED

STATUS OF DEVELOPMENT

Neutron Source Tube

DOE b(3)

[redacted] They are 1-1/4 inches OD x 1-3/4 inches long and 1 inch OD and 1-3/4 inches long. Research on size requirements is being studied at UCRL (Berkeley) and at GEXR. The General Electric X-Ray Department is required to furnish breadboard units in April 1957, and will develop a suitable tube and unit for these applications.

A PIG is not desirable and efforts will be directed to removing it from the tube. The initial tube models do not use PIG's.

One transformer of the size required for these applications has been tested in oil. Considerable development of this part is necessary.

The timer circuit shown in Figure 2 has been built in breadboard form and has been tested. Preliminary data from HE experts have been found indicating that the probable accuracy of the HE timer is acceptable.

A modified SA-519 capacitor is planned for use as the energy-storage capacitor. Power supplies for use at 28 volts DC are being developed in Divisions 1469 and 1472.

A high-current, low trigger voltage cold-cathode tube is being developed in 1450. The tube is also being ruggedized to withstand high accelerations.

DOE b(3)

POSSIBLE FUTURE SYSTEMS

On a considerably longer time scale, a system which does not require a separate power supply may be practical. Possible systems are shown in

Figure 8. Here again a pulsed neutron source tube is used but energy and time delay are obtained from high explosives. Energy is transduced to usable voltage and currents by $B_aT_iO_3$ or PZT crystals and ferroelectric materials. The system operation is initiated by either an X-unit detonator or the explosive in the HE space chamber. Also possible, but more in the future, would be a system in which the HE shown in Figure 8 is the HE in the nuclear system.) DOE b(3)

They should be quite small, perhaps so small as 20 cubic inches for a unit. In addition, increased reliability due to decreased complexity might permit the use of a single unit in the weapons.

CONCLUSIONS

Since the time scales involved in systems such as XW-35, etc., are short, it is necessary that existing technology be capitalized upon to as great an extent as possible. Any of the systems proposed in some detail in this report require some development but the system shown in Figure 2 perhaps changes the developed art the least amount and presents at least reasonably small size and sufficiently high reliability possibilities. On the other hand, if radiation problems ruin the diodes in the proposed electronic timers, the explosive time delay system in Figure 4 may be the only usable solution. Its advantages make its use desirable but this system requires more development than the two systems using electronic timers. Subsequent to a good understanding for the radiation problem, it appears advisable to exert considerable effort on the explosive time delay system as a backup to an electronic timer.

The size of Zipper units shall be further decreased, but the proposed sizes look promising for use in near-future applications--11- to 12-inch weapons.

DOE b(3)

FIG. 8 PROPOSED XR CIRCUITS

DOE b(3)

[redacted]. The major problems in size will be related to dielectric strength of materials to protect the circuits from voltage breakdown since the tube should be developed toward a one-shot capability. This would lower the tritium in the tube to an extremely small amount so that the PIG may not be necessary. Tube efficiency should also be increased by lowering secondary emission from the target.

B. J. CARR - 1423

Case No. 755.00
April 12, 1957