AD 654577

Investigations Concerning Feasibility of Various Designs for a Blast Closure Device

Prepared for

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Department of the Navy
on
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INTRODUCTION

This report presents the results of studies conducted on various designs for a blast-closure device under contract NBy-13030. The final design (see Drawing SF-3200 attached hereto) has evolved from investigations covering the principal configurations - the rectangular sliding closure, rectangular vertical-lift closure, wedge-type closure, and valve-type closure.

CLOSURE CONFIGURATIONS

Rectangular Sliding Closure

This design (Figure 1) requires a housing built into the wall or ceiling. It is constructed of steel plate 1/2 inch thick with structural members welded diagonally to afford the strength required to withstand a suddenly applied load of 50 psi resulting from a nuclear explosion. Estimated weight of the structure is approximately 330 pounds. Closure is accomplished by an air cylinder operating a lever arm to slide the door in place. It locks during positive and negative pressure phases by cam positioning.

Principal objections to this design are weight of steel plate, installation cost, long stroke required of cylinder, difficulty of protection against elements, and large number of moving parts.

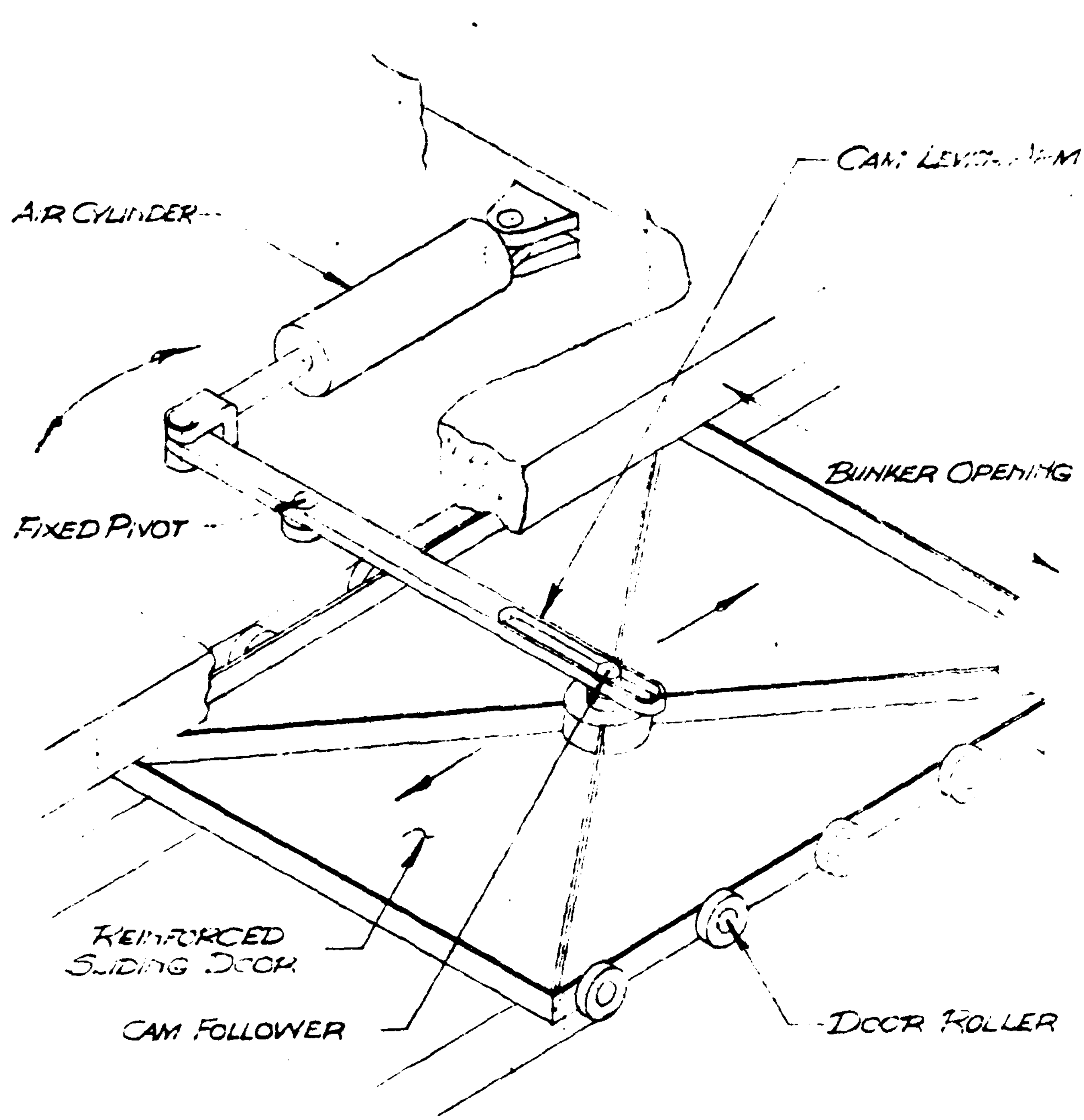


FIG. 1
RECTANGULAR SLIDING CLOSURE

Rectangular Vertical-Lift Closure

This design calls for a fabrication very similar to that employed in the sliding closure except that closure in this case is accomplished by downward motion (Figure 2). The device is actuated by air cylinders acting upon linkage. Again, the fabrication would weigh approximately 330 pounds.

Principal objections to this design are weight, number of moving parts, and additional complications and cost resulting from use of two air cylinders.

Wedge-Type Closure

The wedge-type closure (Figure 3) is a steel fabrication. The design requires a steel or reinforced concrete housing. Consideration of this design indicates not only a costly fabrication but a serious weight problem for the structure in which the closure is mounted. Although originally this device seemed worthy of study, it was set aside in view of these serious drawbacks.

Valve-Type Closure

Next, a valve-type closure was investigated. Head configurations were considered from the standpoint of preventing buildup of damaging pressures resulting from a nuclear explosion.

Figure 4 shows a device utilizing a hemispherical head. So that it can withstand a suddenly applied load of 50 psi, the head is fabricated from 0.437 inch steel plate. A hemisphere of the required proportions weighs

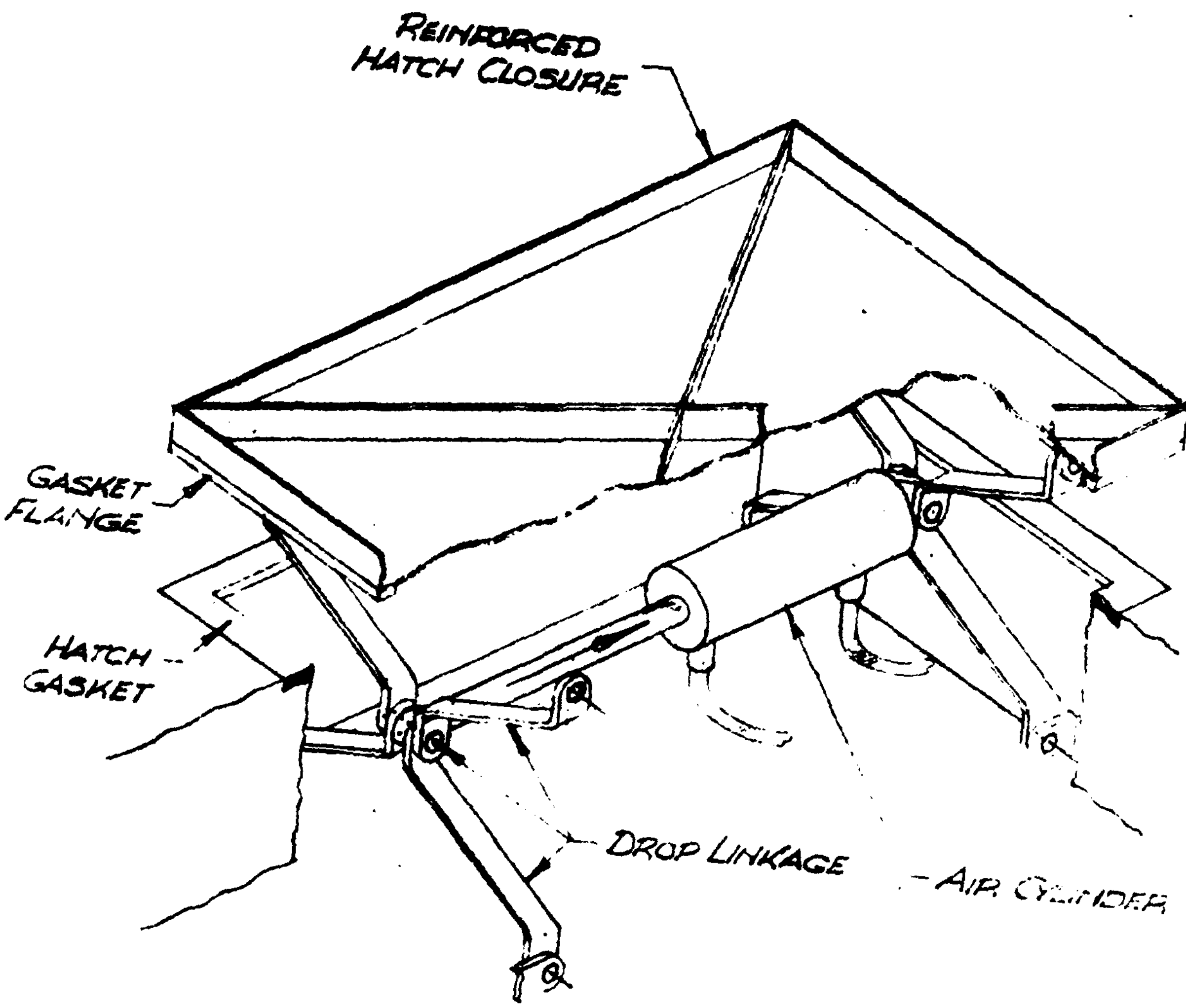


FIG. 2
RECTANGULAR VERTICAL-LIFT CLOSURE

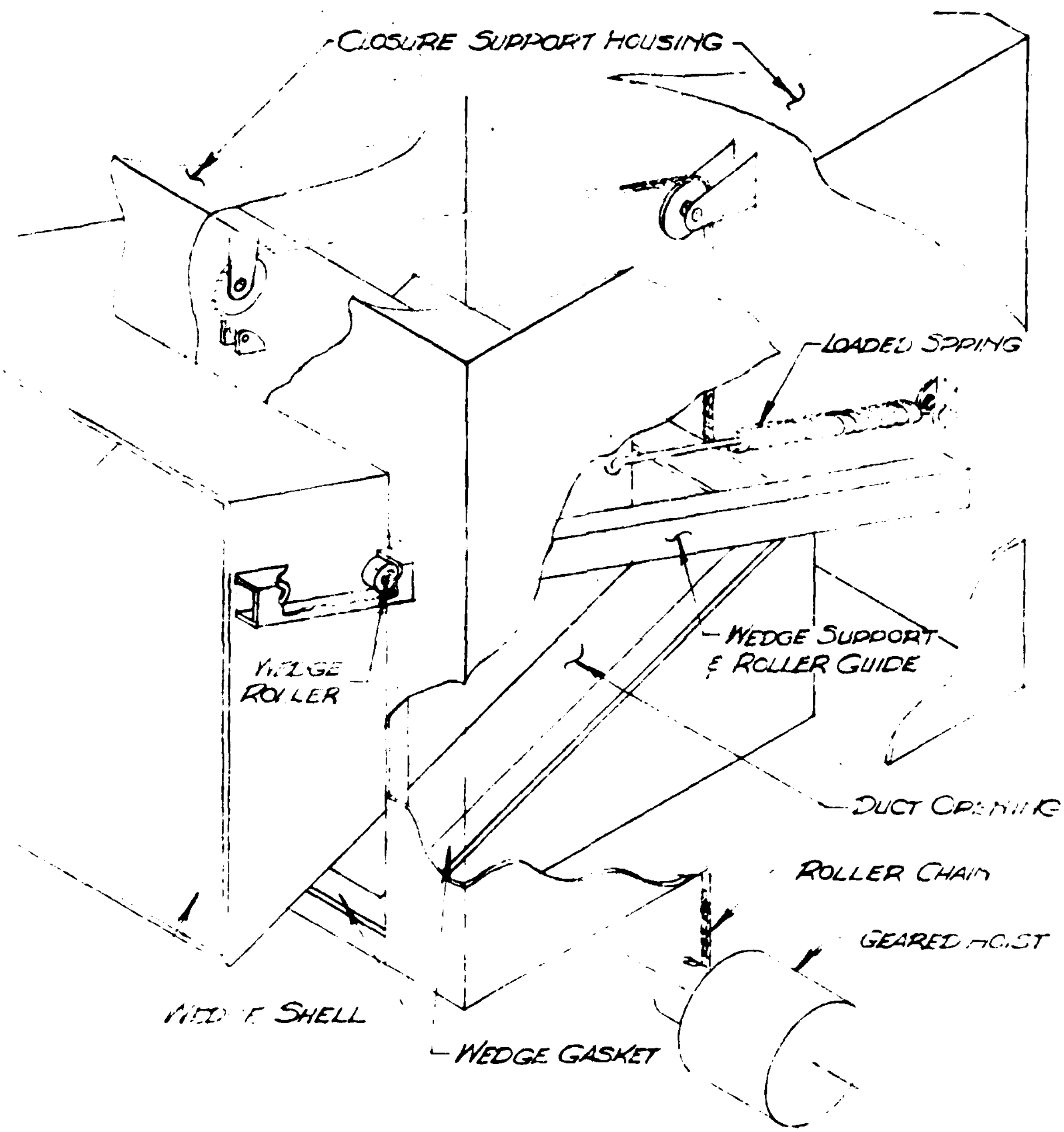


FIG. 3
WEDGE TYPE CLOSURE

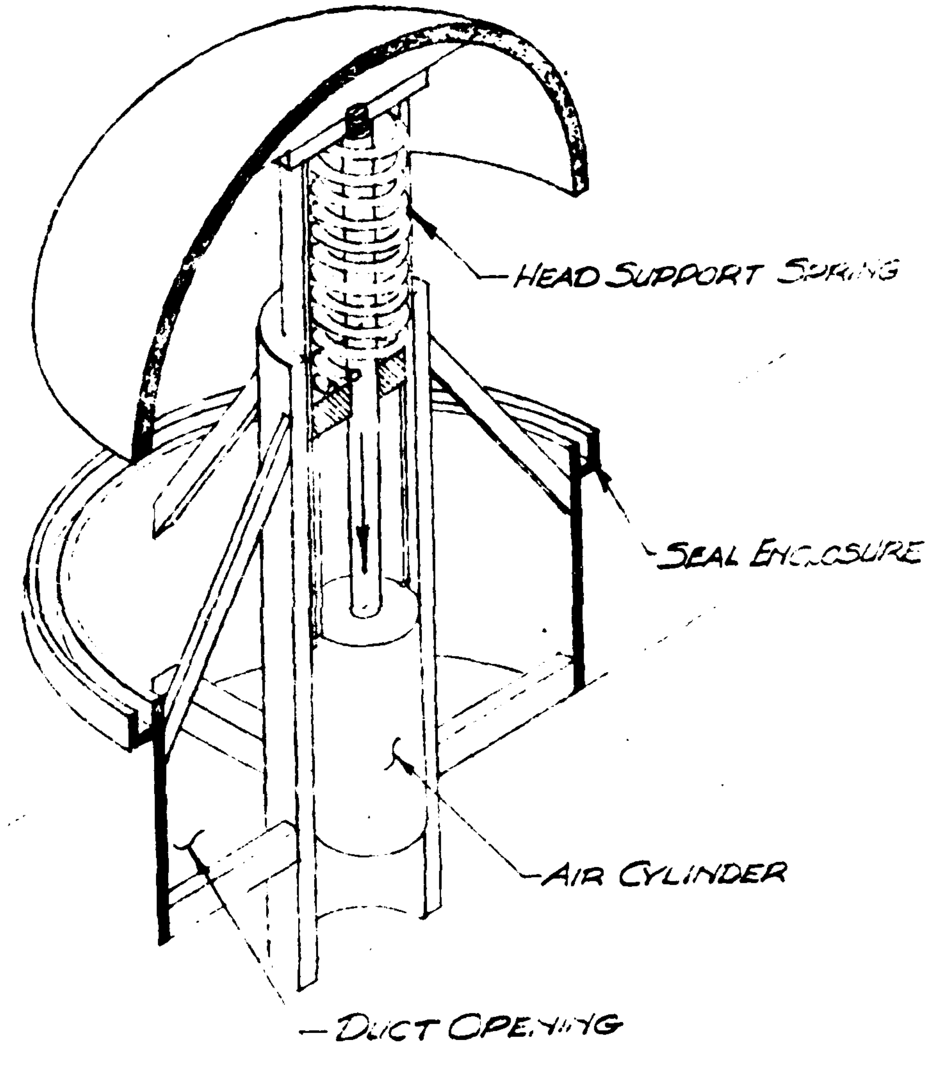


FIG. 4
VALVE TYPE CLOSURE - HEMISPHERICAL HEAD

approximately 346 pounds. With a head of this particular geometry, the air cylinder would have to stroke a distance of 15 inches in order to effect an open area of 1300 square inches as required by the specification. Two serious shortcomings are apparent with the hemispherical shape. First, positioning of the air cylinder far into the head causes an overhung bearing load which could not be tolerated in a horizontal installation. Second, the height of the head into the blast wave would be approximately 27 inches which would permit considerable unnecessary side loading. Moreover, the weight of the head is 346 pounds, with total weight approximately 900 pounds, and the actuator mounting is excessively complicated.

The difficulties inherent in the hemispherical shape led to our investigating a torisphere fabricated from 1/4 inch steel plate with welded-in ribs to afford additional stiffening (Figure 5). This shape is ideal except for its extreme weight (approximately 550 pounds). The great weight not only complicates closure but makes a problem for the spring-return system. Aluminum then was considered because of its light weight. It was decided that holding the required tolerances in an aluminum weldment would increase production costs unreasonably. The torispherical head was therefore designed as an aluminum casting and this was considered the optimum choice for the final design.

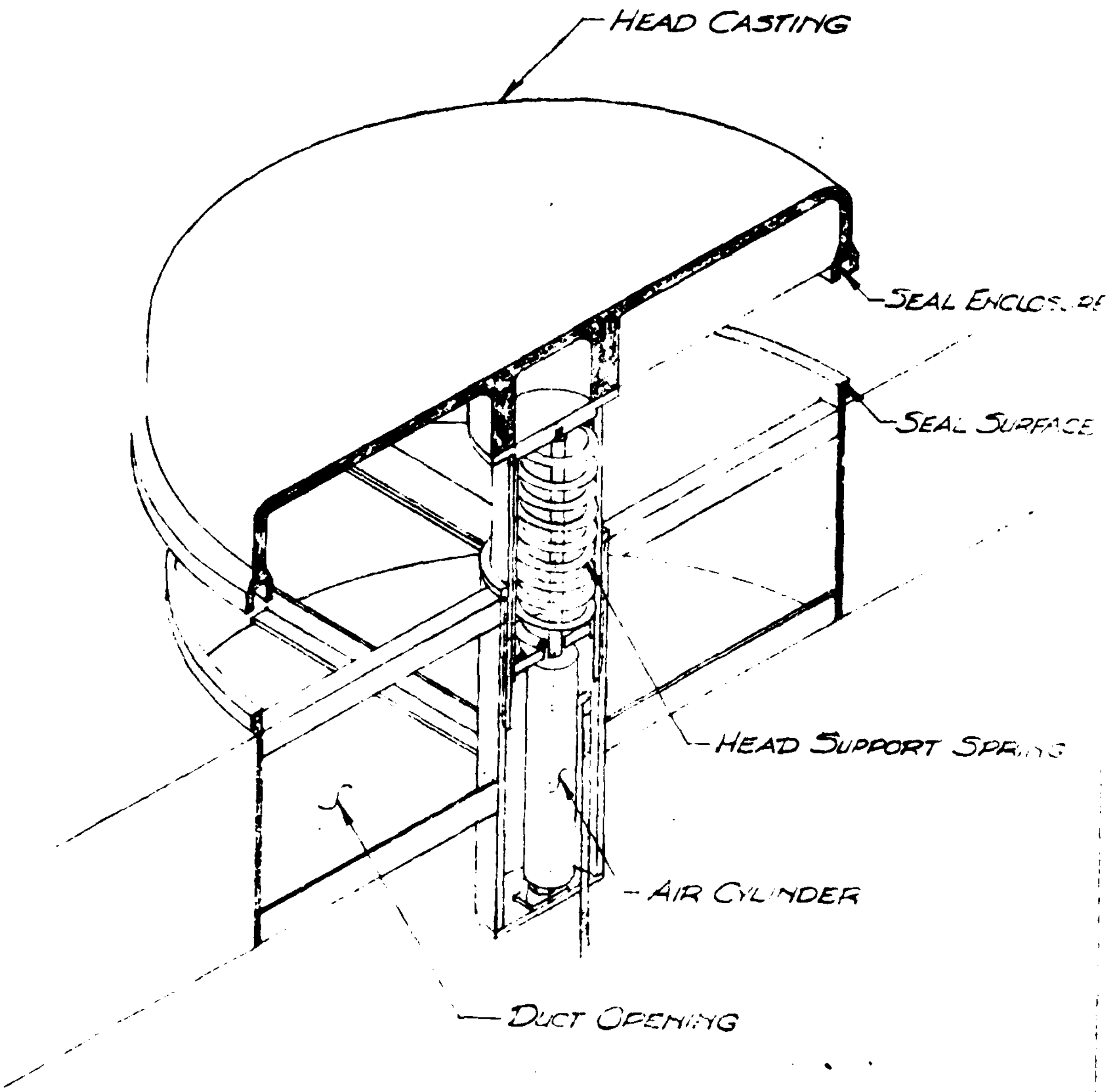


FIG. 5
VALVE TYPE CLOSURE - TORISPHERICAL HEAD

FINAL DESIGN

The cast aluminum head is 49.125 inches in diameter, 7 inches high, and is reinforced with radial and circumferential ribs. The radial ribs originate at an 11 inch hub in the center of the casting. An O-ring groove is machined into the cover to afford seal under the pressures specified. The total weight of the head is about 265 pounds.

A chromium plated slide tube and flange is bolted to the hub in the center of the casting. The slide tube acts within a bronze sleeve bearing. Antirotation keyways keep the parts properly oriented.

The mounting tube is of 1/4 inch rolled and welded steel plate and has four locking brackets on the inside wall. A sealing seat is brazed to the top edge of the tube, and the bolting flange is welded around the tube's outside circumference. This flange facilitates attaching the closure to the wall or ceiling of the structure. The entire assembly can be installed in a wall or ceiling by cutting a 48 inch diameter hole, inserting the mounting tube, and bolting down the flanged sealing ring.

OPERATION

The device is actuated by a signal from any one of several photocells located to receive light energy from a nuclear explosion. The photocell signal fires a squib in an explosive valve connected to a compressed-gas storage bottle. Releasing the stored energy in the compressed gas actuates a pneumatic cylinder connected to the closure bonnet and pulls the bonnet tight against its O-ring gasket to provide sealing against the positive and negative pressure phases of the blast wave. When the bonnet has reached its closed position, four spring-loaded latches engage striker pins on the bonnet and lock it closed until a later manual release is accomplished.

Pneumatic Circuitry

Drawing SC 1342 (which accompanies this report) shows an arrangement of the pneumatic components. For the operation of our prototype closure device, only one compressed-gas storage bottle and one actuating cylinder are shown. But this pneumatic circuit is well suited to paralleling of its components in a network for the operation of a number of closures installed in a single shelter or in a group of shelters.

Design of the components allows charging of the gas bottle and operation of the system using either compressed air or a compressed inert gas, such as argon or nitrogen. The choice of working fluid is optional, with air being readily available and least expensive and other gases providing an additional measure of protection against possible corrosion or chemical reaction with oil or other contaminants which may be present in the lines. Any gas used should be thoroughly processed and dry to prevent admission of moisture into the system.

A pressure guage is provided and installed to indicate pressure of compressed gas in the storage bottle. It is contemplated that for an active installation periodic inspection requirements will be established at which inspection guage readings of all closure devices would be logged and corrective maintenance accomplished as necessary. In addition, a pressure switch will be piped to the gas bottle and calibrated to produce a signal if the gas pressure drops below a previously established threshold level. This signal could be utilized to flash a warning light at a remote control center or even to shut the closure serviced by the faulty gas bottle by means of a standby auxiliary gas bottle. This bottle and the associated pneumatic and electric circuit items are not included with the prototype closure device but are mentioned here as variations which might be desirable in a field installation.

A manual valve and inlet pipe connection facilitate charging of the gas bottle. This same inlet connection and valve can be used to operate the closure device from an outside pressure source.

A manual bypass valve is installed in parallel with the explosive valve. This valve allows operation of the device manually, without firing the explosive valve, and can be utilized for emergency manual closing of the device and also for routine inspections to check the operation of the equipment. Note that it is necessary to recharge the air bottle after opening this valve.

Flow-control valves are provided with the prototype and can be adjusted to control operating speed of the cylinder. When optimum cylinder speed has been established, production models of the closure device would be equipped with fixed-area restrictions in place of the flow-control valves.

A four-way valve is provided to allow the reverse flow of gas required to extend the cylinder and open the closure. Rotating this valve handle will bleed gas out of the actuating cylinder and at the same time will admit gas to the auxiliary cylinder, thus releasing the spring-loaded latch pins and allowing the closure device to reopen.

The gas bottle, explosive valve, manual valves, etc., will be mounted in a steel enclosure to form a package installation. This pneumatic package will be suitable for wall mounting in an accessible area near the closure device and will be arranged for connection to the device with steel pipe or tubing.

Electrical Circuits

Utilization of light energy from a bomb explosion was determined to be the most desirable method of providing a signal for automatic closure of blast doors. In order that the alarm system be self-sufficient and not dependent on outside electric power, the detection system should include a power source. Two methods of accomplishing this have been evaluated.

One of these systems would convert light energy directly into electrical energy and would allow operation of the closures without drawing on any stored energy source. Hardware items perfected to a high degree of reliability and suitable for such a system are available commercially. This system comprises an explosive valve, requiring only 30,000 ergs input for detonation, and one or more photovoltaic cells with rated output in excess of the valve requirements. The cell, which should be located in an enclosure to shield it from direct sunlight, may receive illumination directly or through lucite light pipes. Enough light transmitters and cell assemblies are required to provide 360-degree coverage in azimuth. Because this system has considerable sensitivity, it is necessary to interpose filter elements to minimize the possibility of erroneous operation from other light sources such as lightning, automobile headlights, reflected sunlight, etc.

Test results with a somewhat similar detection device indicate that a Wratten 89b photographic-type filter will be effective in that it will pass a large percentage of radiant energy exceeding 700 millimicrons in wavelength and will absorb energy of lesser wavelength (see report No. WT 1112, Operation Teapot, Project 6.1.1b, by Armed Forces Special Weapons Project). This near-infrared region (0.75 to 1.00 micron wavelength), although not representing the highest intensity range of the bomb burst emission spectrum, is a fortunate choice in that it minimizes the effects of atmospheric absorption and also is less sensitive to accidental firing from lightning or other light sources.

Another method of minimizing accidental firing is to utilize a circuit containing a capacitor which discharges a large pulsed signal when an energy pulse is generated in the photocells by the sudden intense thermal radiation emitted by a bomb explosion but which does not discharge under steady-state conditions resulting from energy conversion of normal sunlight and usual artificial illumination sources. This circuit arrangement, illustrated in Figure 6a, will be tried out on the prototype device. This system would provide a simpler sensor device, one which would be less susceptible to bomb damage and easier and less expensive to replace.

The foregoing system has been selected as most suitable for an isolated installation having but one opening to be closed, such as an instrument blockhouse or a machinery building.

A second possible system utilizes the signal from the light-sensitive cell to release sufficient stored energy to operate one or many explosive valves (Figure 6b). This has an immediate appeal because a signal from any one of a group of photocells can be used to button up all the enclosures in a large installation and because this system is readily adaptable for central station pushbutton control of all closures, which would be useful in the event that warning of impending attack has been received. This system would be selected for multiple installations such as civil defense shelters, military command posts, etc., where there would be a large number of vent openings to be closed.

ELECTRICAL DIAG

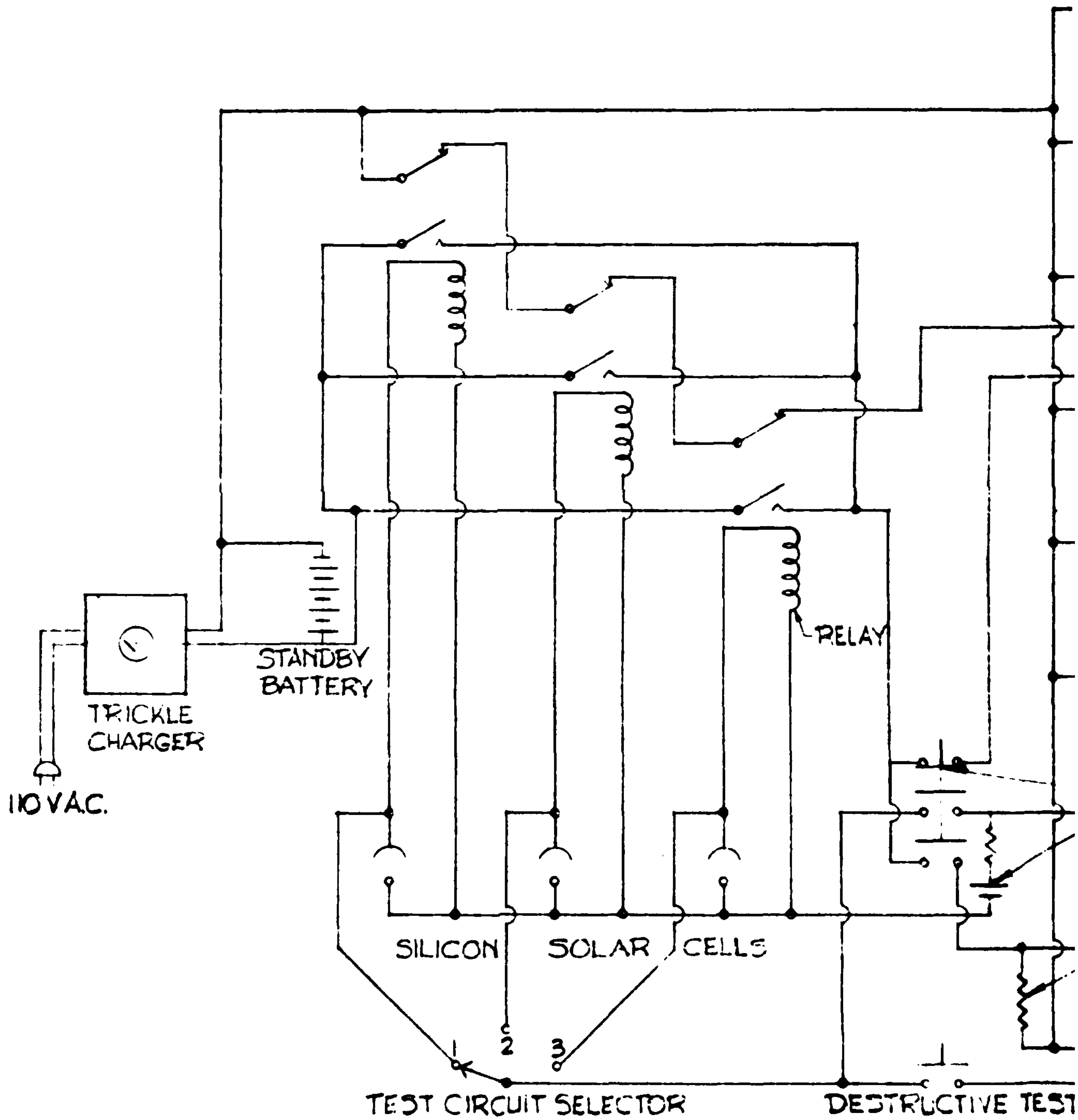
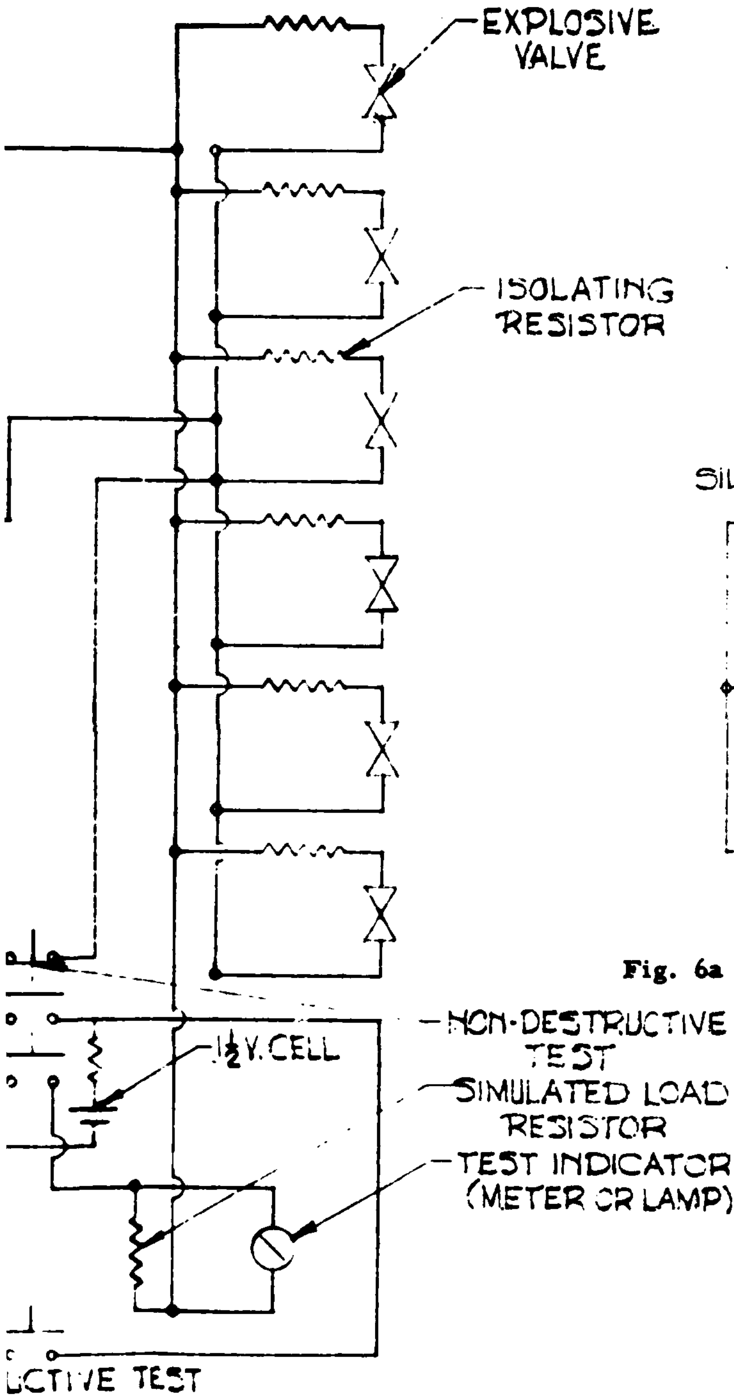


Fig. 6b MULTIPLE CIRCUIT

A

ICAL DIAGRAM



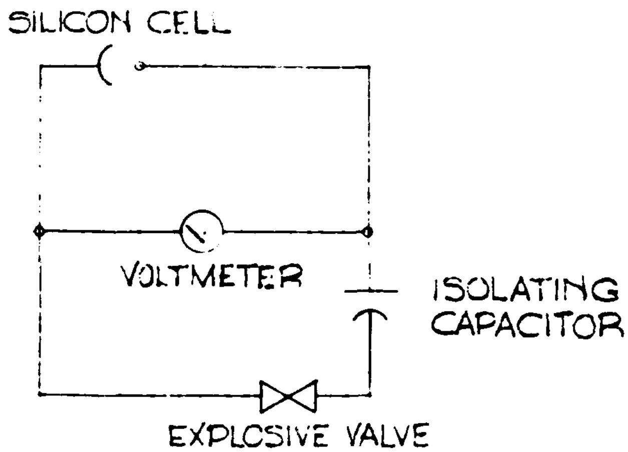


Fig. 6a SINGLE CIRCUIT

The obvious method of providing this action is to utilize a storage battery which discharges to the explosive valve through a relay triggered on signal from the photocell. In locations where frequent inspection discipline is to be maintained, a system using dry cell batteries could be depended upon because the short shelf life of the batteries would be offset by their ready availability and frequent inspection and replacement. For less accessable locations, we recommend the installation of wet cell storage batteries with a trickle charge system powered by the normal electric supply and arranged to monitor the charge as required. This does not violate the requirement that the enclosure devices be independent of normally available power since any sudden power interruption would find the batteries fully charged and ready for an emergency.

The use of a sealed relay and the practice of deliberately operating the relay at intervals will insure a high degree of reliability on the part of this component. Reliability is further increased by the recommended installation procedure, whereby several parallel connections of photocell, relay, and battery circuits can be made; with this arrangement failure of any one component will not prevent normal functioning of the equipment.

SUMMARY OF DESIGN FEATURES

The over-all design includes many features which contribute to the safety and reliability of the device. These include:

(1) Aluminum closure bonnet for light weight of moving parts and reflection of thermal radiation.

(2) The device can be installed either vertically or horizontally.

(3) Materials of construction have been selected to minimize effects of rust, dirt, and corrosion.

(4) Moving parts and linkages have been kept to a minimum.

(5) Electric and pneumatic systems are simple, with minimum number of components.

(6) Self-contained energy source, with no dependence on building electric service.

(7) Provision of simultaneous operation of a group of closure devices from any one of a group of sensor elements.

(8) Sensor elements provided with filters to minimize possibility of triggering on false signal.

(9) Use of explosive valves which can be manifolded to increase reliability.

(10) Use of sensor elements, batteries, and relays which can be paralleled to increase reliability.

(11) Gauge and pressure switch to indicate condition of gas storage bottle.

(12) Provision for limit switch to signal closed condition of closure device.

(13) Provision for simultaneous manually controlled operation of all closures in a group by a pushbutton switch.

SUMMARY OF DESIGN FEATURES (Con't)

(14) Provision for simultaneous automatic operation of all closures in a group by means of interconnection of sensor devices.

(15) Provision for manual operation of individual closure devices by means of manual bypass valves.

(16) Provision for emergency manual operation of individual devices by means of connecting auxiliary pressure source.

(17) Provision for manual closing of individual devices by connection to draw rings.

(18) Self-locking latches to hold down closure during negative phase of blast wave.

(19) Closure device remains latched until manual adjustment of 4-way valve relieves gas pressure on main cylinder and strokes small cylinder to release the latch pins.

(20) Latch pins can be disengaged manually if required.

(21) Basic design allows scaling size of device up or down to suit special closure problems.

(22) Basic design is capable of modification to provide dual function as emergency escape hatch.

(23) Actuation circuitry is flexible to suit various installation requirements.

Production Cost Estimate

Blast Closure Device - NBy 13030

	1 unit	50 units	100 units	250 units
Direct Material				
Purchased Parts	$ 984.10	$ 29,108.00	$ 55,381.25	$132,426.50
Subcontracted Items	1,806.00	74,188.50	145,290.00	360,777.50
Other (raw materials)	152.00			
Direct Manufacturing Labor	232.50	7,500.00	15,000.00	37,500.00
Overhead @ 100%	232.50	7,500.00	15,000.00	37,500.00
Subtotal	$3,407.01	$118,296.50	$230,671.25	$568.204.00
General & Administrative Expenses - 11%	374.78	13,012.62	25,373.84	62,502.44
Subtotal	$3,781.88	$131,309.12	$256,045.09	$630,706.44
Profit - 10%	378.19	13,130.91	25,604.51	63,070.64
Total Selling Price Excluding Tooling	$4,160.07	$144,440.03	$281,649.60	$693,777.08
Special Tooling Cost		8,081.50	8,081.50	8,081.50
Total Price Including Tooling	$4,160.07	$152,521.53	$289,731.10	$701,858.58
Unit Tooling Cost		$ 161.63	$ 80.82	$ 32.33
Unit Price Including Tooling		$ 3,050.43	$ 2,897.31	$ 2,807.43