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# OAK RIDGE NATIONAL LABORATORY SAMPLER FOR THE TAMALPAIS UNDERGROUND NUCLEAR DETONATION EXPERIMENT

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U.S. ATOMIC ENERGY COMMISSION

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Department of Commerce
Washington 25, D.C.

ORNL-2881

Contract No. W-7405-eng-26

CHEMICAL TECHNOLOGY DIVISION

Process Design Section

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Date Issued

JUL 14 1960

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## ABSTRACT

A sampler was designed and fabricated at ORNL and installed at the AEC Nevada Proving Ground. The sampler incorporated explosion-operated valves and special features for fast removal of the samples. Samples were drawn at predetermined time intervals of the gaseous products of an underground atomic device explosion on Oct. 8, 1958.

CONTENTS

## 1.0 INTRODUCTION

This report describes a sampler which was designed and fabricated at ORNL and was installed by ORNL at the AEC Nevada Proving Ground.

On October 8 an atomic device of 72 tons TNT equivalent energy yield was shot at a depth of 330 ft within a mesa at the AEC Nevada Proving Ground. One purpose of the shot, designated the Tamalpais Event of Operation Hardtack Phase II, was to investigate an isotope-producing shot in a salt medium. A 2-ft thickness of mined rock salt lined the walls of the room that contained the device. This work, part of the ORNL MICE program, was done in cooperation with the University of California Radiation Laboratory.

The technical work at ORNL and also at the Nevada Proving Ground reported here was done by B. F. Bottenfield and J. W. Landry of the Chemical Technology Division and M. J. Kelly of the Instrumentation and Controls Division. J. W. Woody of the Instrumentation and Controls Division assisted in the design and fabrication of the timer.

## 2.0 SAMPLING

The Tamalpais sampler arrangement is sketched in Fig. 1. An evacuated pipe passed from the device room through the ambient rock to a sampling room located about 125 ft from the device room. Tracer materials were incorporated in the device and in capsules near the pipe inlet. The arrangement of the capsules is sketched in Fig. 2.

Samples of the underground detonation products were obtained in the form of particles, filterable dust, and gaseous matter. Six gaseous samples, of eight attempted, were obtained in a predetermined time sequence which, with respect to the time of device detonation, was as follows:

One sample starting at zero and ending at 0.01 sec.
One sample starting at zero and ending at 0.11 sec.
Two samples starting at 0.10 sec and ending at 0.11 sec.
One sample starting at 1.0 sec and ending at 1.1 sec.
One sample starting at 10 sec and ending at 11 sec.

In addition to these sequenced samples, two accumulative samples of the gaseous matter were obtained starting at zero and continuing indefinitely.

The particle, filter, and accumulative-gas samples were obtained by the University of California Radiation Laboratory. The sequenced samples were obtained by ORNL.

The equipment for obtaining the samples consisted of the sampling pipe, a cone-and-filter box, an accumulative sampler, a sequenced sampler, and a timer for the sequenced sampler. The first three items were supplied by UCRL; the last two were supplied by ORNL. An assembly sketch and a photograph of the sampling equipment are shown in Figs. 3 and 4.

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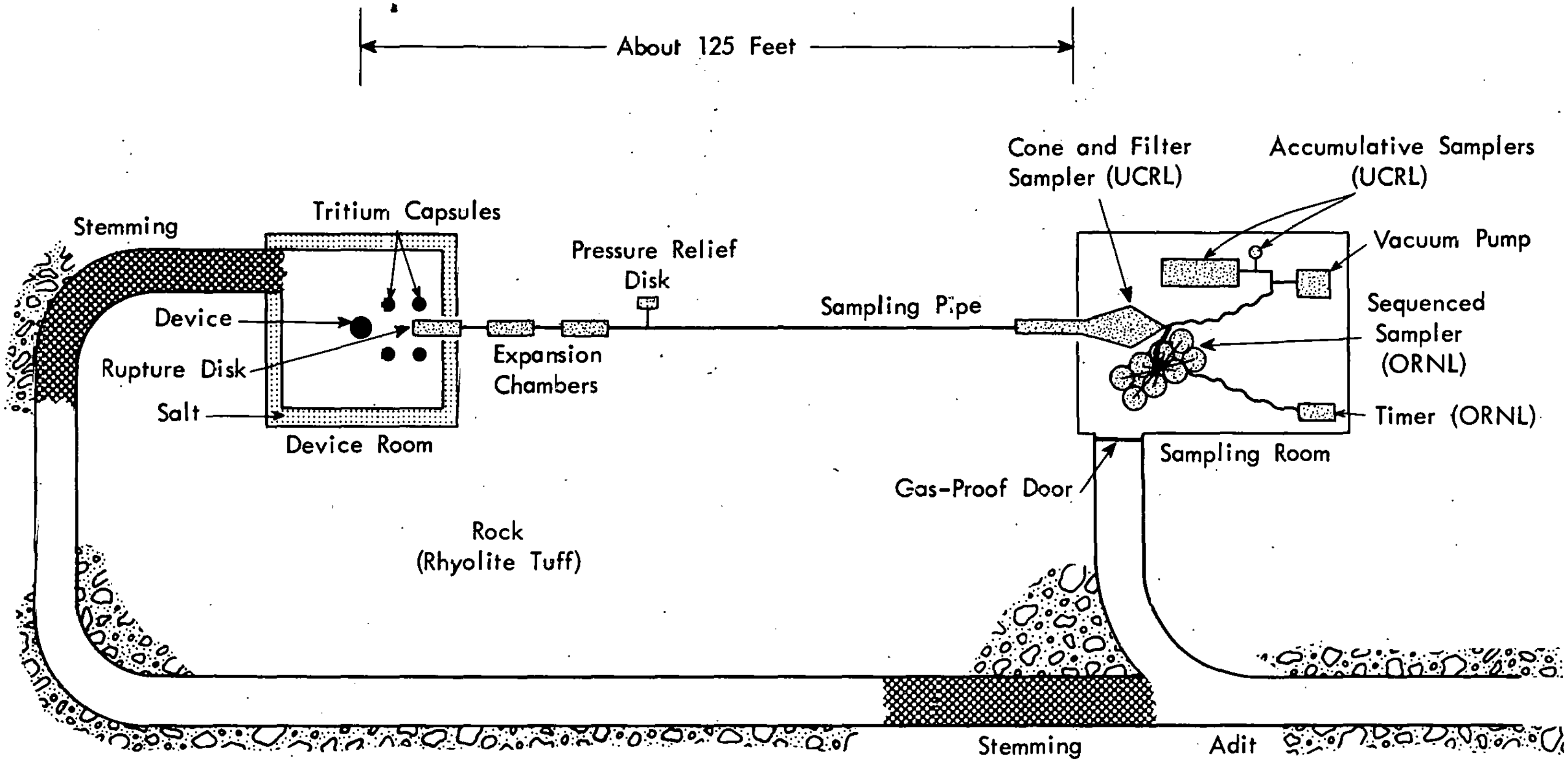


Fig. 1. Plan view of Tamalpais sampling arrangement.

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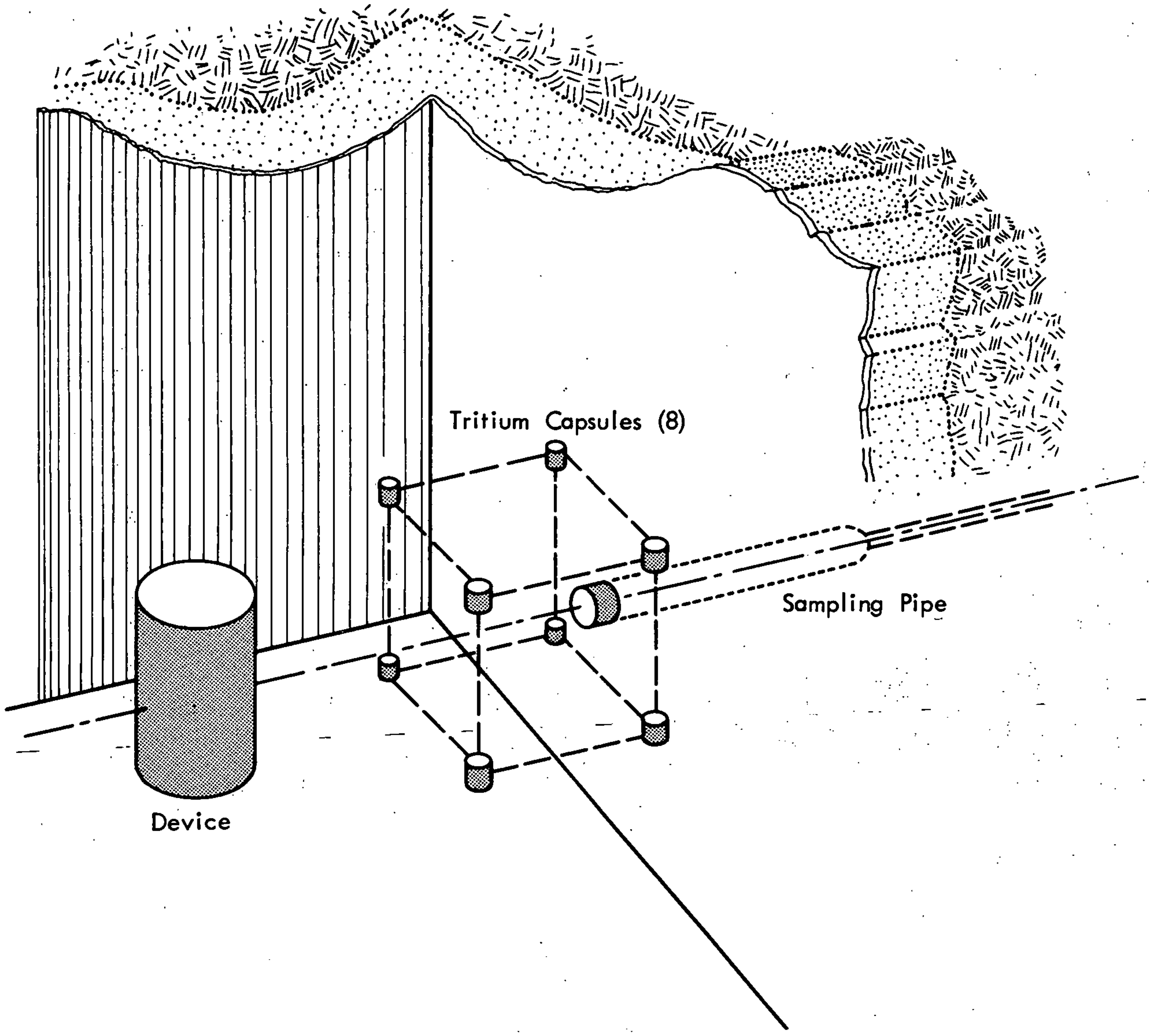


Fig. 2. Tritium capsule arrangement.

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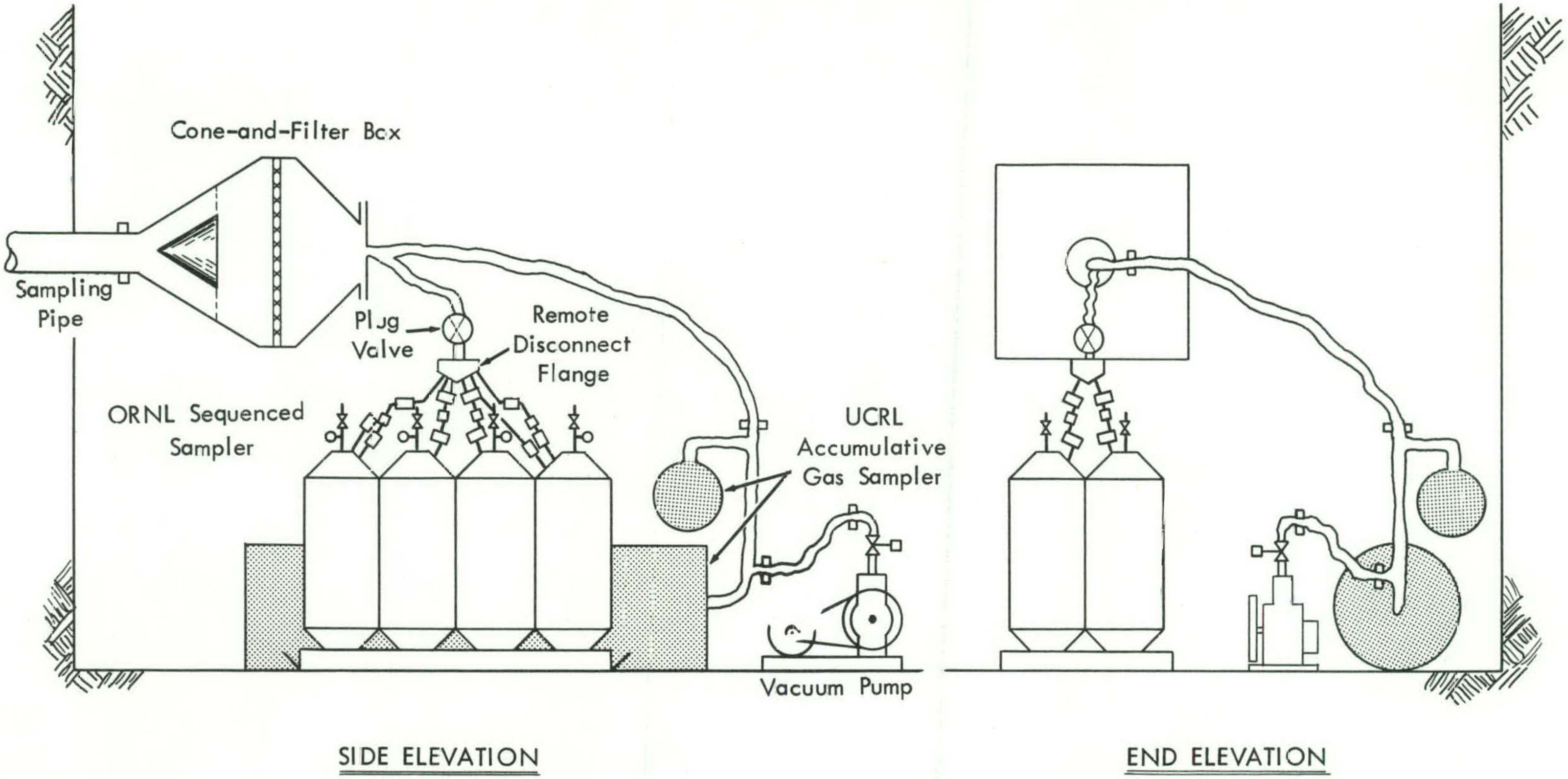


Fig. 3. Assembly for Tamalpais sampling equipment. (Timer is not shown.)


Fig. 4. Tamalpais sampling equipment.

The sample material was conducted from the device to the sampler through a 1-in. schedule 40 pipe with two expansion chambers, made of 6-in. schedule 40 pipe, near the pipe inlet and one similar expansion chamber at the pipe outlet. The pipe inlet was closed with a rupture disk so that the entire sampler could be evacuated prior to the detonation. Detonation effects opened the rupture disk and admitted sample material into the pipe. The expansion chambers controlled the shock effects, and another rupture disk located on a tee in the sampling pipe beyond the first two expansion chambers limited the maximum gas pressure of the sample material to 1 atm gauge pressure. The pipe assembly was grouted with concrete in the ambient rock.

At the sampling room the outlet of the sampling pipe was connected to a box that contained a graphite cone and a filter. Some particles from the detonation passed through the pipe at high velocity and impregnated the graphite cone whose apex was directed into the outlet of the pipe. Lower velocity particles were carried in the gas stream. These were deflected around the graphite cone and impregnated the filter.

Filtered gaseous material flowed from the cone-and-filter box through flexible lines into (1) two metal vessels, one a cylinder of about 3 cu ft capacity and the other a sphere of about 1 cu ft capacity, and (2) the ORNL sequenced sampler. Flexible lines were used because about 6 in. of recoil motion was expected in the sampler equipment after the detonation. The entire sampler was evacuated prior to the detonation by means of a vacuum pump that was connected near the accumulative sampling vessels. The pump operated until 1 sec before detonation, at which time the pump was shut off and the pump connection was closed by a solenoid-actuated valve.

## 3.0 SEQUENCED SAMPLER

The sequenced sampler consisted of eight vessels with valves to start and stop the admission of samples to the vessels. The valves were explosion-operated and were specially assembled dual units manufactured by Conax Corporation of Buffalo, N. Y. The sampler was connected to the cone-and-filter box by a remote disconnect flange, plug valve, and flexible line. Quick-disconnect unions were provided at each of the eight vessels. The special flange and unions were provided for fast removal of, first, the sequenced sampler and, later, the individual sampling vessels. The fast removal was necessary because radioactivity up to 50 r/hr was expected in the sampling room after detonation.

### 3.1 Remote Disconnect Flange

The remote disconnect flange (Fig. 5) connected the sequenced sampler to the cone-and-filter box and timer and distributed sample material to eight lines that led to eight sample admission valves. Connection was made by three explosion-operated latch pins, which could be actuated to disconnect the flange from a distance by impressing a 6-volt potential across the latch pin leads with a hand battery and preinstalled access wires. For maximum reliability, each latch pin used two explosive squibs, either of which alone could operate the latch pin.

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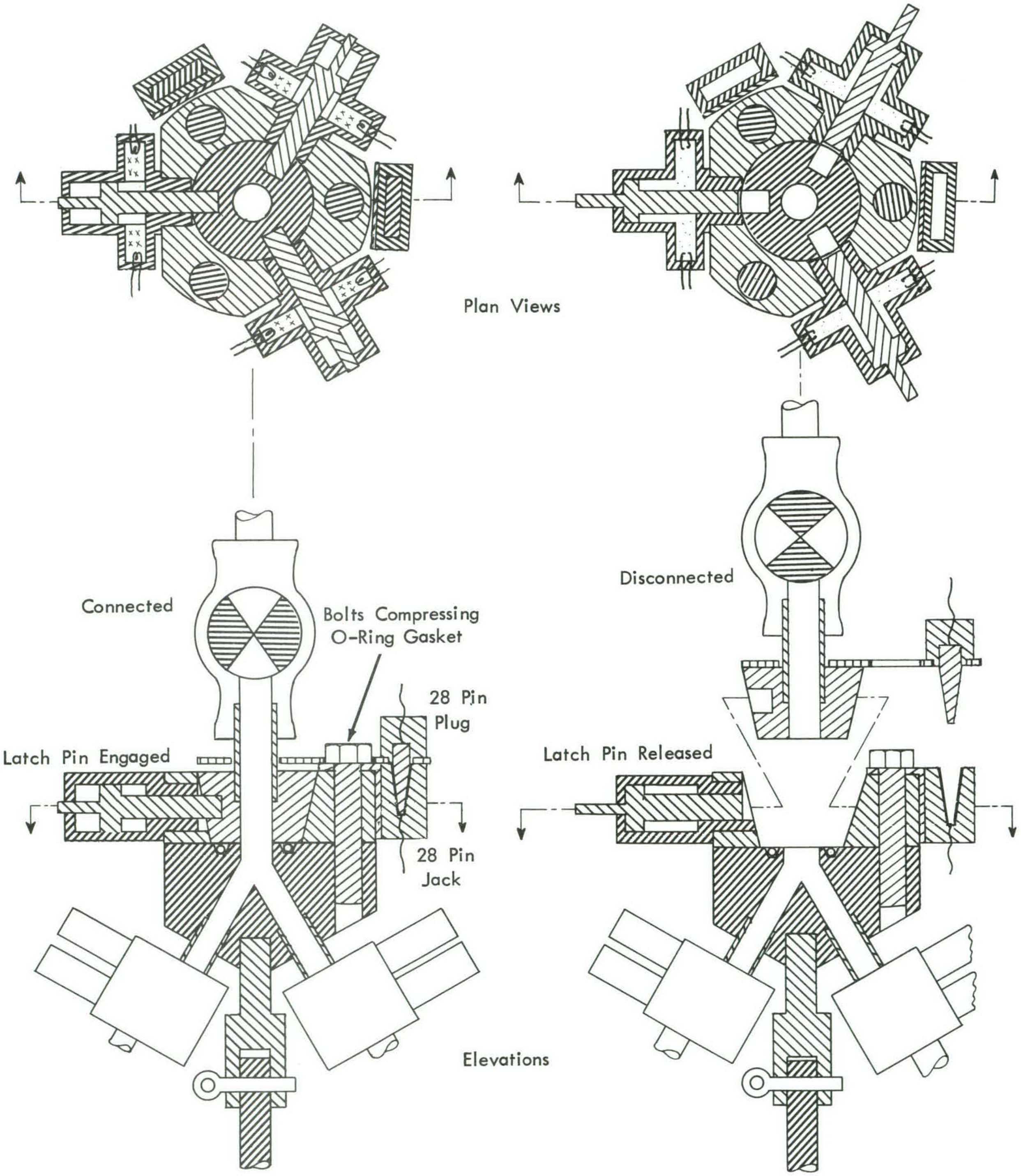


Fig. 5. Operation of remote disconnect flange.

3.2 Explosion-operated Valves

A total of 28 explosion-operated valves (Fig. 6) were installed in the sequenced sampler. These were divided into two groups: admission valves and shut-off valves. Each valve was actuated by discharging a condenser through a triggering filament contained in an explosive squib. The resulting squib explosion operated the valve. Fifty microseconds was required from the time of actuation to the completion of operation. The admission valves were normally closed valves and each operated to open by firing a punch that opened a hole for the samples to pass through. Since the valving element was made of metal that was integral with the metal valve body, it presented absolute zero leakage to the evacuated sampler. The shut-off valves were normally open valves, and each operated to close by firing a plug that closed a hole to the passage of the sample. The plug was fired with sufficient force to practically weld the plug to the seat and thus presented essentially zero leakage to the sample. These valves were all single-use valves.

The valves were dual units (Fig. 7) with two admission valves in parallel per unit or two shut-off valves in series per unit. The two valves in each unit were actuated by two independent timers. If there had been a failure in one of the two channels of timers and valves (there were one timer and fourteen valves per channel), the remaining channel would have been sufficient to secure the samples. In addition to increasing the operational reliability of the sampler, the dual valves increased the flow capacity of the admission valves and increased the leak resistance of the shut-off valves. The admission valves were made of aluminum alloy and saw very brief sampling service (1 sec or less). The shut-off valves had to contain the samples in the sample vessels for an indefinite time (weeks) and were made of stainless steel. The equivalent orifice size of the valves was 9/32 in. dia. Four of the samples were to be drawn in only 0.11 sec or less. Therefore, the valve lines were made as short and direct as possible (Figs. 7 and 8). In a test the sequenced sampler sampled 20 cc of air STP in 0.01 sec with a sample vessel at 40 μ Hg pressure initially and the inlet of the sequenced sampler at 29.4 in. Hg pressure. These pressures corresponded to those estimated for the detonation. It was estimated that the maximum pressure in the cone-and-filter box after detonation would be between 1 and 2 atm gauge.

3.3 Quick-disconnect Unions

The individual sample vessels were connected to the sampler assembly by eight special unions (Figs. 7 and 8) that could be manually disconnected in 1 sec each. Clips were made for operating the unions and locking them in the released position. The unions were located on the shut-off valves. After the eight unions were locked in the released position, the piping assembly could be lifted in a single operation from the eight sampling vessels.

3.4 Sampling Vessels

The eight sampling vessels had a capacity of 1 cu ft each and were made of stainless steel. Each was equipped with a vacuum gauge and with a capped valve for withdrawing the sample. The sampling vessels are shown in Fig. 9. The vessels, unions, valves, flange, and piping were satisfactorily leakfree, as determined by helium leak tests at ORNL.

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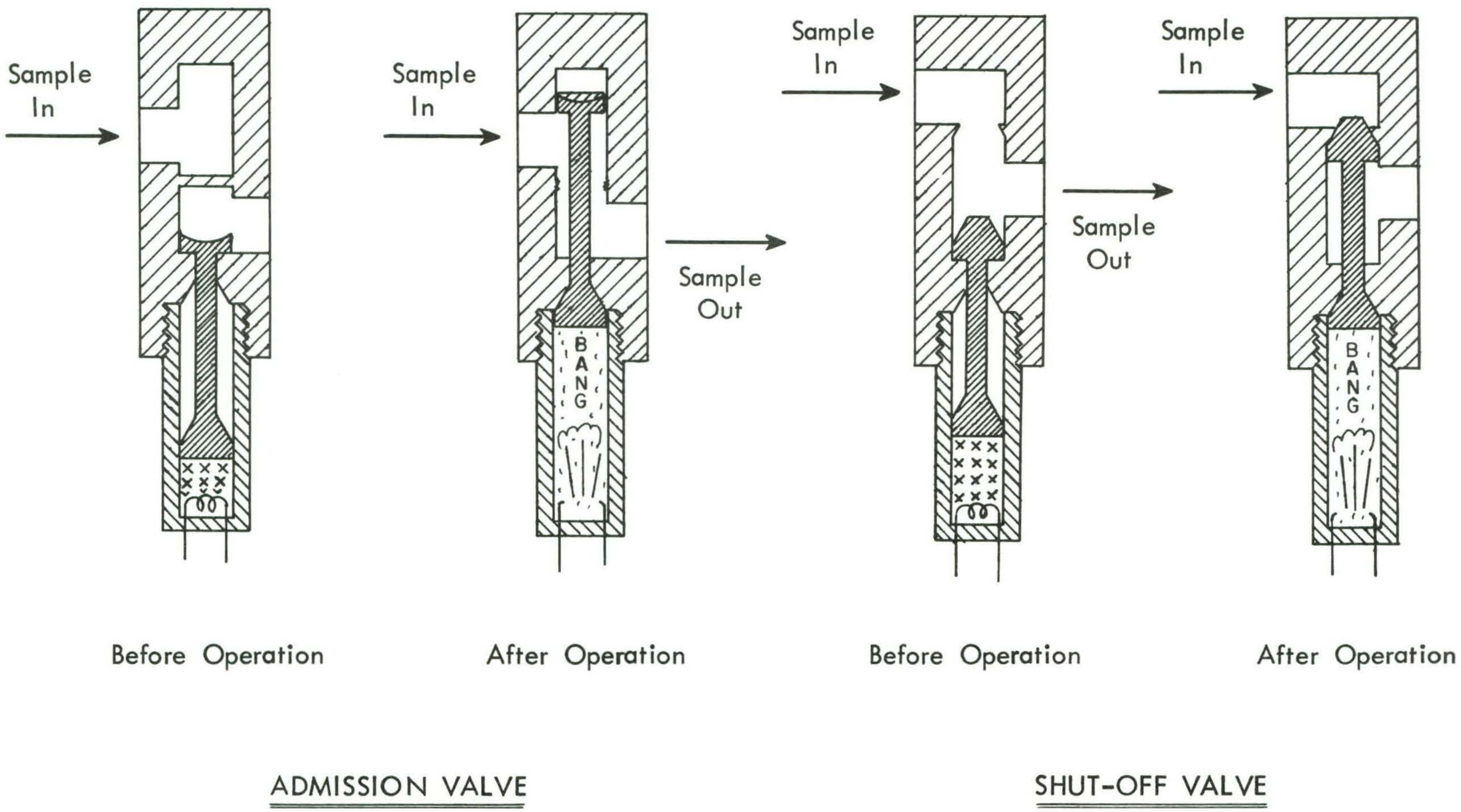


Fig. 6. Operation of explosion-operated valves.

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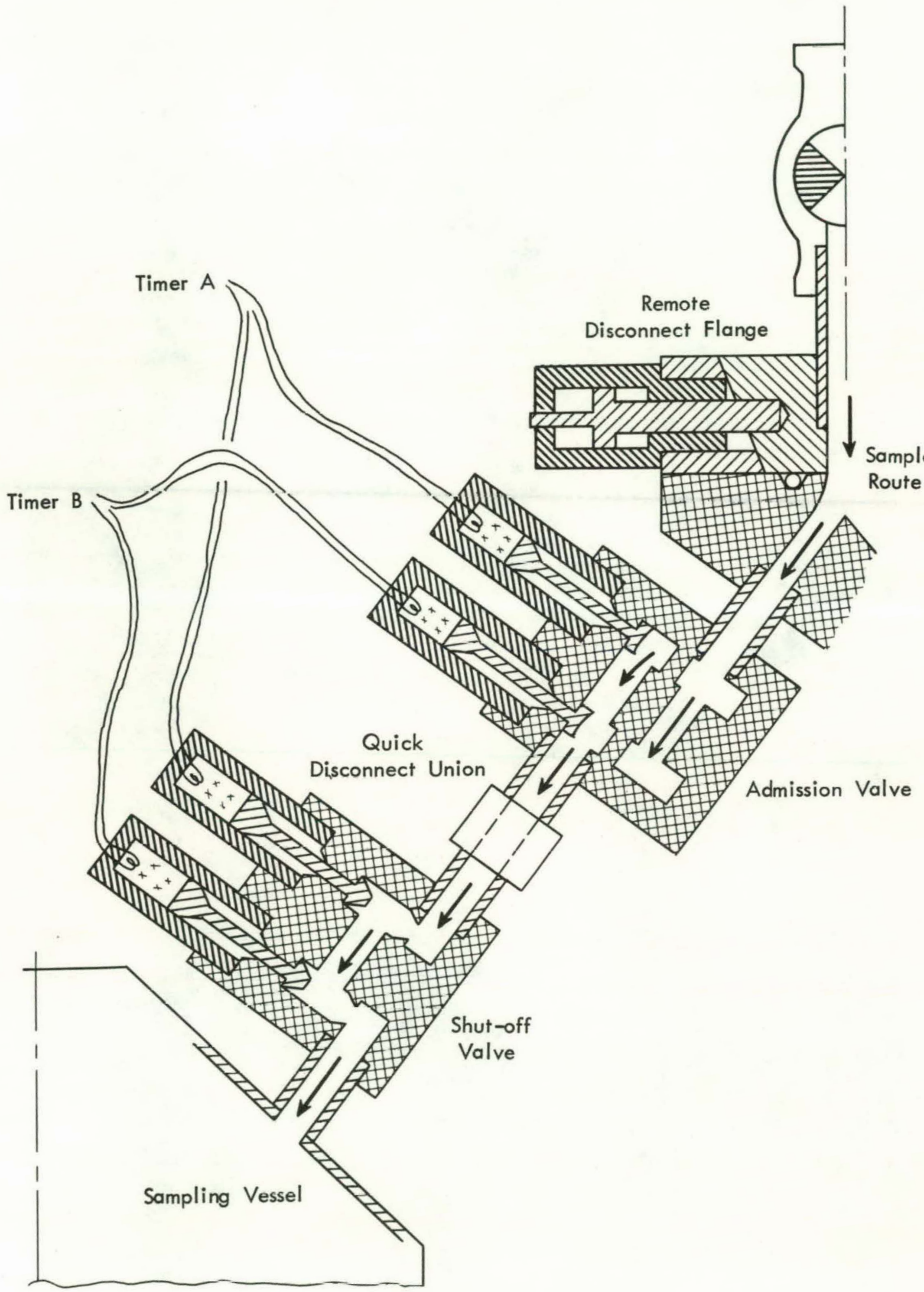


Fig. 7. Dual channel valve arrangement.

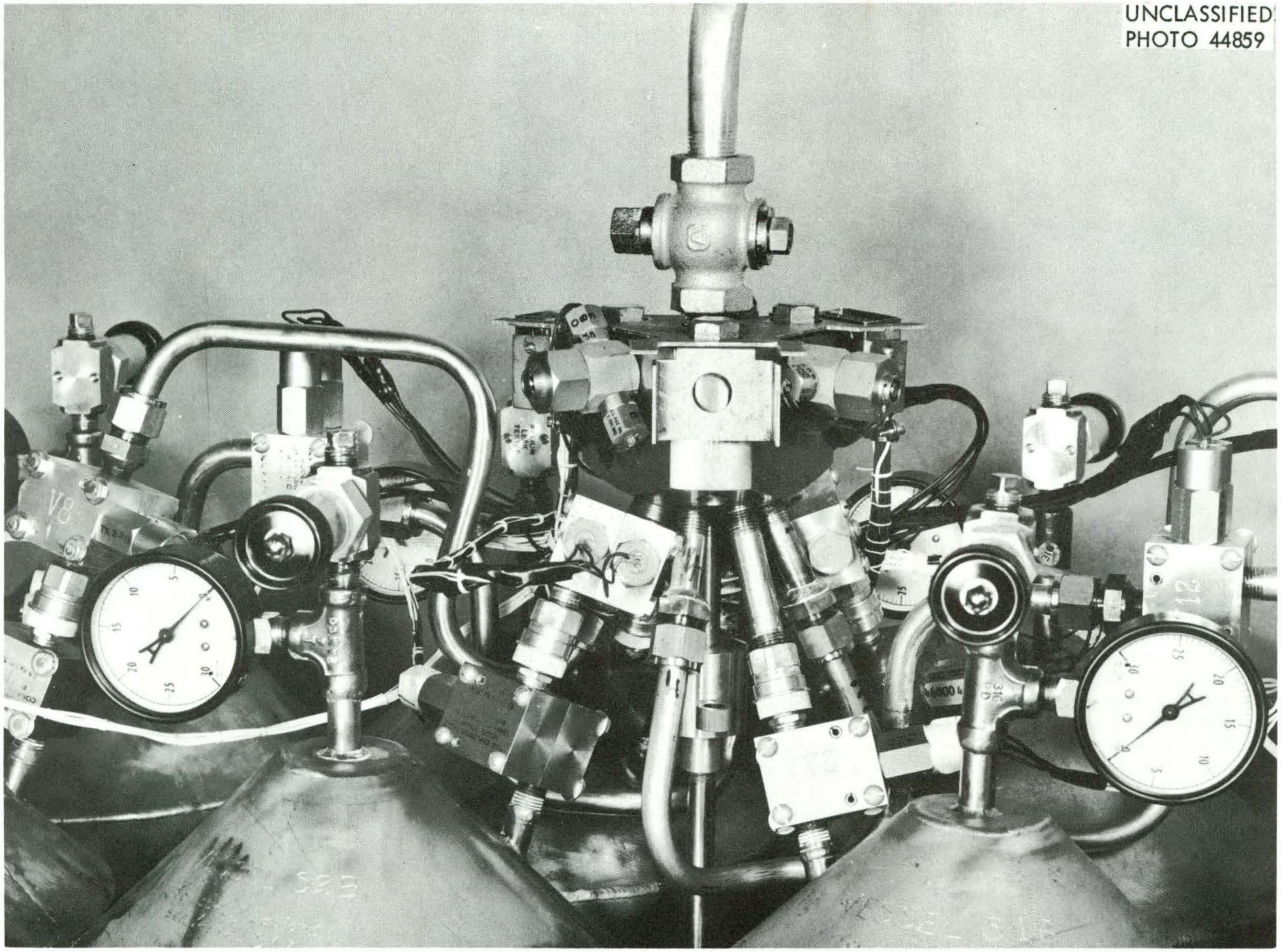


Fig. 8. Disconnect flange, unions, and valves for ORNL sequenced sampler.

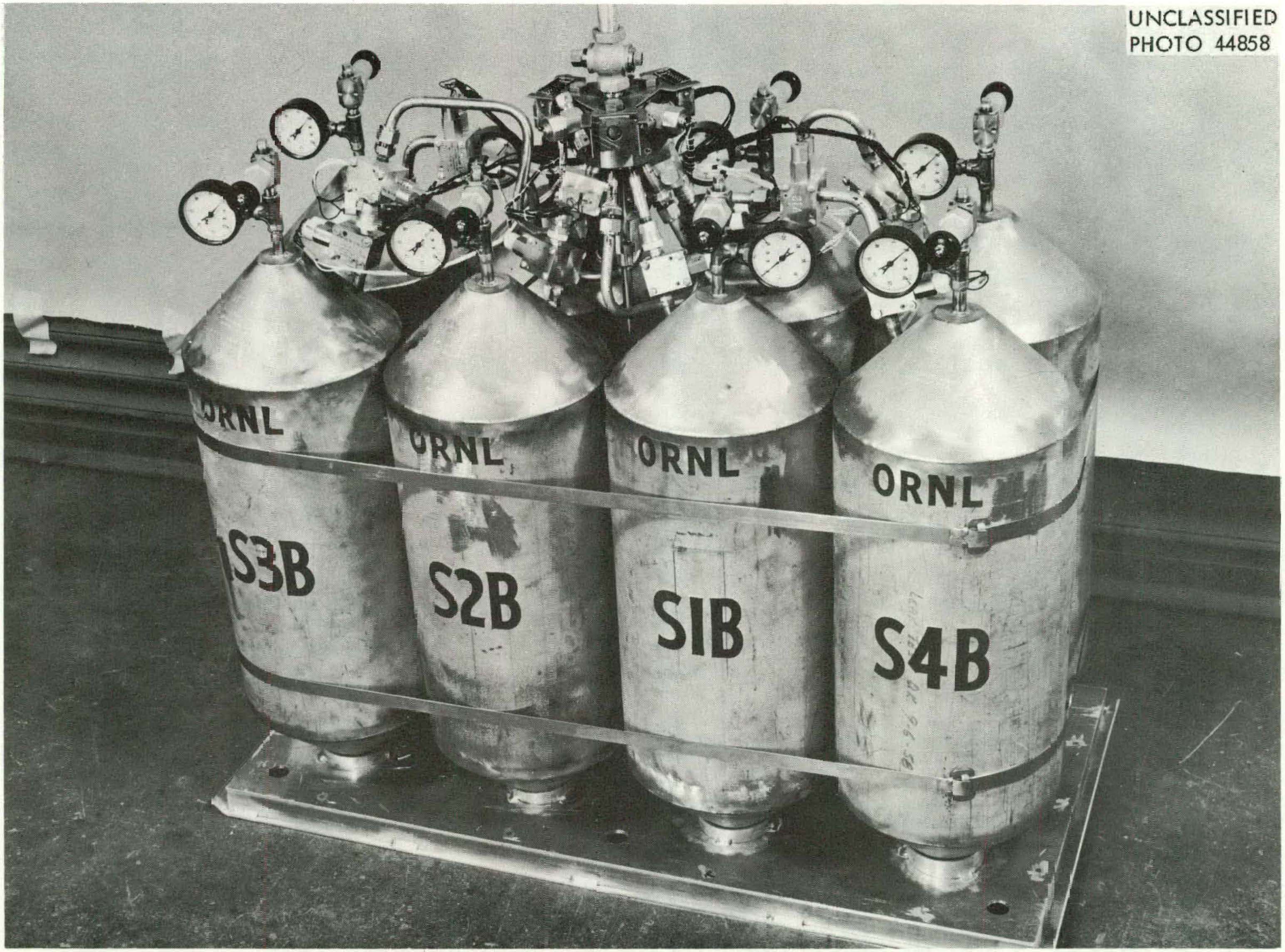


Fig. 9. Sampling vessels for ORNL sequenced sampler.

## 3.5 Timer

An electronic timer (at left in Fig. 4) distributed power to the explosive valves according to the predetermined time sequence stated above. The timer consisted of two completely independent channels for independently actuating each of the two valves in the fourteen dual-valve units. Basically, each channel consisted of a 1000-cycle/sec oscillator that operated a scaler, which operated thyratrons that discharged a condenser to the valve triggers. The oscillator was placed in operation before the device was detonated. The flash of the detonating device operated a photodiode to initiate the zero time signal designated "zero fiducial." The zero fiducial operated a triple diode (6 BC 7 tube) in each timer channel which triggered a flip-flop (6211 tube). The flip-flop gated the oscillator to operate the scaler circuit, which contained five glow-transfer tube decade scaling stages. A 1 kc/sec multivibrator (5844 tube) was included to shape the oscillator pulses for accurate scaler operation. The stages were arranged so that the first stage indicated each individual cycle, i.e., indicated each 0.001 sec, the second stage each 0.01 sec, the third stage each 0.1 sec, the fourth stage each second, and the fifth stage the passing of 10 sec from the time the zero fiducial was received. According to the predetermined time sequence, timed pulses were gated from the scaler by five gating tubes (four 5844 and one 6AL5). The timed pulses actuated fourteen thyratrons (2D21 tubes), which switched the necessary power to fire the fourteen valves connected with the respective timer channel. Each of the two independent valve-firing power supplies consisted of a 2000-μf condenser with bridge rectifier using silicon diodes. The shock-susceptible components, such as the tubes, of the timers were carried on separate rubber-mounted chassis. The cabinet that contained the timers was supported on a foam rubber pad for additional protection from shock damage. Fourteen neon indicators on the front panel of each timer channel provided a visual check on the continuity of each valve circuit. The timer operated on 115-volt 60-cycle a-c power, which was available in the sampling room until detonation time. At that time two holding relays switched the two timer channels to two independent battery-operated 115-volt power supplies.

## 3.6 Post-shot Recovery Procedure

The sequenced sampler was designed so that the following procedure could be used in recovering the samples after the door to the sampling room had been opened and the radiation safety survey had been completed; the sampler points concerned were colored to conform with the procedure:

1. Close the plug valve.

2. Fire the latch pins.

3. Move the sampler to the room door.

4. Sever the eight red wires.

5. Release the eight (yellow) disconnects.

6. Remove the (green) support pin.

7. Cut the two bands.

8. Lift out the top piping assembly.

The sampling vessels are now separate from all connections and ready for shipment to the analytical laboratory at Livermore. The following equipment was supplied for this procedure: a vise-grip pliers affixed to the plug valve shaft for fast operation, a battery for firing the latch pins via wires (preinstalled) from the door of the sampling room, two 10-ft tongs for pulling the sampler to the door, wire cutters, a pin removal handle, and sheet metal snips. The sequenced sampler was mounted on a sled for easy movement.

3.7 Field Installation

The rubber-mounted chassis of the timer vibrated during shipment of the sampler to the Nevada Proving Ground. Some of the wiring connections were fatigued and repair was required. Suspected solder connections were resoldered.

The sequenced sampler was equipped with a 36-in. length of 1/2-in.-i.d. rubber vacuum hose to make flexible connection with the cone-and-filter box. This was replaced, by field forces, with metal braided hose so as to be uniform with other hose connections in the sampling room. The sequenced sampler was designed to collect eight samples in the following sequence:

Two samples starting at zero and ending at 0.01 sec.
Two samples starting at 0.10 sec and ending at 0.11 sec.
Two samples starting at 1.0 sec and ending at 1.1 sec.
Two samples starting at 10 sec and ending at 11 sec.

Two days before detonation time the estimate was revised for the time that the sample material would arrive at the sequenced sampler. These estimates indicated that there was a possibility that the first sample material would not arrive until sometime between 0.01 and 0.1 sec. It was believed that the two sample vessels that were to sample between 0 and 0.01 sec might go empty, and the wiring was therefore changed so that one of these two sampling vessels collected a sample in the interval from 0 to 0.11 sec.

The regular 115-volt 60-cycle a-c power that was supplied by a system of diesel generators for the Tamalpais event was to be available up to 1 sec after detonation time. The sequenced sampler was designed so that holding relays would switch the timer to battery-operated power converters when the regular power failed. There was adequate persistence in the timer circuit to cover the interim switching period. Two batteries and two power converters were to be used in keeping with the independent dual channel philosophy of timers and valves. Two automotive storage batteries were obtained in Nevada. Due to a delay in the availability date, the two power converters were shipped directly from the supplier to the Nevada Proving Ground.

Notice was received at the proving ground that a hazard from explosive gas (carbon monoxide and hydrogen) was expected to occur after detonation and that the regular power would be shut off at zero-plus-one second to reduce the explosion hazard.

The sequenced sampler was equipped with a test accessory in which the valve trigger filaments were simulated with small lamp filaments (GE No. 49 lamps). In trial runs it was found that the test lamps were fired with the sampler operating on regular power but were not always fired with the sampler operating on the battery-converted power. The power converters were of the vibrator type, and it was concluded that hash in the wave-form was responsible for the difference in sampler operation. A single power converter of the motor-generator type was obtained at the proving ground. It produced a somewhat better wave-form than the vibrator type, and was therefore used to replace one of the vibrator type converters. No filters could be obtained in the time available. In further trial runs of the sampler spare valves were used, and it was found that both timer channels would not always fire the test lamps when operated with the power converters but would fire the spare valves satisfactorily.

## 4.0 RESULTS

Recovery of the samples and equipment was delayed for over two months. The explosive gas hazard prevented entry to the sampling room in the first two weeks following detonation. The proving ground schedule was accelerated to meet the October 31 ban on nuclear testing and the effects of subsequent neighboring detonations caused the further delay. The author had hoped to be present for the recovery of the samples and inspection of the equipment but left the proving ground a few hours after seeing one of the succeeding events breach the mesa near the location of the sampling room. The samples were recovered by UCRL personnel in late December.

Six of the sample vessels obtained samples as listed in Sect. 2.0. The quantities of sample obtained were reported as large. One of the 10-11 sec vessels obtained no sample; presumably, the admission valves failed to fire due to the power converter difficulty. One of the 1-1.1 sec samples was lost due to valve leakage during the two-month period before the sample vessel was recovered. The recovery party reported that the latch pins could not be fired.

Analyses of the samples and conclusions will be reported in a subsequent report.

The ORNL sequenced sampler was fabricated in Central Shops and the Instrument Department Shops. The cost complete, including parts, labor, and construction materials, was approximately $20,000. The timer has been returned to ORNL.

Photographs and circuit diagrams as follows are available which show further detail of the ORNL sequenced sampler:

| | |
|---|---|
| ORNL Photo 44852 | Power supply chassis, bottom |
| ORNL Photo 44853 | Power supply chassis, top |
| ORNL Photo 44854 | Timer chassis, top |
| ORNL Photo 44855 | Timer, back |
| ORNL Photo 44856 | Timer chassis, bottom |
| ORNL Photo 44857 | Timer, front |
| ORNL Photo 44858 | Vessel assembly, top |
| ORNL Photo 44860 | Vessel assembly and timer |

| | |
|---|---|
| ORNL Photo 44861 | Vessel assembly, front |
| ORNL Photo 44862 | Vessel assembly, back |
| ORNL Photo 44863 | Disconnect flange |
| ORNL-LR-Dwg. 46600 | Timer block diagram |
| ORNL-LR-Dwg. 46601 | Timer circuit diagram |

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