NAVY DEPARTMENT
DAVID TAYLOR MODEL BASIN
WASHINGTON, D.C.

A DEPTH CHARGE DIRECTION INDICATOR

Developed by

D. Bancroft and G.W. Cook

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1. A device has been developed at the David W. Taylor Model Basin to permit determination within a submerged submarine of the bearing of the source of an underwater shock wave. Operation of the instrument depends on the finite velocity of sound in water; a measurement of the time delay between signals received at two submerged microphones is an indication of the direction from which the sound comes. Accurate measurement of this time interval is accomplished by electronic means, and is greatly aided by the fact that the front of the sound wave sent out by an explosion presents an extremely rapid rise in pressure.

2. The device in its present form does not attempt to measure the time delay, but merely indicates which of four submerged microphones receives the impulse first. The microphones are located at the corners of a square; if the edges of the square run fore-and-aft and athwartships, respectively, it is clear that, whenever the starboard forward microphone receives the sound first, the source of sound lies somewhere between dead ahead and the starboard beam. To obtain a more accurate bearing, considerable refinement would be necessary, and much of the simplicity of the present apparatus would be sacrificed.

3. The "microphones" are merely circuit breakers designed to open a switch when struck by a shock wave, and are constructed as shown in Figure 1. Contact is made between the conical head of a

pin P and an inertia weight W; the latter is constrained to move parallel to the axis by a flexible spring support S. The pin is attached to the center of a thin diaphragm D. A sudden depression or inward movement of the diaphragm breaks the contact between P and W, as shown in Figure 2. However, slow depression of the diaphragm by a static load causes no change in the contact; the device is likewise insensitive to slow vibrations, unless they are extremely intense. The weight W is insulated from the casing, and is connected to the center lead of a shielded cable. The shield itself provides the return circuit and is connected to the microphone casing. In order to prevent damage by large hydrostatic pressures or overloads, the diaphragm is backed up by a thick plate B which is dished in the center to permit only elastic deformation of the diaphragm. The clearance is sufficient to permit actuation of the diaphragm at any operating depth of the submarine.

4. In the schematic wiring diagram, Figure 3, the microphones appear merely as switches, S_1, S_2, S_3, S_4. The opening of any switch results in the immediate ignition of a thyratron or gas-filled triode, four of which are provided, one for each switch. The circuit has been so designed that ignition of any thyratron inhibits the ignition of the other three, and no subsequent manipulation of the other three switches, S_1 to S_4, can either turn out the ignited thyratron, or turn on another. Neon bulbs in the plate circuits of the thyratrons furnish visible evidence as to which thyratron is conducting at any given instant; these neon bulbs are located on the panel of the instrument.

5. In order to sensitize the apparatus, i.e., to put out all the neon bulbs, a reset switch, S_5, of the push-button type is used.

The procedure for operation is simply to press the reset button, and release it. When the shock is received, one of the neon lights comes on and stays on. Subsequent shocks have no effect. If several explosions occur in rapid succession sufficiently fast to preclude manual reset between explosions, the direction of only the first will be indicated. After the direction has been noted, the instrument is reset manually.

6. Installation of the device in a submarine should be simple. The microphones or pickups can be located at convenient points outside the pressure hull; for satisfactory operation, the square which they form must be not less than 3 feet on a side. The four leads must, of course, be brought through watertight connections in the hull plating to the control panel of the instrument. It has been proposed that the external switch casings be welded directly to the hull plating, to guard against casualty due to water entering the microphone unit through a leaky cable stuffing box.

7. Since the equipment is intended to operate under relatively severe conditions, it may be necessary to shock-mount the vacuum tubes and other sensitive parts to prevent damage. It may also prove necessary to provide a vibration-proof mounting for the external pickups, so that normal hull vibration will not affect them. However, the instrument appears to be so simple that such difficulties can be readily overcome.

8. The precision with which the pickups indicate the arrival of the shock wave appears to be 10^{-4} seconds or less. Thus if the pickups are 3 feet apart, the angle of uncertainty would be about 10 degrees. With greater spacing this angle could be appreciably reduced, but for purposes of quadrant indications only, such a step appears to be unnecessary.

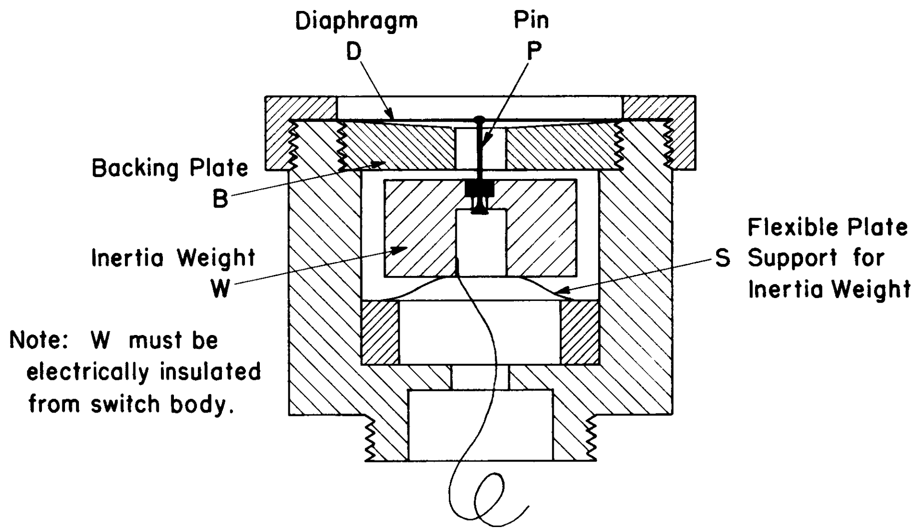

Figure 1 - Microphonic switch

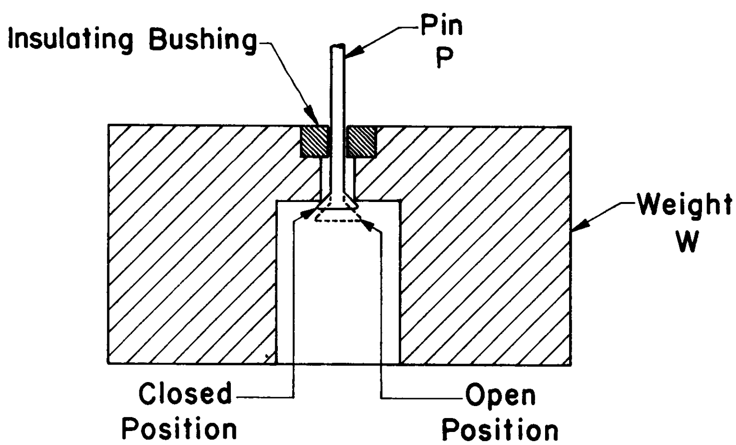

Figure 2 - Large scale detail of pin-contact of microphonic switch

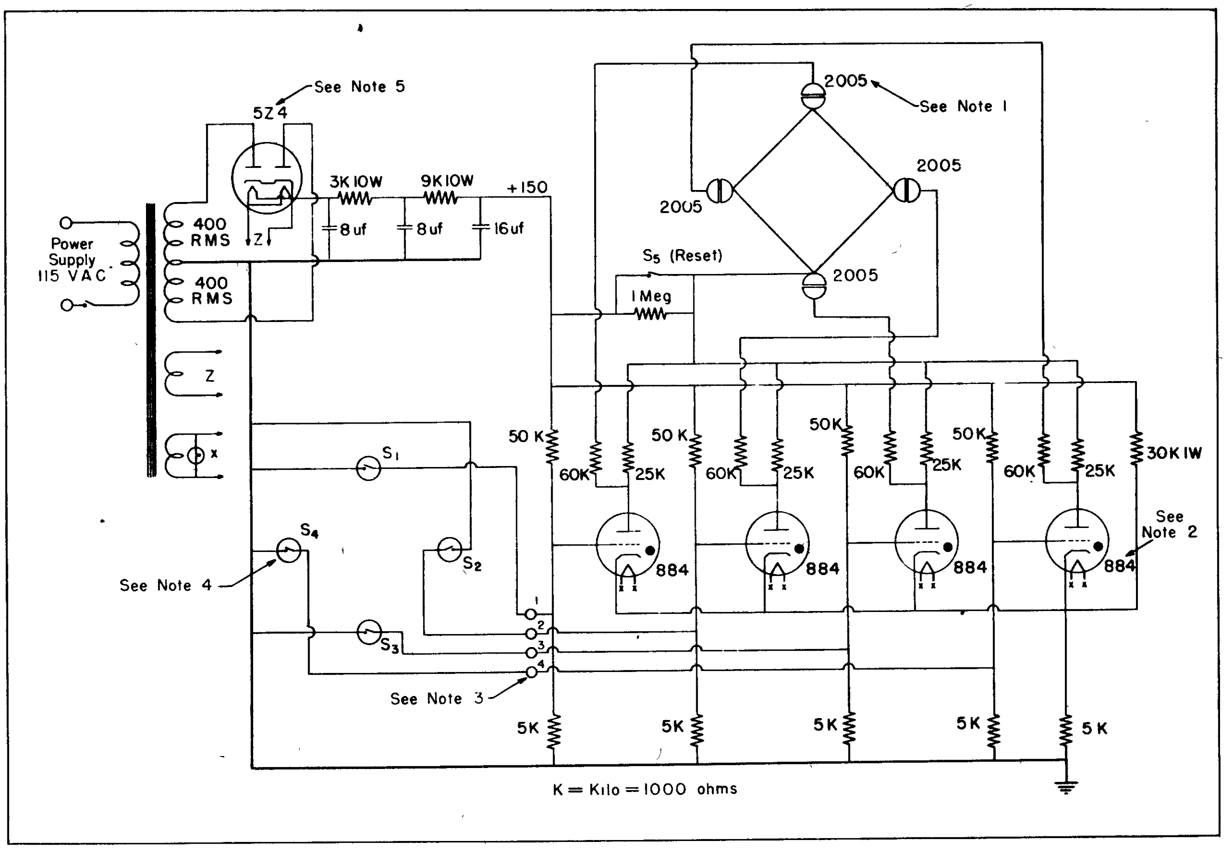

Figure 3 - Quadrant indicator

NOTES FOR FIGURE 3

NOTE 1

The four indicator lamps are General Electric Company Type CD2005 neon lamps. They are similar to the usual type of 1/4-watt neon lamp, but are manufactured without the usual ballast resistor in the base of the lamp.

NOTE 2

Type 884 is a gas-filled triode of the type commonly used as the sweep-circuit oscillator in cathode-ray oscillographs. The characteristics of the Type 884 adopted as standard by the Radio Manufacturers' Association are given hereunder. Type 884 is an indirectly heated tube with a coated unipotential cathode.

TYPE 884, AVERAGE CHARACTERISTICS

Heater	Coated unipotential cathode	
Potential		6.3 a.c. or d.c. volts
Current		0.6 ampere
Direct Interelectrode Capacitances		
Grid to anode		3.5 mmfd.
Grid to cathode		3.5 mmfd.
Anode to cathode		2.5 mmfd.
Tube Voltage Drop		16 volts, approx.

SWEEP-CIRCUIT OSCILLATOR SERVICE

Anode potential* (instantaneous)	300 volts, max.
Peak potential (between any two electrodes)	350 volts, max.
Peak anode current	300 ma., max.
Average anode current:	
For frequencies below 200 CPS	3 ma., max.
For frequencies above 200 CPS	2 ma., max.

Grid resistor: The resistance of the grid resistor should be not less than 1000 ohms per maximum instantaneous volt applied to the grid. Resistance values in excess of 50,000 ohms may cause circuit instability.

GRID-CONTROLLED RECTIFIER SERVICE
(For frequencies below 75 cycles per second)

Peak potential (between any two electrodes)	350 volts, max.

* The ratio of plate breakdown potential to control grid potential for this tube is approximately 9.5:1.

Peak anode current	300 ma., max.
Average anode current (Averaged over period of not more than thirty seconds)	75 ma., max.

Grid resistor: The resistance of the grid resistor should be not less than 1000 ohms per maximum instantaneous volt applied to the grid. Resistance values in excess of 50,000 ohms may cause circuit instability.

NOTE 3

These symbols indicate the watertight connections through which the microphonic switch cables pass from the outside through the pressure hull into the indicating equipment.

NOTE 4

S_1, S_2, S_3, and S_4 are the four microphonic switches. In the diagram shown, the microphonic switches and lamps are mounted in diamond form. The top lamp signifies the bow of the ship, the bottom indicates the stern, and the right and left lamp indicate, respectively, starboard and port. In future designs it appears preferable to mount the microphonic switches and lamps in a square, so that two lamps represent the quadrants on the port and starboard bows and the other two the quadrants on the port and starboard quarters. With this arrangement, a shock followed by the lighting of the starboard bow lamp will signify a turn to port to clear another depth charge dropped at or near the same spot.

NOTE 5

Type 5Z4 is a full-wave high-vacuum rectifier, having the characteristics enumerated hereunder. It is an indirectly-heated tube with a coated uni-potential cathode. The cathode is internally connected to one side of the heater.

Heater	Coated unipotential cathode
Potential	5.0 a.c. volts
Current	2.0 amperes

FULL-WAVE RECTIFIER SERVICE

Peak inverse voltage	1400 volts, max.
Peak plate current per plate	375 ma., max.
With condenser-input filter:	
a.c. voltage per plate (RMS)	350 volts, max.
Total effective plate-supply impedance per plate*	50 ohms, min.

* When a filter-input condenser larger than 40 mfd. is used, it may be necessary to use more plate-supply impedance than the minimum value shown to limit the peak plate current to the rated value.

d.c. output current	125 ma., max.
With choke-input filter	
a.c. voltage per plate (RMS)	500 volts, max.
Input-choke inductance	5 henries, min.
d.c. output current	125 ma., max.