SFP:GFH
V-7

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter
Circular
LC-69

(July 1, 1922)

A PORTABLE PERMEABILITY APPARATUS

A portable permeability apparatus has been designed for the purpose of determining the amount of leakage of hydrogen through the fabric of an airship. In this country at the present time the practice is to find the leaks in a ship either by means of a leak detector of the porous diaphragm type or by observing any bubbles formed when a dope is applied to the part of the fabric in question.

No quantitative results are obtained without removing the fabric and sending it away for test. With the apparatus herein described, however, the rate of leakage may be read directly with more than the necessary accuracy, the time required for making one determination being only about two minutes.

The first instrument of this type was developed in England by G. A. Shakespeare, who has secured a patent[1] in this coun-

---

[1] U. S. Patent No. 1 304 208, 1919

---

try covering various applications of the thermal conductivity method. While this laboratory does not consider his patent valid, as it is preceded by other patents and earlier research work conducted elsewhere, he is the first to use this method for determining the permeability of an airship fabric without removal from the bag, and it is from his principle that the present apparatus has been devised.

The apparatus developed by this Bureau, however, involves several radical differences in design and is believed to be a marked improvement over the Shakespeare instrument, owing to the direct reading feature and the rapidity with which a test can be made.

Principle

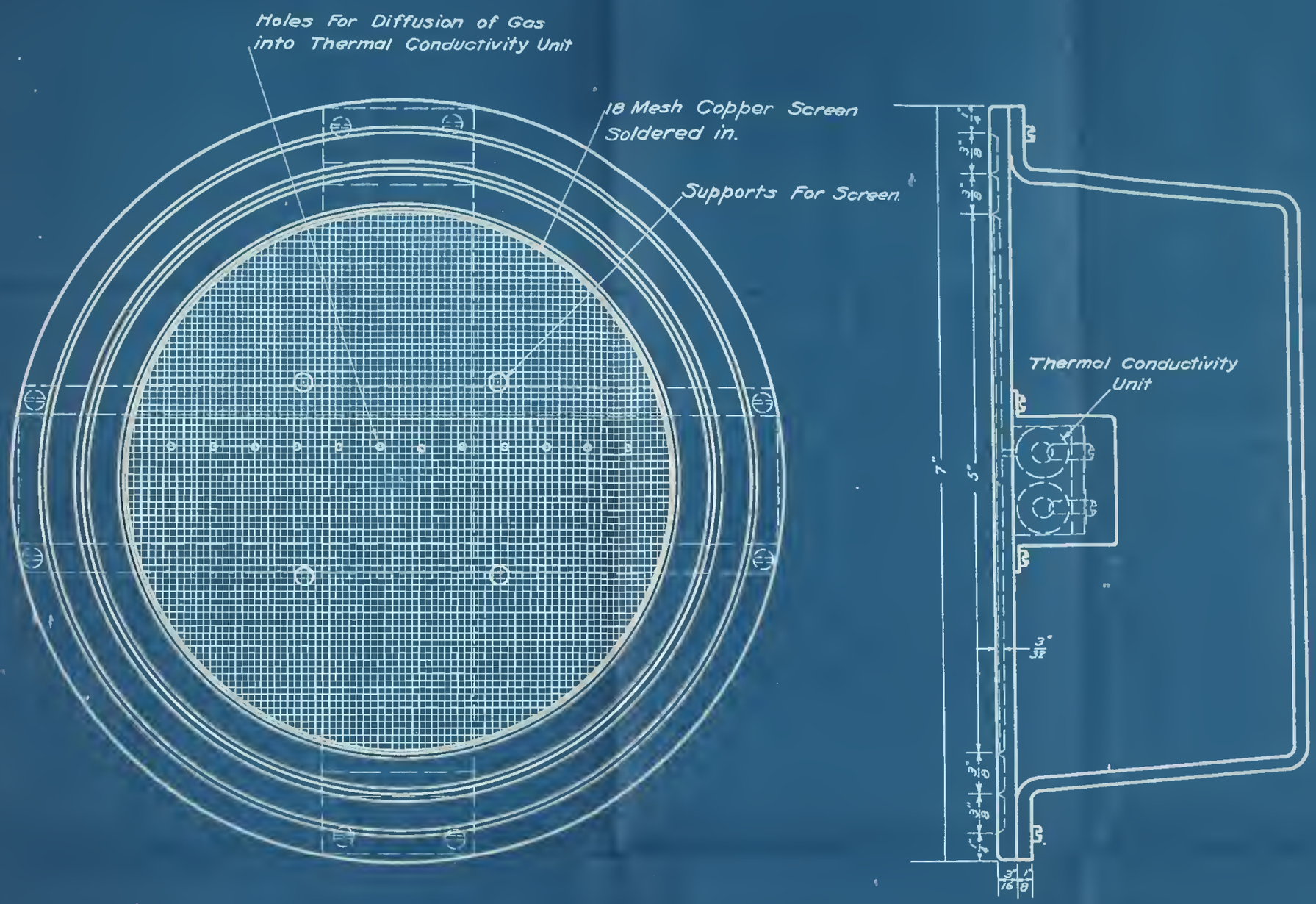
The operation of this instrument is based on the principle that if two similar electrically heated wires are mounted in gas filled chambers, their temperatures, and consequently their resistances, will depend upon the thermal conductivity of the gases surrounding them. Since hydrogen has about six times the conductivity of air this principle readily lends itself to adaptation for these gases. By connecting fine platinum wires in the form of a Wheatstone bridge with two suitable fixed resistances between which is placed a resistance wire with a sliding contact for the galvanometer connection, any desired form of calibration can be obtained. Any change in resistance of either wire, due to change in composition of the gas surrounding it is indicated by the shift in the contact point of the galvanometer necessary to keep the bridge balanced.

In using this method it is essential that the voltage applied to the bridge be kept constant. In order to make this adjustment without the use of a voltmeter, a second bridge is placed in parallel with the first. This bridge consists of two fixed resistances together with one small carbon and one tungsten filament lamp. Since the resistance of the tungsten filament increases while that of the carbon filament decreases with increasing temperature, such a bridge will balance at only one voltage. The same galvanometer is used for adjusting with both bridges.

Description of Apparatus

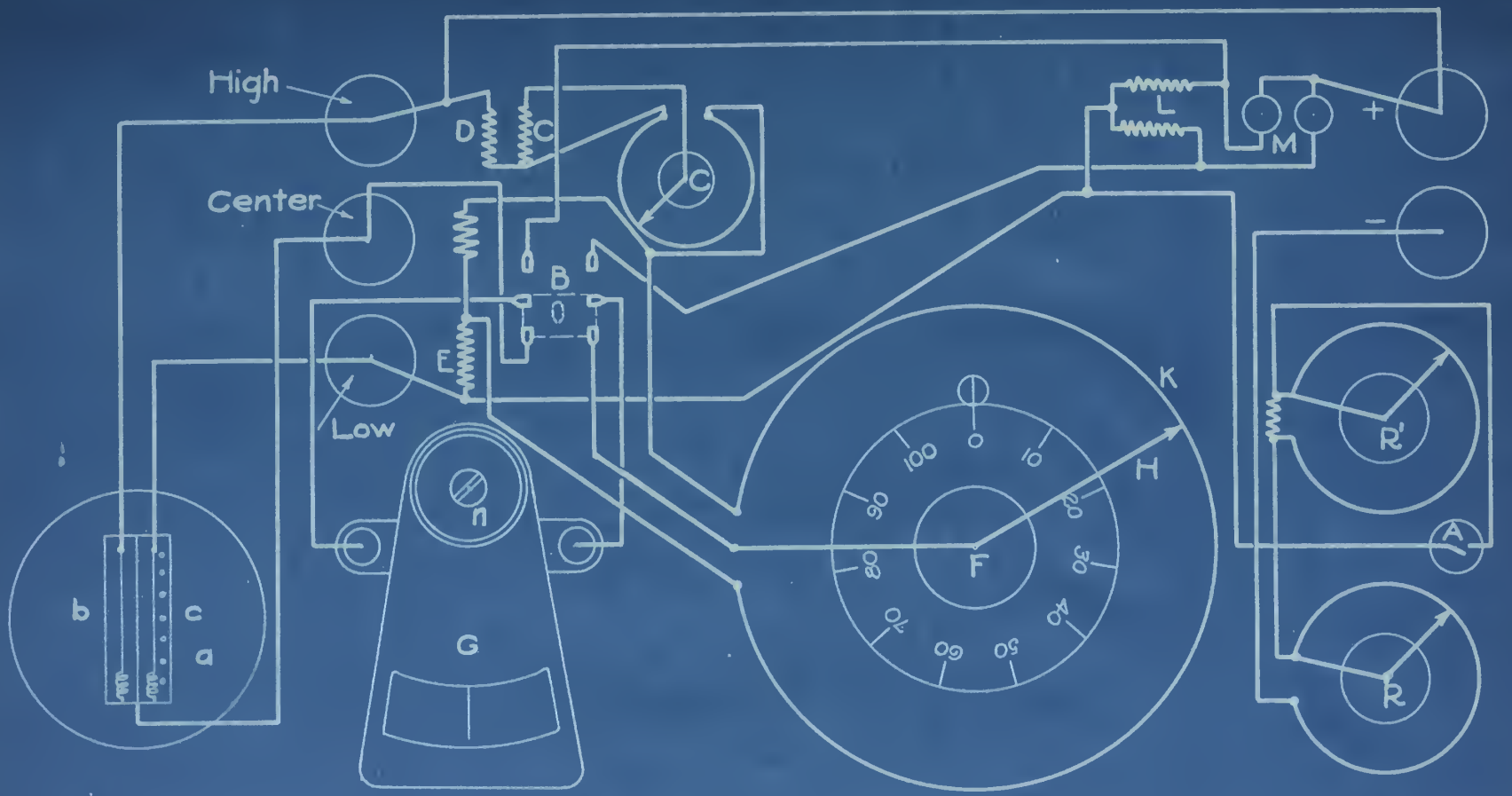
The apparatus consists essentially of a disc-shaped detector (Fig. 1) about seven inches in diameter and weighing about 2-1/2 pounds. This detector is electrically connected by means of three flexible wires about 100 feet in length to a box containing the measuring device. One face of the detector is provided with three concentric ridges raised about 3/32 inch above the surface for the purpose of cutting down outward diffusion of hydrogen. In the circular area inside the inner ridge, which is about 5 inches in diameter, a screen is mounted to prevent the fabric from pressing against the holes leading into the cell (c).

Fig. 2 is a diagrammatic representation of the instrument. Mounted on the disc (a) are two separate cylindrical chambers or cells of brass (b and c) while along the axis of each is



DETECTOR FOR PORTABLE PERMEABILITY APPARATUS

BUREAU OF STANDARDS — JUNE 22, 1922.



WIRING DIAGRAM OF PORTABLE PERMEABILITY APPARATUS

Fig. 2

stretched a fine platinum wire (d and e) one end of which is electrically insulated from the cell. The other end of each wire is connected to the cells. One of these cells (b) is filled with air and hermetically sealed. Holes are drilled through the under side of the disc into cell (c) to permit the diffusion of hydrogen.

When this detector is placed against the gas bag, the hydrogen passing through the fabric diffuses through the holes into the cell containing the platinum wire and gradually builds up in concentration. The rate of increase is proportional to the permeability of the fabric, so that over a given unit interval of time (for convenience a one-minute interval has been adopted) the increase in the percentage of hydrogen is a measure of the permeability and the instrument may be calibrated to ready directly.

After about the first 45 seconds, the percentage of hydrogen increases directly with the time for the ensuing 5 minutes or more. Hence the minute interval may be taken anywhere within these limits and the same reading will be obtained.

On the measuring panel knob (A) turns on the current, (R) and (R') are resistances in series with the batteries for adjusting the voltage, (B) is the switch for galvanometer, (G), while (C) is a resistance in series with one of the fixed resistances (D) and is used to adjust the position of the galvanometer needle as described later. Dial (F) operates the moving contact point (H) along the slide wire (K) which is connected between the two resistance coils (D and E). This dial is graduated to read from 0 to 100 and the apparatus is calibrated to read directly the permeability in liters per square meter per 24 hours. (L) and (M) constitute the voltage adjustment bridge.

Operation

Before turning on the current the galvanometer needle is adjusted by means of the screw (n) until it rests exactly over the line.

To operate the apparatus, button (A) is first pressed down and held with the catch, thereby allowing the current to flow through the circuit. Key (B) is pulled forward so that the galvanometer is connected across the voltage adjustment bridge, and rheostats (R) and (R') are adjusted until the needle is approximately in the central position. (B) is then pushed back and the detector is held against the gas bag at the desired place. After about 45 seconds, knob (C) is turned until

the galvanometer needle stands slightly to the left of the line. The needle will be moving slowly to the right and as it crosses the line time is taken with a stop watch. (Should the needle move in the opposite direction reverse the battery connections.) After about 40 seconds the voltage is again adjusted as before if necessary, then with key (B) pushed back the needle is kept balanced by turning the dial. When one minute has elapsed, the position of the dial indicates the permeability of the fabric.

Blowing gently a few times against the disc will remove the hydrogen so that another test can be made.

If the hydrogen leak should be so great that the dial reaches 100 before the lapse of one minute, a half- or quarter-minute interval may be taken and the result multiplied by the corresponding time ratio. This enables readings to be made over a fairly large range.

For permeabilities of less than 50 liters/sq.in./24 hours, the instrument is accurate to 2 or 3 liters, with a proportional accuracy for higher diffusions.