TECHNICAL DEVELOPMENT REPORT NO. 99

THE EFFECT OF VARIATIONS IN AIR PRESSURE ON INDICATED DENSITIES OF COMPACTED CRUSHED STONE AS DETERMINED BY THE RAINHART DENSITY BALLOON APPARATUS

FOR LIMITED DISTRIBUTION

By

Rufus S Phillips

Airport Development Division
Technical Development
September 1949

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT
INDIANAPOLIS, INDIANA

THE EFFECT OF VARIATIONS IN AIR PRESSURE ON INDICATED DENSITIES OF COMPACTED CRUSHED STONE AS DETERMINED BY THE RAINHART DENSITY BALLOON APPARATUS

In a series of laboratory tests conducted by the Airport Development Division, Office of Technical Development, to determine the effectiveness of certain vibratory compacting devices on dense-graded gravel and crushed stone, a Rainhart density balloon apparatus was used as one of three devices to determine the density of the compacted material Other determinations of density were made by means of a sand pycnometer and by relating the total dry weight of material used in each test to the over-all, compacted volume The materials were compacted in a 5 1/2 by 5 1/2 ft form with the compacted thickness varying from 4 1/2 to 10 in Density samples were taken at the four quarter-points and the average value of density thus obtained was assumed to represent that of the compacted material

In the earlier tests of gravel, the Rainhart balloon was inflated by means of lung pressure. Densities thus determined were consistently higher than those determined from the over-all weight and volume. This suggested that the air pressure was insufficient to force the balloon into the irregular cavities in the sides of the sample holes.

In order to facilitate the application of pressure and vacuum, a small, hand-operated pump[1] was attached to the air tube Two men conducted the test, one operating the pump and the other holding the apparatus firmly against the compacted surface Pressure barely sufficient to produce incipient upward movement of the apparatus was initially assumed to be adequate Variations in diameters of sample holes, however, were sufficient to cause significant variations in the air pressure required to produce this upward movement. The indicated densities were lower, with respect to those determined by other methods, but were no more consistent than those obtained using lung pressure

Further improvement was sought by attaching a Bourdon type gauge to the apparatus and making all volume determinations at a uniform air pressure. The final assembly, including air pump and Bourdon type gauge, is shown in Fig. 1. The use of the modified apparatus and the distribution of the sampling locations are illustrated in Fig. 2.

[1]The particular pump used in our laboratory was obtained from Chicago Apparatus Company, 1735-43 North Ashland Avenue, Chicago, Illinois, as shown in Catalog No. 46, p 57, No 5250.

Comparisons were made between over-all densities, those determined by means of the sand pycnometer, and those obtained with the balloon apparatus operated at controlled pressures of from 1 to 5 psi. Best agreement was obtained at 2 1/2 to 3 psi. Since the indicated densities at 3 psi were slightly lower and therefore more conservative, this pressure was adopted as standard for the remainder of the test series.

Fig. 3 presents a comparison of results determined for graded crushed stone, with balloon air pressures varied from 1 to 5 psi Since the actual densities in these tests were influenced by such controlled variables as moisture content, type of compacting device, and amount of compactive effort applied, comparison is made on the basis of percentages of densities determined at 3 psi The data shown in Fig 3, represent 180 tests, each plotted value being an average of at least 16.

The average indicated densities varied from 112.7 to 95.7 per cent of those determined at 3 psi for a range in balloon pressure from 1 to 5 psi. This would represent a spread of 20 pounds per cubic foot or more in a compacted granular base course of this material It is appreciated that a crushed angular material of this type probably represents the worst possible condition under which the balloon apparatus might be used. If only lung pressure were employed, the variation in pressure would be considerably less than that shown here. Lung pressures would fall, however, in the lower range of the curve where the effects of variations in pressure on the indicated densities are greatest. It seems desirable, therefore, that a means of supplying air pressure somewhat higher than average lung pressure be provided, and that a gauge or other device be employed to insure uniform air pressures for all tests where comparisons are to be made The adoption of a uniform pressure as standard for general use would probably eliminate much uncertainty in comparing results obtained on widely separated projects and in determining compliance with specifications.

The equipment as described has produced very satisfactory and consistent results and has been standardized for density determinations at the Experimental Station soils laboratory As it provides much needed accuracy in both field and laboratory density determinations, this information pertaining to its development and operation is submitted for the benefit of others interested in its application to their work.

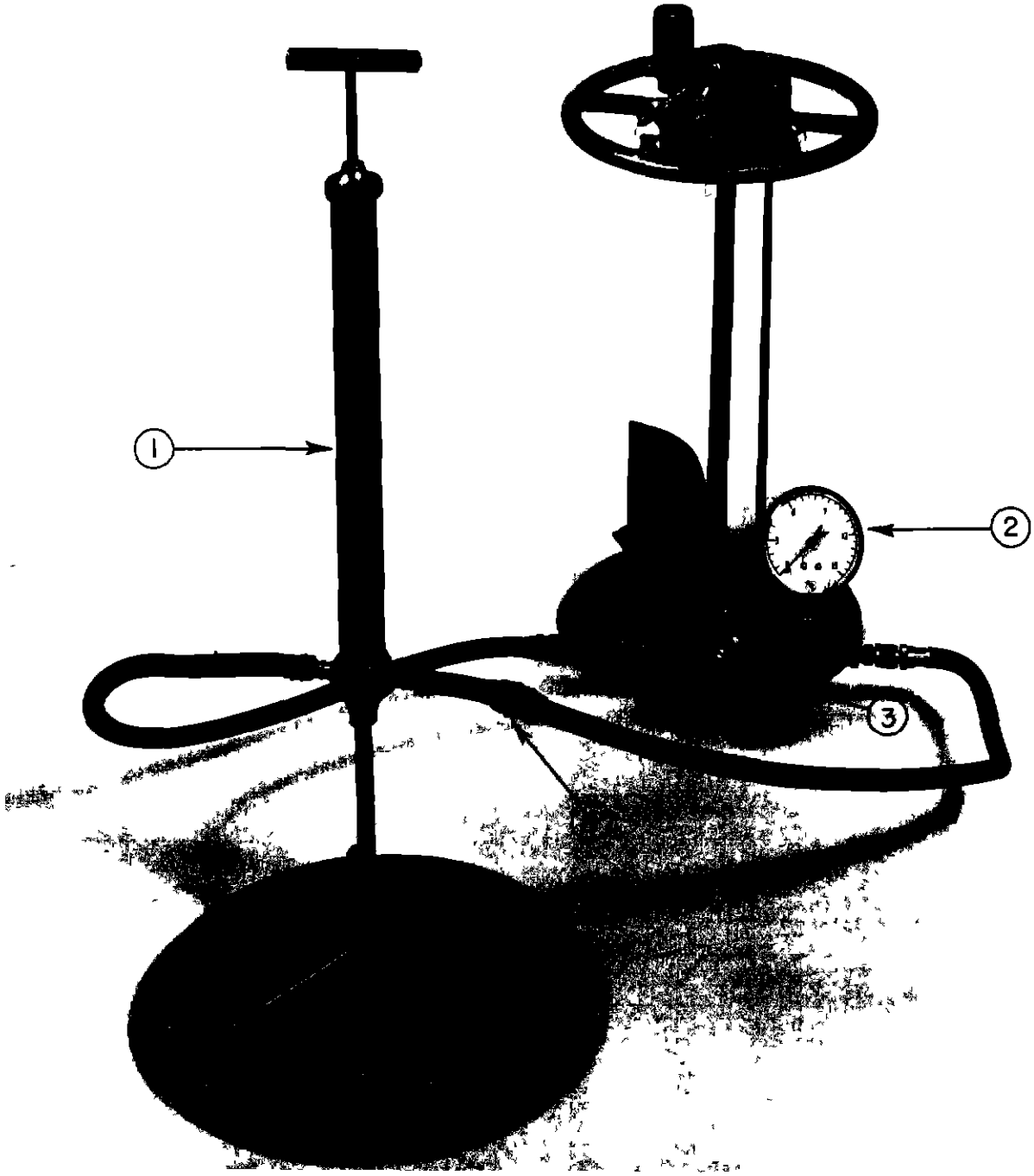

FIGURE 1 MODIFIED RAINHART DENSITY BALLOON APPARATUS SHOWING (1) AIR PUMP, (2) BOURDON TYPE GAUGE, (3) FOUR-WAY COCK (CRANE CO., CATLOG Nº 307), AND (4) BICYCLE TIRE CHECK VALVE NOTE SHEET METAL DUST CAP PUNCTURED BUT LEFT IN PLACE IN OUTER OPENING OF (3)

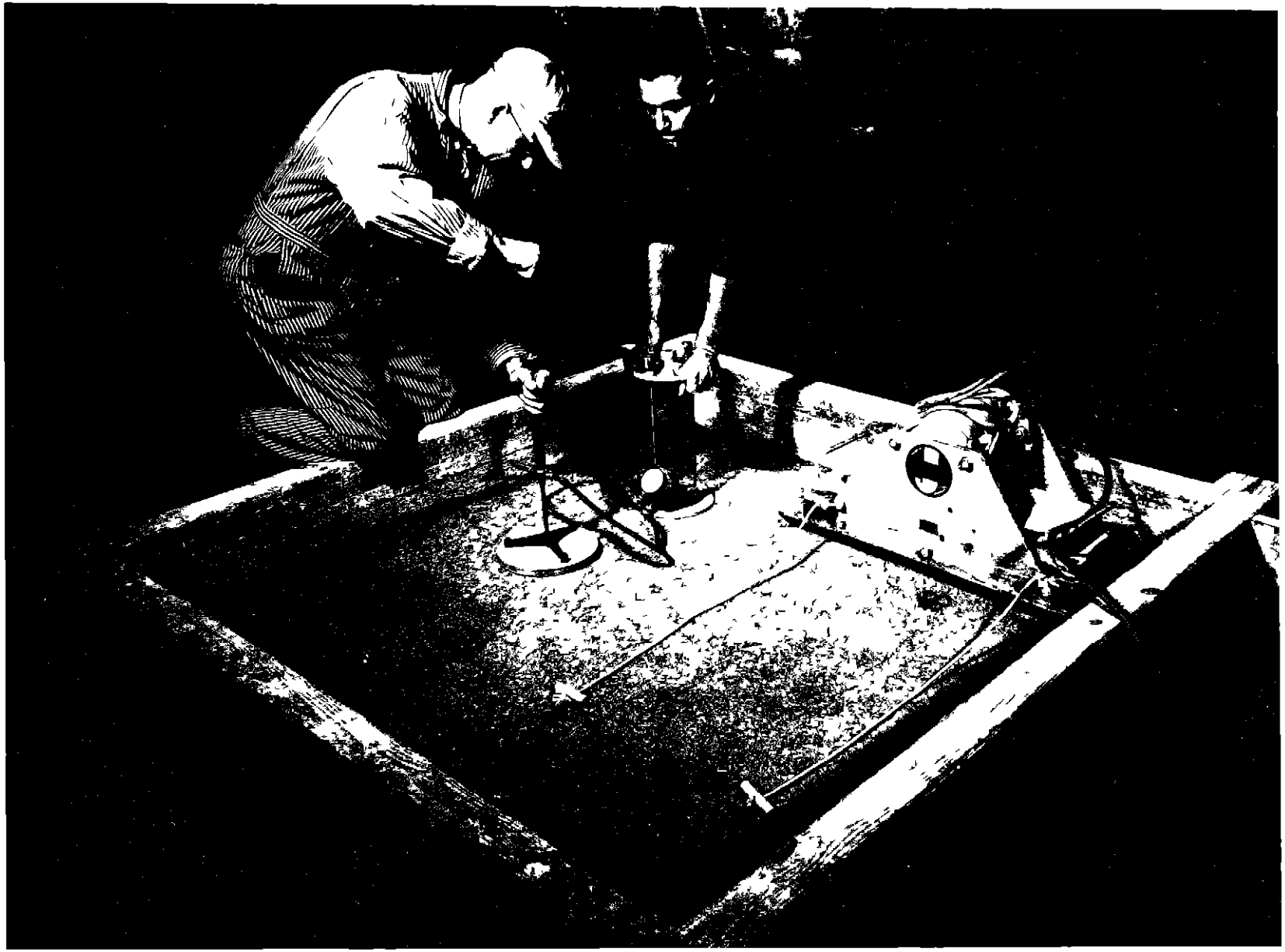

FIGURE 2 MEASURING THE VOLUME OF A SAMPLE HOLE IN A TEST LAYER OF COMPACTED CRUSHED STONE BY MEANS OF THE MODIFIED RAINHART DENSITY BALLOON APPARATUS

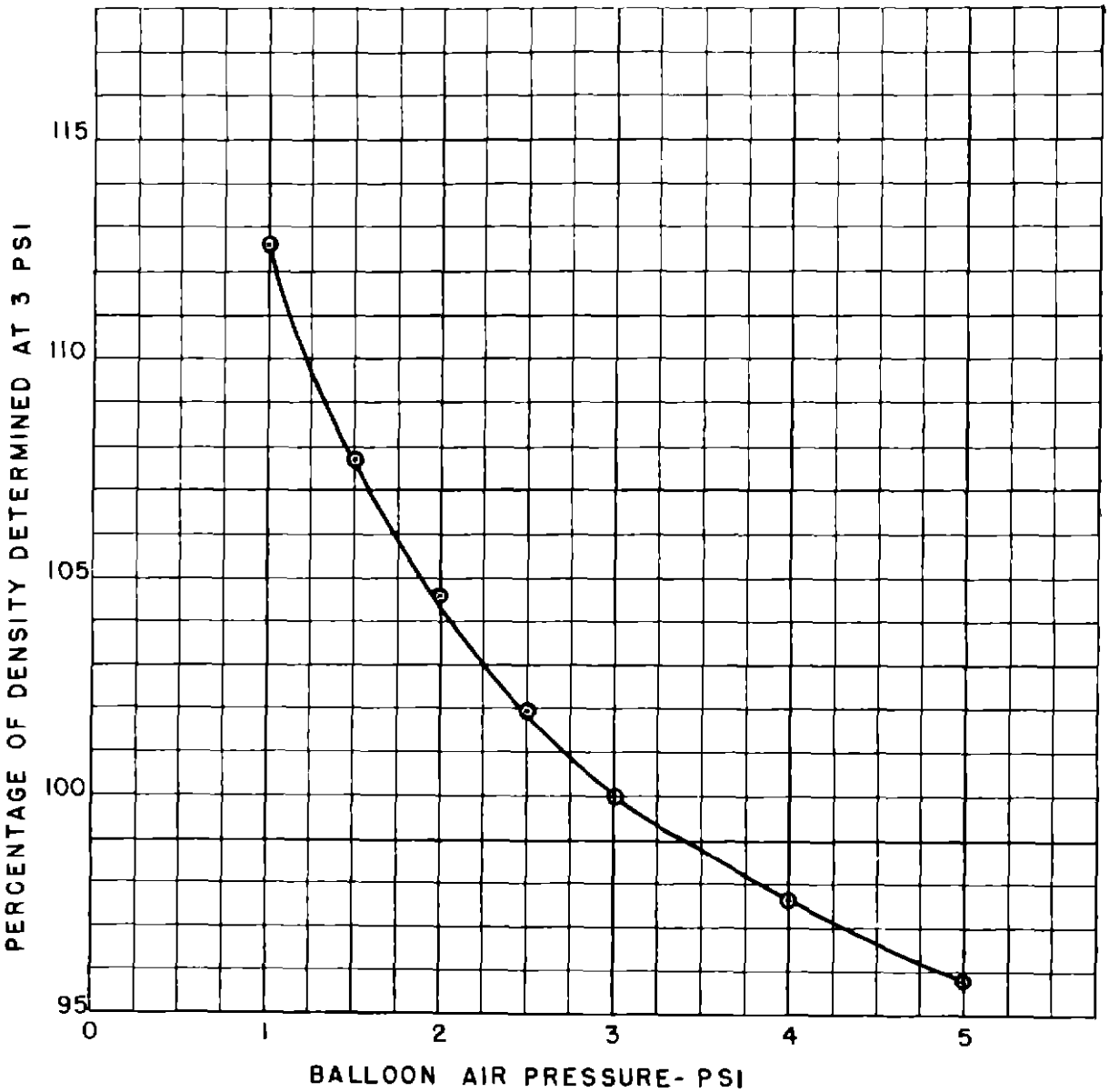

FIG 3 EFFECT OF AIR PRESSURE USED IN RAINHART DENSITY BALLOON APPARATUS ON INDICATED DENSITY OF COMPACTED GRADED CRUSHED STONE