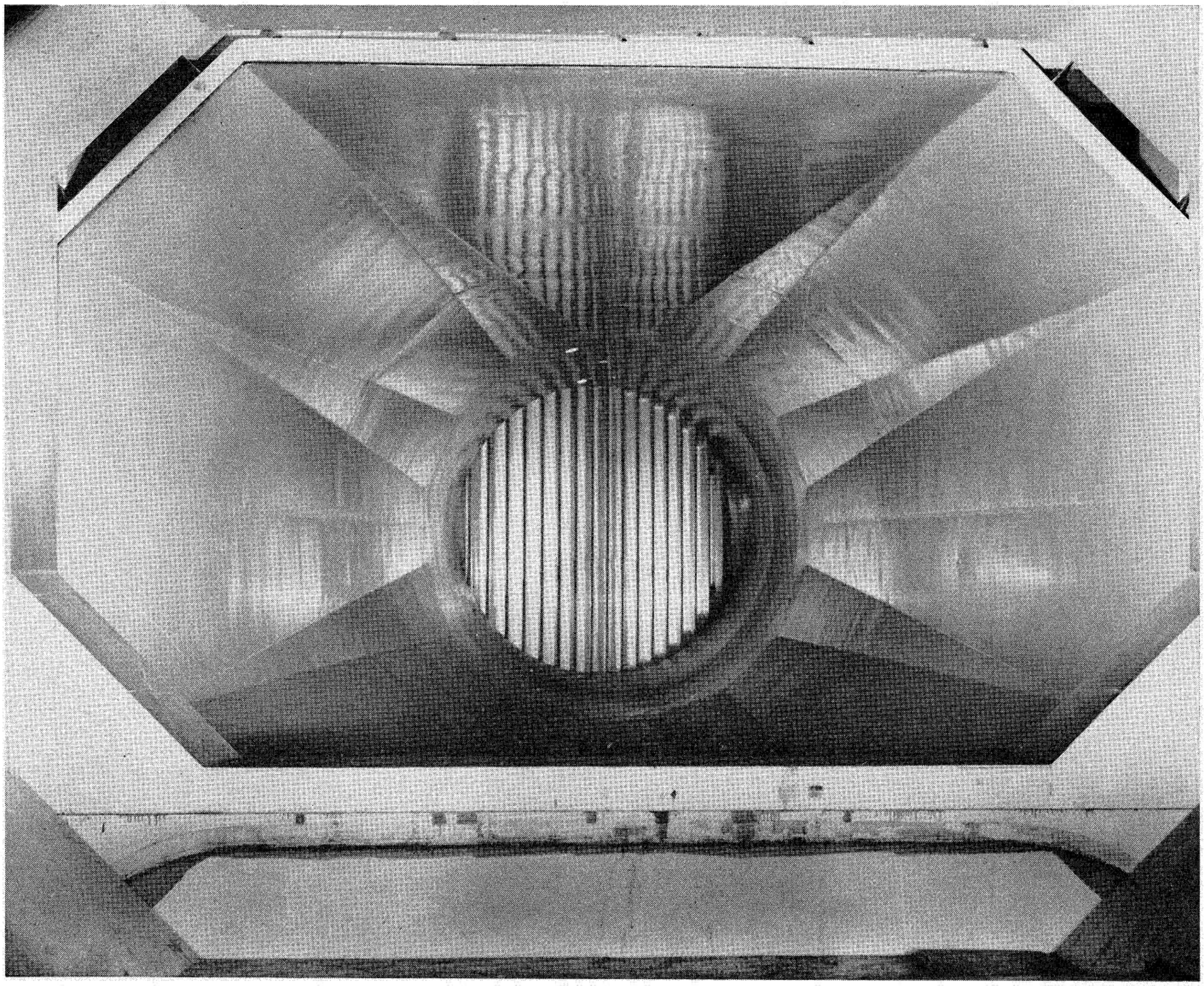


FIG. 23. Exit downstream from working section, showing gate valve beginning to close.

adjust the oil thickness from the control room whenever necessary. He also has a control on two of the base-frame supports, whereby he can adjust the level of the base frame.

TATE-EMERY SYSTEM

THE force-indicating system developed for use in the Cooperative Wind Tunnel is a new application of the principles used in the Southwark-Tate-Emery testing machines, which are manufactured by the Baldwin Locomotive Works in collaboration with the A. H. Emery Company. The Tate-Emery system is a method of hydraulic weighing of forces on the model in the tunnel and remote indication in the control room. This system is composed of two elements—the weighing system and the indicating system.

WEIGHING SYSTEM

The weighing system consists essentially of nine new-type Emery capsules which are located in the suspension system. The Emery capsule is primarily a rigid cylinder and piston unit having a 0.10-inch clearance and less than 0.002-inch stroke. Forces exerted on the capsules are balanced by hydraulic pressures developed within the capsules. The resulting pressure changes within the capsules are transmitted to the indicating system.

The new-type Emery capsule has its piston stayed by two perforated, annular metal stay rings. Forces exerted on the capsule are conveyed to the piston through arms extending from the side of the piston. The piston is double faced and has two metal sheets (one on each end) spanning the gap between the piston and the cylinder, thereby preventing oil leakage. A constant hydraulic pressure is admitted to one end of the capsule from a constant pressure source outside the tunnel. The effect of the constant pressure (preload pressure) is to elevate the pressure on the opposite end of the piston (weighing side) to the same pressure as the constant pressure. This preloading of the capsule permits tensile or compressive forces to be exerted on the piston of the capsule. Such tensile or compressive forces cause the pressure in the weighing side to increase or decrease in proportion to the forces exerted. The pressure in the preload end remains constant because of its outside origin.

A hydraulic motion control (filling control), incorporated in the capsule, limits the capsule stroke, develops the weighing pressure, and compensates for volumetric changes due to temperature changes in the system. The capsules have natural frequencies well above the highest expected vibration frequency within the tunnel.

In the case of the lift capsules the entire weight of the suspension system (50,000 pounds) is supported on the new-type Emery capsules, yet a one-pound weight added

TABLE NO. I—INDICATOR RANGES IN THE TATE-EMERY SYSTEM

Tate-Emery Indicator	High Range	*Smallest Dial Division	Low Range	*Smallest Dial Division
Venturi Pressure (lbs./sq. ft.)	0 to 1,000	1	0 to 100	0.1
Lift Force	0 to +30,000	50	0 to +3,000	5
(pounds)	0 to −15,000	50	0 to −1,500	5
Drag Force	0 to + 5,000	10	0 to + 500	1
(pounds)	0 to − 2,500	10	0 to − 250	1
Pitching Moment	0 to +10,000	20	0 to +1,000	2
(foot-pounds)	0 to −10,000	20	0 to −1,000	2
Rolling Moment	0 to +10,000	20	0 to +1,000	2
(foot-pounds)	0 to −10,000	20	0 to −1,000	2
Yawing Moment	0 to +10,000	20	0 to +1,000	2
(foot-pounds)	0 to −10,000	20	0 to −1,000	2
Cross Wind Force	0 to + 5,000	10	0 to + 500	1
(pounds)	0 to − 5,000	10	0 to − 500	1

*The electrical system furnished by the International Business Machines Corporation indicates and records to one-tenth of the smallest dial division.

to the system produces a readable signal at the indicator in the control room.

INDICATING SYSTEMS

Hydraulic connections from the weighing sides of the capsules transmit pressures to the pressure-sensitive elements in the Tate-Emery indicator cabinet located in the control room. The indicator cabinet is shown at the right of *Fig. 30*. Combinations of pressure-sensitive elements in each indicator permit weighing pressures to

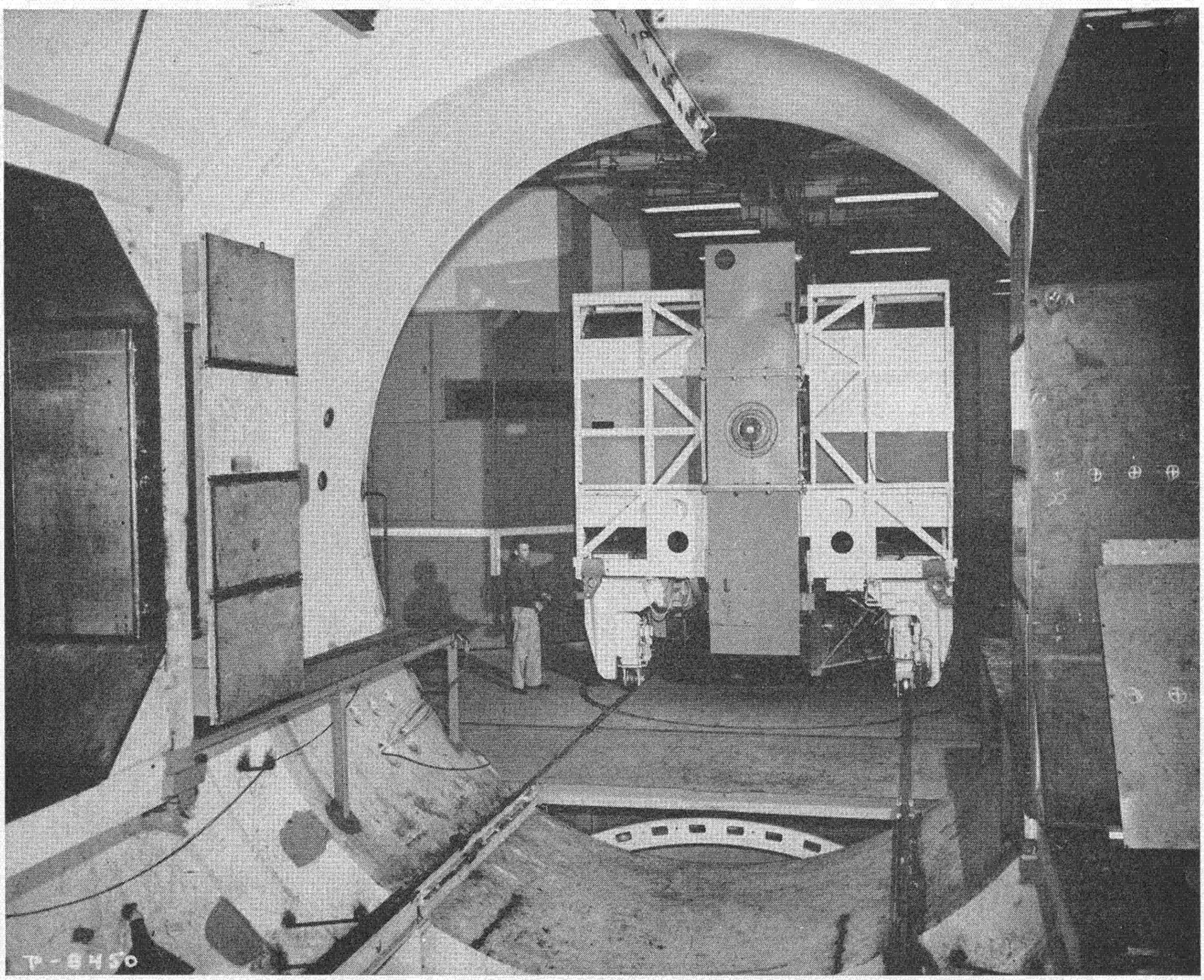
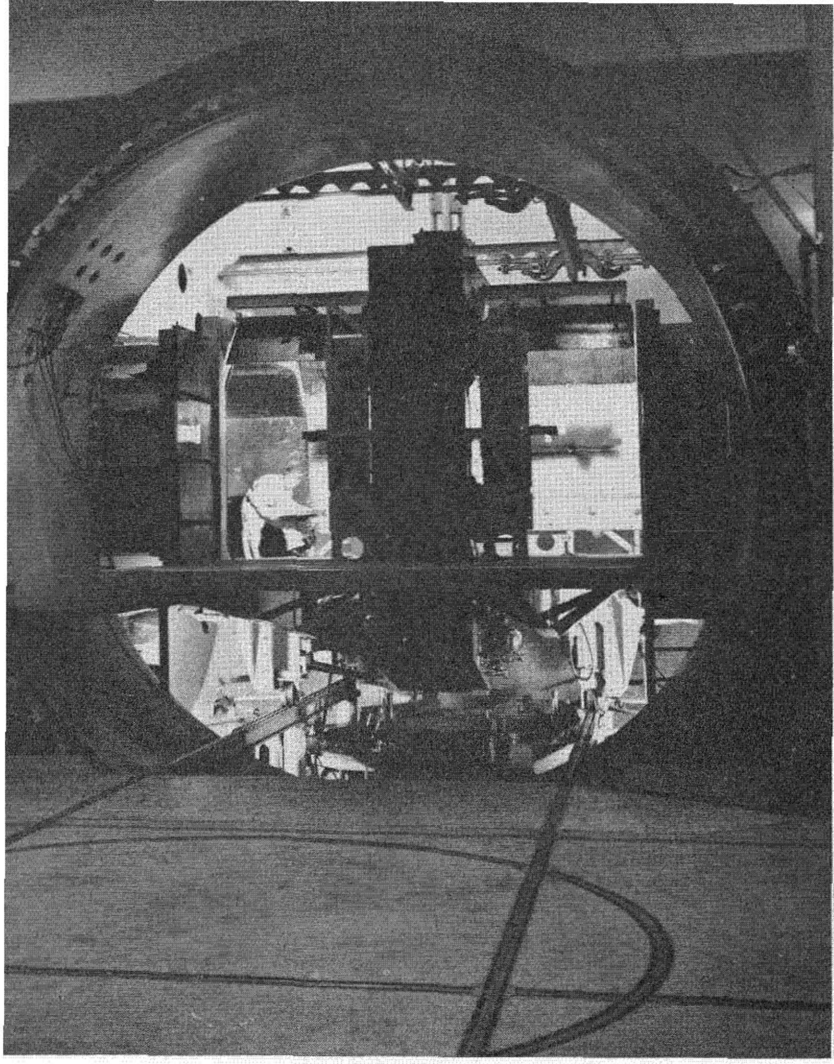


FIG. 24. The model cart is shown at entrance to decompression sphere ready to be rolled into working section.



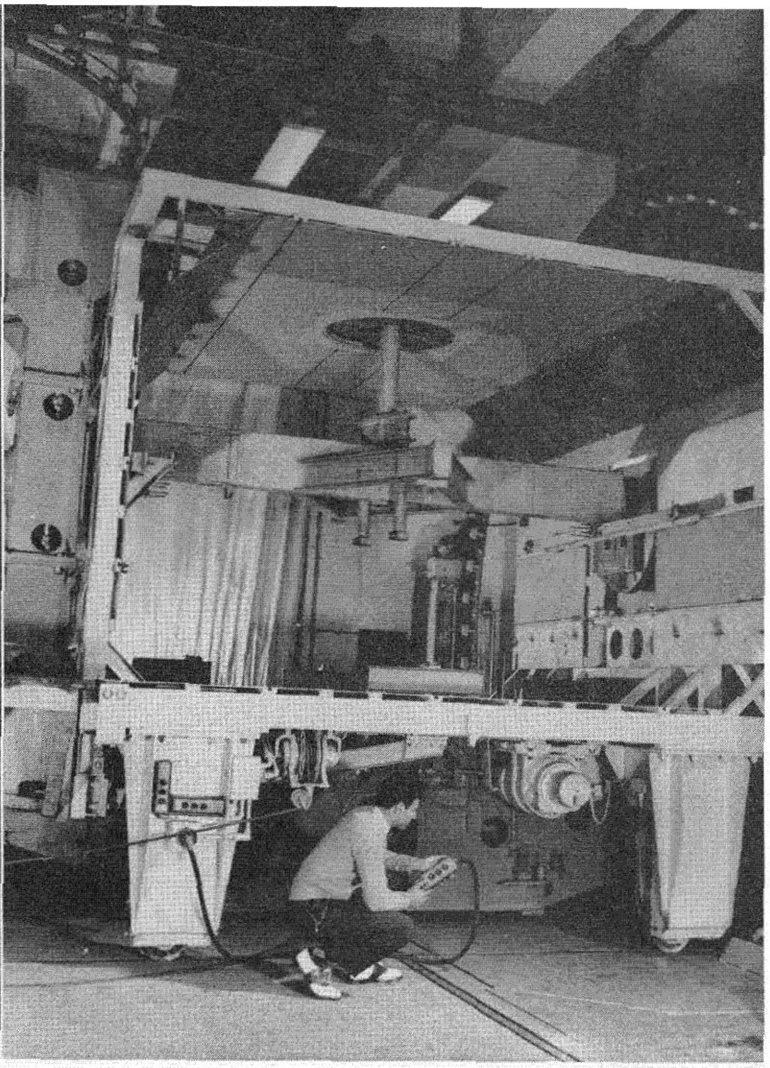


FIG. 25 *(at left)*: Showing model cart in position in working section. FIG. 26 *(at right)*: End view of model cart showing surface plates.

be added to give the sum, or subtracted to give the difference, of the pressures due to forces being exerted in the tunnel suspension system.

In the case of a single indicator, a servo-motor (an outside source of energy) tends to prevent any movement of the pressure-sensitive element due to changes in hydraulic pressures. The servo-motor system in the indicator is air operated. Air is employed because, in association with an orifice, it provides an exceedingly simple as well as exceptionally sensitive device without the necessity for complex auxiliaries. Air enters the system through a reducing valve and a filter and functions through a simple jet orifice system. Oil pressure from the weighing side of the hydraulic capsule enters the pressure-sensitive element. The servo-motor balances the pressure through an isoelastic spring system by a direct pull on the slide rod, tending to prevent movement of the pressure-sensitive element. The force required to restore the element to its original point (the restoring force) is measured by the isoelastic spring system. The isoelastic spring system is a special type helical spring having a linear characteristic between force exerted and deflection. Temperature errors are eliminated by the use of isoelastic metal, which is an elinvar type of alloy.

Indication of the force required to balance the pressure-sensitive element is produced by means of a rack and pinion which operate off the slide rod of the servo-motor. The linear motion of the slide rod produces rotation of the pinion, which in turn rotates the pointer on the front of the Tate-Emery indicator dial.

High and low ranges are provided for all Tate-Emery indicators. These ranges have a ratio of 10 to 1; *i. e.*, the high range has 10 times the capacity of the low range. Change of range can be made during a test by merely depressing a switch. Zero adjustment of each indicator, to compensate for dead weight changes, is accomplished by flicking a toggle switch. Zero adjustment and change of ranges can be made at each indicator or at the I.B.M. lamp bank located on the console.

Indicator ranges provided in the Tate-Emery system are shown in Table I.

AUTOMATIC MEASURING AND RECORDING

ONE of the outstanding features of the tunnel is a group of devices known as I.B.M. automatic measuring and recording machines. They were invented, designed, and built by the International Business Machines Corporation especially for the Cooperative Wind Tunnel and mark one of the latest advances in the field of measuring and computing equipment to meet new requirements in the field of science. When the tunnel was in its formative stages, Dr. A. L. Klein pointed out that if devices were to be developed enabling not only the automatic measuring of test data, but also recording of punched cards, the latter could be automatically processed by I.B.M. standard equipment to compute dimensionless coefficients. The problem was presented to International Business Machines Corporation with the request that development of suitable devices be undertaken and that standard equipment for computing be furnished.