THE LOCOMOTIVE LABORATORY

UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS, NOVEMBER, 1915

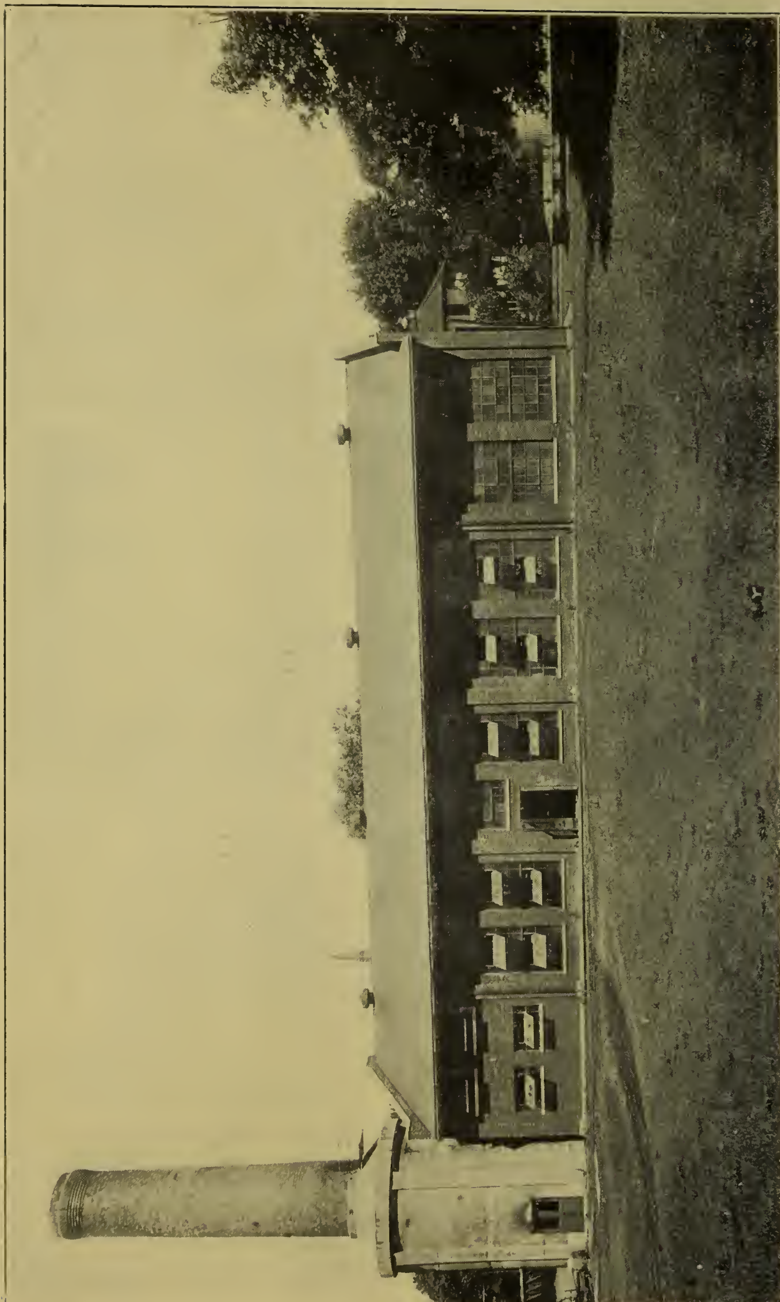


FIG. 1. THE LOCOMOTIVE LABORATORY.

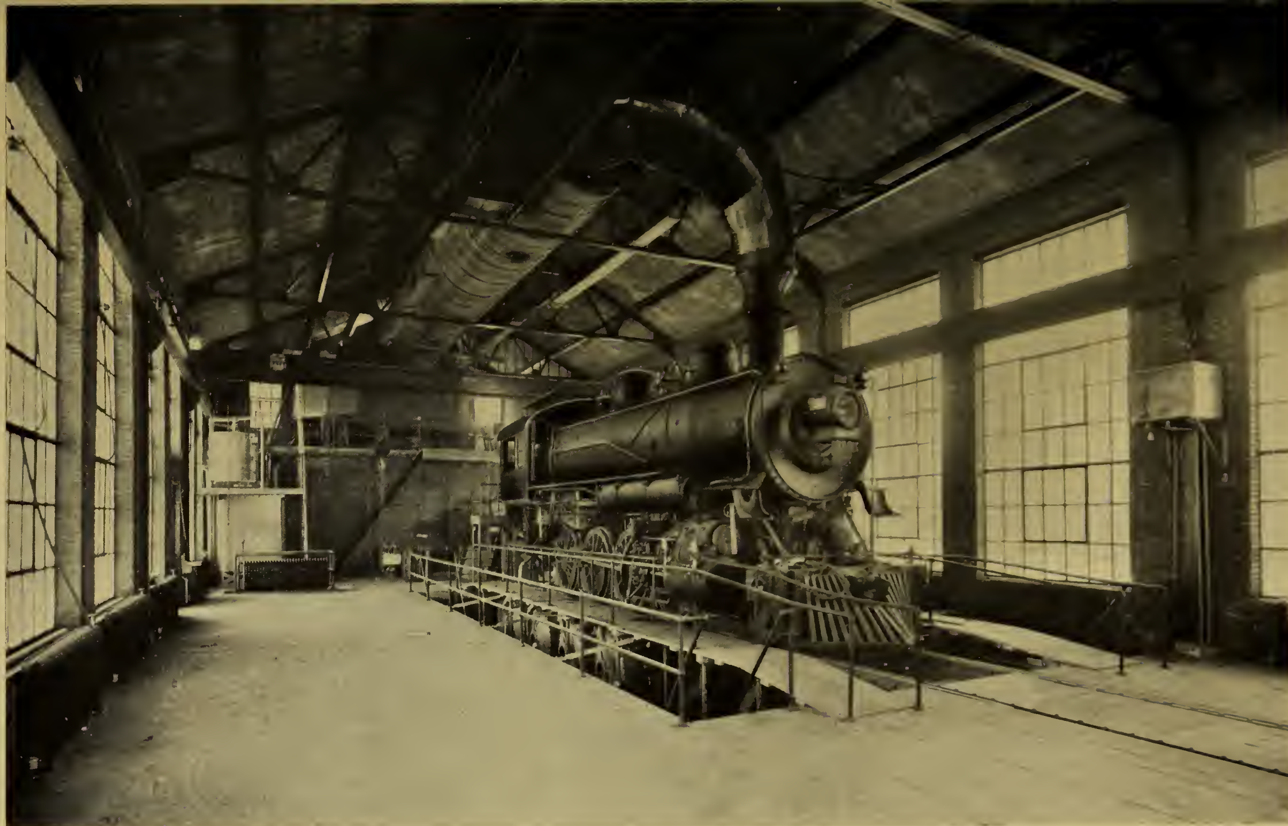


FIG. 2. AN INTERIOR VIEW OF THE LABORATORY WITH A CONSOLIDATION LOCOMOTIVE IN POSITION.

The axles and tires are of the highest grade of heat-treated carbon steel and were donated by the Midvale Steel Company. Provision has been made for replacing the 52-inch wheels by 72-inch wheels for testing high speed locomotives, where the use of the smaller wheels would involve rotating speeds as high as 530 revolutions per minute.

Bearings.—The bearings for the supporting-wheel axles are self-aligning, their shells being carried in spherical sockets which form the upper part of the pedestal. The journals are 9½ inches by 20 inches, and the axles bear on the underside only. Oil for lubrication enters the bearing cap at two points and is supplied under head from an elevated tank. The pedestal is made in two parts, so that by removing the lower section, its height may be adjusted to provide for the 72-inch supporting wheels. This arrangement will continue to bring the top edge of the larger supporting wheels level with the outside track. The base of the pedestal is secured to a massive cast-iron bed-plate by T-bolts held in slots running the entire length of the bed. Each bed-plate consists of three sections placed end to end, 18 inches in height and 36 inches wide over all. The length of the present bed-plate is 42 feet, which provides for a maximum driving-wheel base of 36 feet, and the foundation is built to receive two more 14-foot sections of bed-plate. The supporting machinery rests on a concrete foundation 12 feet wide and 93 feet long, which varies in thickness from 3½ feet at the front to 5 feet at the rear end. The rear end is surmounted by a pyramidal base of reinforced concrete, to which the dynamometer is bolted.

Hydraulic Brakes.—Supported in this way the driving wheels are free to turn and the power produced at the driving wheel rim is absorbed by means of the brakes shown in Fig. 3, 4, and 10. One of these brakes is mounted on each end of each supporting-wheel axle. Each brake consists essentially of three cast iron discs (C, Fig. 10) which, bolted to the cast iron hub (F), are keyed to the supporting axle and form with it an integral revolving element. These three discs rotate between 1/16-inch copper diaphragms (D), bolted to the rim of a stationary housing (H), and flanged over the edges of the floating rings (E) and of the housing, to which they are secured by means of the expanding rings (G). The housing is prevented from turning by means of the links (L) attached to the bed-plate. The rubbing surfaces of the discs and diaphragms are lubricated with a medium grade of cylinder oil which enters the brake under pressure through the oil-header (N) at the periphery of the discs, and through the oil-duct (K). The oil is taken off at M as it oozes out around the disc hub. The diaphragms form also within the casing four water compartments which have no communication whatever with the compartments in which the discs rotate. Water at about 60 deg. F. is forced through 3-inch hose connections into the brake at the lower header (B) and leaves through the upper header (A). The amount of water passing through any individual brake and the water pressure within the brake may be regulated at will by means of suitable valves in the piping. The brake load is controlled by thus modifying the water pressure. This is accomplished simultaneously for all of the brakes by means of the large control-valve in the brake supply main, shown in Fig. 8. The auxiliary brake-valves and gages shown at the left in this same figure permit the separate adjustment of load on each brake. Each of these brakes has the capacity of absorbing 450 horse power, having been designed to develop a resisting torque of 18 000 pounds-feet at speeds up to 130 revolutions per minute. This capacity allows for a considerable increase in wheel loads above that which could be imposed by the most heavily loaded driver of the present day.

Placing the Locomotive.—Fig. 3 shows the mounting machinery arranged to receive an eight-driver locomotive. The top of the supporting-wheels is level with the main floor of the building and one-fourth inch higher than the outside track. Before the locomotive to be tested is placed upon the plant, its wheel-spacing is determined and the supporting-wheel centers spaced accordingly. The tender having been removed, the locomotive is backed into the laboratory and onto the temporary track shown in place between the supporting-wheels. The drivers run on their flanges over the temporary track, which leaves their treads free to engage the supporting-wheels, so that when the locomotive is properly placed the supporting-wheels carry all of the weight except, of course, that borne by leading or trailing trucks. The temporary track being relieved, may be removed. Mounted in this way, the locomotive is held in place and prevented from moving forward or backward by means of the dynamometer draw-bar, which is supplemented by two safety-bars that come into play in case of failure of the draw-bar. These three bars are shown in Fig. 8. Forward and trailing-truck wheels are carried on track sections which are level with the supporting wheels.

The Dynamometer.—The dynamometer, the chief function of which is to permit the tractive force of the locomotive to be measured, is

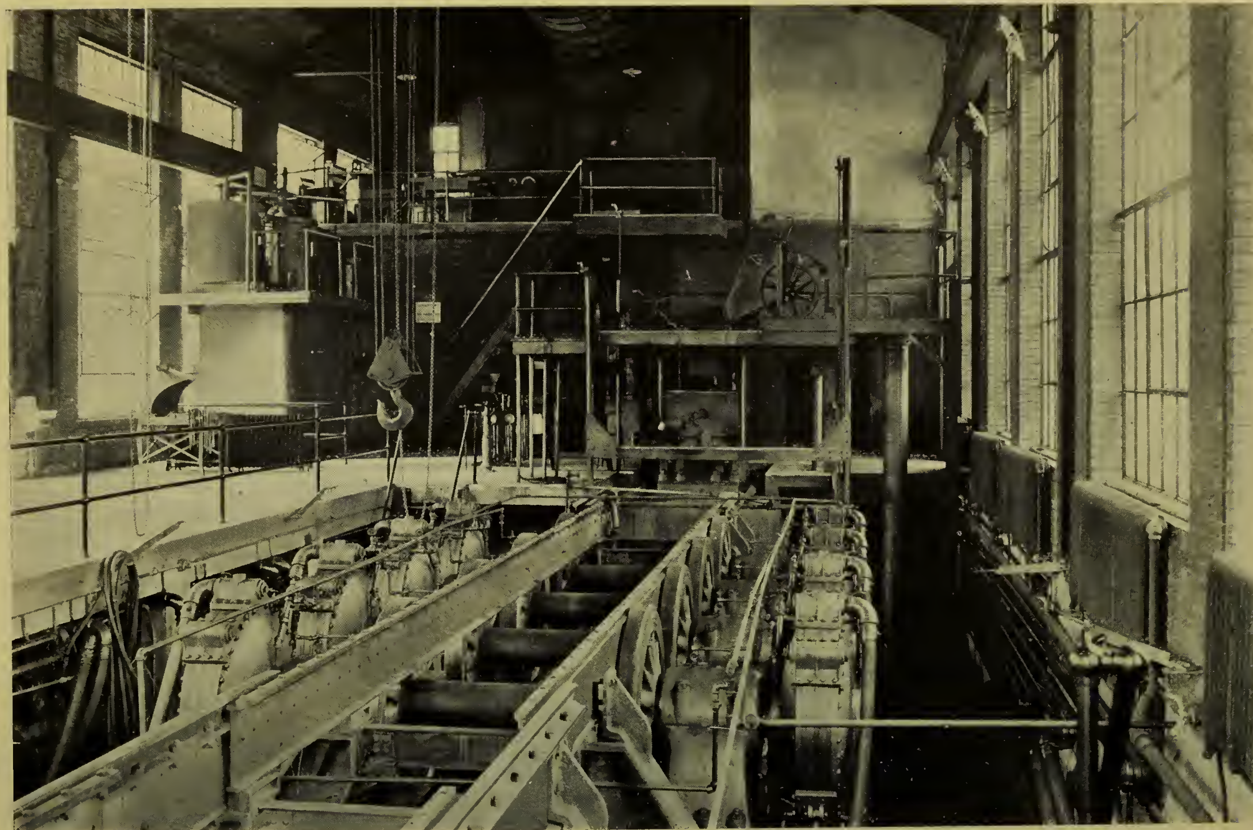


Fig. 3. The Rear End of the Testing Pit, Showing the Removable Track, the Supporting Wheels and Their Bearings, and the Brakes.

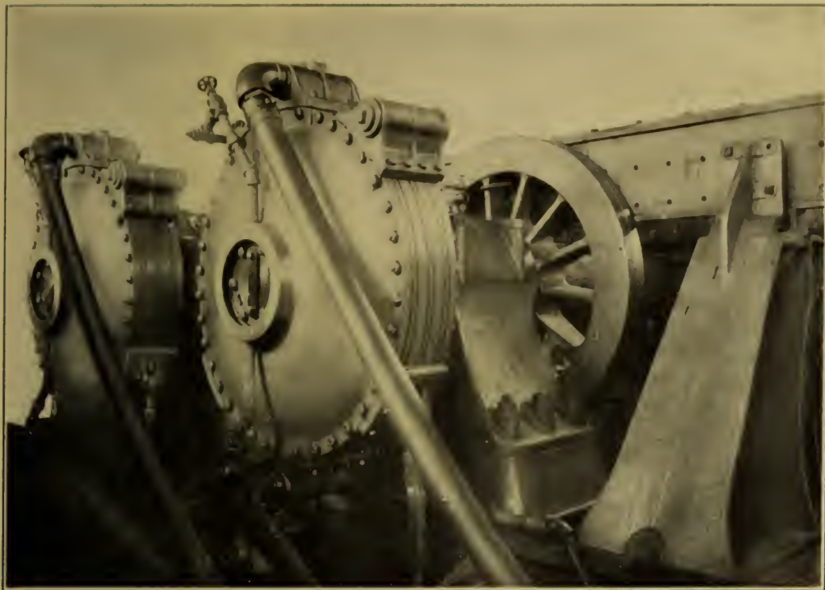


Fig. 4. An Exterior View of the Brakes.

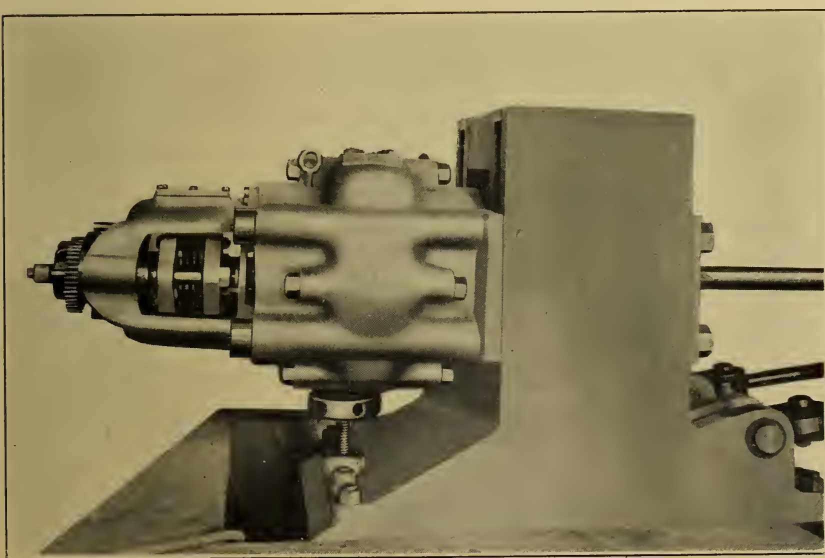
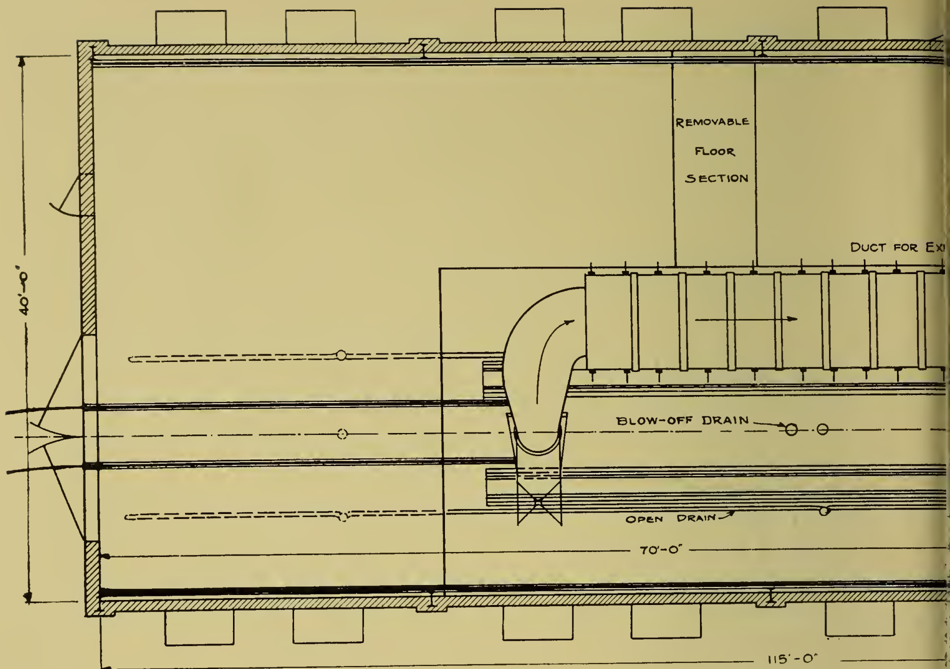


Fig. 5. The Weighing Head and Pedestal of the Dynamometer



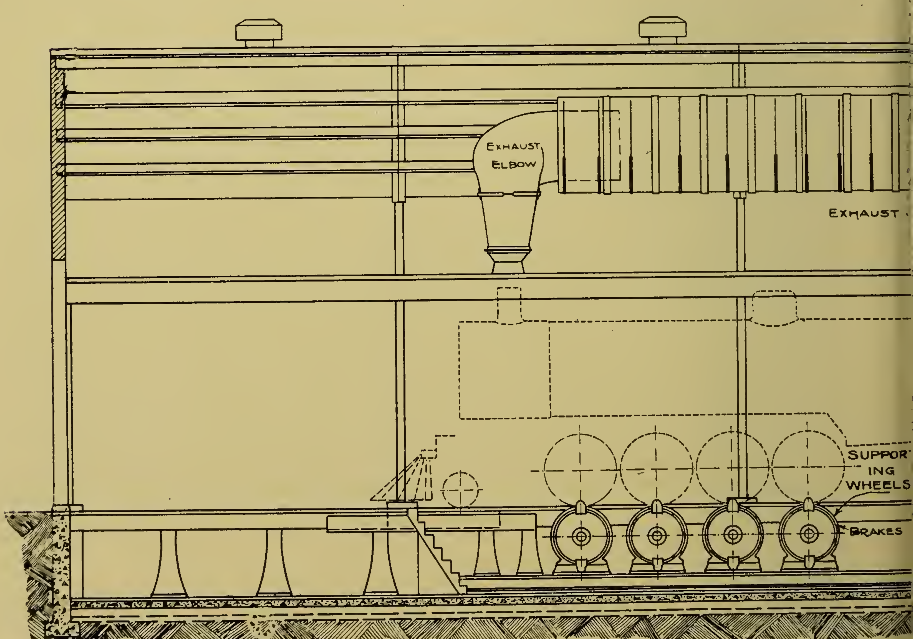
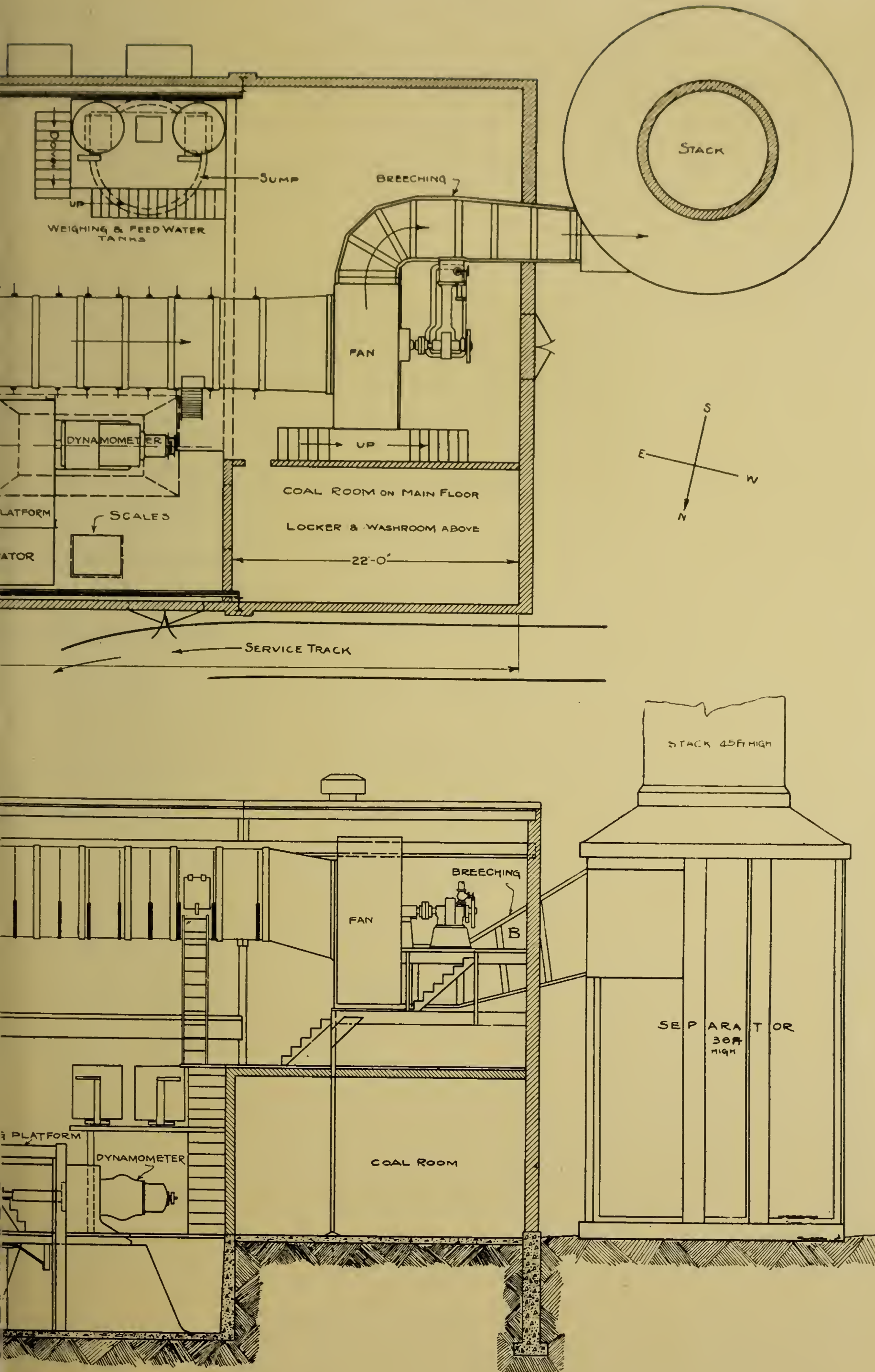


FIG. 6. SECTIONAL PLA



OF THE LABORATORY.

shown in Fig. 5, 6, and 8. It is of the Emery type and consists essentially of two parts: the weighing head, carried on a pedestal and shown in Fig. 5, and the measuring and recording scale shown in Fig. 8. The weighing head may be raised or lowered to suit the height of the drawbar of any locomotive. Within the weighing head is an enclosed oil-chamber with a flexible wall or diaphragm, which receives and balances any force transmitted through the drawbar of the locomotive. The pressure within this oil-chamber varies with the load, and is transmitted through a copper tube of small bore to a smaller oil-chamber known as the reducing chamber, located in the case with the measuring apparatus. The pressure thus produced in the reducing chamber moves the beam of a substantial but sensitive scale which measures the tractive force of the locomotive.

In order to prevent undue shocks from taking place within the weighing head of the dynamometer on account of variations in the force in the drawbar, an initial load of 50 000 pounds is imposed upon the oil behind the diaphragm by means of the capstan and springs located at the rear of the weighing head and shown at the left in Fig. 5. The weighing head of the dynamometer is so designed that by an adjustment of the capstan the tractive effort may be measured whether the locomotive drivers are turning forward or backward. For the sake of accuracy in determining the drawbar pull it is essential that the locomotive drivers be placed and maintained with their centers precisely above the centers of the supporting-wheels. To satisfy this requirement the longitudinal travel of the dynamometer drawbar from no load to full load must be reduced to a minimum. In this instrument the range of movement is only three one-thousandths of an inch. The scale beam reads directly to 20 000 pounds in 100-pound divisions, and a vernier gives readings to ten pounds. For drawbar pulls of more than 20 000 pounds, weights may be added as required. The dynamometer will measure drawbar pulls as high as 125 000 pounds.

A feature of interest in the design of the scale lies in the fact that the adjustment of the poise weight on the scale beam may be made automatically. This is accomplished by means of a small motor which is mounted on the scale beam and geared to a screw which passes through the poise weight. Attached to the scale beam is a contact arm, and any movement of the beam in either direction causes a series of mercury-cup contacts; the number of contacts depending on the amount of deflection of the beam, which in turn is caused by a change in the load. When contact is made, an electrical circuit is closed and the motor runs in the direction required to bring the poise weight to a position of equilibrium. As soon as the load is balanced, the circuit is broken and the motor stops. This operation is repeated as often as the load changes, and is practically continuous. The action of the poise weight may also be controlled by a hand switch.

Water and Coal Supply.—The general water supply of the University is from driven wells, the demand upon which at times approaches their full capacity. In order therefore that the water which passes through the brakes shall not be wasted, provision has been made for collecting, cooling, and recirculating it. For this purpose a 100 000-gallon concrete storage reservoir (see Fig. 1) has been built in the ground outside of the building. A supply pump for the brakes draws water from this reservoir through a 6-inch main and pumps it through the main control valve to a header, whence it is distributed through auxiliary supply control valves to the several brakes; after which it flows back through another set of auxiliary back-pressure control valves to a sump located in the basement of the laboratory. (See Fig. 6.) The water is drawn from the sump by another pump and forced through five 2-inch whirling-spray nozzles above the surface of the water in the reservoir. Water direct from the University mains may also be used in the brakes when desirable.

Water for the locomotive boiler may be drawn from the reservoir or direct from the University mains, and forced by a separate pump to two elevated tanks which are shown in Fig. 3 and 7. Each of these tanks has a capacity of 2000 pounds and rests permanently on a platform scale. At a supply pressure of 45 pounds, each tank can be filled, weighed, and emptied in two and one-half minutes. From the weighing tanks, the water falls into the 18 000-pound capacity feed tank below, and thence passes through two 4-inch supply pipes to the locomotive injectors. Water for the hydraulic elevator used in raising coal from the main floor to the firing platform may be taken from the University main or from the storage tank. In either case the pressure is maintained at 60 pounds by a throttle-control valve on the supply pump. By these provisions in the piping, reservoir water alone may be used for feed-water, brakes, and elevator.

The coal-room shown in Fig. 6 occupies the rear end of the building. It is 22 feet wide and 40 feet long, and has a storage capacity of 300 tons. Coal for the tests is loaded into 1000-pound capacity wagons, run out onto the scales. raised by the elevator to the firing plat-

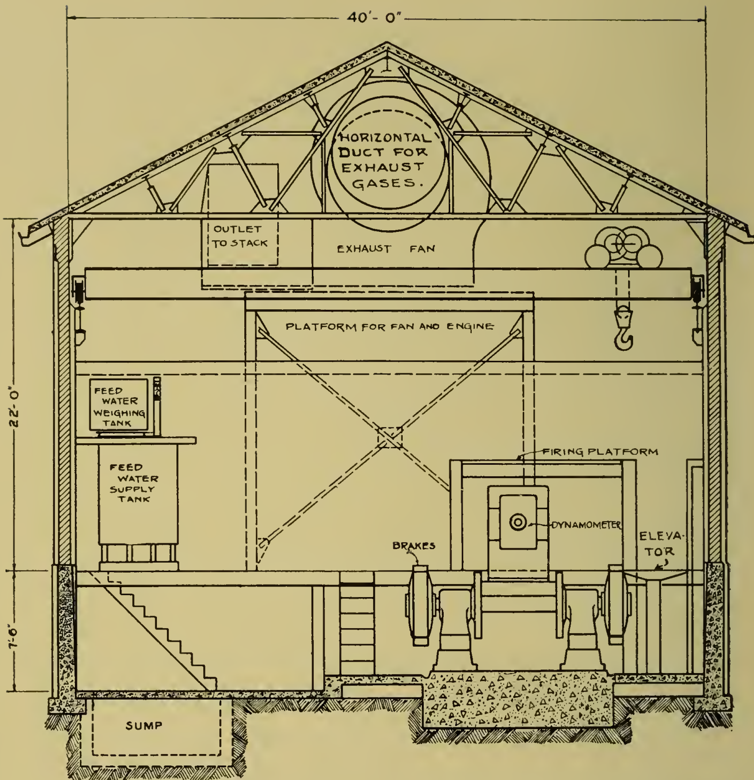


FIG. 7. A CROSS SECTION THROUGH THE MIDDLE OF THE LABERATORY.

form, and there dumped. The firing platform is adjustable in height so as to suit the deck of any locomotive cab. The elevator has a capacity of 2000 pounds. It is also used to raise ashes from the level of the basement.

The Exhaust System.—Recognizing the value of accurate deterRecognizing the value of accurate deterRecognizing the value of accurate determininations of the total amount of cinders lost through the stack of the locomotive, it was early decided that if possible some means should be incorporated in this plant to collect all of the solid matter which passes through the locomotive front end. Preliminary designs of a cinder catcher which should have sufficient capacity to pass the total volume of waste gas, exhaust steam, and entrained air, and at the same time collect all the cinders from the largest modern locomotive working at high power, made it clear that such a collector would be too

Fig. 8. The Brake Control Valves, the Dynamometer Scale, the Drawbar and Safety Links, and the Firing Platform.

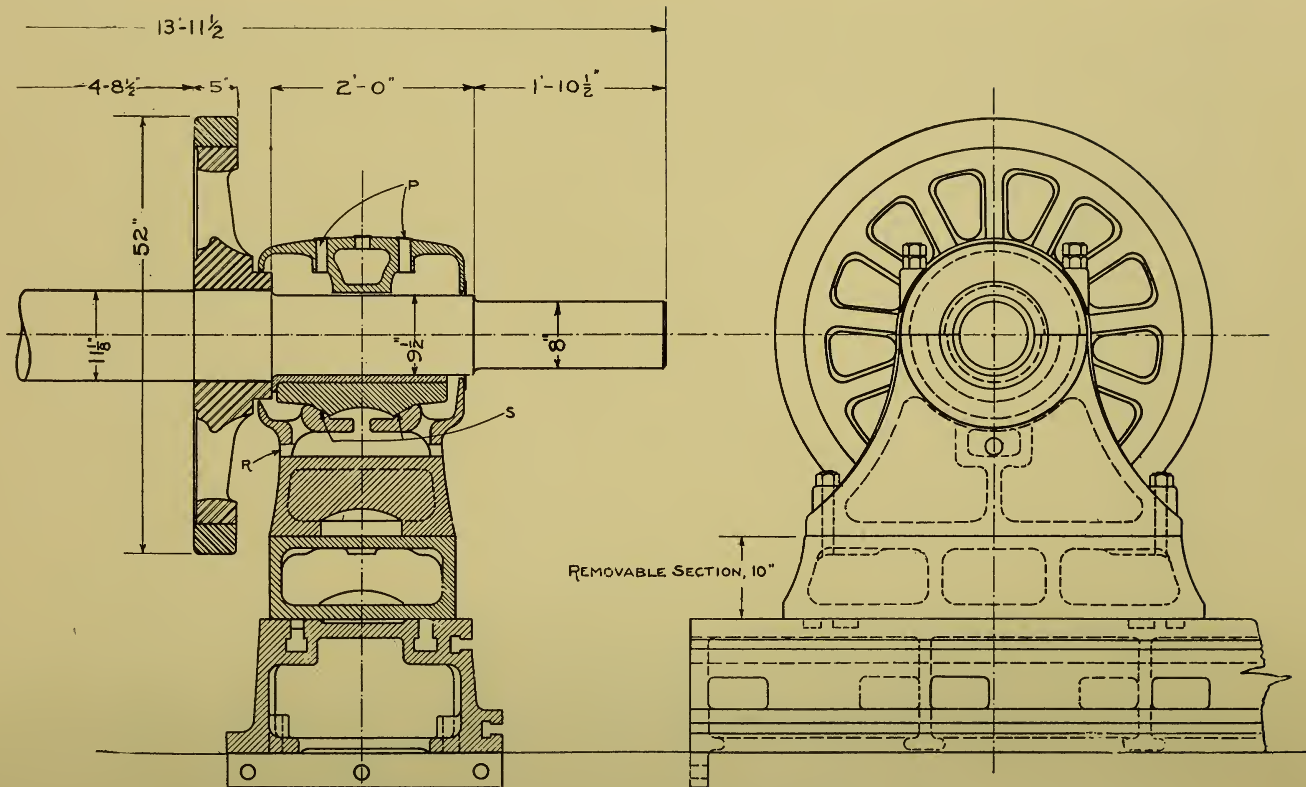


Fig. 9. One of the Supporting Wheels, with its Axle, Bearing, Pedestal, and Bed Plate.

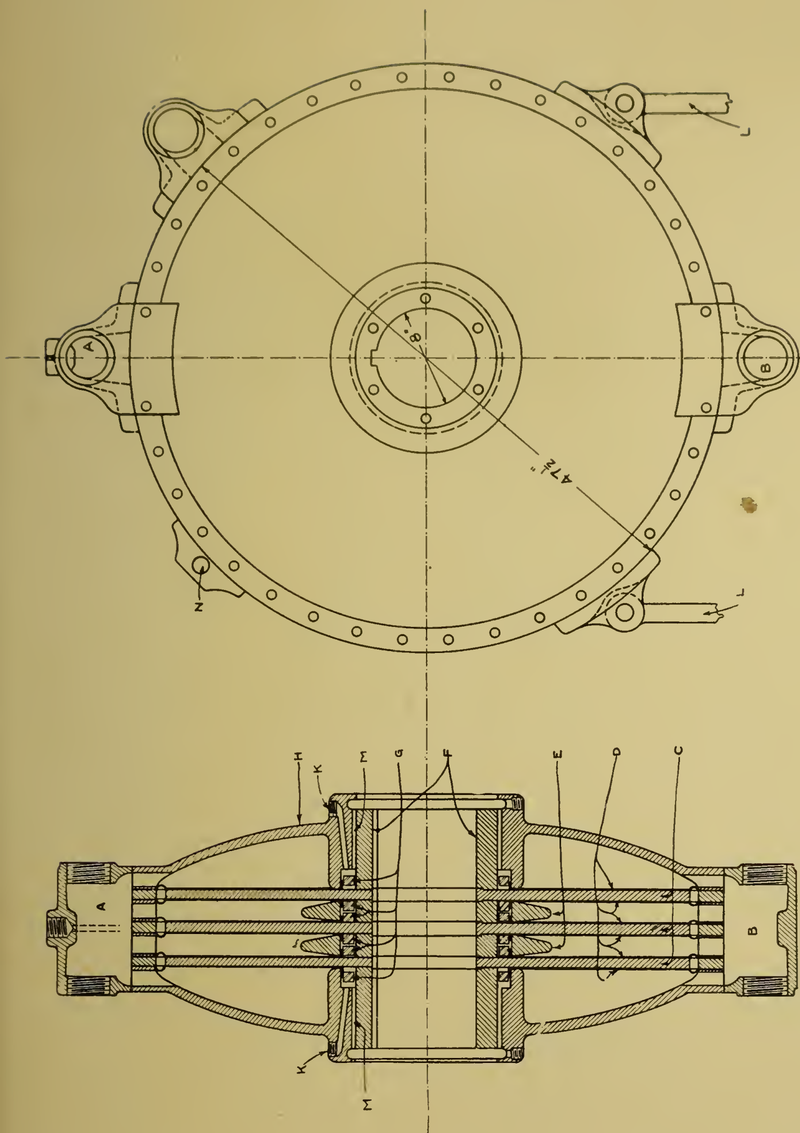


FIG. 10. ONE OF THE BRAKES.

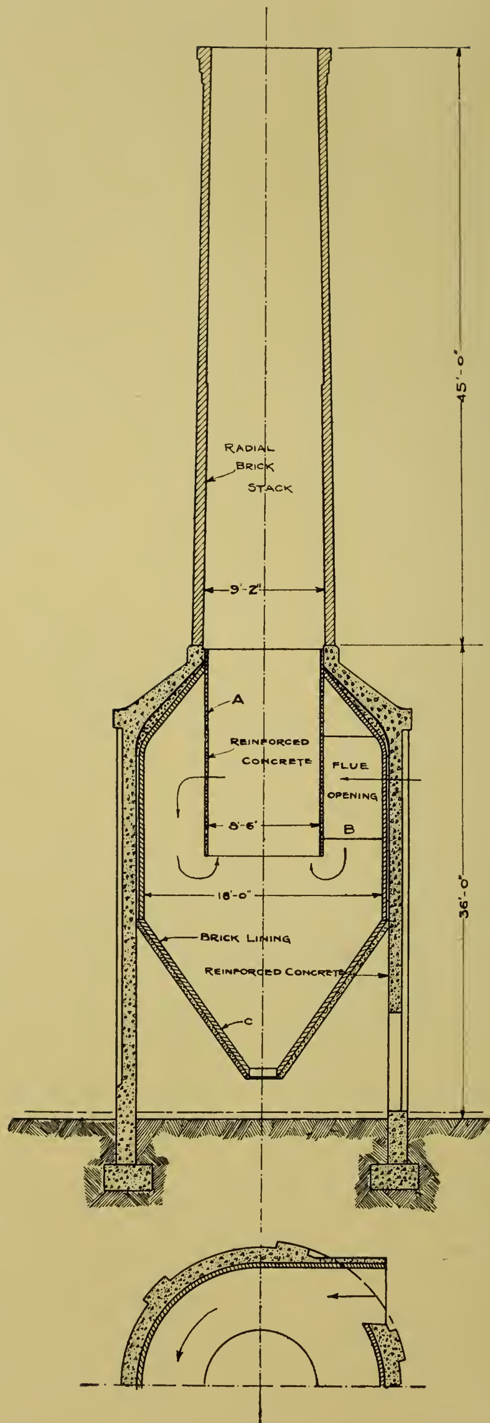


FIG. 11. CROSS SECTION THROUGH THE CINDER COLLECTOR AND STACK.

large to be located conveniently within the building. Another point considered in the design of the exhaust system was the necessity of a stack of sufficient height to insure that the exhaust gases would be discharged far enough above ground to prove inoffensive to occupants of neighboring residences and University buildings. For this purpose it was decided that a stack 8 feet in diameter and 80 feet high would be required. Further study made it apparent that these two decisions could be embodied in one structure combining the cinder separator and the stack. This has been accomplished in the construction represented in cross-section by Fig. 11, and which is located outside and at the rear of the laboratory.

The system will be most easily understood by following the course of the exhaust gases after they leave the locomotive stack. (Fig. 6 and 7.) The gases and exhaust steam are discharged across an open space above the locomotive stack into a steel exhaust elbow, which carries them up and over to a horizontal duct running through the center of the roof-trusses of the building. The gases, exhaust steam, and solid matter are drawn through this elbow and duct by the exhaust fan, located near the roof at the rear end of the building. They are then passed through a breeching or flue to the separator previously referred to, the action within which may be best explained by reference to Fig. 11. The cinder-laden gases enter the separator at B and in order to leave, they must pass downward and around the sleeve A. This operation gives them a whirling motion, which causes the cinders by centrifugal force to move toward the outside wall, along which they drop to the hopper below, while the gases pass downward and out through the mouth of the sleeve. The cinders collecting at the bottom of the hopper are drawn off, weighed, and analysed between tests. The separator is surmounted by a 45-foot radial brick stack, through which the gases and steam are finally discharged.

On account of the corrosive nature of the mixture of exhaust gases and steam, it was necessary to avoid the use of metal throughout the exhaust system, as far as it was possible to do so. The exhaust elbow which receives the gases from the locomotive stack is necessarily made of steel and needs occasionally to be renewed. The horizontal duct, running through the center of the roof-trusses, is made of a hard and tough asbestos board known as "Transite," which is proof against corrosion. This duct is seven feet in diameter, and is built up in sections so that its length may be varied to suit the position of the locomotive stack. The final adjustment of the elbow above the stack of the locomotive is obtained through the medium of a telescopic connection between the elbow and the duct. The fan has a runner six feet in diameter, and at a maximum speed of 300 revolutions per minute, will pass 140 000 cubic feet of gas per minute. The breeching between the fan and separator is also built of transite, and has a minimum cross-sectional area of about 24 square feet. The outer shell of the separator is built of reinforced concrete, and it is lined throughout with a course of hard red brick as protection from the corroding action of the gases. Between the lining and the shell is a 2-inch air space which acts as an insulator to protect the shell from overheating. Any leakage of gas through the lining into the air space is vented to the outside air through openings which are provided in the shell, and which serve also to circulate cool air through the air-space. Both the inside sleeve and the hopper are built of reinforced concrete. The stack itself is unlined, but is laid up with acid-proof cement. Provision was made in the design for traps in the bottom of the horizontal duct, whereby any solid matter that should accumulate within the duct could be removed and weighed. Experience has proved this to be unnecessary, as all portions of the duct and breeching have been self-cleaning under all test conditions thus far encountered.

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