MICHIGAN'S SKID TESTING EQUIPMENT

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SYNOPSIS

This paper describes Michigan's skid testing truck and trailer with their control circuits and instrumentation. The trailer was constructed from a 1949 Buick chassis with modifications of the front end. A 1950 Ford truck was fitted with water tanks, electrical generator for control and measuring circuits, and Brush oscillograph equipment for measuring and recording skid drag force. Several photographs are included and also two circuit diagrams showing the electrical and air-water systems. A complete description of the skid cycle with timing is given.

The calculation of the coefficient of friction corrected for weight shift is illustrated. The use of the coefficient of friction values with a "wear factor" is also described. The determination of a wear factor for each project tested is explained, incorporating a correction for percent of commercial traffic by means of a relative truck-to-car wear ratio.

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The Michigan State Highway Department's early measurements of pavement coefficients of friction (1947-1952), were made using the common and simple method of car stopping distance tests. These tests were generally run from a speed of 20 mph under wet pavement conditions. The time required to run each test proved lengthy and quite often a traffic tie-up would result while wetting, skidding and measuring each test site.

More recently because of the mutual interest of the automotive industry and highway builders in the performance of pavement surfaces and the vehicles using them, a cooperative skid testing program was undertaken in September, 1954 with General Motors Proving Ground and the Michigan State Highway Department as participants.[1] Results of this cooperative venture indicated the need for a comprehensive skid resistance survey of Michigan highways, and as well, the necessity for a rapid method of making skid tests with moving equipment in the traffic stream without interfering with traffic continuity.

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1 Skeels, P. C., Stonex, K. A., and Finney, E. A., "Road Surface Friction From the Standpoint of Automotive and Highway Engineers." Proceedings, Association of Asphalt Paving Technologists, Vol. 25, pp. 353-378 (1956).

Actual testing on this statewide program started in May, 1957. This investigation was initiated with three main objectives: 1) to determine the skid resistance level of all highway surface types now existing in Michigan, 2) from this information to develop methods for increasing the friction level on future pavement surfaces, and 3) to study ways and means of de-slicking existing pavement surfaces found to be below a safe standard.

Michigan's skid testing equipment was designed and built concurrently with that of the General Motors Proving Ground, in close cooperation with Mr. Paul C. Skeels, Head of the Experimental Engineering Department. The two skid testing machines are basically the same, with certain minor differences in axle weight, manner of recording skidding drag force, and control of the skid cycle. Comparative tests were made under wet surface conditions on concrete pavement at 20 mph in identical areas and using the same make of tire (Table 1).

The Highway Department's skid trailer was made from a junked 1949 Buick frame, altered at the front end to connect with a tow truck by means of a regular trailer hitch, as shown in Figures 1 and 2. A concrete weight was cast and attached above and behind the axle to give an axle weight of 1,550 pounds. The two trailer tires are of a standard brand, size 7.60 x 15 which can be easily duplicated, and are mounted on rims with wire spokes to allow for better brake cooling. The hydraulic brakes are air actuated at 40 psi by an electric valve, delivering a total force of about 1100 pounds to the master cylinder.

The tow truck is a two-ton, 1950 Ford dump with two 200-gallon water tanks, air pressurized at 40 psi. Approximately six gallons of water are used for each test and 50 to 55 tests can be run with one loading of the water tanks. Tests are normally run at 40 mph.

A typical skidding trace is shown in Figure 3. The trace paper speed is 25 mm per second. The recording instruments in the right side of the truck cab are a Brush strain analyzer and recording oscillograph as shown in Figure 4. Electrical power for the recording and operating mechanism is furnished by a 3.5-kw, 110-v, a-c generator mounted on the truck. Strain is measured by two SR-4, type A-1 strain gages mounted on the top and bottom of the torque tube just ahead of the differential housing and connected for temperature compensated double output. When running the field skidding tests, the strain analyzer is left on constantly and calibration is checked about every hour. The recorder is turned on and off manually for each test cycle.

The skid cycle, which lasts about 4 seconds, is completely automatic, controlled by electrically powered cams and micro-switches as shown in Figure 5. An electrical diagram for the control circuits is shown in Figure 6. When a single starter button is pushed, the following sequence of events takes place:

1. Two electric valves open, flooding the pavement in each wheel track from water outlets located 10 feet ahead of the trailer wheels.

2. About 1.5 seconds later, the trailer brakes are locked by means of an electric valve and air cylinder linkage on the master cylinder.

3. The brakes are released 1.3 seconds later.

4. About one second later, the water valves close and the cam drive motor shuts itself off.

The equipment in operation at 40 mph is shown in Figure 7. Figure 8 shows the air, water, and brake system of the skid truck and trailer.

Individual sliding strain measurements are converted to a coefficient of friction value, corrected for weight shift using the formula:

$$u_{(corr.)} = \frac{F_B}{1550 - \frac{H}{W} F_B}$$

F_B = braking force measured by strain gage measurements in pounds

1550 = trailer static axle weight in pounds

H = height of trailer hitch above pavement

W = horizontal distance from trailer wheel center to hitch.

The average coefficients from each project are summarized for evaluation along with the age, total and commercial traffic volumes, material and mix details. Interrelation of skid resistance with project age and traffic volume is accomplished by means of a wear factor, which enables comparison of the projects on a common basis. The wear factor is the product of the average daily traffic volume per traffic lane since construction, weighted for percent of commercial traffic, divided by 1000 and multiplied by the age of the project in years. The percent of commercial traffic for each project is converted to an equivalent number of automobiles so the total traffic can be considered entirely as cars. This equivalent number of cars is considered to be the product of the average truck-to-car tire contact area ratio and the truck-to-car weight per unit area ratio. This product reduces to a direct ratio of the average truck weight (loaded and empty) to the average car weight. In general, this ratio has been increasing over the years and has become quite significant, especially on the older projects. The average truck weights are obtained from annual 24-hr loadometer studies and the car weights are computed from annual license registration data.

TABLE 1

COMPARATIVE SKID TESTS
General Motors Trailer and
Michigan State Highway Trailer

Wet Coefficients of Friction at 20 mph					
Test No.	GMPG	MSHD	Test No.	GMPG	MSHD
1	0.66	0.66	7	0.69	0.63
2	0.72	0.71	8	0.66	0.64
3	0.66	0.64	9	0.64	0.66
4	0.66	0.67	10	0.69	0.65
5	0.69	0.69	11	0.69	0.67
6	0.70	0.71	12	0.70	0.69
Avg.	0.68	0.68		0.68	0.66
13	0.65	0.64	19	0.64	0.61
14	0.65	0.64	20	0.66	0.66
15	0.64	0.66	21	0.64	0.60
16	0.62	0.64	22	0.65	0.60
17	0.66	0.68	23	0.66	0.63
18	0.67	0.70	24	0.67	0.65
Avg.	0.65	0.66		0.65	0.63

Figure 1. MSHD skid testing equipment.

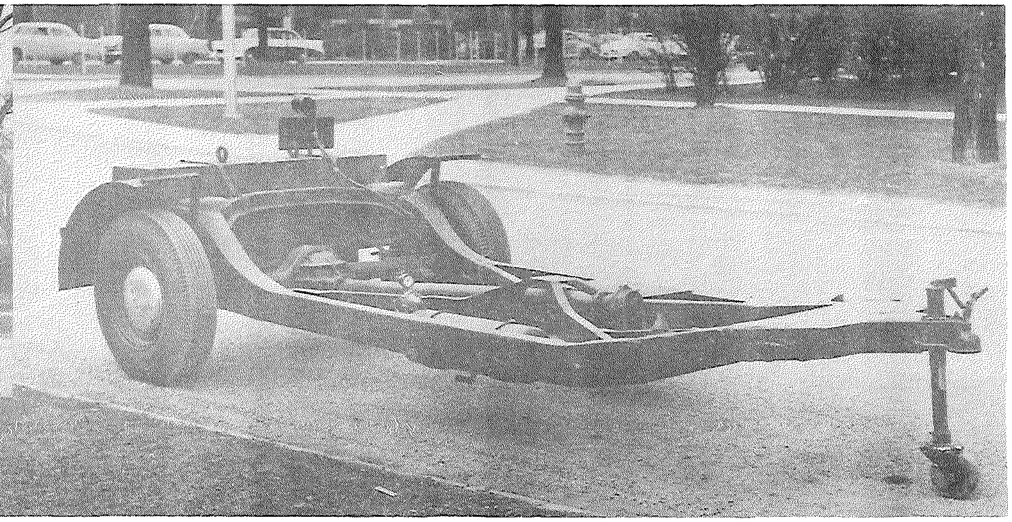


Figure 2. Skid testing trailer.

Figure 3. Typical skidding trace on wet bituminous concrete. 30 m.p.h.

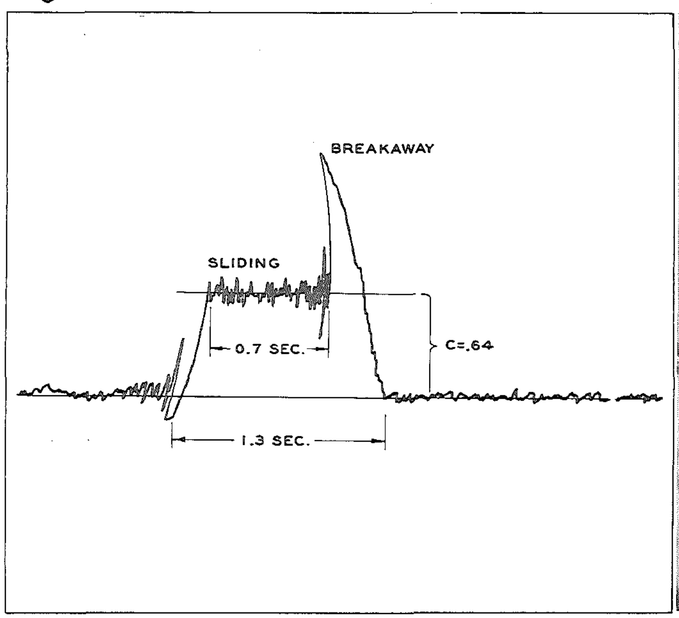


Figure 4. Skid cycle control panel, oscillograph, and strain analyzer.

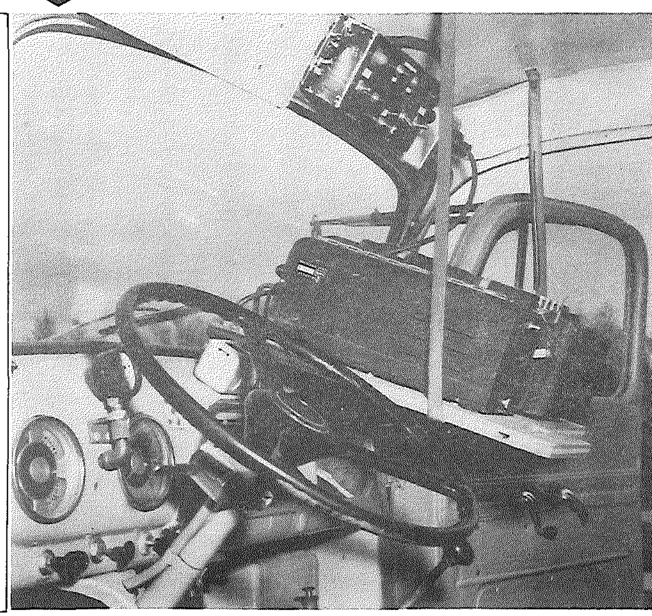
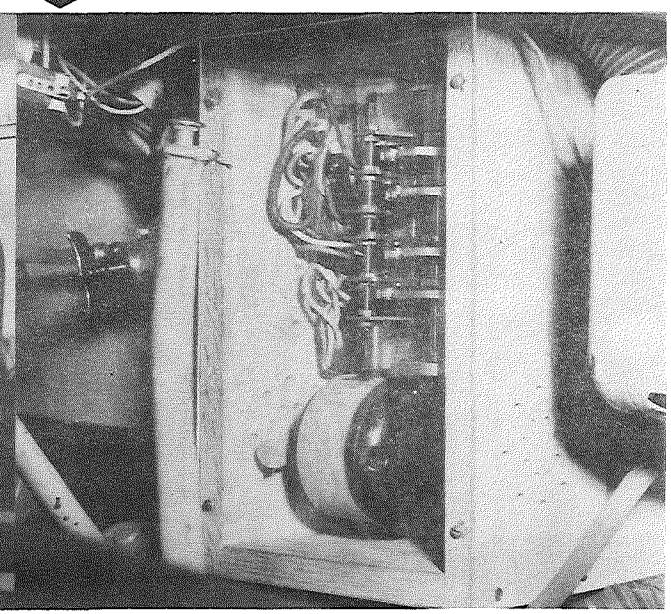


Figure 5. Cycle control cams and motor drive.



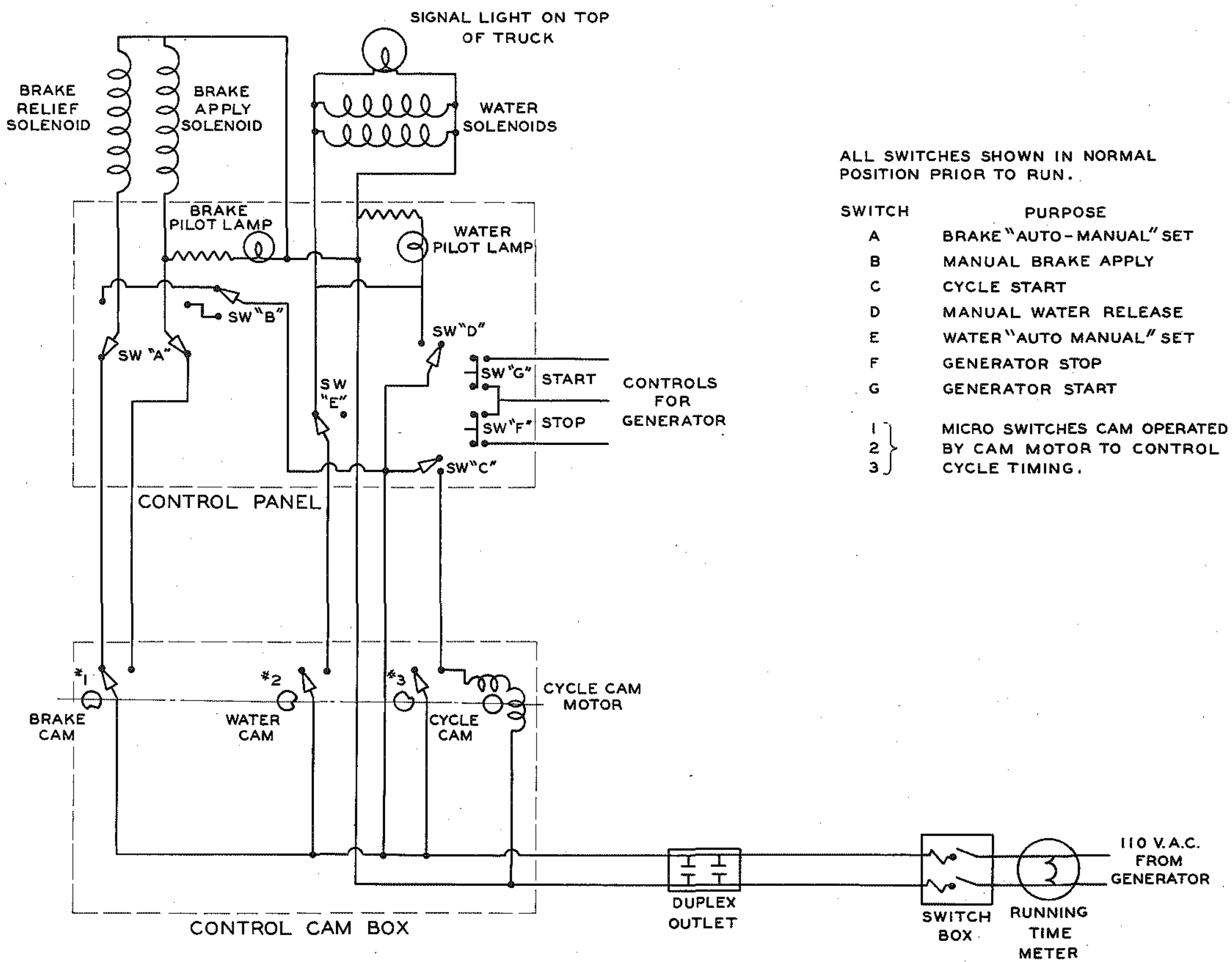


Figure 6. Circuit Diagram of Automatic Electrical Control System for Skid Cycle.

Figure 7. The MSHD Skidometer running a typical test at 40 mph on a bituminous concrete project.

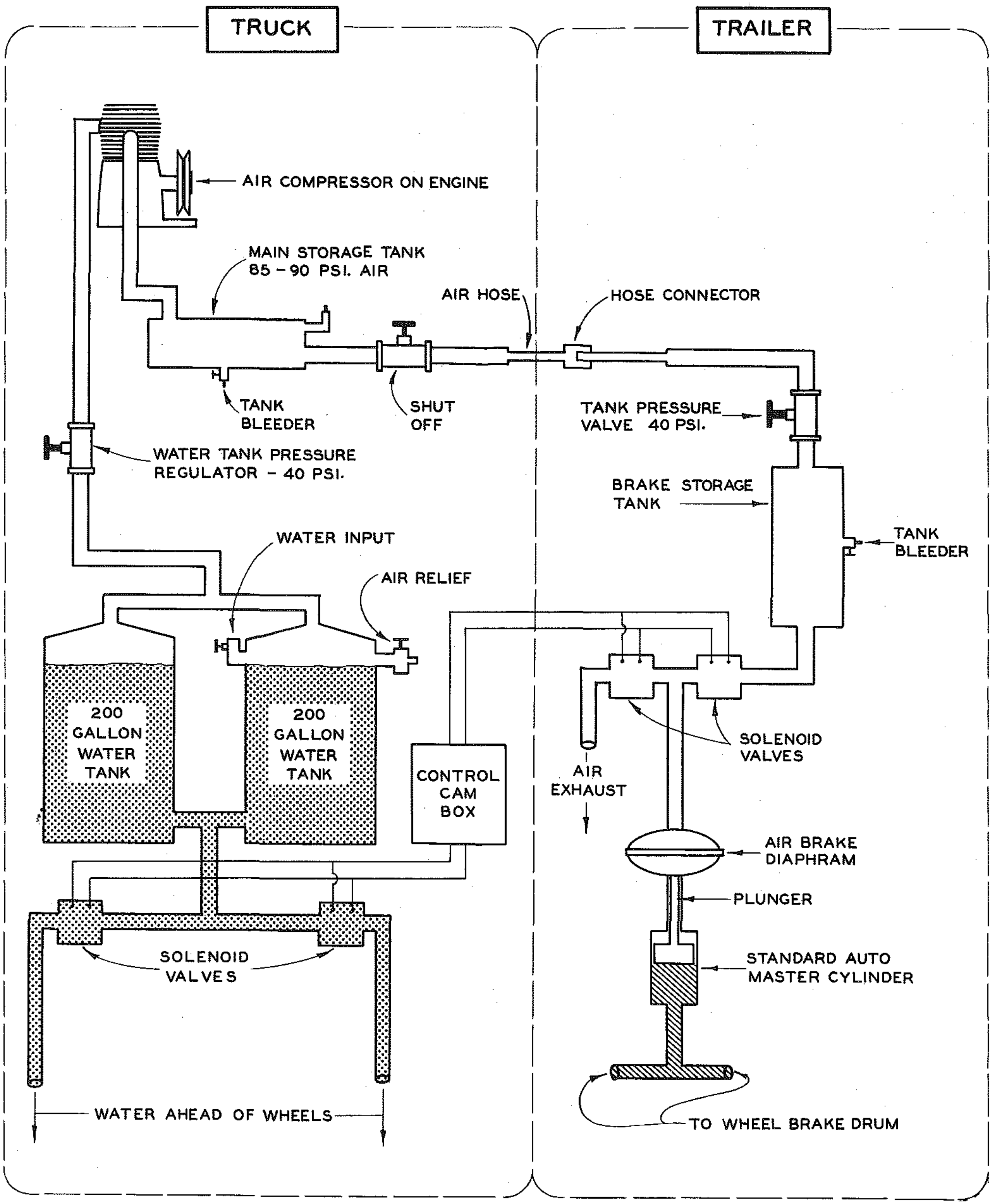


Figure 8. Skidometer: Air, Water and Brake System