where:

T = Tension on net section in pounds per square inch.
$\frac{D}{2}$ = Radius in inches of inside of boiler.
BP = Boiler pressure in pounds per square inch as shown on the gage.
t = Thickness of plate in inches.
E = Efficiency of the boiler seam in per cent.

There are two co-ordinate fields shown on the sheet, both of which are used in determining the tension on a net section. One field consists of a series of straight lines showing the relation between boiler pressure and the inside diameter of the boiler. The equation for these lines is

$$X = \frac{D}{2} \times BP$$

where X is equal to the product of boiler pressure and the radius of the inside of the boiler. This is transferred to the second field in obtaining the tension on a net section.

The second field consists of two series of straight lines crossing each other. The series of lines upon which are marked the thicknesses of plate are plotted from the equation

$$Y = \frac{X}{t}$$

where:

Y = Tension on net section at 100 per cent efficiency
t = Thickness of plate in inches.
X = Value of $\frac{D}{2} \times BP$ as explained above.

The other series of straight lines upon which are marked the different efficiencies, show the relation between the tension on a net section at 100 per cent efficiency and on a net section for the various other efficiencies of seams as noted. These lines have been plotted from the following equation:

$$T = \frac{Y}{E}$$

where:

T = Tension on net section at the desired efficiency.
E = Efficiency in per cent.
Y = Value of $\frac{X}{t}$ as explained above.

Problem 7.—To find the tension on a net section of a boiler of 84 5/16-in. diameter, 27/32-in. thickness of plate, 200 lb. boiler pressure and 82.75 per cent efficiency of seam.

From the point representing 84 5/16-in. diameter on the horizontal axis of field No. 1, project a line vertically until it intersects the 200 lb. line and from this point project a line horizontally into field No. 2 until it intersects the 27/32-in. line. Project this point vertically until it intersects the line representing 82.5 per cent, where it will be necessary to interpolate to reach an imaginary line representing 82.75 per cent. This point projected horizontally to the vertical axis gives the desired tension on net section as 12,100 lb. per sq. in.

Problem 8.—What efficiency must a boiler seam have when the tension on a net section is 12,250 lb. per sq. in. with inside diameter of the boiler 86 in., boiler pressure 200 lb. and thickness of plate 7/8 in.

From the point representing 86 in. on the horizontal axis of field No. 1, project a line vertically until it intersects the 200 lb. line, and from this point project a line horizontally into field No. 2, until it intersects the 7/8 -in. line. The projection of this point on the horizontal line showing 12,250 lb. tension on a net section gives the required efficiency which is by interpolation 80.2 per cent.

SNOW AND ICE ON THE PENNSYLVANIA

A Story of a Seven Weeks' Struggle During the Worst Winter the Eastern Railroads Ever Experienced

THE months of December, January and February have been truly characterized as the "worst winter" in the history of railroading in the Eastern United States. Seven weeks of arctic weather with fifteen-foot drifts on tracks, below-zero temperatures, and blinding gales that made regular running of trains impossible and at times stopped movement altogether. The experiences of the Pennsylvania Railroad in this seven weeks' struggle with the forces of nature have been brought together in a report by Elisha Lee, acting vice-president in charge of operation, an abstract of which is presented herewith.

Surveying all divisions of the lines east of Pittsburgh the features of the weather during the period covered by the report, were not only the record-breaking cold, the heavy snowfalls and high winds, but the unprecedented length of the frigid spells, which gave no breathing time to recover and prepare for the next emergency. In the mountain regions traversed by the Pennsylvania these conditions were practically unbroken throughout the entire time from mid-December until the beginning of February.

The shopmen stood the acid test of fidelity by shoveling snow, breaking ice and clearing switches, often under weather conditions involving severe hardship. The withdrawal of these men from the shops had a serious effect on repairs and construction, but there was no alternative, as without their aid it would have been impossible to open the lines and restore traffic.

The Altoona shops reported that between December 20 and January 21, their men spent 9,225 ten-hour days in snow-shoveling and switch-clearing. This resulted in the loss to the shops of class repairs to 19 engines, the building of 39 steel freight cars, the strengthening of 33 cars, heavy repairs to 25 others, light repairs to 45 passenger cars and the manufacture of 350 car wheels. In addition, the operation of the shops in general was unavoidably slowed up by the temporary disruption of the forces.

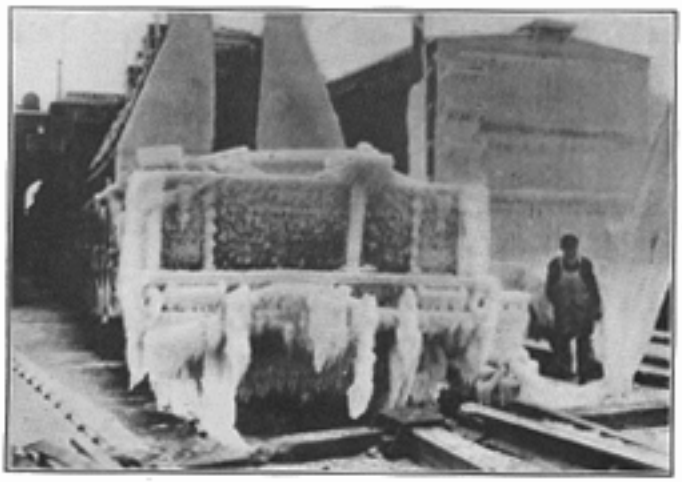
On the Bellwood division, with a shop force of only 259 men, the shopmen spent 11,000 hours in shoveling snow during the same period. This is given in the report as the principal reason for an accumulation of 540 cars awaiting repairs on January 30, the normal capacity of the Bellwood division shops being 150 cars. The Pittsburgh division, for the same reason, reported an accumulation of 2,357 cars awaiting repairs, or 100 per cent above normal.

Showing the disastrous results of a minor accident during severe weather, the Sunbury division reported that during zero weather a truck broke on a freight car east of Boyd, Pa., on the single-track portion of the division. By the time this wreck was cleared, seven following freight trains had frozen up, the crews had to be relieved for rest under the sixteen-hour law, and the cars were stored and the engines towed to the terminal.

Among miscellaneous results reported from the severe cold on all divisions, were air-hose freezing, trains stalling, trains parting due to broken couplings, hot boxes dues to journal boxes being stripped off by snow and ice, broken rails, frozen signals and signal wires, and failure of interlocking plants. Much trouble was experienced with water-

scoops on engines freezing up so that they could not be used. It was frequently necessary to maintain large forces of men at each track tank to remove the accumulation of ice caused by the flying water freezing on the rails and roadway.

The report deals in detail with the effect of extreme cold in lowering the efficiency of unskilled and semi-skilled labor, and in making it impossible in many cases to hold men in the service. On the Cresson division, where conditions were unusually severe, in order to maintain an engine-house force of 149 men, it was necessary to hire 171 new men in four months, making a turnover for that period of nearly



On a Car-float—After a Trip from Norfolk to Cape Charles

115 per cent or at the rate of 344 per cent for the year. The turnover for the entire force of 495 men directly connected with train operations was at the rate of 218 per cent per year.

In the Pittsburgh district the turnover of engine-house forces was at the rate of 192 per cent per year; for firemen and trainmen 120 per cent and for track forces 351 per cent. Furthermore, 55 per cent of the entire force of freight brakemen and 44 per cent of the entire force of firemen on the Pittsburgh division have been in the service less than six months.

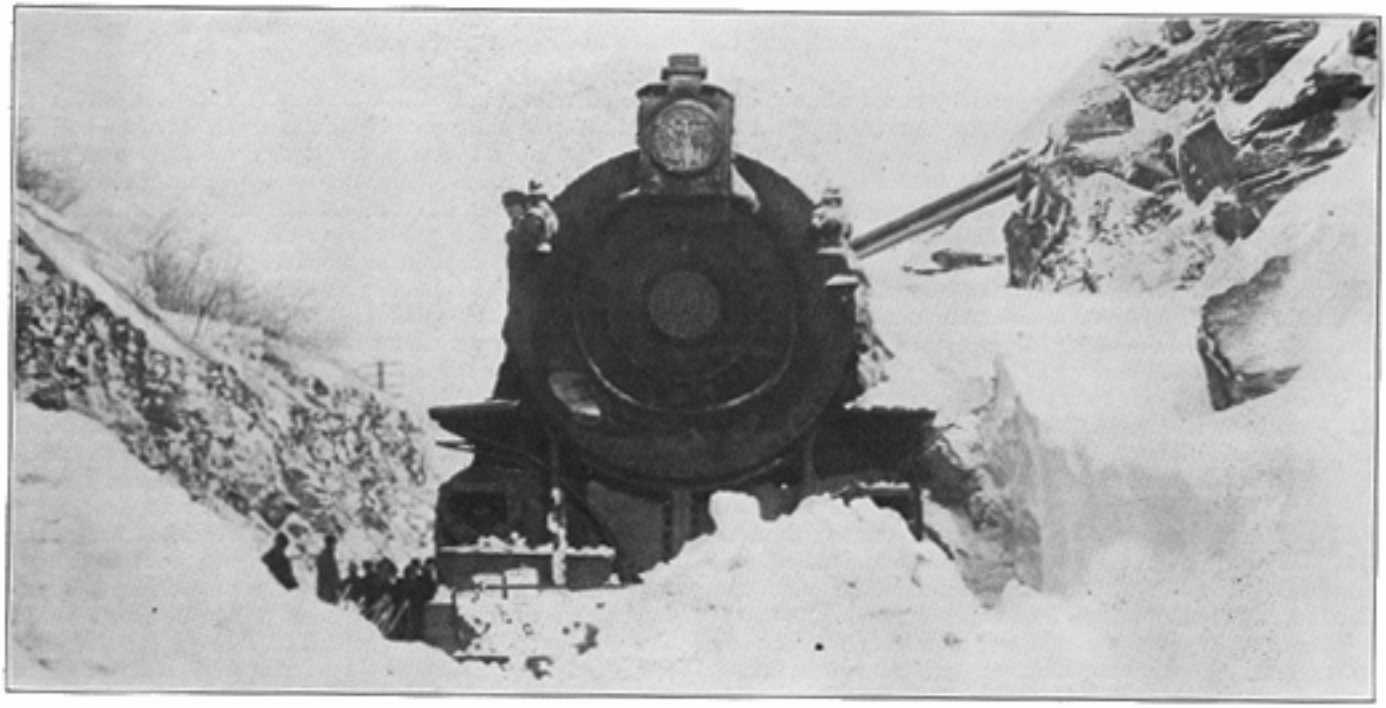
The effect of the weather in reducing the average tonnage carried per freight train was, on the Maryland division, 36 per cent; Philadelphia division, 25 per cent; Middle division, 17 per cent; Pittsburgh division, 38 per cent.

Frozen ash-pans in engines caused thousands of delays

Cut Approaching the Westbound Tunnel near Gallitzin—Drifts 15 ft. Deep

over all portions of the system. Reports on the Cresson and Williamsport divisions show that during zero weather from three to four hours were required to clean one ash-pan, which normally would take from 25 to 40 minutes. The Conemaugh division reported delays due to frozen ash-pans totalling 8,392 hours, which was equivalent to the loss of the services of 35 engines for a month of 30 eight-hour days.

Frozen ash-pans are caused by flying snow, and water dripping from boiler appliances, forming a solid frozen mass with the ashes. Condensed moisture and steam coats the mechanism of the ash-pan so that much time is lost in clearing the working parts, while it is necessary to break



Shop Men Digging Out a Train Stalled on a Branch Line Near Altoona, Pa.

up the solid frozen masses with steam jets and iron bars.

Thousands of delays in the very cold weather were due to the lubrication in the journal boxes of cars freezing, especially where the cars were standing in classification yards. In such cases hot oil had to be used before it was possible to move the cars over the hump. It was often found necessary to push cars down the hump grades because the oil in the axle boxes was so stiffened that they would not run by gravity.

The solidly frozen roadbed, which for weeks at a time was as hard and unyielding as a cement pavement, greatly increased the wear and tear on engines and the amount of repairs required. At the Meadows shop, near Jersey City, from December 30 to January 31, 20 engines arrived at the enginehouse with broken frames, which is a greater number of this class of failures than ordinarily occur in a whole year. Many main and side rods of engines were also broken in the efforts to move cars which had frozen to the rails. The Pittsburgh division reported 576 engine failures in January, 1918, as compared with 398 in January of last year, an increase of 45 per cent. The Conemaugh division reported engines out of service for a total of 4,400 hours in making running repairs, which is equivalent to a loss of 18 engines for a month of 30 eight-hour days.

Much trouble with boilers, especially of engines running in the mountain divisions, was reported from the unavoidable use of water of poor quality, due to the low supply streams, some of which were frozen almost solidly for weeks. This resulted in the failure of thousands of flues and many leaky boilers.

On the night of January 27, when a half dozen through express trains were stalled on the top of the Allegheny mountains near Gallitzin, with the temperature at zero, the wind blowing a gale and the snow drifts in the cuts 12 to 15 feet deep, Train No. 9, the Western Express, with three engines, reached a point half a mile west of Gallitzin, when it was stopped by the snow. The seven rear cars were uncoupled and another engine sent to pull them back, but by the time the tunnel was reached the west portal had drifted shut and it was impossible to go any further. The passengers were taken out of the train and sent to a hotel. It was impossible to move these cars until five o'clock the next afternoon, and then five heavy freight engines were required to pull the seven empty coaches.

Meanwhile the other three cars, together with the three engines which were pulling the train when it stalled, remained a mile and a quarter further on in the drift. Five hundred men worked all the night of January 27 and until the next afternoon, before these three cars and engines were dug out and the track cleared for them to move.

These results, in the face of unprecedented difficulties, were only accomplished by the self-sacrifice, loyalty and devotion to duty of many thousands of officers and employees who cheerfully performed unaccustomed and arduous work and repeatedly faced hardship, danger and real suffering, in the struggle to keep the lines open so that the public and the government might be served.

SUPPLY INTERESTS WRITE MR. MCADOO

An Open Letter to the Director General from the Railway Business Association on Standardization

GEORGE A. POST, president of the Railway Business Association, under date of February 25, sent the following communication to Director General of Railroads McAdoo:

Manufacturers of railway necessaries respectfully invite you to study certain considerations bearing upon mechanical design and practice in the field of rolling stock construction, purchase and maintenance.

The Railway Business Association, of which I have the honor to be president, is a national organization of manufacturers, merchants and engineers dealing with steam railroads. What we have to say from our own experience accurately portrays the problems of the whole railway appliance industry.

It appears from your official announcement that you have delegated to technical committees the work of recommending to you a detailed plan of procedure for the acquirement of new rolling stock by the railroad systems. The phases upon which we desire to address you are those which involve the peculiar interest of makers of appliances or parts as distinguished from assemblers of locomotives and cars.

In the field of transportation inventors and developers of special appliances embody the spirit and function of progress. Our interest and the national interest in this respect are identical. What the manufacturers of railway appliances cherish and what the public as a whole is interested in preserving is that flexibility which leaves the way open to mechanical advance. Always we have before us two antagonistic requirements which must be compromised—improvement through change and stability through standardization.

To a certain extent standardization is essential. As transportation became national and interchange of cars among the several roads became common, convenience and economy in repairs required a tendency toward interchangeability of parts. With the organization of the Railroads' War Board last April came for the first time to any extent use of engines on the rails of roads other than the owner. What has long applied to cars affecting repairs now applies in some degree to engines. The drift, as with cars, is toward interchangeability of parts. The method by which inter-line use of cars was made possible was, to be sure, standardization, but it was a standardization of dimensions. If the car frame were uniform a device of any patent could be used upon it. Thus we attained practical current convenience while preserving variety of design and material, of terms, delivery and dealings, and hence reasonable expedition in the demonstration and introduction of improvements.

We earnestly commend to your favorable consideration the fullest adherence to this method consistent with the most effective rehabilitation and maintenance of transportation facilities in face of the enemy. We are ready for any sacrifice essential to winning the war. We would deplore as disastrous to the nation's business any departure, not clearly necessary for national defense, from competition between patented railway appliances.

Manufacturers of railway goods have borne an honorable part in promoting the progress of transportation science. What they have achieved for the public in safety, comfort, speed and economy of railway operation has been accomplished in an atmosphere of keenest competition. We could try persuasion upon one independent railway manager after another until the test was made and a demonstration afforded. Our work has been marked by variety, elasticity, development. The inventor, the executive and the salesman have been in-