ther surveys of about 200 miles by odometer, pocket compass and pocket level. The stadia survey was made at an average rate of 9½ miles a day, the total time from Hankow to Canton having been 77 days. The 200 miles of compass reconnaissance was thrown in, being done by the Chief Engineer personally. The reader who is familiar with such matters will see that this was a pretty expeditious job. Hankow and Canton are fixed astronomically. Therefore, the accuracy of the stadia line in the main could be somewhat controlled, and in fact it closed on Canton within about one-half mile. The level was carried by means of the stadia.

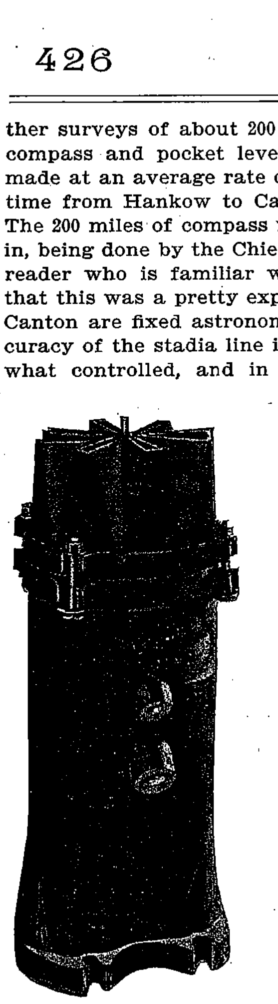

Fig. 1.—The Sweney Nozzle.

The line passes through some difficult country and from end to end it is not easy. Up the Yang-Tse-Kiang and up the Siang-Kiang, an affluent of the Yang-Tse-Kiang, the conditions are difficult in that the level of the country falls away as one goes back from the river, and the flood in the Yang-Tse-Kiang rises 40 and sometimes even 52 ft. Consequently, great areas back from the river are flooded. The rivers are more or less completely diked, but a line built near them must be carried on a very heavy bank. It is not improbable that if this line of railroad is built it will be carried inland some 15 miles from the river to the foothills of the inland plateau, but this would involve its own difficulties, as the foothills are cut by deep ravines and probably the alignment can not be as favorable as by keeping closer to the rivers.

After the Siang-Kiang is left, the line, which follows up a branch of that stream, gets into mountains, and it crosses a divide at an altitude of about 1,200 ft. above the sea. Mr. Parsons here found a pass some distance east of the old trade highway and lower than the pass by which that highway crosses, and he got through the mountains with maximum grades of about one per cent. Going down the southern slope he came to the Pei-Ho,* down which river the line is carried some of the way through difficult cañons.

On the whole, the project is bound to be more costly than has generally been supposed. The southern part of the line will necessitate some heavy rock work and a few short tunnels.

Obviously, it would not be proper to say now anything of the estimates of the future working expenses and revenues of such a railroad. To get facts and make such estimates was part of the work for which Mr. Parsons was sent out. It is enough to say that the Province of Hunan, through which the railroad goes, is rich and thickly peopled and it contains great deposits of coal which would be carried both ways by the railroad. This coal is now brought down by boat to Hankow for the steel mills established there. Coke is made at the mines. The tea trade of the line would also be important and obviously the dense population of the Province must produce and consume a great deal of material.

The Province of Hunan has long been hostile to foreigners and a considerable part of the country over which the survey was carried had never been crossed by a European. Lord Charles Beresford says that it is the most hostile province of China. The Governor of the Province at first declined to permit Mr. Parsons and his party to cross, and the general opinion was opposed to his undertaking the survey. In fact it was carried through with no very serious trouble, although the party, or members of it, were attacked several times by mobs. A considerable guard of Chinese soldiers accompanied the party throughout the expedition. Sometimes this guard numbered 300 men, but we judge that the patience and firmness of the Chief Engineer had a good deal more to do with the safety of the party than the presence of the soldiers.

Mr. Parsons was accompanied on the expedition by Capt. W. W. Rich, recently of Minneapolis, now Engineer to Sheng, the Imperial Director of Chinese Railroads. He had with him five engineers; also Mr. Charles Denby, Jr., son of the late U. S. Minister to China, who acted as interpreter; a physician and two Chinese secretaries of Sheng, the Taotai. These latter gentlemen spoke English fluently. Notwithstanding the hostility of the people of the Province, Mr. Parsons thinks the expedition had less annoyance than an expedition of Chinese surveyors would have in going through many parts of our own country, in which remark we think that we detect an allusion to the enlightened spirit of the average American where the Chinaman is concerned.

The route from Hankow to Canton is an old trade route and was for many years the main course of trade between the Yang-Tse-Kiang Valley and the sea. Some 40 years ago, however, the port of Hankow was opened to trade and now the traffic by the north and south land route is small. This trade is carried on by boats on the rivers, the draft of these boats constantly diminishing until the smallest of them on the upper waters draw but three or four inches. There is a portage over the mountains of about 30 miles. Here is a high-road 15 ft. wide, paved with stone over which goods are carried on the backs of coolies and on ponies. The party was able to carry its supplies by boats by following this old trade route and generally could get back to the boats to sleep. When they were obliged to sleep on land they could find a temple or some vacant public building, such as an examination hall, and occasionally slept in a Chinese inn, which seems to have been the last resort.

For obvious reasons we can say nothing about the present plans of the concessionaries.

While the actual work of carrying on this survey was attended by anxieties and considerable danger, it really was the least perplexing part of the work which had to be done. The most serious of Mr. Parsons' tasks was diplomatic, which part of the enterprise would make a story which would be very entertaining if it could be made public. The Chinese officials were very polite and did what they could to assist the undertaking, while the representatives of the British Government showed their sympathy in the most practical manner to the Anglo-American idea, which feeling is strong in the East.

The members of the engineering party which accompanied Mr. Parsons consisted of R. C. Hunt, engineer in charge; A. E. Coulter, topographer; H. B. Magor, instrument man; W. K. Brice, rodman; W. S. K. Wetmore, rodman.

* There is another and better-known Pei-Ho in the North.

A New Locomotive Exhaust Nozzle.

During the past year Mr. W. H. VanDervoort, Assistant Professor of Mechanical Engineering at the University of Illinois, and Mr. Don Sweney, a post-graduate student, have made some interesting tests of locomotive exhaust nozzles in which the action of a new nozzle designed and patented by Mr. Sweney was compared with that of the Smith triple expansion nozzle and several common round nozzles of different sizes. Prof. VanDervoort has kindly furnished data regarding these tests, and also the records of the performance of several locomotives which have been fitted with the new nozzles. The tests also show in a general way what may be gained by reducing the back pressure in locomotive cylinders.

It was found that, with a smokebox of given size, the vacuum produced by the exhaust jet depends mainly on the velocity of the exhaust at the orifice of the nozzle, and the perfectness of the entraining action on the gases. In the common nozzle the entraining action is weak since the issuing jet, due to its density, does not readily take up the products of combustion until it has become thoroughly expanded in the stack, consequently a higher velocity of discharge is required than is the case where the entraining action is more perfect. High velocity, it is well known, means high back pressure and correspondingly large work losses in the cylinders.

The average 18 or 19 in. by 24 or 26 in. locomotive usually runs with about a 4½ in. single nozzle tip, or 15.9 sq. in. of exhaust area, but more locomotives will probably be found with tips smaller than 4½ in. than larger; light service, large boilers and good coal being the conditions which enable the use of the larger tips. In this connection it is interesting to note that the high speed stationary engine builder uses a 4½ in. exhaust pipe for a 10 by 10 in. engine to avoid the losses due to back pressure, yet the conditions under which a locomotive operates compels the use of a no larger exhaust opening for two 19 by 26 in. cylinders. In the locomotive the two points of contracted exhaust are usually at the steam port, when open to exhaust, and at the tip. When the area of the tip equals the area of the port opening, materially greater reductions in back pressure cannot be expected from the use of larger tips, but this, except in the case of improperly proportioned valves, does not often occur, and naturally the tip is considered the proper point at which to reduce back pressure. Since increasing the area of the tip reduces the vacuum in the smokebox and injures the steaming qualities of the boiler, the limit in this direction is quickly reached, and usually the exhaust is found choked to about 60 per cent. of the port opening. The new nozzle was designed with a view to overcoming the contraction necessary in the usual nozzles by providing a more complete admixture of the steam and products of combustion immediately after the steam leaves the tip, thus producing a powerful entraining action, and maintaining the required vacuum with a lower velocity of the exhaust steam, corresponding larger tip area and lower back pressure in the cylinders.

In Fig. 1 is shown a view of the new nozzle. The pipe enlarges slightly from the base to the tip, being 12 in. inside diameter at the top, and thus forming a small receiver which serves to prolong the exhaust, thereby maintaining a more steady vacuum, with less sharp action on the fire which clinkers the tube sheet and pulls excessive quantities of sparks through the tubes. Each one of the several radiating ports is a separate nozzle. The velocity of the steam does not increase until within a few inches of the top, so that long contracted passages are avoided. The steam issuing from adjacent ports comes together a short distance above the top of the tip and forms with the recesses between the ports vacuum pockets into which the gases are drawn and mixed with the steam at the point of its maximum velocity, thus imparting its high velocity to the gases at the base of the stack. The blower is placed in the center and connected with the upper pipe connections, shown on the side of the nozzle pipe. The air pump exhaust enters at the lower connection. A sectional drawing of the tip is shown in Fig. 2.

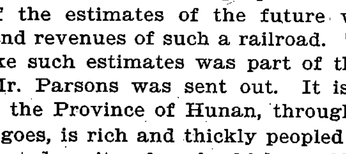

Fig. 2.

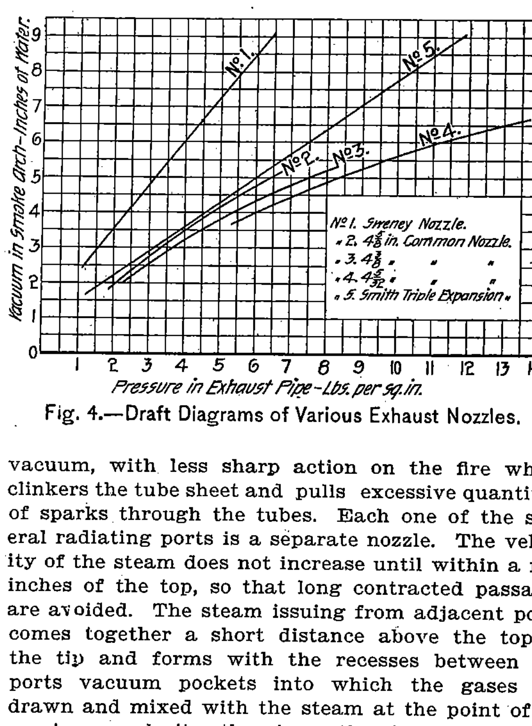

Fig. 4.—Draft Diagrams of Various Exhaust Nozzles.

The experiments with this nozzle were made under actual running conditions on an Illinois Central mogul freight locomotive, No. 420, between Champaign and Centralia. The first series involved draft and back pressure relations with the Sweney nozzle, using pipes of different height, different forms of stack and diaphragm arrangements. A similar series was then made with the plain single pipe using three sizes of tips, and with the Smith triple expansion pipe. In these experiments a pressure gage was connected with the base of the nozzle pipe, and a water gage with the interior of the smoxebox, the arrangements being the same in all cases. A large number of simultaneous readings were taken from the gages and all readings plotted, the observations covering the various conditions as to thickness of fire, speed and working of the engine throughout a run of 125 miles.

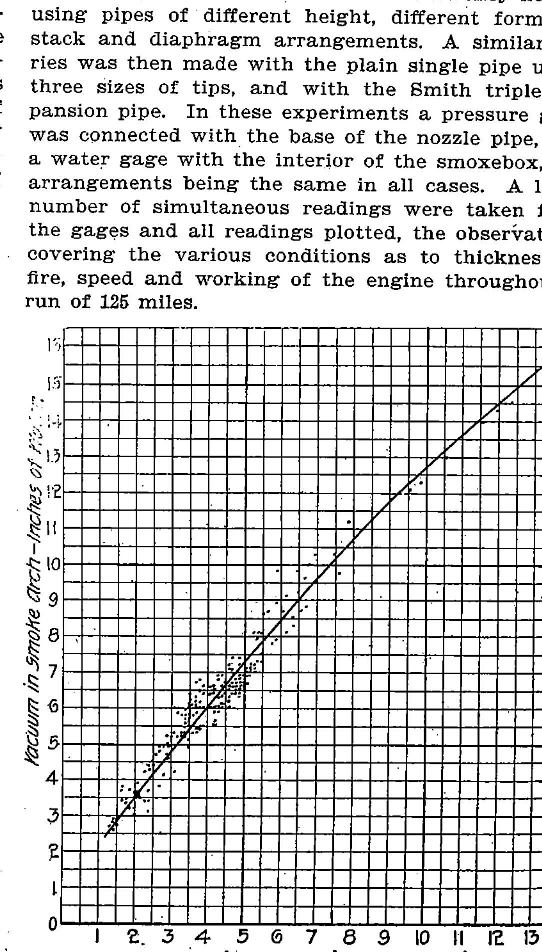

Fig. 3.—Draft Diagram of the Sweney Exhaust Nozzle.

In Fig. 3 is shown the draft diagram for the Sweney nozzle. It will be noted that the draft increases with the back pressure in almost a direct proportion for all working conditions and that it falls slightly for the excessive draft conditions shown by the upper points of the curve. These upper points were obtained by quickly placing the reverse lever forward when running at high speed simply for the purpose of determining the character of the curve. That portion of the curve between four and seven inches of draft represents the working limit, ordinary conditions giving from five to six inches.

The curves for the other nozzles were plotted in the same way and for comparison all curves are shown in Fig. 4. Referring to the curves, No. 1 is for the Sweney tip with 19 sq. in. of exhaust opening; No. 2 for the 4⅝ in. common tip, 16.8 sq. in opening; No. 3 for the 4⅜ in. common tip, 15 sq. in. opening; No. 4 for the $4\frac{5}{32}$ in. common tip, 13.5 sq. in. area, and No. 5 for the Smith triple expansion nozzle with 16.5 sq. in. opening. The test of the Smith pipe was made on an engine in passenger service. In all cases except that represented by curve No. 2, the engines steamed freely. Curve No. 5 is of the same general character as No. 1, the draft increasing almost directly with the back pressure. With nozzles Nos. 2, 3 and 4, however, the curves incline towards the horizontal axis, and show how great the back pressure becomes when a strong draft is required, also, how excessive reductions in tip area on over-cylindered or poor steaming engines, while apparently improving their steaming qualities, do not materially increase the quantity of steam made, but choke the engine to such an extent that it cannot use the steam to advantage. An inspection of these curves shows that the new nozzle produces through the working range, equal draft at about one-half the back pressure required by the other nozzles.

In order to know definitely the engine economy resulting from the use of the larger nozzle, one cylinder of engine No. 417 of the same class as No. 420

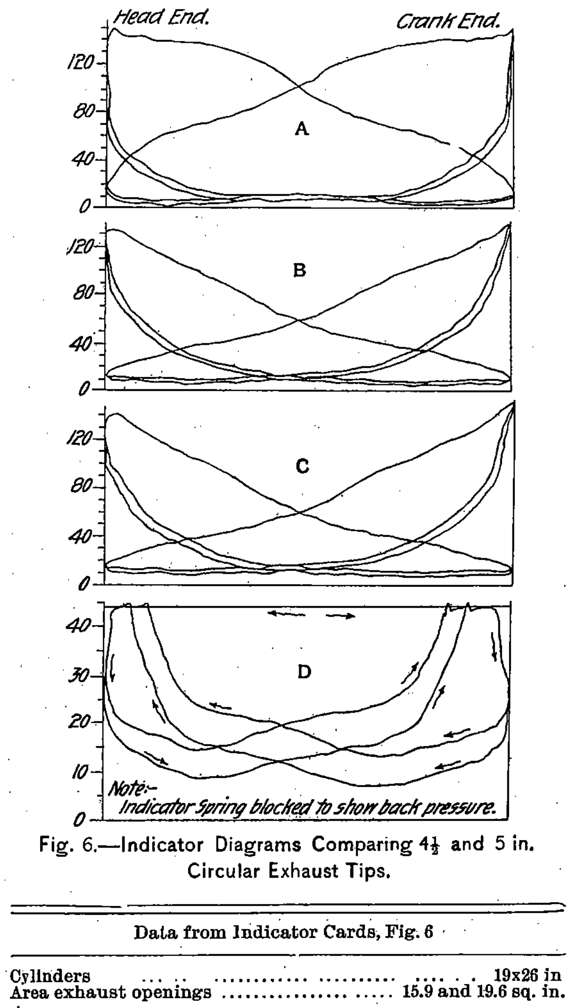

Fig. 6.—Indicator Diagrams Comparing 4½ and 5 in. Circular Exhaust Tips.

Data from Indicator Cards, Fig. 6

Cylinders .... 19x26 in
Area exhaust openings .... 15.9 and 19.6 sq. in.

Card.		A	B	C	D
Speed, miles per hour.	....	12	30	36	14
Cut-off, inches of stroke	....	10	8	8	10
Mean effective pressure, head end, lbs. per sq. in.	Large tip	84 12	45.39	47.66	....
	Small tip	80.42	41.60	42.40	....
	Difference.	3.70	3.69	5.26	....
Gain in M. E. P., per cent.	....	4.6	8.9	12.41	....
Mean effective pressure, crank end, lbs. per sq. in.	Large tip	86 95	47 28	46 8	....
	Small tip	83.28	42.74	42.2	....
	Difference.	3.67	4.54	4.6	...
Gain in M. E. P., per cent.	....	4.4	10.62	10.9	....
Increase in power, per cent.	....	4.5	9.76	11.65	....

was indicated. Since it is necessary to have all conditions alike when diagrams are to be compared, the device shown in Fig. 5 was applied. This tip consisted of the body, A, which was secured in the top of the pipe in place of the regular tip bushing, and the cap B, which was hinged to A, as shown. The shaft, C, which opened or closed B, extended through the smoxebox and was operated on the outside by a lever. When B was closed on A, the steam exhausted through 15.9 sq. in. of tip area, and when B was thrown back into the dotted position the area of the tip was 19.6 sq. in., or approximately 20 per cent. increase; this, for equal steaming, represents closely the increase in area of the Sweney over the plain tip. With this device the tip area could be quickly changed and indicator diagrams for each tip opening taken within five seconds of each other.

In Fig. 6 are shown four diagrams, A, B, C and D, taken in the way described. They are average cards. Diagrams A, B and C, with the data and calculated results given, need little explanation. They are typical locomotive indicator diagrams and the admission and expansion lines so nearly coincide that no difference is apparent in the engraving; on the original cards the lines could scarcely be distinguished one from the other. The increased loss due to back pressure as speed increased is clearly brought out; the percentage of gain being relatively small for slow speeds, but increasing steadily as the speed increases. A conservative estimate would give at least 5 per cent. gain in power for the same steam and fuel consumption due to the reduced back pressure.

Card C is of interest as it shows comparative back pressures on an enlarged scale. The diagram was taken with a 20 lb. spring, the piston of the indicator being blocked. The increased back pressure during the period when both cylinders are exhausting into the pipe is clearly shown on this card.

Last October the experiments were continued by fitting another Illinois Central mogul freight locomotive, No. 413, with one of the new nozzles, having an opening of 20 sq. in., with a view to determining the effect on the engine performance when in regular service. This locomotive has 19 x 26 in. cylinders, and was formerly run with a common 4¾ in. bridged exhaust nozzle having an opening of 16.3 sq. in. The results as shown by the monthly performance sheet are given in Table 1, and it is reported that a marked improvement has been noticed in both the steaming of the boiler and the ability to make fast time.

Table I.—Performance of Illinois Central Freight Locomotive No. 413.

Month.	Ranking position of No. 413.		Miles run per ton of coal.			
	Plain exhaust nozzle.	Sweney exhaust nozzle.	No. 413.		Average of class—20 engines.	
	1897.	1893.	1897.	1898.	1897.	1898.
October	9	6	15.91	15.67	15.56	14.80
November.	3	2	14.58	15 69	13.28	14.74
December.	14	1	13.0	16.03	14.44	13.7
	1898.	1899.	1898.	1899.	1898.	1899.
January.......	* .	3	*.......	14 87	*	13.9
February	*.... .	13	*.......	12.6	*.......	13.75
March	4	2	16.57	15.49	15.87	13.73
April	3	8	17 37	15.58	15 66	15.66

* In the shops.

It is impossible to make anything like exact comparisons from service records, as so much depends on the weight and kind of trains hauled and the way in which the locomotives are handled. As an illustration of the first, the record for April last of the engine fitted with the new nozzle can be cited, as during the month 55 per cent. of the trains hauled happened to be unusually heavy ones. During the whole time shown, however, the locomotive was handled by the same engineman with the exception of three weeks in last February, when an "extra" engineman plainly affected the performance. The ranking position of engine No. 413 for the five corresponding months for which figures are available probably forms the best comparison. During this time its average ranking position in the class of 20 locomotives when fitted with the common form of exhaust nozzle was 6.6, or a little better than seventh place, while with the new nozzle the average rank was 3.8, or a little better than fourth place.

Similar figures are presented in Table II for an 18 x 26 in., Illinois Central, eight-wheel passenger locomotive, No. 965, in which a Smith triple expansion exhaust nozzle, having an opening of 15.8 sq. in., was replaced, during the latter part of February, by a Sweney nozzle with an opening of 18.7 sq. in. The four engines of this class are all in the same service and are double-crewed, the same men handling the engine in question during the months compared.

Table II.—Performance of Illinois Central Passenger Locomotive No. 965.

Month.	Miles run per ton of coal.			
	No. 965.		Average of class—4 engines.	
	1898.	1899.	1898.	1899.
March	26.76	30 98	26.66	28.88
April	26.12	33 72	26.34	30.45
May......	30.21	34.5	30.12	....

* First 15 days only.

It will be noted that there is not only a marked improvement in the coal record of engine No. 965 for the months when the new nozzle was used over similar months of the previous year, but the performance is considerably better when compared with the average performance of all the engines for the same month in 1899. As might be expected, the larger exhaust nozzle enables the locomotive to make better time, and as in the previous case although the draft is mild the boiler steams freely.

One of the new nozzles has also been used with an Illinois Central suburban engine at Chicago since the latter part of March, and the performance sheet for April shows that the number of miles run per ton of coal was 22.1 against 18 miles for the same month of last year when a Smith nozzle was used. Similar figures for the average of the class of ten engines was 20.6 for April, 1898, and for April, 1899, 22.28 miles per ton of coal.

The new nozzles have also been used on the Peoria & Eastern Division of the Cleveland, Cincinnati, Chicago & St. Louis with some over-cylindered consolidation freight engines which had often failed formerly for lack of steam. With these engines the improvement brought about by the new nozzles has been very marked. In this connection, a rather interesting fact has developed that because of the reduction in the back pressure somewhat heavier trains can be hauled over the ruling grades; this is not due to the locomotive exerting more power when pulling at slow speeds, but because it is possible to make a faster run when approaching the foot of the grade.

Since the theory of the Sweney nozzle depends on

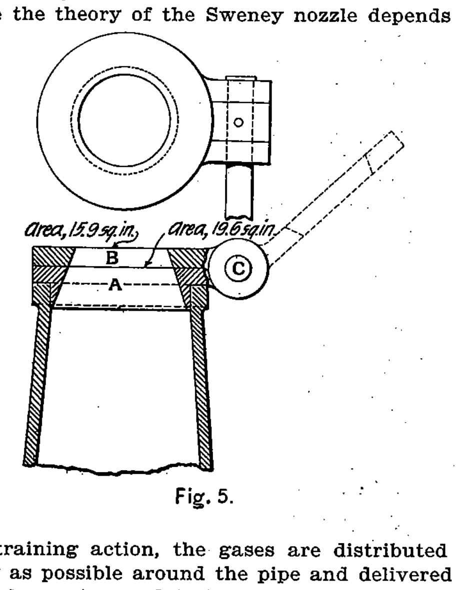

Fig. 5.

the entraining action, the gases are distributed as equally as possible around the pipe and delivered to it at a low point, and in Fig. 7 is shown the front end arrangement which has been used in connection with this nozzle. As shown, the deflecting plate is carried quite low. The horizontal plate is provided with about three square feet of netting around the pipe and the forward netting is placed low, reaching but little above the middle of the arch, with a horizontal plate extending forward to the door. The diaphram is placed ahead of the pipe. An extension to the stack terminating in a wide mouthed flounce reaches to within a few inches of the top of the tip. This arrangement has been found to clean the front end well, and equalize the draft on the tubes. As with all nozzles the exhaust openings will gum up, but the ports are easily cleaned with a knife without taking the tip out. This attention once in two months is said to keep the openings free.

The Tramp and the Railroad.

Finally we come to the great and pathetic class of trespassers. Of these, 3,913 were killed (1897), or more than 60 per cent. of all the fatalities. Relatively, very few of these were killed in train accidents; a few more at highway crossings; about 8 per cent. at stations, and much the greatest number walking on tracks and about yards. To be sure, many of these people were tramps, and could well be spared, but many others were respectable and useful citizens, and innocent children who might have become useful citizens.

This class of railroad mortality is one of the disgraceful facts of our civilization. Year after year more than ten people are killed every day on the railroads of the United States because they are where they have no business to be. These daily deaths are

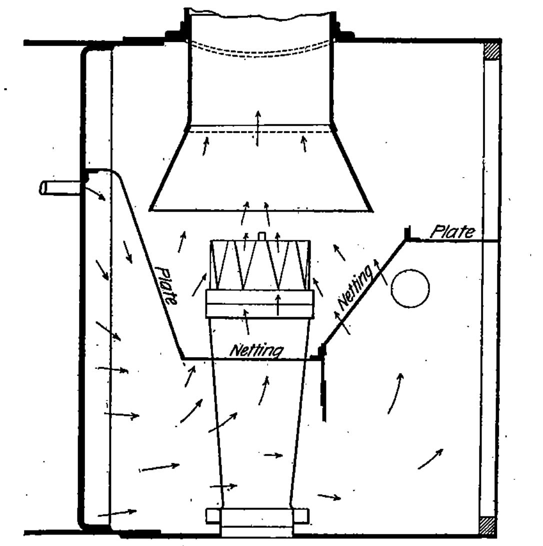

Fig. 7.—Front End Arrangement Used with the Sweney Exhaust Nozzle.

two or three times as many as the deaths among our soldiers in the Philippines since the fighting began there, and they are all to no purpose. It is an absolute waste of human life.

But this is a matter in which the railroads are practically helpless. The American citizen thinks that it is one of the privileges of a freeman to walk on railroad tracks, and one of the privileges of a freeman's boy to play around railroad yards, and swing on the steps of moving cars, and steal a ride