JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXLIV | JULY, 1897 | NO. 1

THE VENTILATION OF PASSENGER CARS ON RAILROADS.*

BY DR. CHAS. B. DUDLEY,
Chemist to the Pennsylvania Railroad Company, Altoona, Pa.

I dare say every one who has spent any time in a railway car has wondered to himself why in the world the railroad company does not ventilate its cars better. The query is a very natural one, but I am sure if the general public knew how much the subject of the ventilation of passenger cars on railways has been studied, and how difficult are the problems presented, they would be more lenient in their criticisms than they sometimes are.

Of course, the first step in the study of a problem of this kind is to find out what is the present state of affairs. Professor Ripley Nichols, of the Massachusetts Institute of Tech-

*A Lecture delivered before the Franklin Institute, Friday evening, January 22, 1897.

nology, some fifteen or more years ago, made a number of analyses of the air from railway cars on the Boston and Providence Road, for the Railway Commissioners of the State of Massachusetts. Also, about fifteen years ago, a system of ventilation of passenger cars was developed by a gentleman who had so much influence back of him that he had a car constructed which was sent to Altoona by the officers of the Pennsylvania Railroad, with instructions to make such experiments as would demonstrate whether that car was better ventilated than the standard passenger car of the road. In connection with the experiments on that car we made analyses of the air from passenger coaches three times; that is, of three different samples. The results obtained both by Professor Nichols and ourselves indicated that the present passenger coach on most of the railways of the country gets into it and out again—which practically constitutes ventilation—somewhere from one-eighth to possibly a tenth as much fresh air per hour as it ought to get. It is rather interesting that Professor Nichols' analyses and our own very closely coincide; and it is also quite interesting to know that Professor Nichols analyzed the air from smoking-cars and found no greater amount of carbonic acid in the air from these cars than from the ordinary passenger coach. I am not aware that any analyses have ever been made of the air of Pullman coaches.* Still further, two or three years ago we spent nearly the whole winter with a passenger coach on the Pennsylvania Railroad, trying to study and develop a system of ventilation.

Notwithstanding this study, and notwithstanding the amount of effort and the cry that is in the technical papers, and sometimes in the daily papers, in regard to the ventilation of passenger cars, I am very sorry to have to say to you, frankly and honestly, that it is not possible at the present time to properly ventilate a passenger car on a railway. No system

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*Since this lecture was delivered, a note from Wm. Forsyth, Mechanical Engineer of the C., B. and Q. R. R., calls attention to the fact that the air from Pullman cars has been analyzed, the results obtained being given in the Proceedings of the Master Car Builders' Association for 1894, pages 234-241.

is at present known by which this can be successfully accomplished. If I succeed in what I have attempted to-night, you will, before I am done, understand why.

Perhaps I may best bring out what I have in mind by asking myself a series of questions and then answering them for you. Accordingly, the first question which I shall ask myself is, what is the problem that we are undertaking to solve when we attempt to ventilate a passenger car? It is, perhaps, not too much to say that no problem in engineering has ever been undertaken by mechanical engineers, or ventilating engineers, if you choose, or chemists, or scientific men, that is so fraught with difficulties as the ventilation of passenger coaches on railroads. Let us see what the problem is.

An ordinary passenger coach contains about 4,000 cubic feet of space—about one-fifth the size of this room, as near as I can estimate. It is proposed to take into this small space at least sixty persons; to keep them in this space continuously, without allowing them a chance to get out, for four hours or longer; to keep these persons warm enough for their comfort in winter, and to supply them with enough fresh air to ventilate the car properly, and at the same time exclude, throughout the year, smoke and cinders, and, in the summer season, dust. I think it is fair to repeat that no problem has ever been committed to the experimental and mechanical engineering departments of the Pennsylvania Railroad since I have been connected with it, now a little over twenty years, so difficult of solution as this problem of car ventilation.

The next question I shall ask myself is, is a system of ventilation on passenger cars essential throughout the year? Do you need to ventilate your cars in summer? Why not open your doors and windows and have all the fresh air you want? This seems, possibly, a very satisfactory solution of the problem, and if one state of affairs could be brought about, which, however, we cannot control, there would be no necessity for anything more than a system of ventilation in the winter season. That state of affairs is this: If the wind always moved at right angles to the direction of the train, you would have no difficulty, for the smoke and cinders and dust would then always be blown away from the cars, and doors and windows could be left open at pleasure. But the wind does not always blow crosswise to the direction of the train, and sometimes there is no wind at all, so that it frequently results that the motion of the train itself brings the smoke and cinders directly from the locomotive back to the coaches. Still further, on roads using dirt or gravel ballast, the amount of dust in the air is sometimes something appalling. In reality, therefore, our problem is to provide a system of ventilation that in the summer season will exclude dust, in the winter season will warm the air properly, and throughout the year will keep out smoke and cinders. We must, therefore, study the problem both from the summer and winter standpoint.

Again, can we have a ventilating system apart from the heating system? I answer that in the course of the years that this problem has been before the experimental departments of the Pennsylvania Railroad, we have been called upon to investigate a number of different systems. It apparently seems to many who have not studied the problem sufficiently, that it is only necessary to make a hole in a car and let the fresh air in, and you have a system of ventilation. Some of the systems that we have examined have practically been very little more than this. The present system of ventilating Pullman cars consists simply in letting cold air into the car through the deck sash near the top of the car, which cold air mixes with the warm air in the car, and may pass out through the ventilators over the lamps, or possibly out through the deck sash on the other side. Other so-called systems simply put ventilators in the deck to draw air out of the car, allowing it to find its way into the car as best it may. It is, perhaps, hardly necessary to say that such attempts can hardly be regarded as worthy of the name of a ventilating system. To our minds, the first requisite, the first essential feature of a system of car ventilation in our climate, is the heating system. There is very little use, if we are right, in trying to study the problem without studying the two systems together. Accordingly, in all our studies, we have tried to develop the two systems in connection with each other, and our belief is that any system of ventilating passenger cars that does not warm the air that is taken into the car, will result in failure. No human being can endure to have the amount of fresh air required for successful ventilation taken into a car in winter, unless that air is warmed.

Just here another interesting question arises, viz.: what is the test of good ventilation? How do you know when a room, or a car, if you choose, is well ventilated? It is obvious that we must have some measure of the ventilation, or else we cannot tell whether we are taking too much or too little air into the car. We have followed, in the studies which we are putting upon this question of the ventilation of passenger cars, Parke's Practical Hygiene, which, as we understand it, is the standard on hygiene for the British army. The seventh edition gives, perhaps, the best summary now available of the information we now possess, on the general subject of ventilation. In this edition it is stated as a test of good ventilation, that any space, be it a room, a passenger car, a theatre, or whatever you choose, is well ventilated when a person coming into that space from outside fresh air detects none of the odor characteristic of badly ventilated spaces. But what measure have we of what is characteristic of no odor? Odors cannot be measured. Fortunately, however, one at least of the substances accompanying the odor characteristic of bad ventilation, and which is proportional to the odor, can be measured.

Let me see if I can make this clear. Three things are continually given off from our bodies, namely, carbonic acid, water vapor and organic matter. Every time we breathe, we breathe out some carbonic acid, we breathe out some water vapor, as every one knows who has been out on a cold morning, and we also breathe out, there is exhaled from our bodies, a certain substance, which, for want of a better name, is simply called organic matter, and which is believed to be the source of the odor. Of these three substances, carbonic acid is easily measurable. That is the substance we measured when we made analyses of the air in the cars, or that Professor Nichols measured in his analyses, and it is customary to take the amount of carbonic acid in the air as the measure of good ventilation.

Many years ago, before this latest test that I have already mentioned here to-night was introduced, it was customary to place an arbitrary limit on the amount of carbonic acid that should be allowed in the air, in spaces which were said to be well ventilated. That is to say, twenty years ago, if the amount of carbonic acid in the air in any given space did not exceed 10 cubic feet in 10,000 of the air, that space was said to be well ventilated; but later studies have changed this view. A very large number of analyses of air have been made to find the amount of carbonic acid that is characteristic of the air when you can just begin to detect an odor. In this book which I have here, Parke's Practical Hygiene, there is given a summary of a very large number of such analyses, giving the amount of carbonic acid that is in the air when one can just begin to detect an odor. The average of these analyses indicates that when two parts, or 2 cubic feet of carbonic acid that comes from our bodies, or the bodies of animals, in 10,000 of air is found, one can just begin to detect an odor in a closed inhabited space. Therefore, 2 cubic feet of carbonic acid given off by human beings or animals in a closed space, in 10,000 cubic feet of air, is taken as the test or measure of good ventilation. I should say for your information, perhaps, that the air in different parts of the world and from many different places has been analyzed a good many times for carbonic acid. From these it is found that there is a certain normal amount of carbonic acid in almost any air. The air in this room, even if the windows were wide open and the room vacant, would contain a certain small amount of carbonic acid. The average of these analyses (they vary somewhat)—in towns the amount is larger than it is in the country—but the average amount is about 4 cubic feet in 10,000; that is, 10,000 cubic feet of air contain normally 4 cubic feet of carbonic acid. Now, if we add to that the 2 that come from our bodies, we would find in what would be called a well-ventilated space an amount of carbonic acid not exceeding 6 cubic feet in 10,000.

Taking then this 2 cubic feet that comes from human beings as the measure of ventilation, we are prepared to take another step forward in our study of the problem. A good many experiments have been made by different investigators as to the amount of carbonic acid that a human being gives off per hour. It has been found that men give off more than women; children less than either; that a man in vigorous work gives off more than a man in idleness; but the average of a mixed community—men, women and children, as they occur—is given as six-tenths of a cubic foot of carbonic acid given off from our bodies, both by the skin and from the lungs, per hour per person. So this is another of the foundations on which we are building up our scheme for the ventilation of passenger cars; namely, six-tenths of a cubic foot of carbonic acid given off by the average of persons from a mixed community such as we carry in our cars, per person per hour.

From these data it only takes a little arithmetic to get some sort of an idea of the answer to the next question which I am going to ask myself; namely, how much air per hour do we need to take into a car and out again in order to have that car properly ventilated? I will not make the calculation; but it is very simple. The data are, if 2 cubic feet of carbonic acid can be added to 10,000 cubic feet of air and still have good ventilation, how many cubic feet of air per hour must be brought into a closed space to bring six-tenths of a cubic foot per person down to a limit of 2 cubic feet in 10,000? If you made this calculation you would find this figure, viz.: that every hour after the first one, the first hour being occupied in saturating the space in which the persons are, 3,000 cubic feet of air per person per hour must be taken into any closed space in order to dilute the carbonic acid that is given off by an average from a mixed community down to the limit required for good ventilation, which is 2 cubic feet in 10,000, which again is the limit when an odor just begins to be perceptible to a person coming into any closed space where human beings are from the outside.

Now, let us take another step. 3,000 cubic feet of air per person per hour are required; but we have 60 people in a car, and 60 times 3,000 is 180,000 cubic feet of air, that must be taken into a car per hour, on the basis of this calculation which we have just made. What does that mean? It means that we must change the total air in that car forty-five times in an hour, or about once in eighty seconds. I say to you very frankly that we have not attempted in our experiments to reach any such figure as this. When we came to get our foundations on which to start our experiments and noted this prodigious figure of 180,000 cubic feet of air per hour required, according to the theory of the best authorities in the books, that we ought to have in order to ventilate our cars well, we were simply appalled. It is practically out of the question to take that amount of air through a passenger car per hour, and I hope a little later to show you why.

I should say at this time, perhaps, that some two years ago experiments were carried on for some time, by a committee consisting of Dr. S. Weir Mitchell and Dr. J. S. Billings, the results of which were published by the Smithsonian Institution. The object of these experiments was to find out to what the drowsy feeling that we have when in an ill-ventilated place was due, and also to find out what produces death from lack of ventilation. Those studies seem to indicate that the amount of fresh air that I have mentioned, namely, 3,000 cubic feet of air per person per hour, is large, and that possibly a smaller figure would be satisfactory. These authorities, however, are very cautious; they give us no definite figures. They apparently could not prove the existence of, or at least could not isolate any poisons in the air that would produce death. They seem to indicate that the drowsy feeling is due principally to increase of carbonic acid and diminution of oxygen. And, finally, they say in so many words that it would be a mistake to assume from their experiments that the ordinary figures applying to ventilation are widely in error.

Now allow me while I ask myself another question. How much heat would be required to heat 180,000 cubic feet of air per hour from the temperature of zero, which is not at all uncommon in our winter here, up to a livable temperature in a car? I have spent some time over this query, but am compelled to utilize, however, the results of other people's experiments somewhat. The best information that I can get on the subject is that the heat from a pound of steam at a pressure of 15 pounds per square inch is sufficient to heat 6,700 cubic feet of air from zero to 70° Fahrenheit. If we follow that through and find the amount of heat that would be required for a train of, say, twelve cars—which is not at all uncommon when traffic is good—we will be led to the result that it would take, in order to warm the air that would be required to ventilate the cars on the calculations that we have already made about 3 per cent. of the power of the locomotive; in other words, it would require about 400 pounds of steam per hour, and the locomotive of the largest type that is now on the Pennsylvania Railroad evaporates about 14,000 pounds of water an hour. This problem we have not met very seriously yet.

We do find, however, with some of the large passenger trains because of the speeds required to be maintained, that the drain on the locomotive is sometimes a little serious, especially when we are doing other things with the locomotive, such as running electric light plant in the baggage car. In the winter season, with six Pullman cars and trying to make high speed, it is sometimes difficult to maintain the steam pressure owing to this drain. The question of the amount of the heat required, however, is not one that ought to enter very strongly into our problem, because if we must have a large amount of heat to warm the air we must furnish it. That is all that can be said on this point. But it is certain that we could not warm twelve cars on the basis which we have been figuring, short of using from 3 to 3½ per cent. of the total evaporation of the locomotive, for heating purposes alone. Still further, I have in the above calculation simply planned to heat the air up to 70°; but as everybody knows, a car above the belt rail or 3 or 4 feet from the floor largely consists of windows, and there are constant leakages around these and the doors, so that it is probable that the air that leaves the heater system would have to leave it perhaps 10° and possibly 20° higher than 70°, on account of these leakages and on account of the large amount of heat lost by the glass. If we had to heat it 90° F., it would possibly take 500 pounds of steam per hour per train of twelve cars, and make a still further draft on the locomotive.

I said a few moments ago that in our experiments we had made no attempt to get anything like so large an amount of air into our cars as 180,000 cubic feet an hour. We had a very careful consultation of the best experts we had on this subject before we began these experiments. I counselled this: "Let us not attempt to do more than half what theory calls for." A recent writer in one of the railroad technical papers calls for 60,000 cubic feet per hour, and wants to have it made by law requisite that every railroad car shall be provided with appliances that will give at least 60,000 cubic feet of air per car per hour, or 1,000 cubic feet of air per person. Just what will be the amount that we will ultimately be able to secure is still an unsolved problem, In most of the experiments we made two years ago, we worked on the basis of securing 90,000 cubic feet of air per car per hour.

I have had several drawings made, shown in Plates I and II, to give you, approximately, an idea of the state of the problem, Let me say that at present the only thing that can be called a system of ventilation in the passenger cars of the Pennsylvania Railroad consists in taking air in through a hood, shown at *a* in Plate I, which air passes down through a sheet iron pipe *b* and is delivered inside the casing *c* surrounding the stove *d*. A vertical diaphragm or partition *e f* divides the space between the stove and casing into two parts. The air is received at the bottom of this space, as is shown by the arrows, passes up one side of the partition and down the other, being heated by contact with the outside surface of the stove during this passage, and is then delivered to a trunk or box *g*, which extends nearly the whole length of the car. From this trunk, the heated air finds its way out through the registers *h h*, situated between the seats into the body of the car, and, finally, out into the open air, through the deck sash *i i*. Of course, also a small amount of the warmed air passes out of the ventilators over the lamps or gas jets. There are two stoves in each car, and two intakes for air, situated at diagonally opposite corners of the car. Several valves *j j* in the hood always secure the passage of the air down the pipe *b*, whichever way the car is moving. This system of warming and ventilating is known as the Spear stove system. A little study shows that this system is open to two serious objections. These are, first of all, the stove. Everybody knows that we are trying to get rid of the stove for car heating, on account of the danger in case of accident. It is not necessary to say much about the deadly car stove. The newspapers do enough of that. Suffice it to say that one of the difficulties of the present system is the stove. The other difficulty is this, and a rather peculiar one it is: When the car is running and the wind is not too strong in the wrong direction, air is forced into the hoods, and thence into the car in the manner described, with the result that the car is fairly well warmed and ventilated. But when the car stands still, or when the wind in the opposite direction is just equal to the speed of the train, what takes place? The air goes in the other direction. The source of heat being higher than the outlets into the car, it is obvious that when the car is standing still, the air currents will move up through the pipe *b* instead of in the opposite direction, as is desired. And this is what we actually find to be the case.

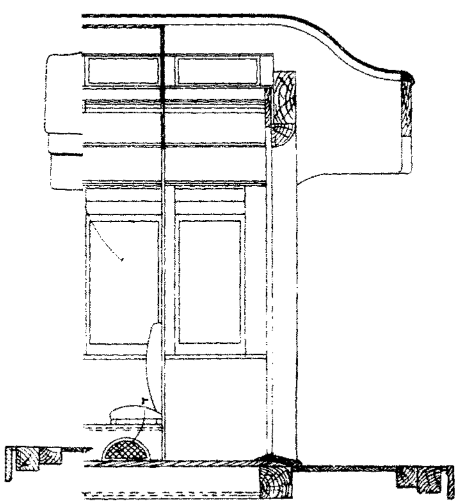
Our studies have been concerned, however, principally with the ventilation of steam-heated cars. The constructions used I may explain, by reference to Plate II. The same hood *a*, on the top of the corner of the car, is used for an intake, as was the case with the Spear Stove System. The air entering this hood passes down through the pipe *b* into a space *c* below the floor, bounded by the floor, the false bottom, the outside sill and the first intermediate sill. This space is about 8 by 14 inches, and extends the whole length of the car. The heater pipes *d d* are situated above the floor in the same trunk that was used to carry and distribute the warm air in the Spear stove system. These pipes are filled with flanges as shown, to increase the surface. It is, perhaps, not necessary for me to go into the heating system further than simply to say that each side of the car has a certain amount of pipe of this kind, running the whole length of the car, which contains steam, of a pressure, say, of from 15 pounds down to no pressure at all, and even a vacuum. We use what is called the return system of heating; that is to say, underneath the car are two parallel pipes, one of which brings the steam from the locomotive, and the other carries the condensed water back to the locomotive again, and so we call our system the return system; that is, we return the condensed water to the locomotive instead of pouring it on the ground. In order to get this water back there is a pump on the locomotive, and under certain conditions the suction may be strong enough so that instead of having a pressure in the heating pipes, we may have a vacuum.

Returning now to the air which we left in the conduit or space underneath the floor, it will be observed that there are a number of apertures *e e* through the floor, directly under the heater pipes. Through these apertures the air passes into the trunk containing the heater pipes, is warmed by contact with these pipes, and then passes out of the apertures *f f* in the trunk into the car. These apertures in the trunk extend the whole length of the car, both between and beneath the seats. From the main body of the car, the air passes out of the ventilators *g g* situated on the top of the upper deck.

The first experiment that we made after the car was fitted up with this device consisted in observing which way the currents would flow when the car is standing still. Quite to our gratification we found them moving in the right direction, namely, when heat is in the car, air passes into the hood *a* down through the pipe *b* into the space or conduit below the floor, thence up through the floor, over the heating system, and out into the body of the car, and, finally, out through the ventilators. It is clear I think why this should be so, since the exit of the ventilators is some 2 feet higher than the topmost point of hood *a*.

So one of the difficulties that was characteristic of the old Spear stove system has been apparently overcome very satisfactorily by this new scheme.

At first the apertures *e e* through the floor underneath the heater system were about 4 inches long and about ¾ inch wide and there was one opposite each seat. Also we had at that time only six ventilators in the upper deck. With a coach fitted in this way we made experiments as follows: We would load the car to its full capacity with men from the shops, the reason for that being that we could take a foreman along and



PENNSYLVANIA RAILROAD.

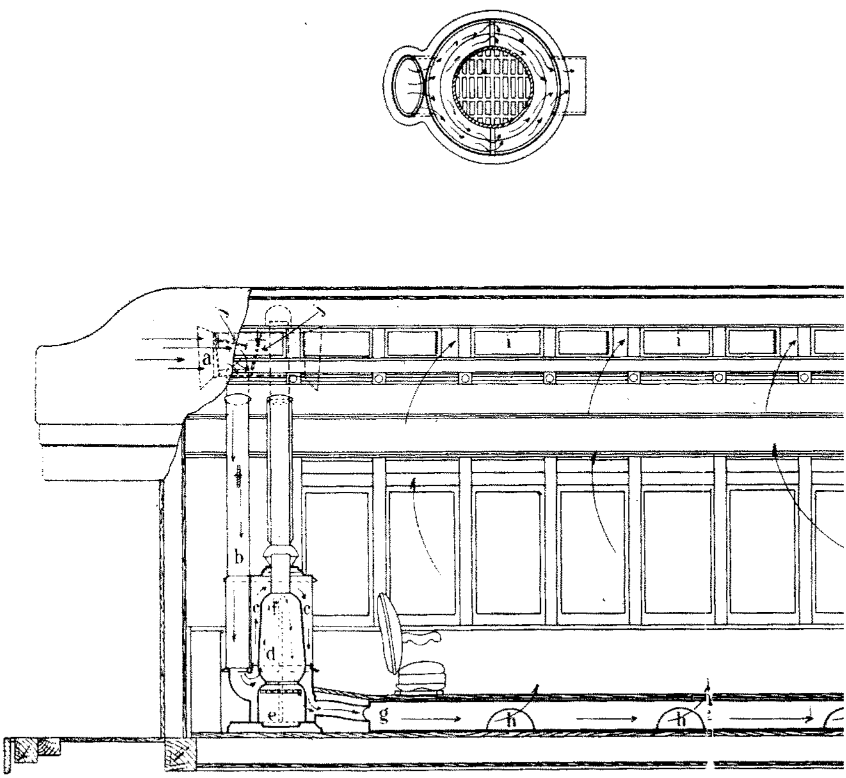
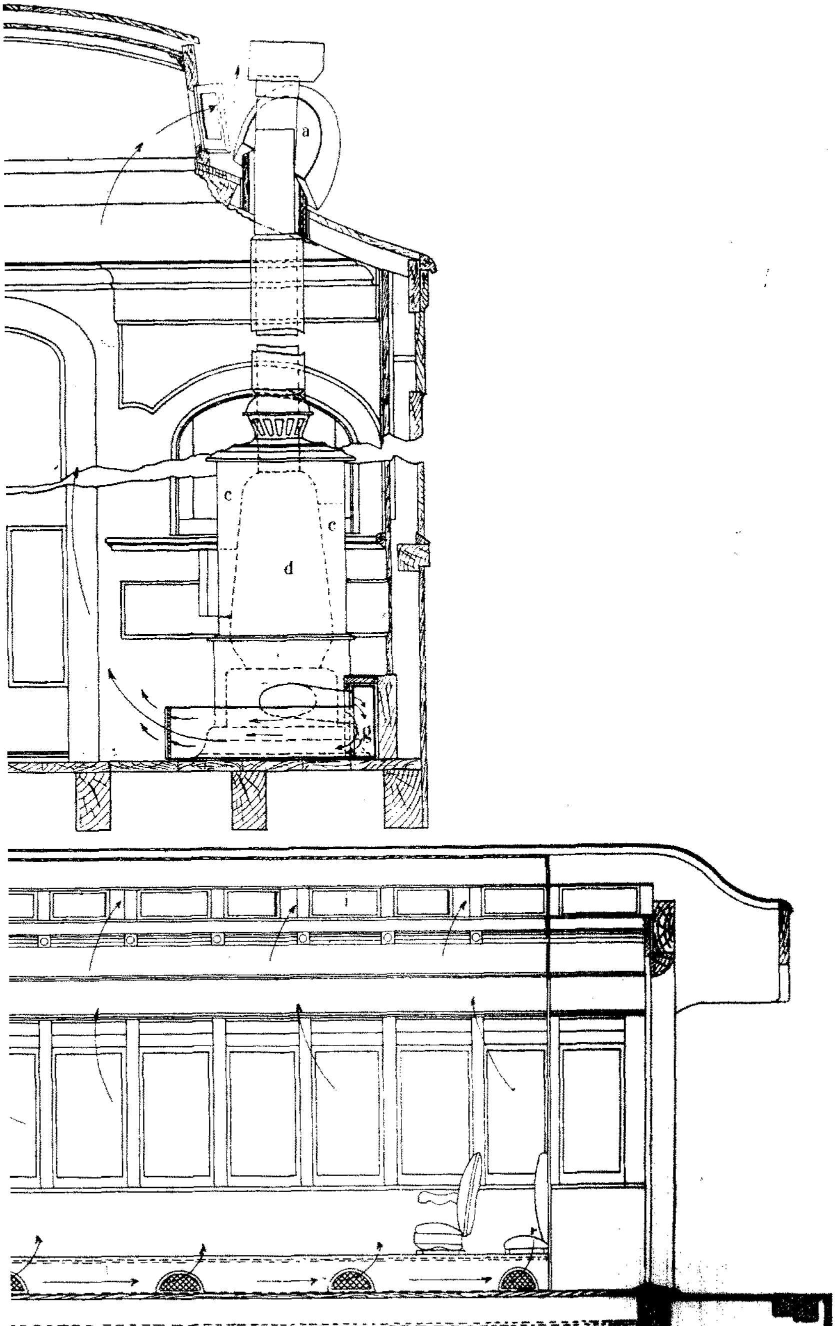


PLATE I.—SHOWING SPEAR STOVE SYSTEM OF HEATI G AND VENT



LATING PASSENGER CARS, NOW IN USE ON PENNSYLVANIA RAILROAD.

control the men in a way to secure the conditions we sought, and know at all times that we had those conditions. We made a trip to Johnstown, some 35 miles from Altoona, and back again. When we got pretty well over towards Johnstown, allowing neither doors nor windows to be opened during the trip, we took some samples of air in rubber bags, with a little hand bellows, walking the whole length of the aisle back and forth, until the bags were filled, several gallons of the air being taken in each case. Then we stood still on the track for about half an hour, without opening doors or windows, to see how well we ventilated when standing still, and took another sample. Then we put the locomotive on the other end of the car, and when we got nearly back to Altoona took a third sample. Those samples were analyzed several hours after the return from the trip, and we found that we were getting on the first trip about 500 cubic feet of air per person per hour, instead of 1,500, as we desired. Standing still we got about 340 cubic feet per person per hour.

We then made some modifications, increasing the size of the apertures underneath the heating system, and made another trip in exactly the same way; and in that case we got about 600 cubic feet of air per person when we were running and about the same when we were standing still, as in the previous trip.

It became evident from these experiments that we were not getting anything like enough air through the car; and we began then a systematic study to find what part of the passageways limited the flow. We first increased the number of apertures in the floor and enlarged their size until we finally reached this point; namely, we put an aperture 4 inches long and 1¼ inches wide every other 4 inches for the whole length of the car under the heater system; in other words, we had 4 inches of aperture, 1¼ inches wide, then 4 inches of floor, then 4 inches of aperture, and so on, on both sides of the car.

Also we increased the intakes *b* from 8 inches square to 14 inches square, and instead of having one on one corner, and one on the diagonally opposite corner, we put one on each corner. Then instead of having six ventilators in the top of the car, we put on twenty. I have given you the final result of a number of successive trips, modifications being made from time to time. With these appliances what did we obtain? With these appliances it is easy to get 90,000 cubic feet of air per hour through the car. But unfortunately here is where we struck a snag, namely, we could only warm that air about 40° above the outside air. When the temperature is zero, it is perfectly clear that the car was uninhabitable for passengers. That was a serious difficulty, as you will all agree.

In order to overcome this difficulty, we planned one further modification, but further study showed that this modification was impracticable.

It is evident, since the trunk or box containing the heater pipes is small, since the passage of the air through this trunk is very rapid, owing to the large volume per hour, and especially since the cold air impinges against the heater pipes, only about half their length, owing to half the space only being apertures, that it is a reasonable query whether we are utilizing our heating system to the best advantage. Does the air that comes in through these apertures utilize that portion of the heater system between the two apertures? My hearers may say, why didn't you make your aperture continuous, from one end of the car to the other? This is what we planned to do, but on a little study, we found that it would be hazardous to cut the whole length of the floor system completely through. The floor system is necessary to the strength of the car. It holds the outside sill to the first intermediate, and is really a very important element in the strength of the car, and to cut through the floor the whole length, would so greatly weaken it, that we did not venture to try it. So we had to stop at this point; namely, we can take 90,000 cubic feet of air per hour into the car and out again, but we cannot warm it with our present heater system and our present means of utilizing it, and that is exactly where we stand to-day. Of course, the problem is not abandoned; we have not given up the question; we are now studying whether a continuous slot through the whole length of the car would warm that amount of air. Those experiments are being made off a car, so that we can control the conditions. But I may be allowed to repeat, we have reached the point where we can get half as much air as theory calls for into a car and out again; but we cannot warm it.

I will only take a few moments more of your time. I want to give you one or two points that are rather interesting to me; and that seem to throw a little side light on the problem. During our experiments we had five or six thermometers hanging from the baggage racks for getting the temperature at different points in the car; and we had anemometers to measure the air currents, and we had a gauge on the heater system, so that we could tell what was going on inside the heater system.

During one of the trips we struck a very peculiar state of affairs; namely, the rear end of the car was 10° to 20° colder than the front end. This was a good deal of a puzzle for a little time; and, really, it was a thing we could hardly account for; but after a little study we found this very interesting state of affairs: As I told you, we had some twenty ventilators on the car. These ventilators are so made that when a current of air is moving at right angles to the axis of the ventilator, air is drawn out of the space with which the ventilator is connected. We found that with twenty ventilators on the car the suction was a little stronger than the supply. The front ventilators, acting first, made such a vacuum in the car that the regular intakes could not fill it and a current of cold air actually came down through some of the rear ventilators into the car. On closing some of the ventilators the difficulty disappeared. I think this has a bearing on the problem of ventilation, in this way: namely, that you must make your intakes to supply fresh air equal to your exits, or you will have the same difficulty. Some persons have thought that all that was necessary to do was to put ventilators on a car and let the air come in wherever it could. That was tried on some cars, and it was found in the winter season that the ventilators must be closed.

I said some time earlier in the evening that one of our problems was to exclude smoke and cinders and dust. That part of the problem we have as yet hardly touched. I don't know to-day of any practicable means by which that can be done. I will say for your information that you will notice in Plate II, under the downtake a little reservoir *h*. We found, to our gratification, that cinders that were large enough to be so caught, come down into this reservoir and remain there. On the other hand, dust and smoke and very fine cinders pass along and up through the apertures and into the car. Indeed, when we had the twenty Globe ventilators and the maximum number appliances that I have described all open on going through the tunnel, the air of the car was so filled with smoke as to be quite suffocating.

In any system of ventilation it is absolutely essential that we should have control over it. Our scheme has been to have a valve in the downtakes; and possibly also valves connected with the ventilators, so that we could close them while passing through a tunnel, or when the wind happened to be in a direction to require it.

To our minds the problem of car ventilation stands now something like this. It is possible to get much more air into a car than any system now in use takes in. It is possible, if we could content ourselves with 20,000 to 30,000 or 40,000 cubic feet of air in severe weather to have such a ventilation system put on the cars to-day. Then in the milder weather we could increase it to the full capacity of the system. That phase of the question is being studied already quite earnestly. On the other hand, as everyone knows who knows anything about railroad matters, where there are 2,500 passenger cars requiring to be changed, it is simply ordinary business prudence to exhaust a subject pretty thoroughly and be sure of the ground before going ahead.

I am sure I am speaking the truth when I say that railroad officers appreciate the hardship of having to sit a number of hours in a badly ventilated coach as much as the public do. I can state, from my own knowledge, that they are thoroughly interested in this subject; and I am safe in saying that the intention is to prosecute it to a successful conclusion as soon as possible.

I thank you very much for your kind attention.