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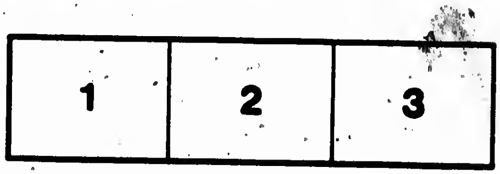

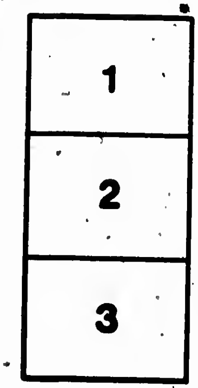

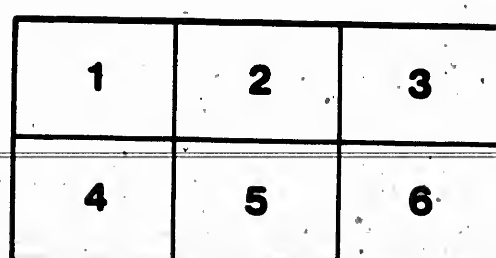

THE WARMING, VENTILATING AND LIGHTING

OF RAILWAY CARS.

BY

J. D. BARNETT,

M. CAN. SOC. C.E.

BY PERMISSION OF THE COUNCIL.

EXCERPT MINUTES OF THE TRANSACTIONS OF THE SOCIETY

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TRANSACTIONS.

THE WARMING, VENTILATING AND LIGHTING OF RAILWAY CARS.

By J. D. BARNETT, M.CAN.SOC. C.E.

A more unsatisfactory question than that of railway car heating and ventilation it would be difficult to find. Not only do car designers disagree, but the passengers have ideas and wishes so diametrically opposite that a satisfactory solution does not at present seem possible. Do not expect it from the author, who will esteem himself happy if he succeeds in conveying a fairly clear idea of the problem, and of those recent attempts at its solution approaching nearest to success.

The problem, considering the wide and rapid variations of a North American climate, is certainly a double one, although experience and the Patent Office records shew that each factor is usually attacked singly; and at first it will perhaps be better so to look at the subject.

The requisites of a good heater are:—

(*a*) That it give out heat sufficient in amount.

(*b*) That it be safe from fire risk, scalding, &c.

(*c*) That it be frost proof.

(*d*) That it be controllable without too much attention.

(*e*) That if it be part of a continuous system, it may be detachable without rendering it useless, and that it may have a variability of from two to fifteen cars.

(*f*) That its heat be distributed equally throughout the car, and close to floor.

Ordinary stoves are wanting only in *b* and *f*, and Spears encloses his hot-air stove in a close-woven, heavy wire netting, slightly elastic, yet strong enough to fill requisite *b*; stoves manufactured from wrought-iron—instead of thin, cheap cast iron—having common-sense doors, and located in centre of length of car, come very near satisfying all requirements.

Steam heating—at low pressure—with the heat supply located in a portion of the train not occupied by passengers, fills all requisites except *c* and *e*, the more recent inventions being endeavours to meet these particular requirements.

The Martin system receives its steam supply from the locomotive. It has for distribution, one through or continuous train pipe under each car, with a metallic double-ball-coupling and expansion-sleeve for connection at each end, and a double vertical line of piping (for heating purposes) on each side of car below seat level, having, however, no provision for keeping car warm when it is not attached to locomotive, or coupled up to station steam warming pipes, or to external portable boiler. Similar crude attempts at steam warming have been made ever since Stephenson's day. The metallic flexible coupling for the through pipe appears to be its distinctive feature; but it is open to doubt if a claim for originality could be sustained should this patent be subjected to legal test. (See historical notice in "The Artisan," July 1st, 1863, page 147.)

The cost of equipment is $200 for engine, $200 for ordinary cars, and $250 for sleeper and parlour cars.

The Sewall and Emerson systems appear in many respects to be identical. They draw their steam supply from the locomotive, and use a hot well under the car to receive the water of condensation. Below the well a fire is placed when the car is standing detached, the car heating pipes being arranged so as to give independent circuit with this reservoir boiler. The auxiliary source of heat—be it coal fire, oil lamp or gas jet (and all have been used)—is dumped, or otherwise dispensed with, as soon as the car is to be coupled up with train, thus meeting requisite *b*.

Many-ply rubber-hose is used to allow of adjustability in the continuous couplings. The expense of renewing each hose may amount to $3 or $4 per year. Sewall has a simple and effective metallic hose coupling, locking by gravity, and readily separating when cars become detached, which will permit of a free interchange of cars with foreign railways on through runs. Emerson has apparently not given this most important point any special attention, and as each car with his equipment, has an independent outlet by pet-cock for the excess of steam and water, there is produced with this arrangement a vapour sometimes obscuring the windows, and the annoyance of a constant drip of water has been noticed. Sewall has a small opening in the through steam pipe to atmosphere at end of last car only, the excess of water in hot well under each car being discharged intermittently by self-acting trap.

The continuous circulation and its control (when car is detached and fire is put under hot well) cannot be said to be perfect with either system, Emerson having to use a second series of pipes on car roof to act as a condenser or cooler, while the Sewall slowly loses its water supply, from the permitted escape of steam through a pin hole at end of the continuous pipe.

The pounds of steam condensed to water per car per hour are variously given, the independent tests (far too limited in number) shewing higher figures than those given by the patentees. The Chicago, Minneapolis & St. Paul Ry. Co. obtained an average of 75 lbs. at temperatures between 20° and 40° above zero; but even their careful experiments will not permit an approximation to the weight of steam required with high winds, and temperatures from 20° to 30° below zero. It may be deduced from some experiments with these systems, and a locomotive with a boiler so large that it is not generally worked up to its maximum capacity, that 1 lb. of soft coal burnt in its fire-box will radiate an amount of heat equal to 2 lbs. of anthracite burnt in the car; therefore, after allowing a margin for fuel used when car is detached from locomotive, the total or annual cost for fuel, when the rolling stock is fully equipped for steam heating, will be but one-half of that now paid for hard coal, ranging at present on various railways from $35 to $55 per year per car.

There is no information as yet, nor can any be obtained until next winter, as to the continued action of "traps" in getting rid of local condensation at extremely low temperature.

Hot water heaters—that is to say, the contained coil and vertical boilers of Owen, Baker, Smith, Johnson, Coughlan, Salmon, etc.—fill all requirements, except "*b*" and "*c*," and various schemes have been tried and suggested to overcome these defects, such as enclosing the whole in a metal safe with self-shutting doors, or making the water-crown of stove boiler of thin cast-iron, so that it shall, in case of accident, instantly fracture, thus drowning the fire, or arranging that derailment open a reservoir of chemicals which shall discharge into and kill the fire. The dead weight of the safe and its contained stove would be dangerous in time of collision; self-quenching arrangements cannot be depended upon if left disused, say, for twelve months; and it is possible that the escaping vapours and acids might prove quite as dangerous to life as hot cinders would.

Exhaust steam from the locomotive cylinder and from the brake air-pump have been slightly experimented with as a source of car heating; but the water carried in suspension is so large in amount and so difficult to get rid of, as to discourage any hope of success in that direction, in Canada, unless it be by the use of the Williams patent, recently experimented upon by the Central Vermont Railway, in which the old pipes employed in single circuit with a hot water heater are utilized. The single circuit is broken, and the pipes on each side of each car are connected under the platform by flexible hose, so that there is opportunity for complete circuit down one side of train and back the other, when the two hose under platform of last car are coupled together.

Exhaust steam from the locomotive, from the air-pump, or from the vacuum-pump, is admitted at forward end of this pipe circuit, and a vacuum-pump is attached at return end (also on locomotive). It is claimed that the vacuum-pump will clear the pipes of all vapour of water of condensation, however many convolutions or "pockets" there may be in the whole circuit.

Its main defect is its complete dependence on the locomotive (or other detached boiler) for heat, and its dependence on the pump to prevent failure by frost.

Mr. D. H. Neale, New York, writes (since the "advance proof" of this Paper was issued) "that a train heated by exhaust steam from the locomotive has been running between Glasgow and Aberdeen for the last two winters, with very satisfactory results, using a cast-iron radiator of a simple form under each seat. When the locomotive is first attached to the train line, steam is turned on until the coaches are warmed, after which a small portion of exhaust steam is found quite sufficient to keep up a comfortable temperature."

Stoves underneath the car frame have been used; but the supply of heat—with the hot air system—is not always adequate, and the gases of combustion are liable to get into the hot-air flues. With these defects, and a first cost about double that of a similarly equipped car with internal stove, the risk from fire is not removed, and cars so fitted have in accidents been destroyed by fire. External heaters for hot water or steam are more effective, but the fire risk is not removed—it is only in part lessened.

The Gold system is practically a storage, rather than a continuous heating system, and has been used only on suburban railways (900 cars). A 3½-in wrought iron tube is almost filled with brine (water and salt), then sealed up, and laid horizontally within a 4-in. steam pipe, so that when steam is admitted into the annulus between the two tubes, it not only radiates externally but heats up the contained brine, thus charging a reservoir, which when steam is cut off continues the radiation by parting slowly with its rapidly absorbed heat, so that, for instance, with an external temperature just at freezing, a street car will retain a comfortable warmth for two hours. To suit ordinary train service it is proposed that the reservoirs shall be charged when the locomotive is running down grade and has steam to spare. The defects of this system are a difficulty in obtaining flexible couplings for high pressure steam, and the risk of scalding in case of accident; and the fact that failure of locomotive would eventually result in freezing out the passengers prevents it from being considered a practical scheme for long through runs or for isolated branch trains.

VENTILATION.—Having continuous steam-pipes throughout the car, the question of ventilation in winter is not a difficult one, a few small inlets close to pipe, with wide-open exhaust-ventilators in roof, giving free exit, are conditions fairly conducive to health and comfort.

The many and variously designed stoves, with passages in or around them, through which air is forced from Cowl or Bellmouth on top of roof when train is in motion, and thence through hot air flues provided with foot registers the length of the car, have not proved a success, being deficient in heat and at the same time making the air too dry. Heat radiated is far more comfortable and healthy than heat delivered by convection.

The *minimum* supply of fresh air required to keep a car carrying 60 passengers, in sweet and healthy condition is 1,000 cubic ft. per minute, and the more this amount can be increased (without inducing draughts) the better.

For summer service a narrowing opening at front end of car under platform hood will no doubt admit enough air when car is moving; but it is not sufficiently diffused, a draught being felt about the 4th or 5th row of seats, which fine wire screens or adjustable louvre boards fail to get rid of. A roof cowl, of almost any pattern, open to front of train will force sufficient air in, and it can be distributed at various points in ceiling, sides or floor, according to the number of distributing pipes and adjustable registers used, but the air there collected is far from pure, the dust not only annoying the passengers, but settling in the pipes, and eventually choking up the passages. Fine wire screens reduce the air pressure out of all proportion to the dust they exclude; and have no effect on smoke, sulphur, etc., from engine, which is apt to trail over the train, especially in woody country and in cuttings. Thirty-three years ago air was so forced through water-spray, the resultant inky colour of the water proving that it performed its work well; but the apparatus occupied too much space, and in damp weather the car was too moist for comfort. Ruttan of Cobourg passed the air over water. This proved not so effective, but the car was dryer; yet his system collected so many impurities in the purposely contracted passages, that it was not used with success on long trips. A double roof with the open space between, bell-mouthed at each end, and the lower roof perforated, will act as efficiently as a distributing flue in securing full admission of air (and a double roof insures a cool ceiling), but it is no nearer to the securing of clean air, and much increases the fire risk. A fan, worked from the car axle, drawing its air supply through gauze-covered opening in the *side* of car, passing it over an ice box, distributing it around top of car from a 6 in. tube and exhausting through the floor, has proved very effective when the car was running at full speed; but when going slow, or climbing grades, it did not give sufficient supply, and passengers were provoked to break the windows which (necessarily in this as in all artificial systems) had been fastened down. It should not be forgotten that all similar schemes result in a car being oppressively close when it is not in motion.

There are several patents for taking air in front of the engine, warming or cooling it there as required, and forcing it to each car through a continuous train pipe by an independent steam motor. The bulk size of the apparatus involved will probably discourage experiment in this direction until all other possible expedients have failed.

For purifying the air there seems be no scheme equalling that of W. D. Mann, who says, "taking my cue from nature's provision in the human nose...... I have adopted a 'nose' through which all air is obliged to pass. This consists of a mass of 'excelsior' (fine wood shavings like hair), held loosely by spindles of wire, and kept moist by the melting of ice over it...... the air being first discharged directly on the surface of a large pan of water, the product of the melting ice."

Lighting.—The existing sources of artificial light are candles, oil, gas (coal, oil, water), and electricity. Candles are wanting in brilliancy, cleanliness and safety, and are not now used. Oil has been roundly abused in the public press and in some State Legislatures; nevertheless mineral oil of 300° fire or flash test is, all things considered, a safe source of light—absolutely so if there be no other source of fire in the car than the lighted lamp itself. Certainly there are but few, if any, cars destroyed by fire in summer, when the increased train service partially balances the fewer hours per night that lamps have to burn, and, if steam warming be adopted, all trains will, in winter, be as safe from fire risk as they now are in summer.

Coal-gas carried within wrought iron reservoirs, under a pressure of about 230 lbs. per sq. in., gives a brilliant light, and a reservoir 10 ft. long by 1 ft. diameter will hold sufficient gas to run a 5 ft. burner 50 hours, or the car for 10 hours. The first cost of fixed plant for compressing and storing coal-gas is heavy, varying from $2,300 to $18,000 per station (not including cost of gas producers), and there is a large daily expense in running the plant in addition to a serious loss of gas, when it is under compression, due to its condensing into a troublesome gummy liquid, which interferes with the action of all the mechanical fittings and the self-acting pressure reducing valve, as well as with the efficiency of the small distributing pipes.

The Pintsch system gets rid of some of these troubles by using gas manufactured from crude petroleum or other natural hydro-carbon, which, in addition to being less sensitive to low temperatures, to loss by compression, and to gummy condensation, gives a clearer white light of higher illuminating power; the economy resulting from the use of this system compared with that of coal-gas is marked. It has but one drawback, viz., that each charging station must be equipped with a complete gas *distilling*, as well as gas compressing apparatus, otherwise special gas storage tanks on wheels must be regularly transported to the distributing points, from the central manufacturing and compressing depot. English experiments shew that colza oil costs per lamp per hour 1.25 cents, and the Pintsch light only ·652 cents.

In electric lighting there have been experiments with primary (or chemical) batteries, secondary (or storage) batteries, independent dynamo, and dynamo taking its power from a revolving car axle. A dynamo deriving motion from an independent engine is costly, requires the constant attendance of a skilled man, and is useless when detached from the train; hence the attempt of Messrs. Houghton & Stroudley and others, who combined a secondary battery with a dynamo driven from a car axle, their action alternating, or even if required supplementing each other, the mechanical details being so arranged that the batteries could not play back into the dynamo when it was running at slow speed; the axle could also revolve in either direction without interfering with the efficiency of the combined apparatus, the whole of which was carried in the guard's van. It is recorded that trains so equipped, made on the Brighton Railway 2,352 trips in 11 months without failure, but at the present date this Company are reported as experimenting with the Pintsch gas light.

The system of electric car lighting, of which we have most exact information, is the Julien secondary battery; it has much less dead weight than the Plante, Faure and other early patents, and it can be charged from any electric source. Its standard cell has 19 plates, and weighs 27 lbs., or, with rubber box and connections, 34 lbs. In order to find the total weight required per car, divide the desired candle-power of the lamp by 2, and this will give the weight of battery per lamp hour. Thus 16 c. p. lamps require 8 lbs. of battery, and 10 lamps 80 lbs., or per night of 10 hours 800 lbs. Allowing 20 per cent. for contingencies the ten 16 c. p. lamps for one night's duty call for 960 lbs. weight of cells, or with connections 1,200 lbs. per car extra weight to be hauled (as a minimum).

The cost, as submitted by the Julien Co. in their recent offer to the New York Central Ry. Co., and actually charged to the Wagner Car Co. for equipping the "Olga," is

60 cells at $13	$780
Wiring, boxes, and lamp fixtures	150
Total cost	$930

The daily cost, using the figures obtained from the Boston and Albany Railway, is

60 cells at $13 = $780, depreciation at 30 p.c. =	$234.00
24 lamps at 85c. = $20.40, each lamp lasting 2 months, 6 renewals at $20.40 =	122.40
Charging battery 365 days at 75c. =	273.75
Interest on $9.30 at 4 p.c. (cost of installation) =	37.20
Total cost of 24 lamps per year	$667.35
Cost of 24 lamps one day	1.83
Cost of one lamp per day	0.76

The batteries will probably last longer than 3 years, although actual experience with them covers little more than 2½ years; the negative plates never give out, and the positive plates have not yet done so, whatever the violent motion inseparable from railway travel may yet result in.

The weight of this installation will exceed one ton, and should the exigencies of train working require that a second set of cells be kept for charging, while the other set are in use, the cost for a car as fully lighted as the "Olga" would exceed $1,700.

The North British Railway Co. has artificially lighted a train performing much tunnel service by electrically charging an insulated central rail with which circuit to coach lamp wires is made automatically by wheel coming in contact with the raised rail at entry into tunnel. The rail drops and circuit is broken at exit from tunnel, thus the lamps are alight only when train is within tunnel.

To sum up:—it may be said, that if boiler-power can be supplied, there are no great difficulties under average conditions in heating a train by steam supplied from the locomotive. Boiler power in midwinter on any other than short local runs is, however, rarely in excess of absolute needs, and if boilers large enough are built the locomotive will be so much heavier as to probably call for the strengthening of bridges, &c. If compressed gas be used for lighting, it can readily be adapted as a source of heat, in connection with any system of steam circulation or water pipes.

Ventilation, in winter when steam pipes are used, taking air supply through sides of car close to pipes, and keeping exhausts open in raised roof, is easily accomplished. In summer it is different, and some artificial means for supplying, cleansing, and distributing a large amount of air is necessary. Such schemes will not work if passengers have the option of opening side windows, thus destroying the artificial currents. There are strong objections to machinery, as it must not be recognized as such by the passengers, must not be too expensive, must not require too much attention, nor be liable to derangement.

It is known to all familiar with the plenum system of ventilation (air forced in by fan)—as adopted for the Houses of Parliament and for Public Buildings at Washington—that it is not satisfactory, although the conditions are much more favourable to success than those limiting the ventilation of trains.

Induced currents by air-jets, worked from the brake air-reservoir, may yet accomplish this work satisfactorily.

The ejectors would be very small and distributed over the whole area of the coach at such points as experiments may determine, and acting on the contained air within the coach by suction would permit of the fresh air being received both summer and winter at the same point, viz., at *sides* of coach where it can be obtained (without special filtering) in the purest condition. In winter these ejectors would not be required.

If each passenger is to be allowed to do what is right in his own eyes, it is probable that side windows hung so as to swing vertically, instead of to lift horizontally, would keep out more of the cinders, etc.

For lighting, oil and oil gas are safe enough, and ignoring the question of interest on the heavy first cost of the equipment, the actual daily outlay for gas would probably be less than for oil (taking all breakages of lamps, etc., into consideration.)

Electric lighting—cool, safe, and pure—is as yet somewhat uncertain in effect, too expensive in first cost, and calls for too highly paid skill in attendance, to be generally adopted.

Not only for economy in the use of light, but also for cheerful effect in daytime, the internal "finish" of cars should be in light coloured woods, and with the object of lessening fire risks, the "finish" should be, where possible, in wood rather than in woven fabrics.

Cars wholly framed in metal, whatever be their relation to fire risks, are not likely to be a success for passenger service, because of the difficulty in deadening the annoying vibrations and noise incident to motion.

The last few months have been prolific with car heating patents, many of which could not yet be said to have reached the experimental stage. One attempt by Mr. Wilder kept the old hot water heater and its pipes intact, but an additional wrought iron drum was added under the sills, to which the water circulation pipes were coupled, so as to make the drum part of the coach circuit. A through train steam-pipe from engine (by branch under each coach) admitted steam into a coil within the drum, thus heating up the water and putting it into circulation throughout that coach. When coach was detached and standing, the heater could be lighted up, and circulation maintained as at present.

DISCUSSION.

Mr. Wallis remarked that the warming of railway cars is a subject to which, on this continent especially, much attention has been given.

The use of ordinary stoves has been unsatisfactory, from the difficulty of maintaining an equable temperature, and in first class coaches, at any rate, they have, on most railways, given place to various systems of diffusing heat through the medium of water at a temperature of about 212° Far. The hot water system with independent heaters is, no doubt, a considerable step in advance of the stoves, perhaps as much so as the stoves are in advance of the foot warmer used in Great Britain and other milder climates; but like the stove, it has one serious objection which has existed since its inception, and has become prominent, and made the question of car warming of vital importance, during the past winter. The lamentable accidents in which the car heater has figured so conspicuously and unfortunately, and to the use of which the lives of many sufferers are believed to have been sacrificed, has brought into prominence a crop of arrangements or systems, many of which the author of the paper has fully described. These systems seek to establish a central source of heat in the fire box of the locomotive, and thus to reduce the number of disastrous possibilities to a minimum.

That the principle is a correct one, there can be no doubt.

During the past winter, on several railways, steam has been successfully used with some of the sys.ems mentioned, and most of those present have seen the same in operation on the New York elevated railways. While, however, the principle appears sound, the working out of the same is attended with difficulty. The one central source of heat may fail and in a northern climate with storms of snow and spells of intense cold, the result may be but a remove from that which the system is intended to avert.

Clearly then there must be auxiliary sources of heat, and the system which most successfully combines the two (that is, the Central and Auxiliary) will find most favour with the officers of railways. It is too well known that the maintenance, in proper working order, of devices, which are used only in cases of emergency, is difficult; and this fact, and the apparant necessity of such a device, is the great drawback to the use of steam from the locomotive.

The question of first cost is an important one, and this would suggest the use of the piping forming the present generally adopted hot water system.

The further difficulty which may arise from the inability of the locomotive to furnish the necessary steam, in long through trains, will have to be met either by a reduction of train load or an increase of the power of the engine, which in either case is serious, having regard to the radical nature of such a change on railways fully equipped at present.

The author's estimate of economy to be derived from the continuous system is rather a high one.

The mean temperature at Montreal for the six winter months, from November to April inclusive, is, as nearly as possible, 20° Far. (See Prof. McLeod's meteorological reports), and if the water of condensation amounts to 75 lbs., at temperatures ranging from 20° to 40°, an evaporation say of 6 lbs. of coal, which is fair locomotive practice during winter, would account for 13 lbs. coal per car per hour, or about 7 per cent. more than that actually now used for haulage.

Making due allowance for the preparation of the cars a reasonable time prior to their occupation, the consumption of coal for the year, that is, for the six winter months during which coal would be used, would be 8 tons, or say $30 per car.

In a continuous system of heating, the constant interchange of cars between railrays, makes a universal coupling essential, and before much headway can be made such a coupling will have to be agreed upon. The coming winter will no doubt see much done by way of experiment to solve this important question.

As long as such a difference of opinion exists on the part of railway travellers, as to what constitutes comfort in the shape of ventilation, it would seem hopeless to insist upon the adoption of devices, whose object can be rendered nugatory at the will of the individual.

Those who hold somewhat extreme views on this question are apt to mistake rise of temperature for imperfect ventilation.

The railway car of this continent is of a construction to be easily ventilated. The end doors, the side and upper deck windows, all form excellent passages of ingress and egress for the air, which can be admitted in greater or less quantity, as required.

In car lighting, one advantage in using oil is that a high fire test oil may be obtained (300° flashing point) at a reasonable price. Such oil will not a cause a fire, though it would feed one started from another cause; and in illuminating power it is equal at 20c. per gallon to gas at 45c. per 1000 cubic feet. An ordinary car roof lamp of the double type burns from 2 to 4 oz. of oil, and a highly lighted car, therefore, only costs 25c. per hour for its light.

There is no doubt excessive comparative wear and tear of lamps; but with all this there is a great margin of cost in favour of oil, which is one of the good things nature has provided.

Mr. A. T. Drummond.

The subjects, especially of the heating and lighting of railway cars, which Mr. Barnett discusses, have received more than usual attention from the public during the last few months, in consequence of the terrible disasters at White River Junction and Dedham.

With regard to the heating of cars, the popular verdict, without doubt, favours heating by steam derived from the locomotive, as being absolutely safe from the dangers of fire in the event of collision or other disaster. The system also produces an uniform, pleasant heat, under easy control. The inventor of the Baker heater contends that he can furnish a self-acting furnace, which can be charged with coal in New York, and will not require to be opened for recharging or any other purpose until such a distant point as Chicago is reached. He also contends that such a furnace can be made so strong and be so securely guarded, as to resist fracture, and retain the coal in case of any accident whatever. This, in Mr. Drummond's opinion, is not possible. It is not the ordinary, if the term might be used, but the extraordinary accidents, where the complete collapse of the cars is probable, that have to be most guarded against. No stove, however strong, or however well cased in an iron jacket, is altogether proof against the effects of such disasters, and the very weight of the stove is an element of danger when it is displaced by the overturning of the car at the embankment or bridge, or by the collision. Nor is a heater suspended under the car less source of danger. What must be avoided is any system which, in the case of the complete collapse of the car, would permit of live embers being scattered broadcast over the car furnishings and debris.

Whilst, however, the popular verdict is in favour of steam derived from the locomotive, the railway manager has not only its practicability but its economy to consider. Its practicability is now becoming less of an experiment, and more of a certainty. There are still some minor difficulties which further experience will readily overcome. Various railway managers and superintendents, after actual trial, have testified in its favour, and the superintendent of motive power on the New York, Lake Erie and Western railway goes even so far as to say that "unless the outside temperature is below zero, warming a train of cars by steam on a railway of an average gradient will not increase the draft on the locomotive one per cent.; the size of the train has nothing to do with it." As to its cost, the result of the enquiries made by the Massachusetts and New York Board of Railroad Commissioners appears to prove that it is little, if any, more expensive than present methods. Abundant warmth, it was shewn by continuous experiments, was obtained even when the temperature was 20 ° below zero, and only a moderate pressure was required, ranging on one railway from 2½ lbs. to 5 lbs. when the thermometer varied between 5 ° and 13 ° below zero. The Intercolonial Railway authorities fear, after the experience of the past winter, when trains were snow-bound for several days, that cars heated by steam from the locomotive might be placed at a grave disadvantage if detained in a snow drift. It is, however, impossible to foresee every such contingency, and even for the ordinary heater it is not usual to carry several days' supply of coal.

It is said that the Boston and Albany through New York train is heated from the locomotive in twenty minutes, and it is claimed by the Martin System people that eight cars can be thus heated without any loss of power to the locomotive. On the other hand, they also claim that when once a car is properly heated, it will remain comfortable for at least hafl an hour after being cut off and side-tracked. These are important points regarding which some further experience is needed.

The subjects of lighting and heating must, however, be considered together by railway managers if accidents from fire are to be prevented. It is merely taking away one risk of fire, if steam from the locomotive is employed as a heating agent, whilst oils or even gas are still retained for lighting purposes.

Mr. Drummond does not agree with Mr. Barnett, that for lighting cars, oils or oil gas are safe enough, and that mineral oil of 300 ° fire test is absolutely safe, if there is no other source of fire in the car than the lighted lamp itself. Though claimed, it has by no means been established, that a sudden shock to the car would necessarily at once put out all such lights in it, and thus quickly remove the source of danger. There is some evidence to the contrary. Now, the swaying of a Pullman sleeper, in the event of its being precipitated from the track, would be liable to bring inflammable material like curtains and bedding into contact with the lighted lamps, and if they should take fire, such fire would find increased fuel should the oil have become scattered over the car by the breaking of any of the lamps. It may be urged that the occurrence of extraordinary accidents is assumed, but it is these very extraordinary cases that have most to be provided against, as when they occur, the loss of life is greatest.

Gas is open to a similar objection in case of collision or derailment and it has this greater objection that, if the reservoir of highly compressed gas should be burst open by the shock, as is probable, a large amount of very explosive material would be let loose.

The only absolutely safe means of lighting, at present known, appears to be the electric light, and considerations of expense can alone prevent its general adoption. It does not add to the heat of the car, is under immediate, easy control, has the advantage of cleanliness and freedom from unpleasant odours, and gives a steady, agreeable light. The first cost in fitting out a car with it is considerable, in fact, much more than it should be. In railway economy, however, safety should be a consideration long prior to that of expense.

Mr. McIlwain.

Mr. McIlwain fully endorses the remarks of Mr. Barnett, regarding the difficulty of obviating all the objectionable features of car heating and lighting, and having taken up this question has much pleasure in giving some of his experience. He has made a number of tests with the object of finding a system of heating and lighting, that combined safety with efficiency and economy.

In all the experiments, where the heating of the cars was affected by burning coal, whether the heat was diffused by means of hot water steam, hot air, or by direct air contact and radiation, a practically indestructible fire pot was employed. He found that this kept the coal from being scattered, if upset or detached in case of accident; but the combustion products escaping through the air openings, necessary to maintain combustion under normal conditions, are of such a high temperature as to ignite wood or debris piled on the fire pot. In one instance, the sides of the fire pot set the wood, upon which it had fallen, on fire.

Water calculated to extinguish the fire automatically, in case the stove is upset, could not be relied upon under all the different conditions that may exist in a wreck. Fire extinguishing devices, that automatically generate carbonic acid, are not safe, and also not as effective in cooling a bed of incandescent anthracite as they would be in extinguishing a wood fire.

Further, whoever has witnessed the terrible rapidity with which carbonic acid destroys human or animal life would object to the introduction of a carbonic acid extinguishing device. The presence of a large mass of red hot anthracite seems almost incompatible with safety.

Steam heating would abolish all danger of a fire in case of accident; but the difficulties this climate offers to the mechanical execution of this plan seem almost insurmountable, and if accomplished, the drain on the Locomotive, and the cooling down, if a car is detached from the train, add further troublesome features, not yet fully overcome.

Mr. McIlwain is now testing a device invented by a German chemist, which promises well if it proves successful in practice. He hopes to be able to speak more positively on this in the near future.

Regarding the lighting of cars, he concurs with Mr. Barnett that 300 per cent. test oil is practically safe (as there are no authenticated cases where life has been lost or property destroyed in railway accidents, caused by the use of oil of this description), and with some of the modern burners, an illumination of the car can be produced that cannot be excelled by the electric incandescent.

The simplicity and absolute reliability of oil lighting is another strong point in its favour. The electric incandescent in railway cars has made such a poor show, especially in view of reliability and economy, that it can only be considered to be in its first experimental stage.

Secondary batteries lose their efficiency readily, and this with their enormous weight and first cost has greatly diminished the adoption of the storage system.

Dynamos want attention and power, and more of both than the light they furnish is worth.

Chemical batteries consuming zinc have been mentioned and advertised as being the true electric generator for car lighting; careful tests have shown it to be much more expensive than oil lighting, in fact, entirely out of the question, as far as practical work is concerned.

He does not look upon gas lighting in as favourable a light as Mr. Barnett. Oil has a freedom from complicated construction and plant that may get out of order; oil is independent of any definite source of supply, always ready, can be handled by the brakeman or porters, is just as safe as gas, and if there is a difference of price in favour of gas, it is so small as to be of no consequence in view of the many desirable qualities oil possesses.

The extended interest and research, that have been caused by the deplorable loss of life in last winter's accidents, will no doubt result in methods of heating cars much more safe than those now in use.

VENTILATION.—After trying almost every known device for ventilating cars, all of which have failed in the one important feature, i.e., in giving the same (or nearly so) amount of ventilation when the car is standing still as when moving; Mr. McIlwain has arrived at the conclusion that the coming system of ventilation to be successful, must be one that will fully give the necessary amount of fresh air circulation under all conditions. This can, in his opinion, be accomplished by automatic arrangement, whereby in warm weather, when the car is at a standstill, the ventilators will be open to their fullest extent, and gradually reduced as the momentum of the train is increased, until at last the minimum amount of air required to properly ventilate a car will be admitted only, and the reverse as the speed is reduced. Inventive ingenuity will be adequate to accomplish this, when it is found that the ventilation of railway cars is as important as automatic draw-bars, or continuous power train brakes.

Mr. G. Gibbs.

Mr. Gibbs, of the Chicago, Milwaukee and St. Paul Ry., fears that he can at present add little of value to the published accounts of their experiments last winter. These were very far from complete, on account of the limited range of temperatures encountered. The highest recorded temperature at which test was made was 40° Far., and the consumption of steam was 70 lbs per car per hour. At 30° the amount rose to 85 lbs., and at 10°, 100 lbs. Except at these temperatures no reliable figures can be given. A "heating-up" test, however—standing—at 10° below zero was made, and it took 285 lbs. of steam per car to bring the inside temperature up to 70° Far., and three hourstime. If the total condensation is divided by three, 95 lbs. is obtained as average consumption per car per hour. At present there hardly seem sufficient grounds for deducing from this figure one for running test under same temperature condition, as the further loss of heat due to the motion of train would much depend upon the build of the coach, the principal losses occurring from leakage and not from conduction.

It would be exceedingly interesting to be able to work out an approximate law for steam consumption at various temperatures. Mr. Barnett suggests in a letter that the condensation may increase in a geometrical rather than arithmetical ratio with temperature fall. Mr. Gibbs is inclined to doubt this, however; in fact, he hopes that the condensation will not be as great even as in inverse ratio of temperatures. He has been led somewhat to this conclusion from the fact that considerable heat must be wasted at the moderate temperatures of the tests, while with care at low temperatures much of this would be saved, at the expense of good ventilation, however.

Running over some of the points made in Mr. Barnett's excellent paper:—

He entirely agrees with him in what he says, in reference to stoves, encased or otherwise, or other individual heaters outside or in; also in regard to use of steam from exhaust of locomotive cylinders, air-pumps, etc. He has maintained that one of the most vital points connected with continuous steam heating was in dealing with the water of condensation. The rapidity with which water issuing hot from parts of a locomotive will freeze in the severe Northern climate, is almost inconceivable; and he, therefore, lays great stress upon the perfect action of the "trap" used, and would give it the least possible work to do by using the dryest steam.

He has been in favour of wholly metallic couplings between cars, but after some experience with these, believes that the purpose can be more satisfactorily accomplished, by securing flexibility by the use of stout steam-hose, having couplings arranged to permit of very readily replacing a broken hose by an extra one always carried at hand.

In practical train operation, there are certain to be some complications introduced by use of continuous heating; but Mr. Gibbs feels convinced that the operating department can deal with these, if it is supplied with a mechanically good arrangement. As might be naturally supposed, the arrangements on the market at present are far from perfect or well thought out.

There is a good field for inventors in this direction, to devise a simple coupling, traps and means of regulating radiating surface for varying degrees of cold, and, as far as possible, for needful ventilation. Beyond this, the so-called "systems" amount to nothing, and the expectation that railroads will pay exorbitant prices for the privilege of using what is already theirs is certainly doomed to failure.

His company is about to embody in a new arrangement being prepared for next winter, a scheme for good ventilation, but the details have not been sufficiently worked out yet to be made public.

Mr. Gibb, agrees with Mr. Barnett in his remarks about use of 300° fire-test mineral oil for lighting. He considers it perfectly save from the danger of setting the car on fire, under any condition of collision wreck, provided no other source of fire is at hand. The difficulty of inflaming the grade of oil is well known to any one handling it, and the slight shock necessary to put out all lamps using this oil can be easily determined by experiment.

Mr. Barnett.

Mr. Barnett, in reply, said the estimated economy in fuel by steam-warming was based upon experiments carried out with locomotives hauling short trains (therefore, having light fuel consumption per sq. ft. of grate surface, and excellent evaporation per lb. of soft coal burnt), and in districts to the south and west, where the average [illegible] was milder than in the province of Quebec but not so mi[illegible] in any appreciable reduction in the amount of hard coa[illegible] keeping heaters alive night and day.

The explanation of this apparent anomaly is in the fact that hard [illegible] is not readily combustible, and will not keep alight when in conta[illegible] a cooling metallic surface, unless a certain intensity or activity of [illegible] is maintained in excess of that absolutely required for h[illegible], thus occasioning a waste in the use of hard coal that lo[illegible] steam heating would probably avoid.

Also, aside from the higher market price of hard coal, its evaporative duty, when burnt under similar conditions, is but 74 per cent. of that achieved by soft coal. (See author's paper April, 1886, in Proceedings Canadian Institute, Toronto.)

The desired universal coupling will probably be found in the Sewell patent, if it can be effectively cleared of the water of condensation. Whether this be so or not, it is at present the best coupling offered for light steam pressures.

Mr. Gibbs very properly qualifies his belief that the water of condensation (at present the only satisfactory measure of the amount of heat taken from a locomotive) will not—at extremely low temperatures—increase even "in inverse ratio," by saying that the free mouvement of air through the car required in his experiments at medium temperatures would not be allowed in winter. Granting that a restriction may be to some extent permissible, there is no physical reason why the air in a car should not be changed as frequently in mid-winter as at any other season when artificial heating may not be required. The demands of a healthy body are practically the same in all seasons, although in mid-summer we may desire positive draughts because of their cooling influence.

The difficulty of inflaming high grade mineral oil may be tested any time by dropping a mass of saturated cotton waste, when in full blaze, into a barrel of 300° oil, with the invariable result of the oil putting the fire out at once. There is no authenticated case of such oil being the primary cause of destruction by fire of any car in any railway accident on this continent.

Mr. Drummond is correct in saying that a heater suspended underneath the car is no less a source of danger. The P. & R. Ry. have had at least two coaches so equipped burnt up in accident, and the B. & E. Ry. one.

The statement he quotes, that steam warming will not increase the draft on the boiler one p.c., cannot be sustained. A coach to carry 60 passengers requires from 126 to 140 supl. feet. of pipe surface for steam, or 200 ft. for hot water, with an average temperature of 160° F. Where steam is used for the warming of domestic dwellings, despite the facts that walls are thick, and double windows and doors are used, the condensation averages ⅓, often raising to ½ a lb. per ft. per hour; and it is self evident that a coach having its doors often opened, and a large glass surface to radiate heat, will suffer a much greater condensation. Using, however, the small figure of a ½ lb. per sq. ft., the condensation over 140 ft. will total to 70 lbs. per hour, or per 10 coaches 700 lbs., which is 1 p.c. of 70,000 lbs., equivalent to an evaporation of 7,000 galls. and the burning of more than 5 tons of coal per hour. If 2,000 galls. are to be evaporated, the locomotive must not stop during the hour, so that its artificial blast may draw air enough through the small grate to consume this large amount of fuel.

That steam, at such low pressure as 2 to 5 lbs., will warm a train, or that the fractional opening of an ½ in. valve will pass steam enough, is no proof that the consumption of steam is small in quantity, or that there is no loss of power to the locomotive; all tests of the definite amount condensed contradict this statement.

It is the heavy expense and necessity for skilled attention that will restrict the use of the Electric light on trains. Even when primary batteries are used as a source of electricity for equal candle power, the cost is equivalent to coal gas at $3.25 per thousand feet; there is a possibility of risk to life, for it is not yet proven that a charged storage battery—or even a primary battery—is not a source of danger to passengers at time of a passing thunder storm.

It may be remarked that in all discussions on the cost of lighting by Dynamo, worked from coach axle that have come under Mr. Barnett's notice, the factor of expense involved in giving motion to the machine is ignored, it being tacitly assumed that the resistance to the train is not increased, although a Dynamo so coupled up is a most effective electric brake.

The extreme cost for lighting the "Olga" is qualified by the consideration that it is to some extent an advertisement, its 24 electric lamps when all alight giving 384 candle power, 120 candle power being enough to permit reading in any part of an ordinary coach. This may be obtained by 8 oil lamps, using argand burners of 15 candle power, which is about the quantity of light given out by a first-class argand student lamp. The consumption of about one pint of oil per hour will develop 120 candle power.

There may be risk in the presence of reservoirs of compressed gas in time of accident; but although the Pintsch systsm has been used in Germany since 1770, and 40,000 vehicles are now equipped with it, no case of injury to life or property in time of railway accident is attributed to it.

Mr. McIllwain's statement as to lack of success in electric lighting is probably limited to experiments made on this continent; the Pacific Railway Co. having made more than any other railway, and the Co. is still experimenting.

That special ventilation is not required when car is standing, is open to question. It is often asked for by passengers, and the conditions of the problem are such as to scarcely justify elaborate machinery or extensive outlay to attain perfect ventilation, only when the coach is in motion. If train motion is to be a factor in the equation, the outlook at present suggests but a qualified success in the supply of fresh air at low train speeds.

At the conclusion of the discussion on Mr. Barnett's paper, Professor Leeds, of Harvard University, described a method of water purification with special reference to aeration, precipitation and mechanical filtration.