Urgent

Public Works (1899) Department.

RAILWAY BRANCH.

G.O., No. 305-6. Rys

DATED 18th March 1899.

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[Despatch Abstract.]

Stone's Electric Light System.

Ordered that the correspondence containing Mr. Winter's reply on Mr. Carden's Criticisms & observations on the report by the former on the condition of — together with a note thereon by the Cons. Engr. for Rys. be forwarded to the Govt.

Forwarding Correspondence containing Mr. Winter's reply to Mr. Carden's criticisms & observations on the report by the former on the condition of — together with a note thereon by the Cons. Engr. for Rys.

Indexed.

BACK PAPERS.

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RAILWAY.

Government {1899} of Madras.

PUBLIC WORKS.

Recd. } 1899. *Enclosures*

Regd. } *Spare copies*

G.O., No. 305 Ry., 18th March 1899.

MARCH.

Stone's Electric Light System

Ordered that the correspondence containing Mr. Winter's reply on Mr. Cardew's criticisms and observations on the report by the former on the condition of —, together with a note thereon by the Consulting Engineer for Railways, be forwarded to the Government of India.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Railway.

Read G.Os., Nos. 116–117 Ry., dated 27th January 1899.

Read also the following paper:—

From—The Secretary to the Government of India, Public Works Department.
To—The Joint Secretary to the Government of Madras, P.W. Dept., Ry. Branch.
Dated—Simla, 28th January 1899, No. 166 R.S.

I am directed to forward, herewith, copy of a report, No. 6908/49 S. & M., dated 14th October 1898, by Mr. C. E. Cardew, M.I.M.E., Locomotive and Carriage Superintendent, Burma Railways, containing his criticisms and observations on the report, dated 27th April 1898, by Mr. G. B. Winter on the condition of Stone's electric light plant and the system of working the same on the South Indian Railway.

2. I am to request that Mr. Cardew's report may receive the consideration of the Government of Madras, and that such further report may be submitted for the information of the Government of India on the working of the South Indian Railway installation of Stone's system, as the Consulting Engineer for Railways, Madras, is in a position to make.

ENCLOSURE.

From—The Locomotive and Carriage Superintendent, Burma Railways.
To—The Agent, Burma Railways Company (Limited), Rangoon.
Dated—Insein, 14th October 1898, No. 6908/49 S. & M.

Stone's Electric Light System.

I beg to acknowledge receipt of your No. 6509/148 M. of 2nd ultimo, forwarding a copy of a report by Mr. G. B. Winter on the condition and working of Stone's electric light experimental installation on the South Indian Railway.

2. I have studied this report most carefully and am glad to be able to state that from my own knowledge and experience of Stone's system, I am unable to agree with several of the conclusions arrived at in this report. Further, I am of opinion that they are incorrect and likely to unjustly prejudice the system for no real faults of its own but for ones which are apparently the result of the system not having been properly carried out on the South Indian Railway. I therefore venture to make the following criticisms and observations with a view to justifying my opinion, and setting in a proper light some matters which have been misrepresented in this report.

3. The first point in which I disagree with Mr. Winter, is in his opening account on page, I, of the nature of the failure. He says: "*I have been unable to ascertain what actually happened which necessitated the electric light installation being removed from the carriage, but I gather from what I have seen of the correspondence that the light had for some little time been unsatisfactory and that ultimately the lamps would neither light when the train was standing still nor when running. My own observation early in January, when travelling to Madras in the composite in which the installation was fixed was, that while the train was standing at the platform of a station the lamps were brilliantly lit,*

but as soon as the train had attained the speed at which the dynamo is switched in, the lights suddenly went down to about half their former illuminating power." If, however, the accumulators were ultimately exhausted they must have told their own tale, for the cells in their discharge would become heavily sulphated and result in the lead plates getting much buckled by the expansion of the sulphate of lead deposited on them. Mr. Winter, however, makes no remarks on either the physical condition of the cells or what amount of residual charge they yet retained when examined by him. Things, however, could scarcely have happened as described by him. Whatever may have gone wrong it is certain that the lamp resistance would remain constant, while the voltage of the cells *if being run down* would rapidly decrease, so that it is impossible to imagine the lamps glowing *brighter* when taking all their current from the accumulators while the train was standing, than when it was running and the current going direct to lamps from the dynamo, as described by him. Such brighter glow could only happen when the voltage of the accumulator battery was higher than that being produced by the dynamo, and would be no proof of the cells being run down, but rather the contrary.

4. Mr. Winter next states: "*There can only be one cause for this, namely, that the dynamo was being run at a voltage which was insufficient to overcome the back electromotive force of the accumulators. The result of this would be that a considerable portion of the current which flows through the lamp circuit would be withdrawn from that circuit and flow instead through the dynamo and drawing at the same time on the reserve in the accumulators.*" These remarks are by no means clear or to the point. If he refers to the small portion of current passed through the shunt circuit for the excitation of the field magnets they are incorrect, as the shunt current varies as the total current from the dynamo and could not seriously rob the current going through the lamp circuit. I take it, however, that what he means is that the dynamo instead of acting as a generator would be driven as a motor by the battery. If so, this would indicate that the governor had gone wrong, and that the dynamo had been switched in too soon before the voltage of its current had risen sufficiently to overcome the electromotive force of the battery. Mr. Winter, however, does not definitely suggest this as the cause.

5. Mr. Winter proceeds: "*This waste of current if not compensated for by 'day running' must ultimately lead to the exhaustion of the cells, and this is what I believe must have happened. When the cells become exhausted the dynamo field magnets could no longer be excited by the accumulators before being switched in on to the lamps, and the dynamo in consequence of loss of magnetism would lose the power of generating any current, and so the whole lighting system would collapse. I have come to this conclusion as a result of my examination of the dynamo. When I first heard of the failure of the electric light and being on one occasion at Negapatam, I had the dynamo started running, and I attached an incandescent lamp on to its terminals. I was unable to obtain the faintest glow in the lamp although I carefully adjusted the brushes. I came away with the impression that this failure was possibly due to the loss of residual magnetism. On my recent visit to Negapatam for the special purpose of examining the dynamo, I put my supposition to the test. With twenty Leclanché cells I sent a current through the field magnets and started the dynamo, the glow lamp being attached. I at once obtained a brilliant light in the lamp, and the current was so powerful that the lamp quickly blackened and burst.*" Matters may have happened as here represented, but it is a great pity that Mr. Winter did not test the accumulators to see if they had wholly lost their charge as surmised by him. I do not believe that they could have been so completely discharged as imagined, nor that the field magnets could have lost all residual magnetism. He does not say how long he ran the dynamo without any cells attached, but in such case it, I believe, often takes 10 to 15 minutes before a current, excited by residual magnetism, gathers force enough to show itself. Possibly Mr. Winter did not run it long enough. From this report also it is impossible to say whether or not he ran the dynamo with the accumulator cells attached before employing Leclanché cells.

6. Mr. Winter next describes the injuries which he found to have happened to the insulation of the armature winding, but as he has omitted to tell us how the injury occurred, or whether it at all impaired the efficiency of the dynamo, that portion of his report is comparatively worthless. From my own experience here, I cannot conceive how these injuries could have happened, except through some grossly careless or improper treatment of the dynamo. It would be interesting to have further details hereon.

7. Mr. Winter then goes into a long discussion to prove that the dynamo was unable to overcome the back resistance of the accumulators when the full light lamp circuit is closed. I find it difficult to follow his figures, partly for want of the South Indian Railway time-table quoted, partly by his incomplete explanation, and partly through printers' blunders and omissions which are only too obvious. The whole of his 2nd page though may be reckoned as a slaying of the slain, for if the dynamo were not giving a sufficient output its speed should have been regulated to make it right. It is purely academic, if not waste of time, to explain the *rationale* of faults which can be easily cured. He suggests three cures: (1) giving carriage a longer day run, (2) tightening belt of dynamo to make it run faster, and (3) reduction of number of lamps. For practical considerations (1) and (3) are inadmissible. To adopt them would be to condemn Stone's system as unsuitable for railway work and its conditions.

8. My own surmise regarding the South Indian Railway installation is that there was nothing much wrong with it, except that the dynamo was not giving the necessary output on account of the driving belt being too slack, either by having stretched, or that it had never been properly adjusted from the first. Slipping would therefore occur too soon and the dynamo fail to give the necessary output after being switched in. Messrs. J. Stone & Co. give particular instructions for testing the output by an ammeter and regulating the tension on the belt accordingly. On this the most important point of all, or what attention it received on the South Indian Railway, Mr. Winter is absolutely silent. I am much of opinion that to its neglect all their troubles may be traced. My own experience is that by employing a piece of good cotton belt thoroughly stretched before being used no trouble by subsequent stretching is experienced. With the experimental installation on these railways, I have had the same belt in use for over six months without any need of adjustment. At first I had some trouble when using a special rubber composition belt supplied by Messrs. J. Stone & Co. which stretched badly, got sticky almost to melting point so that it seized the flanges of the pulleys, overriding them and turning itself inside out till it finally broke. This mischief was caused by the great heat reflected off the ballast during the hot weather. That sort of belting may be suitable enough for temperate climates but not for the tropics. It would be interesting to learn whether it was in use on the South Indian Railway, as if so I can readily understand its misbehaving.

9. Mr. Winter in his paragraph II refers to the adjustibility of the centrifugal governor for switching in the dynamo at the speed requisite for producing a current of sufficient electromotive force for overcoming the back pressure of the accumulator battery, namely 16 volts. For a given dynamo this occurs of course at a certain speed and once the initial adjustment has been made by the makers the governor weights are fixed to prevent further change. From Mr. Winter's remarks, however, one might suppose that further adjustment was permissible and allowed for by the makers. This is not the case, and any meddling with the governor would be mischievous.

10. In his paragraph III Mr. Winter discusses Messrs. J. Stone & Co.'s method of regulating the speed of dynamo by allowing the belt to slip as above referred to. He, however, unconsciously reasons in a vicious circle and wrongly arrives at the conclusion that Messrs. J. Stone & Co. have given an untrue explanation of the slipping action. He says "*allow the dynamo to run on open circuit, that is do no work, and I believe no slipping will take place within a large range of speed.*" Quite so: but unfortunately he has forgotten that the dynamo never runs on open circuit from the moment it is switched in at a comparatively low rate of speed and commences to produce a small current of some 5 or 6 amps. only. Again he says: "*The effort required to revolve the dynamo varies approximately as the square of the speed when the circuit is closed, the drag on the belt * * * * increases in that proportion, and ultimately the tension on the belt will arrive at the critical point at which slipping takes place. * * * In a shunt dynamo the speed remaining the same, as the output, and consequently the effort to rotate it at that speed, increases with the current drawn out of the machine. Therefore by increasing the current generated the speed at which slipping takes place is reduced.*" Quite so: but the current drawn from the machine is all that it is making, and as all resistances are constant the draft depends solely on the speed of revolution. There is therefore no increasing of current but by increase of speed, and Mr. Winter's remarks do not hold good. Again he says: "*The inference one would draw from Messrs. Stone's explanation would be that the speed at which slipping occurs is constant whether the dynamo be doing little or no work, or whether it be working full load, and this, I think, is for the reasons above given untrue.*" This is a faulty inference and one which I am sure Messrs. J. Stone & Co. would not admit. The effort to revolve the dynamo varies approximately as the square of the speed, but the resistance being constant and quite independent of the speed, it follows that the same amount of work is always done at any given speed and the effort to revolve the dynamo at that speed is always the same. Therefore slipping will always take place at one and the same critical speed so long as the initial tension on the belt remains unaltered. Hence Messrs. Stone's explanation is strictly true. Mr. Winter has confused himself by forgetting that the load is not variable but increases with the speed up to a certain maximum and then becomes constant. I attach copy of a table published by Messrs. J. Stone & Co. which fully bears out my view of the matter.

11. In his paragraph IV (page 3) Mr. Winter suggests that Stone's system of a separate dynamo for each vehicle will be only a temporary expedient during the period that a railway may be engaged in fitting its rolling stock, but that ultimately when that work has been completed, it "*will gravitate either to the use of one generating dynamo at the end of the train or else to charging stations at different parts of the line, where vehicles fitted with accumulators can be replenished* in situ *by cables attached to the vehicles from the charging house.*" Mr. Winter has clearly not yet grasped the problem of railway electric lighting, nor are his proposals original. The first is the better of the two, but it is the proverbial putting of one's eggs all in one basket. Anything going wrong with the single dynamo means a whole train instead of a single coach being put in darkness. Beside this he wholly ignores the difficulties met with in electrically coupling the vehicles composing a train, which are unfortunately only too formidable for trains liable to be broken up and remarshalled. The second proposal is an ideal one not feasible with our present

knowledge of accumulator design and construction. To employ accumulators solely would mean at least doubling if not trebling the number and weight of them to be carried, a sufficiently serious objection in itself, but as unfortunately a battery cannot be charged at a much faster rate than it is intended to be discharged, the time occupied would entail a great loss by the vehicles being withdrawn so long from running service. To meet this objection it has been proposed to remove the discharged cells and replace them by fully charged ones, but with their great weight and the somewhat delicate nature of their component parts this, so far, has never been accomplished with sufficient success for railway work.

12. I do not consider Mr. Winter's proposals for working Stone's system (page 4) if introduced on a large scale, to be the best to meet the difficulties successfully. No. (1) *an instructional installation* would be a luxury. Nos. (2) and (3) *the employment of trained lascars* (coolies he means) would be most unsuitable, as such unskilled labour will never do. Good intelligent Native and Eurasian mechanics, supervised by a trained European electrician, would be required at terminal and changing stations only. No. (4) *reporting irregularities* and No. (6) *a repairing shop* would both be necessary, but No. (5) *providing duplicating parts for every train and terminal station* is rather overdoing it, as to carry parts on a train would be useless, there being no time or opportunity for making replacements.

13. Finally, Mr. Winter is altogether wrong in his description (page 4) of the double accumulator system, when he asserts that the dynamo is not in direct communication with the lamps or that the lamps are fed solely from one set of accumulators while the other set is being charged. The fact is the dynamo is quite as much in direct communication with the lamps in the double system as in the single system, but while one battery is being charged the other acts as a regulator, giving current to the lamps when required to supplement that from the dynamo while running slowly, and taking up from the dynamo at high speeds any slight excess of current over and above that required for supplying the lamp circuit and the battery under charge. While the dynamo is at rest, or running too slowly to come into action, the currents from the two batteries are automatically short circuited into parallel and supply the lamp circuit and the field magnets of the dynamo. The double system is only necessary where vehicles have a *great deal of very slow running or standing at stations with lights on.* For all ordinary railway work the single system amply suffices and it is 40 per cent. cheaper in cost of installation.

ENCLOSURE.

To demonstrate that to whatever extent the speed of the train might vary without increasing the speed and output of the dynamo beyond its predetermined limit, the following experiments were made in the presence of Professor Slaby, Director of the Royal Technical College of Berlin, and Professors Hagen and Neesen of the German Patent Office, each of whom expressed himself greatly pleased and fully satisfied with the results demonstrated:—

Speed of pulley on axle of motor, Representing axle of Railway Carriage, Revls. per minute.	Equivalent speed of train in miles per hour (approximate).	Speed of dynamo revolutions per minute.	Equivalent speed of dynamo if no slip were to take place.	Output of dynamo, amperes.	Remarks.
100	12	500	500	0	The predetermined limit for speed of dynamo in these tests was 915 revls. per minute producing 20 amps. of current which it will be noted was not exceeded, although the speed of pulley on axle of motor (representing speed of train) varied from an equivalent of 24 miles per hour when this limit was first reached, to 72 miles per hour.
138	16	690	690	2	
150	18	750	750	6	
168	20	840	840	14	
175	21	870	875	16	
185	22	885	925	17	
195	23	900	975	18½	
205	24	915	1025	20	
225	27	915	1125	20	
250	30	915	1250	20	
275	33	915	1375	20	
300	36	915	1500	20	
325	39	915	1625	20	
350	42	915	1750	20	
375	45	915	1875	20	
400	48	915	2000	20	
450	54	915	2250	20	
500	60	915	2500	20	
600	72	915	3000	20	

The same results have also been demonstrated before many of the principal Railway and Electrical Engineers of this country, all of whom have expressed their complete satisfaction with the tests.

Report from G. B. WINTER, Esq., A.M.I.C.E., A.I.E.E., Assist. Engr., S.I.Ry., dated 22nd February 1899.

With reference to Mr. Cardew's report on Stone's system and his criticisms of my report, I have the following remarks to make.

Paragraph 2.—The disagreement between Mr. Cardew and myself is much less than I think he makes out. The whole drift of my report was to show that the failure was due to no fault of the system but to want of a little experience in the manipulation of the adjustments, and I laid particular stress on the need of training men to do this, the accomplishment of which, I anticipated, would present no difficulty.

Paragraph 3.—Mr. Cardew in this paragraph quotes a passage from my report and says he disagrees with it. As the passage quoted relates to matters of fact, I can hardly see how he can disagree. I did not mention the fact of the lights suddenly going down when the dynamo was switched in as a *proof* of the exhaustion of the accumulators. I mentioned it as being due to the dynamo being switched in before the electromotive force at its terminals was sufficient to overcome that of the accumulators.

As regards the physical state of the accumulators I did not see them when they first came in from the line and before I had seen them they had been dismantled and the plates and cells cleaned. I saw some of the plates; the "positives" bore unmistakable evidence of the cells being in a low state of exhaustion. But none of the plates that I saw had buckled nor had sulphating badly set in.

Paragraph 4.—Mr. Cardew then quotes further from my report giving my deductions from the facts quoted in the 3rd paragraph, I think my remarks are clear and can be understood. At the time the dynamo was switched in, the dynamo was being run at a voltage which was insufficient to overcome the back electromotive force of the accumulators. It follows, the stronger overcoming the weaker, that the accumulator would send a current through the dynamo, both through its armature and field magnet coils, the expenditure for which must be met from the reserve in accumulators. That the fault was due to the switch acting too soon would have been obvious had Mr. Cardew not dissected my statements and quoted them apart from the context and in addition Mr. Cardew will find that I showed later on in the report exactly how the effect observed could be remedied.

Paragraph 5.—I regret that I was unable to make any direct test on the accumulators to see if they had wholly lost their charge, the fact was they had all been dismantled and I would have had to have obtained and mixed fresh acid and set the cells up together again and I had not the time at my disposal. As I did not make this direct experiment I cannot maintain what was only a surmise; viz., that the cells were *absolutely* exhausted, but that they were so much exhausted as to interfere seriously with the light, is a fact. That the lighting might collapse in the manner suggested as possible and even probable in inexperienced hands, I maintain. As regards loss of magnetism in the field magnets, this was a fact proved by experiment. It is well known that small dynamos are liable to this phenomenon. That this was anticipated as being possible is evidenced by Messrs. Stone & Co. making special provision for exciting the field magnets with the full pressure of the battery immediately before switching in the armature of the dynamo.

Mr. Cardew suggests that possibly I did not run the dynamo long enough. I may mention the dynamo was running over two hours without any result and I could detect no *polarity* at the cheeks of the dynamo field magnets by means of a small pivoted compass needle which I had with me.

Paragraph 6.—The injury to the dynamo was obviously due to ill-usage. It was impossible to ascertain how or by whom, as the dynamo in the course of the trials had been manipulated by a good many people. The efficiency of the dynamo was not impaired as the experiments made with the Leclanché cells was made before one of the coils was renewed.

Paragraph 7.—Mr. Cardew here says that I go into a long discussion to prove that "the dynamo was unable to overcome the back resistance of the accumulators when the full lamp circuit is closed." This does not make sense and I certainly never tried to prove such a proposition. My argument was to show that there was insufficient margin in the mail runs between Trichinopoly and Madras to keep the

accumulators charged. That whereas the amount of charge only amounted to 107 ampére hours the discharge was as much as 96. That this was insufficient, was proved by the trouble experienced in keeping the accumulators charged. Mr. Bell had frequently to run the carriage by day from Madras to Chingleput in order to recharge the accumulators. Mr. Cardew then says "The whole of the 2nd page, though, may be reckoned as the slaying of the slain; for if the dynamo were not giving sufficient output its speed should have been regulated to make it right." Mr. Cardew has evidently missed the point. If one finds that the lamps are not burning brightly when running at full speed, by all means tighten the belt till the desired effect is obtained; because that is the correct thing to do. The point at issue, however, was the question of receipt and expenditure. I assumed the belt to have been correctly adjusted and found that, notwithstanding this, there was insufficient margin to provide for contingencies. If this is so, further tightening of the belt would not be the best remedy; for by doing so you run into danger of bursting the lamps and of certainly greatly shortening their life. As regards the three cures suggested, I am of opinion that with carriages fitted with the full number of lights and fitted with the single accumulator system, all night running without day running would be insufficient and that therefore carriages so fitted should be allowed plenty of day run. As regards (2) this would be feasible if the lamps were being under-driven. As regards (3) the first-class composite in all compartments was brilliantly lighted. Such brilliant illumination is not necessary in the third-class carriages and with the same floor area less lights would be required; the fewer lights required would leave ample current for keeping the accumulators charged and for this reason it is suggested not to use the double accumulator arrangement on third-class carriages.

Paragraph 8.—Mr. Bell, the officer who had charge of this installation, paid particular attention to the adjustment of the belt, and in earlier portion of the trials the belt was adjusted so as to maintain as bright an illumination in the lamps when the carriage was running as when standing still. Mr. Bell, who is now away in England on leave, took great interest in these experiments and was fully conversant with all the adjustments and so long as he personally looked after the carriage the lighting was a perfect success; but even then as I have before explained he found that the accumulators were losing charge and required special day trips to replenish them. It is obvious, however, that Mr. Bell could not always be looking after the carriage as he had his own work to do—the system would not be worth considering if it necessitated such close and skilled attention. The carriage was, however, looked after by an Eurasian mechanic and for a time the lighting was successful, but there was always difficulty in keeping the accumulators charged. Whether this man or his successor (as I believe he was changed) fully understood these adjustments or whether it was he was inattentive or whether he was afraid to alter the adjustments I cannot say; but it was evident from my investigation that the irregularities in the lighting were due to want of adjustment and that the failure of the lighting was ultimately due to the practical exhaustion of the accumulators.

A leather belt was used in these experiments and I understand from the Loco Superintendent that no complaints were made as to the belt stretching. Mr. Cardew's description of the results of using the composition belting is interesting and is a practical object lesson teaching us to adhere to cotton or leather in this country.

Paragraph 9.—If Mr. Cardew will refer to the 6th paragraph on page 19 of G.O., No. 116 Ry., dated 27th January 1899, he will see that Messrs. Stone & Co. recommend the same remedy that I suggested. In the case of the dynamo received on this line the weights were not permanently fixed, they were only held in place by the bite of a stud screw.

Paragraph 10.—I have been totally misunderstood on this point. I did not question the fact that slipping took place at a critical speed. I admitted it. The point was this. A statement was made to the effect *that the tension on the belt increases with the speed of the train.* In most cases, when a shaft is being driven by a belt, the belt may be driven at different speeds without any appreciable variation in the *tension* of the belt, excepting of course, during the time when the speed is changing. I thought therefore it would be interesting to look for the *cause* of this increase of tension with increase of speed. One might suppose without looking sufficiently into the

question that it had something to do with the peculiar method of suspension and such was my first thought; it has of course got nothing to do with it, and for the *cause* one must look and see what the dynamo is doing, and this investigation led me to the following conclusions:—

(1) That the cause of the increase in tension of the belt with increase of speed is due to the fact that the work done by the dynamo increases in a much faster proportion than directly as the speed (the more usual phenomenon) and nearly as the square of the speed.

(2) That the critical speed at which slipping takes place is dependent upon—

(*a*) The regulation of the portion of the weight of the dynamo supported by the belt.

(*b*) The current being drawn out of the dynamo.

The upshot of Mr. Cardew's argument in paragraph 10 is, I think, to the effect that at constant speed (*b*) is constant, since the total resistance in circuit is constant. In this connection I would like to know the results of the following experiment: Run the carriage at constant speed, and with the switch at "full lights" and with the dynamo switched in and observe the ammeter. Now switch the lights to "half lights" and again observe the ammeter. I am not sure whether the observer will not notice a marked drop in the current indicated as flowing through the ammeter in the second case. I assume of course that the ammeter is inserted in the circuit *between* the dynamo and the accumulators so as to measure the sum of the currents flowing through the accumulator and lamps together.

A variation in current strength in the above experiment, should such there be, would of course indicate that the total resistance *was not* constant. It must be remembered that switching out lights has the effect of increasing the resistance of the lamp circuit, for instance half the number of lights would double this resistance. The question is—Is the increase of resistance sufficiently counterbalanced automatically by a large fall in the resistance of the accumulators?

Paragraph 11.—My prophecy regarding the future of electric lighting of trains may be a bad one. What I think is that when once all the stock is electrically fitted, the difficulty experienced in lighting trains as experienced on the Midland in England will not be nearly so formidable. We have yet to gain experience of Stone's system; time will show whether the method of running a lot of little dynamos on one train when one might suffice, will be more successful than the Midland experiments. So far I hear that Stone's system has been a great success and I understand that the Midland are ordering some of this plant.

Paragraph 12.—I do not think an *instructional installation* would be a luxury. There would always be a spare dynamo and set of spare accumulators at head-quarters. A counter-shaft and four wires with lamps suspended therefrom, stretched from wall to wall of the rooms, would all that would be necessary.

Nos. (2) *and* (3).—1. Trained lascars are not coolies. Smart telegraph lascars on the Madras Railway have sometimes risen to be telegraph inspectors and I think such men would do well for the purpose.

(5) Mr. Cardew has quoted me wrongly. I said that each train should carry a complete set of *small* parts and a spare armature at each of the terminal stations. If a lamp filament breaks *en route*, a new lamp can be refixed in two minutes at the next station; the same with a safety fuze. A spare armature at the terminal station may or may not be necessary, it depends whether the traffic can afford to loose the carriage for 24 hours until a new armature arrives from head-quarters.

Paragraph 13.—My description of the double accumulator system was given from information obtained from Messrs. Stone & Co.'s pamphlet. My description was sufficiently exact to explain the *principle* of the double accumulator system, the fact of the dynamo being connected to the discharging set of accumulators through a high resistance is a detail and not absolutely necessary. The lamps are almost entirely dependent on the discharging set of accumulators for their light, a small surplus finding its flowing through at high speeds, and the dynamo is not in direct connection with the lamps, since there is a high resistance interposed between the dynamo and the lamps. I quote below the passage from Messrs. Stone & Co.'s pamphlet.

Conclusion.—In conclusion I have to add that I wish Mr. Cardew could have given us more information about his experiments with this system of lighting. Such information would enable one to compare the conditions under which both these trials were made and a juster estimate made of the capabilities of the one accumulation system. The information one would like to know concerning Mr. Cardew's experiments would be —

(*a*) Number of hours of night and day run respectively per trip (up and down).
(*b*) Number of lights lit at one time on "full" and "half" light, respectively.
(*c*) Whether difficulty has been experienced in keeping the accumulators charged.
(*d*) Whether there is, as a general rule, any noticeable fluctuation in the intensity of the illumination when the dynamo is switched in as compared with the light when standing at a station.

Finally I would draw attention to Messrs. Stone & Co.'s reply to my report which was sent to that firm. If my report had been all that Mr. Cardew tries to make out that it was, I feel sure Messrs. Stone & Co. would have been sufficiently alive to their own interests to have controverted the so-called misrepresentations; instead of doing so however I think their reply may be taken as expressing general concurrence.

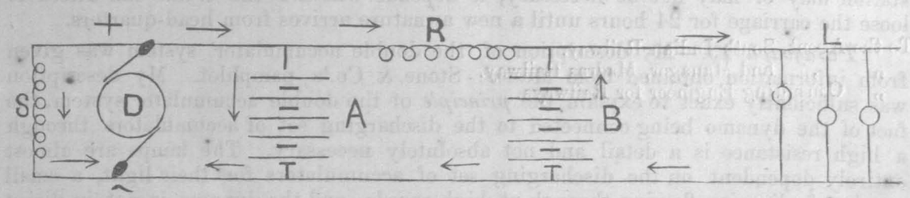
Extract from Messrs. Stone & Co.'s Pamphlet.

Double Accumulator Arrangement.

In this arrangement, instead of the accumulators being supplied in one set, two sets are provided, which are alternately charged by the dynamo, the battery which is not being charged supplying the current to the lamps, the governor and contact board of the dynamo being modified to automatically effect this purpose. In dynamos thus constructed, the two sets of contacts into which the rocking arm is pushed by the governor, according to the direction in which the train is moving, are kept separate and control the charging circuits of the two batteries, so that while a train is going in one direction the one battery is charged; in the opposite direction the other battery will be put in circuit with the dynamo. At the same time it will be observed that a projecting arm on the rocking arm operates the "see saw" switch, which causes the current for the lamps to be always supplied from the battery which is not being charged. The two batteries are never, however, entirely disconnected, but an iron wire resistance is provided, through which the current may pass from one to the other; this resistance being short circuited, by means of a small pivotted lever when the train is at a standstill, or should the dynamo from any other reason not be working.

It will thus be understood that the greater part of the current generated by the dynamo will go to charge the accumulator, which is not in direct connection with the lamps, but at the same time a comparatively small amount of current passes through the resistance to the battery supplying the lamps. As the resistance is so proportioned that the maximum current which passes through it is not more than is required to run the lights, the lamps cannot possibly be over-run, and the resistance R (shown on page 8) is therefore not in this case necessary.

Note.—I understand from the above description that the circuits are arranged as follows:—



D = Dynamo.
S = Fixed magnet coils of dynamo.
A = Set of accumulators being charged.
R = High resistance.
B = Discharging set of accumulators.
L = Lamp circuit.

Read also the following :—

Note by the Consulting Engineer for Railways, Madras.

There would appear to be no essential difference between Mr. Cardew and Mr. Winter in regard to the excellence of the system. Their arguments have reference chiefly to the supposed causes of the partial break down of the experimental instalment on one carriage of the South Indian Railway. But nobody had any right to expect that so limited an experimental installation, with no spare parts and not able to secure much expert attendance (for Mr. Winter is not in the Locomotive Department of the South Indian Railway), could do otherwise than break down after several months' running. That it should under such circumstances have run so well and so long is, I consider, greatly in its favour. In arriving at a decision as to when to begin to bring the system of electric lighting for trains into use, we would not be justified in hanging back for want of data based on experiment in this country. I learn that the experimental carriage on the Burma Railways has run, quite successfully, about 17,000 miles, and that on that Railway all first and second class carriages on the Rangoon-Mandalay mail train are to be fitted up with Stone's system at once. From experiments conducted there it would appear that the resistance due to the dynamo is about $\frac{1}{2\frac{1}{2}}$nd part of the resistance of an 18-ton bogie coach. The system would appear to have proved itself a great success wherever it has been adopted, if one is to believe all that one reads of it in the current professional literature; and I believe it to be the best system of train lighting that has ever been brought out. This Government has already, in letter No. 117 Ry., dated the 27th January 1899, strongly recommended to the Government of India that arrangements be now entered into for equipping seven mail trains on the South Indian Railway with Stone's system of electric lighting. The present oil lighting is bad and expensive. There is nothing in Mr. Cardew's note or in Mr. Winter's comments thereon which would lead me to change the opinion under which I recommended Government to support the scheme.

Madras,
13th March 1899.

Francis J. E. Spring,
Consulting Engineer for Railways.

Order—No. 305 Ry., dated 18th March 1899.

A copy of these Proceedings will be forwarded to the Government of India for such orders as they may see fit to pass on the recommendation contained in this Government's letter No. 117 Ry., dated the 27th January 1899.

[Here enter No. 306 Ry., dated 18th March 1899.]

(True Extract.)

Francis J. E. Spring,
Joint Secretary.

To the Agent, South Indian Railway.
" " and Manager, Madras Railway.
" Consulting Engineer for Railways.

Exd. T. K. Narayana Aiyangar.

34

Public Works (1899) Department.

Railway
CURRENT No. 184

BP 7P

From The Govt of India

Order No 15 R P 9/2/99 cancel Fr. 9.0. 7/99

recorded
JLd
7/4/99.

No. 166 R S.

D: This should not be recorded. It is a letter from India — must be answered.
7/99
D/S

Dated 28th January 1899
Received
Registered 6. 2. 99
Enclosures 1
Spare copies

SUBJECT.

Stone's Electric Light System.

Forwarding copy of a report by Mr. Cardew Loco and carriage Supdt. Burma Rys, containing his criticisms & observations on the report by Mr. Winter on the condition of — and requesting that a further report may be submitted by the Consg Engrs on the working of the above system on the S.I.Rly.

speed

BACK PAPERS.

No.	Date.

FURTHER PAPERS.

No.	Date.

n 8f

Letter No.6908/49.S & M,dated Insein,the 14th October 1898,from Mr.C.E.Cardew,M.Inst: M.E.,Locomotive and Carriage Superintendent,to the Agent,Burma Railways Company,Limited, Rangoon.

Print

Stone's Electric Light System.

I beg to acknowledge receipt of your No.6509/148.M., of 2nd ultimo,forwarding a copy of a report by Mr.G.B.Winter on the condition and working of Stone's Electric light experimental installation on the South Indian Railway.

2. I have studied this report most carefully and am glad to be able to state that from my own knowledge and experi--ence of Stone's system,I am unable to agree with several of the conclusions arrived at in this report. Further,I am of opinion that they are incorrect and likely to unjustly prejudice the system for no real faults of its own but for ones which are apparently the result of the system not having been properly carried out on the South Indian Rail--way. I therefore venture to make the following criticisms and observations with a view to justifying my opinion,and setting ina proper light some matters which have been mis--represented in this report.

3. The first point in which I disagree with Mr.Winter is in his opening account (on page 1) of the nature of the failure. He says:- "I have been unable to ascertain what actually happened which necessitated the electric light installation being removed from the carriage,but I gather from what I have seen of the correspondence that the light had for some little time been unsatisfactory and that ulti--mately the lamps would neither light when the train was standing still nor when running. My own observation early in January,when travelling to Madras in the composite in which the installation was fixed was, that while the train was standing at the platform of a station the lamps were brilliantly lit,but as soon as the train had attained the

speed

speed at which the dynamo is switched in,the lights suddenly went down to about half their fromer illuminating power." If, however the accumulators were ultimately exhausted they must have told their own tale,for the cells in their discharge would become heavily sulphated and result in the lead plates getting much buckled by the expansion of the sulphate of lead deposited on them. Mr.Winter,however,makes no remarks on either the physical condi--tion of the cells or what amount of residual charge they yet retained when examined by him. Things ,however,could scarcely have happened as described by him. Whatever may have gone wrong it is certain that the lamp resistance would remain constant, while the voltage of the cells if being run down would rapidly decrease,so that it is impossible to imagine the lamps glowing brighter when taking all their current from the accumulators while the train was standing,than when it was running and the current going direct to lamps from the dynamo,as described by him. Such brighter glow could only happen when the voltage of the accumulator battery was higher than that being produced by the dynamo,and would be no proof of the cells being run down,but rather the contrary.

4. Mr. Winter next states:- "There can only be one cause for this,namely,that the dynamo was being run at a voltage which was insufficient to overcome the back electromotive force of the accumulators. The result of this would be that a consider--able portion of the current which flows through the lamp circuit would be withdrawn from that circuit and flow instead through the dynamo and drawing at the same time on the reserve in the accumu--lators." These remarks are by no means clear or to the point. If he refers to the small portion of current passed through the shunt circuit for the excitation of the field magnets they are incorrect,as the shunt current varies as the total current from the dynamo and could not seriously rob the current going through the lamp circuit. I take it,however,that what he means is that the dynamo instead of acting as a generator would be driven as a motor by the battery. If so,this would indicate that the governor had gone wrong,and that the dynamo had been switched in too soon before the

the voltage of its current had risen sufficiently to over--come the electromotive force of the battery.Mr.Winter,however does not definitely suggest this as the cause.

5. Mr.Winter proceeds:- " This waste of current if not compensated for by "day running" must ultimately lead to the exhaustion of the cells,and this is what,I believe, must have happened. When the cells become exhausted the dynamo field magnets could no longer be excited by the accumulators before"being switched in on to the lamps,and the dynamo in consequence of loss of magnetism would lose the power of generating any current,and so the whole light--ing system would collapse,I have come to this conclusion as a result of my examination of the dynamo. When I first heard of the failure of the electric light and being on one occasion at Negapatam,I had the dynamo started running, and I attached an incandescant lamp on to its terminals. I was unable to obtain the faintest glow in the lamp although I carefully adjusted the brushes. I came away with the im--pression that this failure was possibly due to the loss of residual magnetism. On my recent visit to Negapatam for the special purpose of examining the dynamo,I put my suppo--sition to the test. With twenty Lelanche cells I sent a current through the field magnets and started the dynamo. The glow lamp being attached,I at once obtained a brilliant light in the lamp,and the current was so powerful that the lamp quickly blackened and burst." Matters may have happen--ed as here represented but it is a great pity that Mr. Winter did not test the accumulators to see if they had wholly lost their charge as surmised by him. I do not be--lieve that they could have been so completely discharged as imagined,nor that the field magnets could have lost all residual magnetism. He does not say how long he ran the dynamo without any cells attached,but in such case it,I believe,often takes 10 to 15 minutes before a current, excited by residual magnetism,gathers force enough to show itself. Possibly Mr. Winter did not run it long enough.

From

From this report also it is impossible to say whether or not he ran the dynamo with the accumulator cells attached before employ--ing Lelanche cells.

6. Mr. Winter next describes the injuries which he found to have happened to the insulation of the armature winding,but as he has omitted to tell us how the injury occurred,or whether it at all impaired the efficiency of the dynamo,that portion of his report is comparatively worthless. From my own experience here,I cannot conceive how these injuries could have happened, except through some grossly careless or improper treatment of the dynamo. It would be interesting to have further details hereon.

7. Mr.Winter then (bottom of page 1 and page 2) goes into a long discussion to prove that the dynamo was unable to overcome the back resistance of the accumulators when the full light lamp circuit is closed. I find it difficult to follow his figures, partly for want of the South Indian Railway time-table quoted, partly by his incomplete explanation,and partly through printers blunders and omissions which are only too obvious. The whole of his 2nd page though may be reckoned as a slaying of the slain, for if the dynamo were not giving a sufficient output its speed should have been regulated to make it right. It is purely academic, if not waste of time to explain the rationale of faults which can be easily cured. He suggests three cures (1) giving carriage a longer day run, (2) tightening belt of dynamo to make it run fas--ter,and (3) reduction of number of lamps. For practical consider--ations (1) and (3) are inadmissible. To adopt them would be to condemn Stone's system as unsuitable for railway work and its conditions.

8. My own surmise regarding the South Indian Railway instal--lation is that there was nothing much wrong with it,except that the dynamo was not giving the necessary output on account of the driving belt being too slack;either by having stretched,or that it had never been properly adjusted from the first. Slipping would therefore occur too soon and the dynamo fail to give the neces--sary output after being switched in. Messrs.J.Stone & Co.give particular instructions for testing the output by an ampmeter

and

4 & P

and regulating the tension on the belt accordingly. On this the most important point of all,or what attention it received on the South Indian Railway,Mr.Winter is absolute--ly silent. I am much of opinion that to its neglect all their troubles may be traced. My own experience is that by employing a piece of good cotton belt thoroughly stretched before being used no trouble by subsequent stretching is experienced. With the experimental installation on these railways,I have had the same belt in use for over 6 months without any need of adjustment. At first I had some trouble when using a special rubber composition belt supplied by Messrs.J.Stone & Co.which stretched badly,got sticky almost to melting point so that it seized the flanges of the pulleys,overriding them and turning itself inside out till it finally broke. This mischief was caused by the great heat reflected off the ballast during the hot weather. That sort of belting may be suitable enough for temperate climates but not for the tropics. It would be interesting to learn whether it was in use on the South Indian Railway, as if so I can readily understand its misbehaving.

9. Mr.Winter in his paragraph II (page3) refers to the adjustibitity of the centrifugal governor for switching in the dynamo at the speed requisite for producing a current of sufficient electromotive force for overcoming the back pressure of the accumulator battery,namely 16volts. For a given dynamo this occurs of course at a certain speed and once the initial adjustment has been made by the makers the governor weights are fixed to prevent further change. From Mr.Winter's remarks,however,one might suppose that further adjustment was permissible and allowed for by the makers. This is not the case,and any meddling with the governor would be mischievous.

10. In his paragraph III (page 3) Mr.Winter discusses Messrs. J.Stone & Co's method of regulating the speed of dynamo by allowing the belt to slip as above referred to. He,however,unconsciously reasons in a vicious circle and wrongly arrives at the conclusion that Messrs.J.Stone & Co.

have

have given an untrue explanation of the slipping action. He says "allow the dynamo to run on open circuit,that is do no work,and I believe no slipping will take place within a large range of speed." Quite so: but unfortunately he has forgotten that the dynamo never runs on open circuit from the moment it is switched in at a comparatively low rate of speed and commences to produce a small current of some 5 or 6 amps only. Again he says "The effort required to revolve the dynamo varies approximately as the square of the speed when the circuit is closed,the drag on on the belt x x x increases in that proportion,and ultimately the tension on the belt will arrive at the critical point at which slipping takes place. x x In a shunt dynamo the speed remaining the same as the output,and consequently the effort to rotate it at that speed, increases with the current drawn out of the machine. Therefore by increasing the current generated the speed at which slipping takes place is reduced." Quite so: but the current drawn from the machine is all that it is making and as all resistances are constant the draft depends solely on the speed of revolution. There is therefore no increasing of current but by increase of speed,and Mr.Winter's remarks do not hold good. Again he says "The inference one would draw from Messrs.Stone's explanation would be that the speed at which slipping occurs is constant whether the dynamo be doing little or no work,or whether it be working full load,and this I think is for the reasons above given untrue." This is a faulty inference and one which I am sure Messrs.J.Stone & Co. would not admit. The effort to revolve the dynamo varies approximately as the square of the speed but the resistance being constant and quite independent of the speed, it follows that the same amount of work is always done at any given speed and the effort to revolve the dynamo at that speed is always the same. Therefore slipping will always take place at one and the same critical speed so long as the initial tension on the belt remains unaltered. Hence Messrs.Stone's explanation is strictly true. Mr.Winter has confused himself by forgetting that the load is not variable but increases with the speed up to a certain maximum and then becomes constant. I attach copy of a table published by Messrs.J.Stone & Co. which fully bears out my view of the matter.

11. In his paragraph IV (page 3) Mr.Winter suggests that Stone's system of a separate dynamo for each vehicle will be only a temporary expedient during the period that a railway may be engaged in fitting its rolling stock but that ultimately when that work has been completed,it "will gravitate either to the use of one generating dynamo at the end of the train or else to charging stations at different parts of the line,where vehicles fitted with accumulators can be replenished in situ by cables attached to the vehicles from the charging house." Mr. Winter has clearly not yet grasped the problem of railway electric lighting nor are his proposals original. The first is the better of the two,but it is the proverbial putting of one's eggs all in one basket. Anything going wrong with the single dynamo means a whole train instead of a single coach being put in darkness. Besides this he wholly ignores the difficulties met with in electrically coupling the vehicles composing a train , which are unfortunately only too formidable for trains liable to be broken up and remar--shalled. The second proposal is an ideal one not feasible with our present knowledge of accumulator design and construction. To employ accumulators solely would mean at least doubling if not trebling the number and weight of them to be carried,a sufficiently serious objection in itself,but as unfortunately a battery cannot be charged at a much faster rate than it is intended to be discharged, the time occupied would entail a great loss by the vehicles being withdrawn so long from running service. To meet this objection it has been proposed to remove the discharged cells and replace them by fully charged ones,but with their great weight and the somewhat delicate nature of their component parts this,so far,has never been accomplished with sufficient success for railway work.

12. I do not consider Mr.Winter's proposals for working Stone's system (page4) if introduced on a large scale,to be the best to meet the difficulties successfully. No.(1)

an

an instructional installation would be a luxury. Nos. (2) and (3) the employment of trained lashers (coolies he means)would be most unsuitable,as much unskilled labour will never do. Good intelli-gent Native and Eurasian mechanics,supervised by a trained European electrician,would be required at terminal and changing stations only. No.(4) reporting irregularities and No.(6) a repairing shop would both be necessary but No.(5) providing duplicating parts for every train and terminal station is rather overdoing it ,as to carry parts on a train would be useless,there being no time or opportunity for making replacements.

13. Finally ,Mr.Winter is altogether wrong in his description (page 4) of the double accumulator system,when he asserts that the dynamo is not in direct communication with the lamps or that the lamps are fed solely from one set of accumulators while the other set is being charged. The fact is the dynamo is quite as much indirect communication with the lamps in the double system as in the single system,but while one battery is being charged the other acts as a regulator,giving current to the lamps when required to supplement that from the dynamo while running slowly, and taking up from the dynamo at high speeds any slight excess of current over and above that required for supplying the lamp circuit and the battery under charge. While the dynamo is at rest, or running too slowly to come into action,the currents from the two batteries are automatically short circuited into parallel and supply the lamp circuit and the field magnets of the dynamo. The double system is only necessary where vehicles have a great deal of very slow running or standing at stations with lights on. For all ordinary railway work the single system amply suffices and it is 40% cheaper in cost of installation.

TO DEMONSTRATE that to whatever extent the speed of the train might vary without increasing the speed and output of the dynamo beyond its predetermined limit,the following experiments were made in the presence of Professor Slaby ,Director of the Royal Technical College of Berlin,and Professors Hagen and Neesen of the German Patent Office,each of whom expressed himself greatly pleased and fully satisfied with the results demonstrated.

Speed of pulley on axle of motor.(Representing axle of Railway Carriage).	Equivalent speed of train in miles per hour. (approximate)	Speed of dynamo Revolutions per minute.	Equivalent speed of dynamo if no slip were to take place.	Output of dynamo Amperes.	
Revs.per minute.					
100	12	500	500	0	The predetermined limit for speed of dynamo in these tests was 915 revs.per min. producing 20 amps.of current which it will be noted was not exceeded, although the speed of pulley on axle of motor (representing speed of train) varied from an equivalent of 24 miles per hour when this limit was first reached,to 72 miles per hour.
138	16	690	690	2	
150	18	750	750	6	
168	20	840	840	14	
175	21	870	875	16	
185	22	885	925	17	
195	23	900	975	18 1/2	
205	24	915	1025	20	
225	27	915	1125	20	
250	30	915	1250	20	
275	33	915	1375	20	
300	36	915	1500	20	
325	39	915	1625	20	
350	42	915	1750	20	
375	45	915	1875	20	
400	48	915	2000	20	
450	54	915	2250	20	
500	60	915	2500	20	
600	72	915	3000	20	

The same results have also been demonstrated before many of the principal Railway & Electrical Engineers of this country,all of whom have expressed their complete satisfaction with the tests.

From J.Stone & Co's descriptive pamphlet.

P.R. Report 1824/99
21
13

8 0 Print

With reference to Mr Cardew's repo
on Stones System & his criticisms of my rep
I have the following remarks to make:-

Para 2 - The disagreement between Mr Cardew
and myself is much less than I think he m
out - The whole drift of my report was to sho
that the failure was due to no fault of the sy
but to want of a little experience in the mani
-pulation of the adjustments, and I laid pa
-ticular stress on the need of training men
to do this, the accomplishment of which, I
anticipate would present no difficulty.

Para 3 - Mr Cardew in this para quotes a pa
-sage from my report and says he disagree
with it. As the passage quoted relates to
matters of fact, I can hardly see how
he can disagree. I did not mention the
fact of the lights suddenly going down when
the dynamo was switched in as a proof
of the exhaustion of the accumulators. I
mentioned it as being due to the dynamo
being switched in before the electromotive force
at its terminals was sufficient to overcome
that of the accumulators.

As regards the physical state
of the accumulators I did not see them when
they first came in from the line and before
I had seen them they had been dismantled
and the plates and cells cleaned. I saw
some of the plates, - the "positives" bore un
-mistakable evidence of the cells being in a

low State of exhaustion. But none t, is a
plates that I saw had buckled Colla
Sulphating badly set in Sand
do,

Para 4 - Mr Cardew then quotes fur regnetic
my report giving my deductions from et proo
quoted in the 3rd para. I think my Sma
are clear and can be understood. Upon
time the dynamo was switched in possibl
dynamo was being run at a Voltage ma
was insufficient to overcome the back elec
- motive force of the accumulators. Batte
the Stronger overcoming the weaker, thana
accumulator would send a current thro
the dynamo, both through its armatur
and field magnet coils, the expendi
for which must be met from the reserve b
accumulators. That the fault was due
the coils acting too soon would have bee
Obvious had Mr Cardew not dissected ou
Statements and quoted them apart fr
the Context and in addition Mr Card
will find that I showed later on in the
exactly how the effect observed could be

Para 5 I regret that I was unable to
any direct test on the accumulators to
they had wholly lost their charge, the face
was they had all been dismantled and
I would have had to have obtained an to
mixed fresh acid & set the cells up together
and I had not the time at my disposal
I did not make this direct experiment
Cannot maintain what was only a surm

viz, that the cells were absolutely exhaust
but that they were so much exhausted a
to interfere seriously with the light, is a
fact. That the lighting might collap
in the manner suggested is possible and
even probable in inexperienced hands,
maintain. As regards loss of magnetis
in the field magnets, this was a fact prov
by experiment. It is well known that dyna
dynamos are liable to this phenomenon.
That this was anticipated as being possible
is evidenced by the provision for exciting the field
-ing Shunt Coils of the magnets with the full pressure of the batte
magnets with the full pressure of the batte
immediately before switching in the armat
of the dynamo.

Mr. Cardew Suggests that possibly
I did not run the dynamo long enough.
I may mention the dynamo was running b
over two hours without any results au
I could detect no polarity at the ch
of the dynamo field magnets by means
a small pivoted compass needle which
I had with me

Para 6 :- The injury to the dynamo
obviously due to ill-usage. It was impos
to ascertain how or by whom, as the dyna
in the course of the trials had been manip
-lated by a good many people. The effe
of the dynamo was not impaired as the
experiments made with the Leclanché cells
was made before one of the coils was rem

would be necessary

para 7 :- Mr. Cardew here says that I go into a long discussion to prove that " the dynamo was unable to overcome the back pressure of the accumulators when the full la[illegible] Circuit is Closed ". This does not make se and I certainly never tried to prove s[illegible] a proposition . My argument was to show that there was insufficient margin in the mail runs between Trichinopoly and Madras to keep the accumulators charged . That where the amount of Charge only amounted to 107 ampère hours the discharge was as muc[illegible] as 96 . That this was insufficient, was proved by the trouble experienced in keeping the accu- -mulators charged . Mr. Bell had frequent- -ly to run the carriage by day from Madra[illegible] to Chingleput in order to recharge the a[illegible] -cumulators . Mr. Cardew then says " The whole of the 2nd page, though may b[illegible] reckoned as the slagging of the slain ; for o[illegible] the dynamo were not giving sufficient e[illegible] output, its speed should have been regula[illegible] to make it right ". Mr. Cardew has evide[illegible] missed the point . If one finds that the la[illegible] are not burning brightly when running a[illegible] full speed , by all means lighten the [illegible] till the desired effect is obtained ; becau[illegible] that is the Correct thing to do . The point at [illegible] however was the question of receipt and [illegible] expenditure . I assumed the belt to have b[illegible] Correctly adjusted and found that , notwiths[illegible] -ing this , there was insufficient margin to p[illegible] for Contingencies . If this is so, further tigh[illegible] of the belt , would not be the best remedy ; [illegible]

that would be necessary

the lighting was a perfect success; but
even then as I have before explained
Mr. Bell found that the accumulators
were losing charge and required special
day trips to replenish them. It is obvious
however that Mr. Bell could not always
be looking after the carriage as he had
his own work to do - the System would not
be worth Considering if it necessitated
such close & skilled attention. The car-
-riage was however looked after by an
Eurasian mechanic & for a time the lighting
was successful, but there was always
difficulty in keeping the accumulators
charged. Whether this man or his successor
(as I believe he was changed) fully
understood these adjustments or whether
if was he was inattentive or whether he
he was afraid to alter the adjustment
I cannot say - but it was evident from
my investigation that the irregularities
in the lighting were due to want of adjustment
& the failure of the lighting ultimately
to the practical exhaustion of the accumulat-
-ors.

A leather Belt was used in these
experiments & I understand from the
Superintendent that no Complaints were
made as to the belt stretching. Mr. Crom-
description of the results of using the Cor a-
-Sition belting is interesting and is a
practical object lesson teaching us to
to Cotton or leather in this Country.

that would be necessary

Para 9. If Mr Cardeo will refer the 6th para on page 19 of G.O. No 116 Ry. dated 27 Jany. 1899, he will see that Messrs. Stone & Co. recommend the same remedy that I suggested. In the case of the dynamo received on this line the weights were not permanently fixed, they were only held in place by the bite of a Stud Screw

Para 10— I have been totally misunderstood on this point. I did not question the fact that Slipping took place at a critical Speed I admitted it. The point was this:— A Statement was made to the effect that the tension on the belt increases with the Speed of the train. In most cases when a shaft is being driven by a belt - the belt may be driven at different Speeds without any appreciable variation in the tension of the belt excepting of course, during the time when the Speed is changing. I thought therefore it would be interesting to look for the cause of this increase of tension with increase of Speed. One might suppose without looking sufficiently into the question that it had something to do with the pecu method of suspension and such [was my first thought it has of course got nothing to do with it and for the cause one must look and see what the dynamo is doing and this investigation led me to the following Conclusions -

(1) That the cause of the increase in tension of the belt with increase of Speed

that would

is due to the fact that the work done by the dynamo increases in a much faster proportion than directly as the Speed (the more usual phenomenon) and nearly as the Square of the Speed.

(2) That the critical Speed at which Slipping takes place is dependent upon

(a) The regulation of the portion of the weight of the dynamo supported by the belt

(b) The Current being drawn out of the dynamo.

The upshot of Mr Cardew's argument in para 10 is I think to the effect that at Constant Speed (b) is Constant. Since the total resistance in circuit is constant. In this connection I would like to know the results of the following experiment:- Run the carriage at Constant Speed and with the Switch at "full lights" & with the dynamo Switched in and observe the ammeter. Now Switch the lights to "half lights" and again observe the ammeter. I am not sure whether the observer will notice a marked drop in the current indicated as flowing through the ammeter in the Second Case. I assume of course that the ammeter is inserted in the circuit between the dynamo and the accumulators so as to measure the Sum of the currents flowing through the accumulator and Head lamps together.

A variation in current strength in the above experiment, Should Such there be, would of Course indicate that the total resistance was not Constant. It must be remembered

that Switching out lights has the effect of increasing the resistance of the lamp circuit for instance half the number of lights would double this resistance - the question is - Is the increase of resistance sufficiently counterbalanced automatically by a large fall in the resistance of the accumulators?.

Para 11 - My prophecy regarding the future of electric lighting of trains may be a bad one - what I think is that when once all the Stock is electrically fitted, the difficulty experienced in lighting trains as experienced on the midland in England will not be nearly so formidable - we have yet to gain experience of Stones Syst time will shew whether the method of running a lot of little dynamos on o Train when one might Suffice, will be more successful than the Midland ex -pents. So far I hear that Stones Syst has been a great Success and I und Stand that the Midland are orderin some of this plant.

Para 12 - I do not think an instruct installation would be a luxury. There would always be a Spare dynamo a Set of Spare accumulators at Hea Quarters. A counter Shaft and 4 c with lamps Suspended therefrom Stret from wall to wall of the rooms woul that would be necessary -

Nos. (2) & (3) - 1. Trained lascars are not coolies
Smart Telegraph Lascars on the Madras
Railway Telegraph have sometimes risen to be
men would do well for the purpose
(5) Mr. Cardew has quoted me wrongly
I said that each train should carry a
complete set of small parts and a spare
armature at each of the terminal Statio
If a lamp filament breakes en route, a
then one can be refixed in two minutes at
the next station; the same with a safety
fuse. A spare armature at the termi
Station may or may not be necessary,
it depends whether the traffic can affor
to loose the carriage for 24 hours or more
until a new armature arrives from Hea
Quarters.

Para 13 :- My description of the double a
-cumulator System was given from inf
-mation obtained from Messrs. Stone &
pamphlet. My description was sufficien
exact to explain the principle of the dou
accumulator System, the fact of the
dynamo being Connected to the disc
Set of accumulators through a high res
-tance is a detail and not absolute
necessary. The lamps are almost entir
dependent on the discharging Set of accum
-tors for their light a small surplus
finding its flowing through at high
and the dynamo is not in direct
-nection with the lamps. Since t

there is a high resistance interposed between the dynamo and the lamps. I quote below the passage from Messrs. Stone & Co's pamphlet.

Conclusion:- In conclusion I have to add that I wish Mr Cardew could have given us more information about his experiments with this system of lighting. Such information would enable one to compare the conditions under which both these trials were made and a fuller Estimate made of the Capabilities of the one accumulation System. The information one would like to know Concerning Mr Cardew's experiments would be:-

(a) The number of hours of night day run respectively per trip (up as well as down).

(b) The number of lights lit at one time on "full light" and "half light" respectively.

(c) Whether any difficulty has been experienced in keeping the accumulators charged.

(d) Whether there is as a general rule any noticeable fluctuation in the intensity of the illumination when the dynamos are switched in as compared with the light when Standing at a Station -

Finally I would draw attention to Messrs. Stone & Co's reply to my report which was sent to that firm. If my report had been all that Mr Cardew tried to make out that it was I feel sure Messrs. Stone & Co would have been Suffic-

3° proof Rec 18 13 99.

13

Draft Statutes Pamphlet 19

12

alive to their own interests to have Contro-
-verted the so called misrepresentation
instead of doing so however I think th
reply may be taken as expressing
general concurrence -

A.M. Inst. C.E. - A.I.E.E
Assistant Engineer

3d proof Rec 18 13 99.

Extract from Stone & Co. Pamphlet 13 no 9

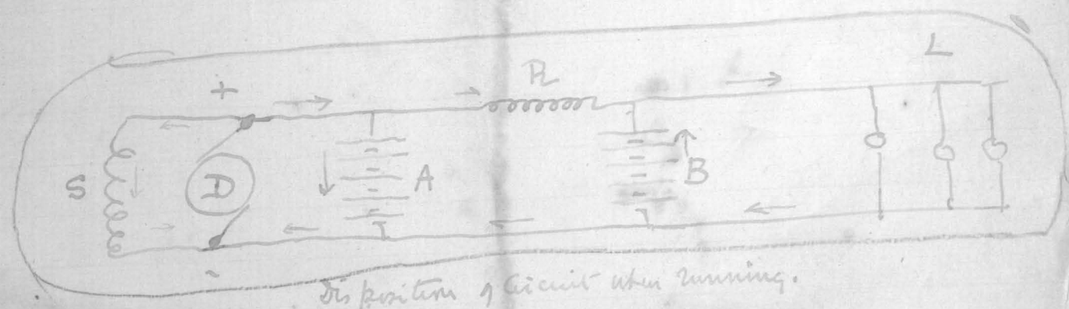
Double accumulator Arrangement.

In this arrangement, instead of the accumulators being supplied in one set, two sets are provided, which are alternately charged by the dynamo, the battery which is not being charged supplying the current to the lamps, the governor and Contact board of the dynamo being modified to automatically effect this purpose. In dynamos thus constructed, the two sets of Contacts into which the rocking arm is pushed by the governor, according to the direction in which the train is moving, are kept separate and Control the charging Circuits of the two batteries, so that while a train is going in one direction the one battery is Charged; in the opposite direction the other battery will be put in Circuit with the dynamo. At the same time it will be observed that a projecting arm on the rocking arm operates the "See Saw" Scotch, which Causes the current for the lamps to be always supplied from the battery which is not being Charged. The two batteries are never, however, entirely disconnected, but an iron wire resistance is provided, through which the Current may pass from one to the other, this resistance being short-circuited, by means of a small pivotted lever when the train is at a Standstill, or should the dynam-

from any other reason not be working.

It will thus be understood that the greater part of the Current generated by the dynamo will go to charge the accumulator, which is not in direct connection with the lamps, but at the same time a Comparatively Small amount of current passes through the resistance to the battery supplying the lamps. As the resistance is so proportioned that the maximum current which passes through it is not more than is required to run the lights, the lamps cannot possibly be over-run, and the resistance R (Shewn on page 8), is therefore not in this Case, necessary.

Note :- I understand from the above description that the circuits are arranged as follows :—



Description of Circuit when running.

D = Dynamo.
S = Field magnet Coils of Dynamo
A = Set of Accumulators being Charged
R = High Resistance
B = Discharging Set of Accumulators.
L = Lamp Circuit.

Inspector
22 12 99

3° proof Rec 1893 [illegible]

Reply to Simla

18

No. 166 R.S.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

RAILWAY STORES.

All communications should be addressed to the Secretary.

JOINT SECRETARY TO GOVT. OF MADRAS RYS. RECEIVED 6 FEB. 1899

Print

To

The Joint Secretary to the Government of Madras,

Public Works Department, Railway Branch.

Simla, the 28th January 1899.

S 32

Sir,

I am directed to forward herewith copy of a report, No. 6908/49 S & M dated 14th October 1898 by Mr. C. E. Cardew M.I.M.E. Locomotive and Carriage Superintendent, Burma Rail-ways, containing his criticisms and observations on the report dated 27th April 1898 by Mr. G. B. Winter, on the condi-tion of Stone's electric light plant and the system of working the same on the South Indian Railway.

page 7 S 82

2. I am to request that Mr. Cardew's report may receive the consideration of the Government of Madras, and that such further report may be submitted for the information of the Government of India on the working of the South Indian Railway installation of Stone's system, as the Consulting Engineer for Railways, Madras, is in a position to make.

I have the honour to be,

Sir,

Your most obedient servant.

C. J. Cole

Offg. Under Secretary.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Railway.

Read G.Os., Nos. 116–117 Ry., dated 27th January 1899.

Read also the following paper:—

From—The Secretary to the Government of India, Public Works Department.
To—The Joint Secretary to the Government of Madras, P.W. Dept., Ry. Branch.
Dated—Simla, 28th January 1899, No. 166 R.S.

I am directed to forward, herewith, copy of a report, No. 6908/49 S. & M., dated 14th October 1898, by Mr. C. E. Cardew, M.I.M.E., Locomotive and Carriage Superintendent, Burma Railways, containing his criticisms and observations on the report, dated 27th April 1898, by Mr. G. B. Winter on the condition of Stone's electric light plant and the system of working the same on the South Indian Railway.

2. I am to request that Mr. Cardew's report may receive the consideration of the Government of Madras, and that such further report may be submitted for the information of the Government of India on the working of the South Indian Railway installation of Stone's system, as the Consulting Engineer for Railways, Madras, is in a position to make.

ENCLOSURE.

From—The Locomotive and Carriage Superintendent, Burma Railways.
To—The Agent, Burma Railways Company (Limited), Rangoon.
Dated—Insein, 14th October 1898, No. 6908/49 S. & M.

Stone's Electric Light System.

I beg to acknowledge receipt of your No. 6509/148 M. of 2nd ultimo, forwarding a copy of a report by Mr. G. B. Winter on the condition and working of Stone's electric light experimental installation on the South Indian Railway.

2. I have studied this report most carefully and am glad to be able to state that from my own knowledge and experience of Stone's system, I am unable to agree with several of the conclusions arrived at in this report. Further, I am of opinion that they are incorrect and likely to unjustly prejudice the system for no real faults of its own but for ones which are apparently the result of the system not having been properly carried out on the South Indian Railway. I therefore venture to make the following criticisms and observations with a view to justifying my opinion, and setting in a proper light some matters which have been misrepresented in this report.

3. The first point in which I disagree with Mr. Winter, is in his opening account on page, 1, of the nature of the failure. He says: "*I have been unable to ascertain what actually happened which necessitated the electric light installation being removed from the carriage, but I gather from what I have seen of the correspondence that the light had for some little time been unsatisfactory and that ultimately the lamps would neither light when the train was standing still nor when running. My own observation early in January, when travelling to Madras in the composite in which the installation was fixed was, that while the train was standing at the platform of a station the lamps were brilliantly lit,*

but as soon as the train had attained the speed at which the dynamo is switched in, the lights suddenly went down to about half their former illuminating power." If, however, the accumulators were ultimately exhausted they must have told their own tale, for the cells in their discharge would become heavily sulphated and result in the lead plates getting much buckled by the expansion of the sulphate of lead deposited on them. Mr. Winter, however, makes no remarks on either the physical condition of the cells or what amount of residual charge they yet retained when examined by him. Things, however, could scarcely have happened as described by him. Whatever may have gone wrong it is certain that the lamp resistance would remain constant, while the voltage of the cells *if being run down* would rapidly decrease, so that it is impossible to imagine the lamps glowing *brighter* when taking all their current from the accumulators while the train was standing, than when it was running and the current going direct to lamps from the dynamo, as described by him. Such brighter glow could only happen when the voltage of the accumulator battery was higher than that being produced by the dynamo, and would be no proof of the cells being run down, but rather the contrary.

4. Mr. Winter next states: "*There can only be one cause for this, namely, that the dynamo was being run at a voltage which was insufficient to overcome the back electromotive force of the accumulators. The result of this would be that a considerable portion of the current which flows through the lamp circuit would be withdrawn from that circuit and flow instead through the dynamo and drawing at the same time on the reserve in the accumulators.*" These remarks are by no means clear or to the point. If he refers to the small portion of current passed through the shunt circuit for the excitation of the field magnets they are incorrect, as the shunt current varies as the total current from the dynamo and could not seriously rob the current going through the lamp circuit. I take it, however, that what he means is that the dynamo instead of acting as a generator would be driven as a motor by the battery. If so, this would indicate that the governor had gone wrong, and that the dynamo had been switched in too soon before the voltage of its current had risen sufficiently to overcome the electromotive force of the battery. Mr. Winter, however, does not definitely suggest this as the cause.

5. Mr. Winter proceeds: "*This waste of current if not compensated for by 'day running' must ultimately lead to the exhaustion of the cells, and this is what I believe must have happened. When the cells become exhausted the dynamo field magnets could no longer be excited by the accumulators before being switched in on to the lamps, and the dynamo in consequence of loss of magnetism would lose the power of generating any current, and so the whole lighting system would collapse. I have come to this conclusion as a result of my examination of the dynamo. When I first heard of the failure of the electric light and being on one occasion at Negapatam, I had the dynamo started running, and I attached an incandescent lamp on to its terminals. I was unable to obtain the faintest glow in the lamp although I carefully adjusted the brushes. I came away with the impression that this failure was possibly due to the loss of residual magnetism. On my recent visit to Negapatam for the special purpose of examining the dynamo, I put my supposition to the test. With twenty Leclanché cells I sent a current through the field magnets and started the dynamo, the glow lamp being attached. I at once obtained a brilliant light in the lamp, and the current was so powerful that the lamp quickly blackened and burst.*" Matters may have happened as here represented, but it is a great pity that Mr. Winter did not test the accumulators to see if they had wholly lost their charge as surmised by him. I do not believe that they could have been so completely discharged as imagined, nor that the field magnets could have lost all residual magnetism. He does not say how long he ran the dynamo without any cells attached, but in such case it, I believe, often takes 10 to 15 minutes before a current, excited by residual magnetism, gathers force enough to show itself. Possibly Mr. Winter did not run it long enough. From this report also it is impossible to say whether or not he ran the dynamo with the accumulator cells attached before employing Leclanché cells.

6. Mr. Winter next describes the injuries which he found to have happened to the insulation of the armature winding, but as he has omitted to tell us how the injury occurred, or whether it at all impaired the efficiency of the dynamo, that portion of his report is comparatively worthless. From my own experience here, I cannot conceive how these injuries could have happened, except through some grossly careless or improper treatment of the dynamo. It would be interesting to have further details hereon.

7. Mr. Winter then goes into a long discussion to prove that the dynamo was unable to overcome the back resistance of the accumulators when the full light lamp circuit is closed. I find it difficult to follow his figures, partly for want of the South Indian Railway time-table quoted, partly by his incomplete explanation, and partly through printers' blunders and omissions which are only too obvious. The whole of his 2nd page though may be reckoned as a slaying of the slain, for if the dynamo were not giving a sufficient output its speed should have been regulated to make it right. It is purely academic, if not waste of time, to explain the *rationale* of faults which can be easily cured. He suggests three cures: (1) giving carriage a longer day run, (2) tightening belt of dynamo to make it run faster, and (3) reduction of number of lamps. For practical considerations (1) and (3) are inadmissible. To adopt them would be to condemn Stone's system as unsuitable for railway work and its conditions.

8. My own surmise regarding the South Indian Railway installation is that there was nothing much wrong with it, except that the dynamo was not giving the necessary output on account of the driving belt being too slack, either by having stretched, or that it had never been properly adjusted from the first. Slipping would therefore occur too soon and the dynamo fail to give the necessary output after being switched in. Messrs. J. Stone & Co. give particular instructions for testing the output by an ammeter and regulating the tension on the belt accordingly. On this the most important point of all, or what attention it received on the South Indian Railway, Mr. Winter is absolutely silent. I am much of opinion that to its neglect all their troubles may be traced. My own experience is that by employing a piece of good cotton belt thoroughly stretched before being used no trouble by subsequent stretching is experienced. With the experimental installation on these railways, I have had the same belt in use for over six months without any need of adjustment. At first I had some trouble when using a special rubber composition belt supplied by Messrs. J. Stone & Co. which stretched badly, got sticky almost to melting point so that it seized the flanges of the pulleys, overriding them and turning itself inside out till it finally broke. This mischief was caused by the great heat reflected off the ballast during the hot weather. That sort of belting may be suitable enough for temperate climates but not for the tropics. It would be interesting to learn whether it was in use on the South Indian Railway, as if so I can readily understand its misbehaving.

9. Mr. Winter in his paragraph II refers to the adjustibility of the centrifugal governor for switching in the dynamo at the speed requisite for producing a current of sufficient electromotive force for overcoming the back pressure of the accumulator battery, namely 16 volts. For a given dynamo this occurs of course at a certain speed and once the initial adjustment has been made by the makers the governor weights are fixed to prevent further change. From Mr. Winter's remarks, however, one might suppose that further adjustment was permissible and allowed for by the makers. This is not the case, and any meddling with the governor would be mischievous.

10. In his paragraph III Mr. Winter discusses Messrs. J. Stone & Co.'s method of regulating the speed of dynamo by allowing the belt to slip as above referred to. He, however, unconsciously reasons in a vicious circle and wrongly arrives at the conclusion that Messrs. J. Stone & Co. have given an untrue explanation of the slipping action. He says "*allow the dynamo to run on open circuit, that is do no work, and I believe no slipping will take place within a large range of speed.*" Quite so: but unfortunately he has forgotten that the dynamo never runs on open circuit from the moment it is switched in at a comparatively low rate of speed and commences to produce a small current of some 5 or 6 amps. only. Again he says: "*The effort required to revolve the dynamo varies approximately as the square of the speed when the circuit is closed, the drag on the belt * * * * increases in that proportion, and ultimately the tension on the belt will arrive at the critical point at which slipping takes place. * * * In a shunt dynamo the speed remaining the same, as the output, and consequently the effort to rotate it at that speed, increases with the current drawn out of the machine. Therefore by increasing the current generated the speed at which slipping takes place is reduced.*" Quite so: but the current drawn from the machine is all that it is making, and as all resistances are constant the draft depends solely on the speed of revolution. There is therefore no increasing of current but by increase of speed, and Mr. Winter's remarks do not hold good. Again he says: "*The inference one would draw from Messrs. Stone's explanation would be that the speed at which slipping occurs is constant whether the dynamo be doing little or no work, or whether it be working full load, and this, I think, is for the reasons above given untrue.*" This is a faulty inference and one which I am sure Messrs. J. Stone & Co. would not admit. The effort to revolve the dynamo varies approximately as the square of the speed, but the resistance being constant and quite independent of the speed, it follows that the same amount of work is always done at any given speed and the effort to revolve the dynamo at that speed is always the same. Therefore slipping will always take place at one and the same critical speed so long as the initial tension on the belt remains unaltered. Hence Messrs. Stone's explanation is strictly true. Mr. Winter has confused himself by forgetting that the load is not variable but increases with the speed up to a certain maximum and then becomes constant. I attach copy of a table published by Messrs. J. Stone & Co. which fully bears out my view of the matter.

11. In his paragraph IV (page 3) Mr. Winter suggests that Stone's system of a separate dynamo for each vehicle will be only a temporary expedient during the period that a railway may be engaged in fitting its rolling stock, but that ultimately when that work has been completed, it "*will gravitate either to the use of one generating dynamo at the end of the train or else to charging stations at different parts of the line, where vehicles fitted with accumulators can be replenished* in situ *by cables attached to the vehicles from the charging house.*" Mr. Winter has clearly not yet grasped the problem of railway electric lighting, nor are his proposals original. The first is the better of the two, but it is the proverbial putting of one's eggs all in one basket. Anything going wrong with the single dynamo means a whole train instead of a single coach being put in darkness. Beside this he wholly ignores the difficulties met with in electrically coupling the vehicles composing a train, which are unfortunately only too formidable for trains liable to be broken up and remarshalled. The second proposal is an ideal one not feasible with our present

knowledge of accumulator design and construction. To employ accumulators solely would mean at least doubling if not trebling the number and weight of them to be carried, a sufficiently serious objection in itself, but as unfortunately a battery cannot be charged at a much faster rate than it is intended to be discharged, the time occupied would entail a great loss by the vehicles being withdrawn so long from running service. To meet this objection it has been proposed to remove the discharged cells and replace them by fully charged ones, but with their great weight and the somewhat delicate nature of their component parts this, so far, has never been accomplished with sufficient success for railway work.

12. I do not consider Mr. Winter's proposals for working Stone's system (page 4) if introduced on a large scale, to be the best to meet the difficulties successfully. No. (1) *an instructional installation* would be a luxury. Nos. (2) and (3) *the employment of trained lascars* (coolies he means) would be most unsuitable, as such unskilled labour will never do. Good intelligent Native and Eurasian mechanics, supervised by a trained European electrician, would be required at terminal and changing stations only. No. (4) *reporting irregularities* and No. (6) *a repairing shop* would both be necessary, but No. (5) *providing duplicating parts for every train and terminal station* is rather overdoing it, as to carry parts on a train would be useless, there being no time or opportunity for making replacements.

13. Finally, Mr. Winter is altogether wrong in his description (page 4) of the double accumulator system, when he asserts that the dynamo is not in direct communication with the lamps or that the lamps are fed solely from one set of accumulators while the other set is being charged. The fact is the dynamo is quite as much in direct communication with the lamps in the double system as in the single system, but while one battery is being charged the other acts as a regulator, giving current to the lamps when required to supplement that from the dynamo while running slowly, and taking up from the dynamo at high speeds any slight excess of current over and above that required for supplying the lamp circuit and the battery under charge. While the dynamo is at rest, or running too slowly to come into action, the currents from the two batteries are automatically short circuited into parallel and supply the lamp circuit and the field magnets of the dynamo. The double system is only necessary where vehicles have a *great deal of very slow running or standing at stations with lights on.* For all ordinary railway work the single system amply suffices and it is 40 per cent. cheaper in cost of installation.

ENCLOSURE.

To demonstrate that to whatever extent the speed of the train might vary without increasing the speed and output of the dynamo beyond its predetermined limit, the following experiments were made in the presence of Professor Slaby, Director of the Royal Technical College of Berlin, and Professors Hagen and Neesen of the German Patent Office, each of whom expressed himself greatly pleased and fully satisfied with the results demonstrated :—

Speed of pulley on axle of motor, Representing axle of Railway Carriage, Revls. per minute.	Equivalent speed of train in miles per hour (approximate).	Speed of dynamo revolutions per minute.	Equivalent speed of dynamo if no slip were to take place.	Output of dynamo, amperes.	Remarks.
100	12	500	500	0	The predetermined limit for speed of dynamo in these tests was 915 revls. per minute producing 20 amps. of current which it will be noted was not exceeded, although the speed of pulley on axle of motor (representing speed of train) varied from an equivalent of 24 miles per hour when this limit was first reached, to 72 miles per hour.
138	16	690	690	2	
150	18	750	750	6	
168	20	840	840	14	
175	21	870	875	16	
185	22	885	925	17	
195	23	900	975	18½	
205	24	915	1025	20	
225	27	915	1125	20	
250	30	915	1250	20	
275	33	915	1375	20	
300	36	915	1500	20	
325	39	915	1625	20	
350	42	915	1750	20	
375	45	915	1875	20	
400	48	915	2000	20	
450	54	915	2250	20	
500	60	915	2500	20	
600	72	915	3000	20	

The same results have also been demonstrated before many of the principal Railway and Electrical Engineers of this country, all of whom have expressed their complete satisfaction with the tests.

Report from G. B. WINTER, Esq., A.M.I.C.E., A.I.E.E., Assist. Engr. S.I.Ry., dated 22nd February 1899.

With reference to Mr. Cardew's report on Stone's system and his criticisms of my report, I have the following remarks to make.

Paragraph 2.—The disagreement between Mr. Cardew and myself is much less than I think he makes out. The whole drift of my report was to show that the failure was due to no fault of the system but to want of a little experience in the manipulation of the adjustments, and I laid particular stress on the need of training men to do this, the accomplishment of which, I anticipated, would present no difficulty.

Paragraph 3.—Mr. Cardew in this paragraph quotes a passage from my report and says he disagrees with it. As the passage quoted relates to matters of fact, I can hardly see how he can disagree. I did not mention the fact of the lights suddenly going down when the dynamo was switched in as a *proof* of the exhaustion of the accumulators. I mentioned it as being due to the dynamo being switched in before the electromotive force at its terminals was sufficient to overcome that of the accumulators.

As regards the physical state of the accumulators I did not see them when they first came in from the line and before I had seen them they had been dismantled and the plates and cells cleaned. I saw some of the plates; the "positives" bore unmistakable evidence of the cells being in a low state of exhaustion. But none of the plates that I saw had buckled nor had sulphating badly set in.

Paragraph 4.—Mr. Cardew then quotes further from my report giving my deductions from the facts quoted in the 3rd paragraph, I think my remarks are clear and can be understood. At the time the dynamo was switched in, the dynamo was being run at a voltage which was insufficient to overcome the back electromotive force of the accumulators. It follows, the stronger overcoming the weaker, that the accumulator would send a current through the dynamo, both through its armature and field magnet coils, the expenditure for which must be met from the reserve in accumulators. That the fault was due to the switch acting too soon would have been obvious had Mr. Cardew not dissected my statements and quoted them apart from the context and in addition Mr. Cardew will find that I showed later on in the report exactly how the effect observed could be remedied.

Paragraph 5.—I regret that I was unable to make any direct test on the accumulators to see if they had wholly lost their charge, the fact was they had all been dismantled and I would have had to have obtained and mixed fresh acid and set the cells up together again and I had not the time at my disposal. As I did not make this direct experiment I cannot maintain what was only a surmise; viz., that the cells were *absolutely* exhausted, but that they were so much exhausted as to interfere seriously with the light, is a fact. That the lighting might collapse in the manner suggested as possible and even probable in inexperienced hands, I maintain. As regards loss of magnetism in the field magnets, this was a fact proved by experiment. It is well known that small dynamos are liable to this phenomenon. That this was anticipated as being possible is evidenced by Messrs. Stone & Co. making special provision for exciting the field magnets with the full pressure of the battery immediately before switching in the armature of the dynamo.

Mr. Cardew suggests that possibly I did not run the dynamo long enough. I may mention the dynamo was running over two hours without any result and I could detect no *polarity* at the cheeks of the dynamo field magnets by means of a small pivoted compass needle which I had with me.

Paragraph 6.—The injury to the dynamo was obviously due to ill-usage. It was impossible to ascertain how or by whom, as the dynamo in the course of the trials had been manipulated by a good many people. The efficiency of the dynamo was not impaired as the experiments made with the Leclanché cells was made before one of the coils was renewed.

Paragraph 7.—Mr. Cardew here says that I go into a long discussion to prove that "the dynamo was unable to overcome the back resistance of the accumulators when the full lamp circuit is closed." This does not make sense and I certainly never tried to prove such a proposition. My argument was to show that there was insufficient margin in the mail runs between Trichinopoly and Madras to keep the

accumulators charged. That whereas the amount of charge only amounted to 107 ampére hours the discharge was as much as 96. That this was insufficient, was proved by the trouble experienced in keeping the accumulators charged. Mr. Bell had frequently to run the carriage by day from Madras to Chingleput in order to recharge the accumulators. Mr. Cardew then says "The whole of the 2nd page, though, may be reckoned as the slaying of the slain; for if the dynamo were not giving sufficient output its speed should have been regulated to make it right." Mr. Cardew has evidently missed the point. If one finds that the lamps are not burning brightly when running at full speed, by all means tighten the belt till the desired effect is obtained; because that is the correct thing to do. The point at issue, however, was the question of receipt and expenditure. I assumed the belt to have been correctly adjusted and found that, notwithstanding this, there was insufficient margin to provide for contingencies. If this is so, further tightening of the belt would not be the best remedy; for by doing so you run into danger of bursting the lamps and of certainly greatly shortening their life. As regards the three cures suggested, I am of opinion that with carriages fitted with the full number of lights and fitted with the single accumulator system, all night running without day running would be insufficient and that therefore carriages so fitted should be allowed plenty of day run. As regards (2) this would be feasible if the lamps were being under-driven. As regards (3) the first-class composite in all compartments was brilliantly lighted. Such brilliant illumination is not necessary in the third-class carriages and with the same floor area less lights would be required; the fewer lights required would leave ample current for keeping the accumulators charged and for this reason it is suggested not to use the double accumulator arrangement on third-class carriages.

Paragraph 8.—Mr. Bell, the officer who had charge of this installation, paid particular attention to the adjustment of the belt, and in earlier portion of the trials the belt was adjusted so as to maintain as bright an illumination in the lamps when the carriage was running as when standing still. Mr. Bell, who is now away in England on leave, took great interest in these experiments and was fully conversant with all the adjustments and so long as he personally looked after the carriage the lighting was a perfect success; but even then as I have before explained he found that the accumulators were losing charge and required special day trips to replenish them. It is obvious, however, that Mr. Bell could not always be looking after the carriage as he had his own work to do—the system would not be worth considering if it necessitated such close and skilled attention. The carriage was, however, looked after by an Eurasian mechanic and for a time the lighting was successful, but there was always difficulty in keeping the accumulators charged. Whether this man or his successor (as I believe he was changed) fully understood these adjustments or whether it was he was inattentive or whether he was afraid to alter the adjustments I cannot say; but it was evident from my investigation that the irregularities in the lighting were due to want of adjustment and that the failure of the lighting was ultimately due to the practical exhaustion of the accumulators.

A leather belt was used in these experiments and I understand from the Loco Superintendent that no complaints were made as to the belt stretching. Mr. Cardew's description of the results of using the composition belting is interesting and is a practical object lesson teaching us to adhere to cotton or leather in this country.

Paragraph 9.—If Mr. Cardew will refer to the 6th paragraph on page 19 of G.O., No. 116 Ry., dated 27th January 1899, he will see that Messrs. Stone & Co. recommend the same remedy that I suggested. In the case of the dynamo received on this line the weights were not permanently fixed, they were only held in place by the bite of a stud screw.

Paragraph 10.—I have been totally misunderstood on this point. I did not question the fact that slipping took place at a critical speed. I admitted it. The point was this. A statement was made to the effect *that the tension on the belt increases with the speed of the train.* In most cases, when a shaft is being driven by a belt, the belt may be driven at different speeds without any appreciable variation in the *tension* of the belt, excepting of course, during the time when the speed is changing. I thought therefore it would be interesting to look for the *cause* of this increase of tension with increase of speed. One might suppose without looking sufficiently into the

question that it had something to do with the peculiar method of suspension and such was my first thought; it has of course got nothing to do with it, and for the *cause* one must look and see what the dynamo is doing, and this investigation led me to the following conclusions:—

(1) That the cause of the increase in tension of the belt with increase of speed is due to the fact that the work done by the dynamo increases in a much faster proportion than directly as the speed (the more usual phenomenon) and nearly as the square of the speed.

(2) That the critical speed at which slipping takes place is dependent upon—

(*a*) The regulation of the portion of the weight of the dynamo supported by the belt.

(*b*) The current being drawn out of the dynamo.

The upshot of Mr. Cardew's argument in paragraph 10 is, I think, to the effect that at constant speed (*b*) is constant, since the total resistance in circuit is constant. In this connection I would like to know the results of the following experiment: Run the carriage at constant speed, and with the switch at "full lights" and with the dynamo switched in and observe the ammeter. Now switch the lights to "half lights" and again observe the ammeter. I am not sure whether the observer will not notice a marked drop in the current indicated as flowing through the ammeter in the second case. I assume of course that the ammeter is inserted in the circuit *between* the dynamo and the accumulators so as to measure the sum of the currents flowing through the accumulator and lamps together.

A variation in current strength in the above experiment, should such there be, would of course indicate that the total resistance *was not* constant. It must be remembered that switching out lights has the effect of increasing the resistance of the lamp circuit, for instance half the number of lights would double this resistance. The question is—Is the increase of resistance sufficiently counterbalanced automatically by a large fall in the resistance of the accumulators?

Paragraph 11.—My prophecy regarding the future of electric lighting of trains may be a bad one. What I think is that when once all the stock is electrically fitted, the difficulty experienced in lighting trains as experienced on the Midland in England will not be nearly so formidable. We have yet to gain experience of Stone's system; time will show whether the method of running a lot of little dynamos on one train when one might suffice, will be more successful than the Midland experiments. So far I hear that Stone's system has been a great success and I understand that the Midland are ordering some of this plant.

Paragraph 12.—I do not think an *instructional installation* would be a luxury. There would always be a spare dynamo and set of spare accumulators at head-quarters. A counter-shaft and four wires with lamps suspended therefrom, stretched from wall to wall of the rooms, would all that would be necessary.

Nos. (2) *and* (3).—1. Trained lascars are not coolies. Smart telegraph lascars on the Madras Railway have sometimes risen to be telegraph inspectors and I think such men would do well for the purpose.

(5) Mr. Cardew has quoted me wrongly. I said that each train should carry a complete set of *small* parts and a spare armature at each of the terminal stations. If a lamp filament breaks *en route*, a new lamp can be refixed in two minutes at the next station; the same with a safety fuze. A spare armature at the terminal station may or may not be necessary, it depends whether the traffic can afford to loose the carriage for 24 hours until a new armature arrives from head-quarters.

Paragraph 13.—My description of the double accumulator system was given from information obtained from Messrs. Stone & Co.'s pamphlet. My description was sufficiently exact to explain the *principle* of the double accumulator system, the fact of the dynamo being connected to the discharging set of accumulators through a high resistance is a detail and not absolutely necessary. The lamps are almost entirely dependent on the discharging set of accumulators for their light, a small surplus finding its flowing through at high speeds, and the dynamo is not in direct connection with the lamps, since there is a high resistance interposed between the dynamo and the lamps. I quote below the passage from Messrs. Stone & Co.'s pamphlet.

Conclusion.—In conclusion I have to add that I wish Mr. Cardew could have given us more information about his experiments with this system of lighting. Such information would enable one to compare the conditions under which both these trials were made and a juster estimate made of the capabilities of the one accumulation system. The information one would like to know concerning Mr. Cardew's experiments would be —

(*a*) Number of hours of night and day run respectively per trip (up and down).
(*b*) Nnumber of lights lit at one time on "full" and "half" light, respectively.
(*c*) Whether difficulty has been experienced in keeping the accumulators charged.
(*d*) Whether there is, as a general rule, any noticeable fluctuation in the intensity of the illumination when the dynamo is switched in as compared with the light when standing at a station.

Finally I would draw attention to Messrs. Stone & Co.'s reply to my report which was sent to that firm. If my report had been all that Mr. Cardew tries to make out that it was, I feel sure Messrs. Stone & Co. would have been sufficiently alive to their own interests to have controverted the so-called misrepresentations; instead of doing so however I think their reply may be taken as expressing general concurrence.

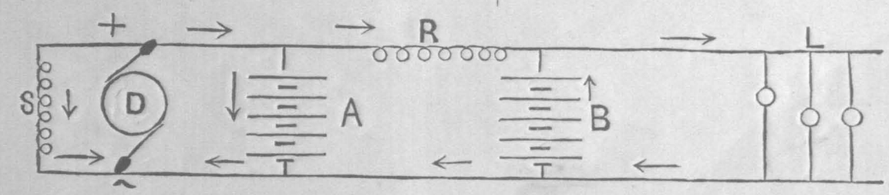
Extract from Messrs. Stone & Co.'s Pamphlet.

Double Accumulator Arrangement.

In this arrangement, instead of the accumulators being supplied in one set, two sets are provided, which are alternately charged by the dynamo, the battery which is not being charged supplying the current to the lamps, the governor and contact board of the dynamo being modified to automatically effect this purpose. In dynamos thus constructed, the two sets of contacts into which the rocking arm is pushed by the governor, according to the direction in which the train is moving, are kept separate and control the charging circuits of the two batteries, so that while a train is going in one direction the one battery is charged; in the opposite direction the other battery will be put in circuit with the dynamo. At the same time it will be observed that a projecting arm on the rocking arm operates the "see saw" switch, which causes the current for the lamps to be always supplied from the battery which is not being charged. The two batteries are never, however, entirely disconnected, but an iron wire resistance is provided, through which the current may pass from one to the other; this resistance being short circuited, by means of a small pivotted lever when the train is at a standstill, or should the dynamo from any other reason not be working.

It will thus be understood that the greater part of the current generated by the dynamo will go to charge the accumulator, which is not in direct connection with the lamps, but at the same time a comparatively small amount of current passes through the resistance to the battery supplying the lamps. As the resistance is so proportioned that the maximum current which passes through it is not more than is required to run the lights, the lamps cannot possibly be over-run, and the resistance R (shown on page 8) is therefore not in this case necessary.

Note.—I understand from the above description that the circuits are arranged as follows:—



D = Dynamo.
S = Fixed magnet coils of dynamo.
A = Set of accumulators being charged.
R = High resistance.
B = Discharging set of accumulators.
L = Lamp circuit.

Read also the following:—

Note by the Consulting Engineer for Railways, Madras.

There would appear to be no essential difference between Mr. Cardew and Mr. Winter in regard to the excellence of the system. Their arguments have reference chiefly to the supposed causes of the partial break down of the experimental instalment on one carriage of the South Indian Railway. But nobody had any right to expect that so limited an experimental installation with no spare parts and not able to secure much expert attendance (for Mr. Winter is not in the Locomotive Department of the South Indian Railway) could do otherwise than break down after several months' running. That it should under such circumstances have run so well and so long is, I consider, greatly in its favour. In arriving at a decision as to when to begin to bring the system of electric lighting for trains into use, we would not be justified in hanging back for want of data based on experiment in this country. I learn that the experimental carriage on the Burma Railways has run, quite successfully, about 17,000 miles, and that on that Railway all first and second class carriages on the Rangoon-Mandalay mail train are to be fitted up with Stone's system at once. From experiments conducted there it would appear that the resistance due to the dynamo is about $\frac{1}{22}$nd part of the resistance of an 18-ton bogie coach. The system would appear to have proved itself a great success wherever it has been adopted, if one is to believe all that one reads of it in the current professional literature; and I believe it to be the best system of train lighting that has ever been brought out. This Government has already, in letter No. 117 Ry., dated the 27th January 1899, strongly recommended to the Government of India that arrangements be now entered into for equipping seven mail trains on the South Indian Railway with Stone's system of electric lighting. The present oil lighting is bad and expensive. There is nothing in Mr. Cardew's note or in Mr. Winter's comments thereon which would lead me to change the opinion under which I recommended Government to support the scheme.

MADRAS,
13th March 1899.

FRANCIS J. E. SPRING,
Consulting Engineer for Railways.

ORDER—No. 305 Ry., dated 18th March 1899.

A copy of these Proceedings will be forwarded to the Government of India for such orders as they may see fit to pass on the recommendation contained in this Government's letter No. 117 Ry., dated the 27th January 1899.

[Here enter No. 306 Ry., dated 18th March 1899.]

(True Extract.)

FRANCIS J. E. SPRING,
Joint Secretary.

To the Agent, South Indian Railway.
" " and Manager, Madras, Railway.
" Consulting Engineer for Railways

ENDORSEMENT—No. 306 Ry., dated 18th March 1899.

Forwarded.

(By order.)

FRANCIS J. E. SPRING,
Joint Secretary.

Exd. T. K. Narayana Aiyangar.

Despatched on 24/3/99