

The PRESIDENT then delivered the following Address :—

GENTLEMEN,—I have to thank you very cordially for the honour you have conferred upon me in electing me as your President for the coming year. It is now thirty-six years since I was admitted a Student of The Institution, and since then as Student, Associate Member, and Member, I have enjoyed and appreciated the fellowship and assistance which continuous association with The Institution affords the Civil Engineer of this country in his professional career. Later, as a Member of the Council and Vice-President, I have had the privilege and pleasure of participating in the varied business involved in the management of The Institution, and in assisting my predecessors in this chair to carry out the duties which necessarily fall upon the President during his period of office.

In assuming these responsibilities myself, at your request, I do so with a feeling of the great importance which the efficient continuance and development of this Institution possesses for British engineers and for British interests; as also with reliance upon the sympathetic support of my colleagues in office and of the Members of The Institution generally. Since the early days of The Institution it has been customary for its newly-elected President to deliver an Address to the Members, and for years past this Address has invariably been given as his first act of Presidential service.

In reviewing these deliverances I note that, since no small portion of them has been devoted to a review of the achievements of the profession of Civil Engineering, they constitute to-day a very comprehensive yet concise history of the progress of the profession as viewed from the standpoint of successive Presidents. The most cursory glance, however, very speedily reveals the fact that the question of *Transport* is the theme which gives colour to all their thoughts, and which forms the basal subject knitting together and co-ordinating the many-sided profession to which we belong.

The classic definition of an engineer, as one who directs "the great sources of power in Nature for the use and convenience of man," cannot be improved upon, but the addition thereto of the words "principally in the provision and improvement of means of transport" would assist us to realize more fully the family tie of "transport" in the many departments of our profession. We have for example the class of engineer so ably represented by our Past-President, Sir William Matthews, who designs and builds those huge structures which come within the general term of Marine Works, such as harbours, breakwaters, and docks. These works

form places of refuge and protection at the points of transfer from sea to land for vessels engaged in transport by water. The Canal Engineer provides the means of transport by water within the coastline. The Railway Engineer provides the means of transport by land, as does the Road Engineer. Here, then, is a great group of branches of the engineering profession whose works are entirely dissimilar, but whose sole aim is to further transport by providing the facilities which another great group of engineers, viz., the Shipbuilder, the Locomotive Constructor, and, I must add now, the Motor-Car builder, require for the efficient use of the machines which they respectively construct for the carrying or hauling of goods and passengers. The Constructor of Machinery, the Waterworks, the Sanitary, the Mining, the Gas, and the Electrical Engineer, may all be claimed to form a group to whom transport is all-important in the execution of their various works. Now when we remember that methods of transport on sea and land have within less than a century not only brought about changes in the character of our civilization, but have also profoundly affected the relations subsisting between most of the countries of the world, it is evident that, as time passes, sea and land conditions affecting questions of transport assume a position of primary importance and concern not only to engineers, to users, and to capitalists, but to States and Empires. The greatest political movement of the century, and it may be, in its results, of all the centuries, is that variously referred to as the "awakening of the East," or the "Westernizing of the East," both far and near. This movement, affecting the lives of more than half the population of the globe, is the direct outcome of transport facilities and Western initiation, the missionaries of which have been engineers, and they, too, mostly of British nationality.

Lord Cromer, after recounting the numerous and successful works, mainly for irrigation, carried out in Egypt, almost entirely by Members of this Institution, largely under the guiding hand of our late Past-President, Sir Benjamin Baker, concludes a chapter of his important work on modern Egypt with the following reference to irrigation and its results. "The British Engineer, in fact, unconsciously accomplished a feat which, in the eyes of a politician, is perhaps even more remarkable than that of controlling the refractory waters of the Nile. He justified Western methods to Eastern minds." Can any reflection enable the Members of this Institution to gauge better the importance of their calling, and the necessity for continued striving after greater and greater efficiency in the exercise of their profession, than that the efforts of those

who have gone before, and of many who are here now among us, have been mainly responsible for this unparalleled revolution in Eastern ideas.

The occasion seems to me an appropriate one—especially so from a personal point of view—to refer to the question of transport, and, in his association with that subject, to name one of the great members of our profession—Isambard Kingdom Brunel—in the contemplation of whose life's work we may find many useful lessons. Lapse of time finds me in the position of continuing and working what is perhaps the greatest creation of his genius, viz., the Great Western Railway, of which he was the Constructive Engineer. If I can show that the engineering achievements of a master mind have, as I would venture to say, an effect on posterity beyond their immediate economic return, and that such effect is undoubtedly to the public good in the long run, I may perhaps enable others to appreciate the results of what have hitherto been to them merely isolated achievements; while we may remind ourselves, in this somewhat specializing age, that breadth of view is a quality which, exercised by an engineer, invariably benefits the whole community. As one instance of the broadness of conception and foresight displayed by Mr. Brunel I may refer to Paddington Terminus, which remains to-day substantially as it was when first constructed 60 years ago. It is true that it has been added to, but such additions have only secured the more efficient and economical use of the terminus as a whole. At the present time, in and out, over 500 trains are being dealt with daily, and about 26,000,000 passengers use it in the course of a year, illustrating very forcibly the enormous benefit to the public, as well as to the Railway Company, which may result over a long period from a work designed and constructed on sound lines. Again, the possession of a main trunk line between Swindon and London with a ruling gradient of 1 in 400, is a unique advantage for a Railway Company to enjoy in its access to the greatest city of the world.

But not only has the science of engineering in its relation to transport been responsible for many great achievements and great national progress; it has naturally been also the occasion of some marked differences of engineering opinion and practice. Probably the most notable of these was what is known as the "Battle of the Gauges" which raged so fiercely in the "forties," and sharply divided into two camps those members of the civil engineering profession who were interested in railways. There can be no doubt that the present standard railway gauge of 4 feet 8½ inches was originally adopted in a somewhat haphazard manner. Before the era of locomotives

there were tramways the gauge of which had been made to suit the wheels of country carts and colliery wagons, and when George Stephenson introduced the locomotive, he adhered to the gauge of the tram lines then in existence, and laid out the Stockton and Darlington line accordingly. The same course was adopted in the case of the Manchester and Liverpool, the Grand Junction, and the London and Birmingham lines; and the main consideration which seems to have influenced Stephenson in laying out subsequent lines was that of the free interchange of traffic between the different railway systems.

Thus the present standard width of track—or what came to be known as the “Narrow Gauge”—had secured a considerable footing when, in 1833, Mr. Brunel was appointed engineer of the projected line between Bristol and London—the Great Western Railway. Mr. Brunel was the champion of great things; and when the majority of railway engineers and promoters were looking to railways as mere improvements of public roads, on which vehicles were to be permitted to pass on payment of tolls, he had a clear perception of their enormous possibilities, in regard to the conveyance of both goods and passengers at high speed. It is not known exactly at what date he formed the opinion that an increase of gauge was desirable. He himself said that he became impressed with the idea even when surveying for the Great Western line in 1833-4, and we have it on his authority that the omission from the Act authorizing the construction of that line of a clause defining the gauge was largely due to his representations to the then Lord Shaftesbury. By 1835 he had arrived at definite conclusions, and in a report to the directors setting out his reasons for the recommendation he advised the adoption of a wider gauge. So far as I am aware that report has never been published, and I therefore attach it to this Address as an Appendix *in extenso* (Appendix A). In a further report, dated August 1838, Mr. Brunel said that, having regard to the excellent gradients and curves of the new line, it was thought that unusually high speed might be easily attained, which feature appeared to involve the question of the width of gauge. Moreover, in referring to the Royal Commission appointed in 1836 to report as to the establishment of railways in Ireland, he said that the views expressed therein—to the effect that a wide gauge should be adopted owing to the favourable conditions likely to operate in that country—were identical with his own. Mr. Brunel conceived that the configuration of the London and Bristol line was even more favourable in the matter of gradients and curves than any railway likely to be constructed in Ireland, and he arrived at

the conclusion therefore that the gauge of the Great Western should be 7 feet. He was a great believer in speed, which was another instance of his remarkable prescience. The public, he said, will always prefer that conveyance which is most nearly perfect, and speed within reasonable limits is a material ingredient in perfection of travelling. To the Gauge Commissioners he expressed the view that, looking to the speeds contemplated and the masses to be moved, it seemed that the whole machine then developed was too small for the work to be done, and it required that the parts should be on a scale more commensurate with the mass, and the velocity to be attained by it.

Another point was the anticipated advantage which the broad gauge would give in the construction of engines and rolling-stock. Machinery had already been cramped by the limited width between the wheels, rendering repairs difficult and restricting the size of the fire-box and boiler. He also thought that the greater width of base for the carriages would give increased steadiness and smoothness of motion, with greater safety, particularly at high speeds.

I think I have dwelt sufficiently on the objects sought to be obtained by an increase of gauge. It should, however, be remarked that it was recognized that the difference involved an inconvenience so far as exchange of traffic was concerned; but Brunel's idea was that the Great Western Railway, having broken ground in an entirely new district, and having projected branches in various directions, should effectually and permanently secure to itself the whole trade of the south-west of England, with that of South Wales and the south of Ireland; "not by a forced monopoly, which could never long resist the wants of the public, but by such attention to these wants as shall render any competition unnecessary and hopeless." May I say that that is the true principle on which alone railways in this country can be "districted."

With the development of railways, however, the "Battle of the Gauges" soon became acute, and following on a protracted parliamentary fight between rival schemes for broad- and narrow-gauge lines north of Oxford to Worcester and Wolverhampton—in which, notwithstanding a contrary recommendation by the Board of Trade, the broad gauge was preferred—a Commission was appointed to report as to the gauge of railways. The general conclusions of the Commissioners were that they were inclined to the adoption of the narrow gauge. Following the Commissioners' report, an Act was passed, in the Session of 1846, for regulating the gauge of railways, in which it was provided that it should not be lawful to construct any railway for the conveyance of passengers of any gauge other than

4 feet 8½ inches in Great Britain, and 5 feet 3 inches in Ireland, with exceptions in favour of certain lines in the West of England and South Wales and also any authorized broad-gauge lines.

The broad gauge, therefore, whilst fettered as regards the future, remained in existence, and—with the further development of the mixed gauge—continued until May, 1892, when the final conversion took place of the line between Exeter and Penzance. As an Appendix (B) to this Address, I have given a list of lines originally constructed on the broad gauge, together with the dates of their conversion; and, as one who was concerned in the last act in the gauge question in this country, I desire to place on record my admiration of the genius of its originator, who strenuously championed its great possibilities, and whose keen insight into the future of railways enabled him to appreciate and foresee some of the problems which are to-day confronting engineers and traders alike.

Having thus briefly alluded to one interesting phase in the development of Railways in this country, I should like to make a few observations on their position to-day. As all who are interested in British Railway Stock know, an alarming depreciation in its value has occurred. Part of this depreciation is due to unusual monetary considerations and to a certain feeling of insecurity in regard thereto, and the balance to excessive competition brought about and kept alive mainly by the systematic approval by Parliament of competitive lines in localities already served by other systems or companies, and the unstable condition of affairs due to the demands of “labour.” Unfortunately, powers to construct competitive lines have been not infrequently granted to syndicates, local and otherwise, having no reasonable prospects of being able to carry out the schemes themselves, much less of working the lines if constructed, which schemes would often have to be acquired at a fictitious value by a railway company desirous of protecting its own territory.

The policy of Parliament has been to maintain keenness of competition, although the natural aggregation of railways, when left to normal economic conditions, has persistently gone on. Coupled with efficiency of operation and reasonable facilities to the public and trade, agreement and co-operation have already had a great effect, and that effect has been one of advantage to the public at large. I, however, suggest that the policy of empowering and endorsing competition or anti-combination, which has been the keynote of parliamentary and mercantile practice towards railway companies, must be restricted, if the financial status and efficient performance of the railway system of this country, upon which so much depends, are to

escape from depreciation beyond the hope of redemption. In London, the Traffic Commission has reported on a situation developed on the lines of "scramble": following the policy adopted in New York, it should have been recognized that in a centralized control of the numerous inter-urban lines one possibility at least of avoiding the present situation would have presented itself. But notwithstanding this Commission was behind its time, even its Report has not yet been acted upon, although there is much to be done in this respect.

It is only now dimly dawning in controlling quarters that there is a science of transport; and the fact that while British Railways cost over £50,000 per mile, lines in Germany cost only about £20,000, in France £27,000, in America, £11,000, and so on, is symptomatic only of the extent to which British legislation, when it is allowed to proceed on unsound lines, may prejudice vital interests.

The other factor to which I have referred, namely, the "labour" situation, is equally important. In our age of development, old theories and practices must make way for modern ideas, and it is granted that this is as true in regard to labour problems as in others. It is obvious that the goal has not yet been reached, nor have many weighty proposals, such, for instance, as co-operation, in its largest sense, received the amount of study which must in the future be bestowed upon them. Many students of co-operation, amongst them our late respected member Sir George Livesey, have devoted much thought and attention to the problem, and results should follow which will assist in further adjusting the relations of capital and labour. In the meantime, any attempt to raise artificially the remuneration of labour either in State or railway employ will assuredly only retard the ultimate adjustment.

I can imagine some saying "What has all this to do with Engineering?" I answer that it has as much to do with it as the composition of coal has to the design, user and efficiency of the mechanism of the locomotive in which it is consumed. No consideration has a greater influence on design than labour conditions—as has been made clear in numerous cases on railways; while conditions of user are as necessary engineering factors as the principles of dynamics. Amongst these conditions of user, an important element is the character of the service. For instance, frequency of travel has an important bearing on the volume of traffic in a given district. General experience has shown that much travel can be developed by frequent and punctual services for short distances. I may give you two instances from centres other than

London, to show that the principle holds from the greatest populated centres to the smallest to which it can be applied.

**A.**

	Passengers.
Period of 12 months prior to establishment of frequent service . .	595,000
"    "    "    after                    "                    "    "    . .	1,941,328
Increase . . . . .	{ 1,346,328 or 226%
Increase in number of trips per day . . . . .	103%
Length of line covered, 10½ miles.	

**B.**

Period of 12 months prior to establishment of frequent service . .	58,600
"    "    "    after                    "                    "    "    . .	716,758
Increase . . . . .	{ 658,158 or 1,123%
Increase in number of trips per day . . . . .	263%
Length of line covered, 17 miles.	

These results directly depend on a sufficient frequency of the service, and even more on reliable time-keeping for these short journeys. A feature brought out by Mr. W. B. Parsons in his Paper last Session on the New York Rapid-Transit Subway was the great increase in travel caused by the differentiation of slow and fast services. This was to me an interesting case on a suburban railway. It illustrates precisely the great change which is coming over railway administration in this and other countries on main lines and for long distances. Trains running at reasonably high speeds are becoming more and more necessary items in railway management, if the greatest receipts are to be got from a given system.

Steady running at commercial maximum speed is the universal desideratum in all cases, and, owing to the numbers of passengers carried, most of all on railways. Steady running depends, as has been proved, very largely on the engines and carriages employed, as well as on the permanent way. Accurate balancing of the moving parts of engines and carriages is essential, and the further this feature of construction is carried, the longer will be the life of the unit; but I venture to submit that the greatest factor in providing for smooth running is the perfecting of the alignment and the top surface of the rail. In this connection it may be remembered that the permanent way is as much a part of the "transport" machine as the locomotives and carriages which run on it. It is as necessary



to design a permanent way as part of the whole machine, on true mechanical principles, as it is to apply such principles to the construction of the rolling-stock. Now, this can be done and is done, although in the past its necessity has not been so generally recognized as it must be in the future, as speeds become higher and loads heavier. Accuracy of gauge, is, of course, the predominating factor in the avoidance of oscillation, and the design which gives accuracy of gauge for the longest period during the life of the component parts of the permanent way, is at once the safest and most economical, and therefore the most important feature to be provided for and maintained in the construction of railway permanent way.

In thus cursorily reviewing some phases of the railway position as it exists to-day, the question of safety naturally claims attention. Although, unfortunately, some serious accidents have occurred on the railways of the United Kingdom, a review of those accidents reveals the fact that they have been, in the majority of cases, due to the failure of the "human machine," and not so much to defect of permanent way, signalling or rolling-stock, or to oversight on the part of those responsible for the maintenance or the practical operation of the line. The provisions for the safety of railway working in this country are, I firmly believe, superior to those in any other, and statistics of accidents reveal our standard of railway working in a most favourable light. In this matter since the year 1840, in which an Act was passed conferring statutory powers upon the Board of Trade—it being then considered "expedient for the safety of the public to provide for the due supervision of railways"—that Department has taken a considerable part in railway history. By the Act referred to, the Department was empowered to appoint Inspectors, who were authorized to have access at all reasonable times to the railway stations, engines, etc., of railway companies. In 1842, by another Act, the Board were empowered to inspect railways before opening. These two early Acts established the principle of government supervision, and were followed at intervals by other Acts, increasing the scope of such supervision. During the next 28 years more Acts were passed, extending the powers of the Board of Trade; and in 1871 the Regulation of Railways Act was passed, confirming and extending the Act of 1842, and defining more particularly the character of new passenger lines required to undergo inspection before opening. In 1873 an Act known as "The Return of Signal Arrangements, Workings, etc., Act," was passed, enabling the Board of Trade to call upon the Companies to inform them by means of a yearly statement what progress had been made in the interlocking of

points and signals, and the provision of block telegraph apparatus. In 1878 another Act was passed, having exactly the same object, in regard to continuous brakes. Upon the strength of the Government Inspectors' Reports upon accidents which they had investigated, the Companies had been urged to find and adopt a system of brakes which could be applied simultaneously to all the wheels of a passenger train; but they were already alive to the necessity for these brakes, the London and North Western Company having actually introduced such a brake in 1877, while the Great Northern Company had a continuous brake of the vacuum type in use at the time.

Although, however, the Department were placed in a position to demand returns of interlocking, etc., and brakes, it had no power to order works to be carried out, which is an interesting fact in the light of the words in the Act of 1840, as to its being "expedient for the public safety, etc.," and it was not until 1889 that Parliament made the block telegraph, interlocking of signals, points, etc., and continuous brakes, compulsory. In that year, however, 93 per cent. of the passenger-train mileage of the United Kingdom was run by trains fitted with continuous brakes. The Act of 1889 further invested the Board of Trade with power to place a time limit on the execution of any Order which it thought fit to make, and altogether the Act gave the Board more authority than any previous Act, but, of course, no responsibility.

The last Regulation of Railways Act is that of 1900, known as "The Prevention of Accidents Act," and was largely the outcome of the reports of a Royal Commission presided over by Lord James of Hereford. This Act gives the Board of Trade power to make rules on a variety of subjects, and marks a distinct stage in the development of governmental supervision over the operation of railways in this country; e.g., while the authority granted under the Act of 1840, giving a Board-of-Trade Inspector unlimited powers of inspection, was restricted by the 1871 Act to the inspection of new works or the investigation of accidents, by the 1900 Act the powers of the Board of Trade were extended to the inspection of any railway for the purpose of seeing whether its Rules were being carried out, or, in fact, whether there was any ground for procedure under the Act. The requirements, therefore, which have been made by the Board of Trade by virtue of the powers vested in it are of a very extensive character, and embrace the inspection of new lines, provision of block telegraph, signalling, interlocking, position of points, stations, gradients, working of single lines, etc.—from which it will be seen that the part taken by the Department in the control and supervision of railways is a very large one; but the

responsibility for safe working rests with the Companies alone, and the Government control may be assumed to be part of the price which has to be paid for the concession by Parliament of the powers under which the undertakings have their being.

As to the extent to which Government control should be exercised, there is much to be said on either side. It is undoubtedly highly desirable that there should be means of enforcing such requirements as are necessary for the purpose of bringing a backward railway company up to that standard of efficiency which the safety of the public demands; but, on the other hand, the heaping-up of orders and restrictions on up-to-date railways at the instance of a Department without operative responsibility, must have a considerable bearing upon and, in some cases, be a determining factor, in questions of railway working as well as in regard to proposals for railway extension, more particularly in sparsely-populated and purely agricultural districts; and it was recognition of this aspect of the case which led up to the Light Railway movement of the "nineties," to which I will venture to refer.

The movement in favour of Light Railways as a system of transport arose out of two considerations, the combination of which pointed to the need for special legislation. The first of these considerations was the continually-increasing depression taking place in the agricultural industry of the country, and the second was the very high cost of construction of standard railways, coupled with the restrictions and requirements of the Board of Trade in the matter of their equipment and operation. In fact the Light Railways Act of 1896 was an emphatic expression of the view that the "means" should bear some relation to the "end," a principle which, up to that time had not been evident, inasmuch as a branch railway involving the use of more than one engine in steam at the same time came within the scope of the same requirements and conditions as those applying to a main trunk line. In the construction of the branch lines enormous capital has been expended owing to the statutory and other conditions attaching to railway construction generally having to be complied with in all cases, irrespective of the circumstances. It, therefore, came to be realized that if rail-communication was to be afforded in purely agricultural and sparsely-populated districts, new measures were necessary, and as it was considered that "Light" Railways would be of utility in meeting the needs of the agricultural community, the Act referred to was passed. The anticipations as to the probabilities of success of this new venture were based upon the action taken by foreign countries, notably Belgium, Italy, and France, where there had been a

large development of railway facilities through rural districts by means of a cheaper and simpler plan than that applied to trunk lines. It was contended that by virtue of this, producers in the countries named were enabled to compete successfully in our home market against English producers. It was further considered that Light Railways or steam or electric tramways would benefit populous urban districts by providing a cheap means of travel for work-people, or by leading to the establishment of manufacturing in suburban or outlying districts: also that such facilities would militate against the migration of the population from rural districts into the large towns.

By the Act of 1896 a Court was appointed, styled the Light Railway Commissioners, for the purpose of considering applications for permission to construct light railways, and with power to make Orders authorizing such railways. Any Order so made has to be submitted to the Board of Trade, who confirm it or otherwise, after considering it in the light of expediency, safety, or objections made in accordance with the Act. In its variations of the provisions applying to ordinary railways, this Act authorizes the enactments of the Railways Clauses and Lands Clauses Acts to be omitted, except so far as they are incorporated or applied, at the discretion of the Commissioners, by the Order authorizing the railway.

It may be thought that the light railway legislation—which not only removed a number of stipulations leading to expense, but also enabled the Treasury, in certain circumstances, to render financial assistance to any scheme for which an Order was granted—has not been attended with a very successful result, as an examination of the following figures will show. In a period of 10 years since the passing of the Act, 192 applications for light-railway Orders were made, of which 130 were granted, 22 were withdrawn by the promoters, and 40 were rejected. Out of the 130 Orders approved by the Commissioners about 40 were Orders amending others of an earlier date; 38 granted were allowed to lapse; in 30 cases no capital had been raised at the end of 1906, and in 7 others the capital had only been partially raised. It is questionable whether more than 20 *bonâ fide* light railways have been brought to fruition since the passing of the Act of 1896. Some of these have been constructed by or with the direct countenance and assistance of established railway companies, and some proportion, in the absence of the Light Railways Act, would have been promoted by Bill in Parliament. It would appear that the defect of the Act has been primarily due to its provisions stopping short of actually financing the several schemes. This view is supported by the

Light Railway Commissioners, who, in a Report of their proceedings up to December, 1906, recommended a reconsideration of the conditions under which financial or other assistance should be granted to such lines by the State and local authorities, and by those more directly or indirectly benefited in each case.

In the circumstances which I have rehearsed, the history of Light Railways has been a disappointing one, certainly when the function they perform on the Continent and in other countries is considered; and it is an interesting speculation as to how far the steady development of traction by road-motors, for both passengers and goods, will direct outlying sources of traffic into definite channels, resulting in these channels becoming over-taxed, with the eventual need of the substitution of light railways to cope with the congested motor-traffic. I could quote from my own experience cases of this development, in which the establishment of a light railway has been the sequence to the introduction of a road-motor service in a district where formerly there was an entire absence of all public communication other than that afforded by carrier's carts. This shows the very important rôle which road-motor vehicles already play in the transport problem as a whole, by enabling the roads to afford transport of a character which will foster traffic, and so pave the way to the provision of the superior transport afforded by railways. Undoubtedly the introduction of road-motors marks a stage in the development of transport in this country.

I will now turn to matters which more intimately concern this Institution, and will first make a short reference to the important and far-reaching achievements of the Engineering Standards Committee, which has been engaged for 6 or 7 years on the problem of standardization in British Engineering practice. The actual initiation of this work was brought about on the motion of Sir John Wolfe Barry, by the Council of The Institution in 1901, and the movement thus started was fostered and enlarged by the co-operation of the Institution of Mechanical Engineers, the Iron and Steel Institute, the Institution of Naval Architects and the Institution of Electrical Engineers, whose representatives occupy places on the Main Committee. Eminent Engineers and others associated with engineering pursuits to the number of some 280 have given their services unsparingly and gratuitously in carrying out the work of the Main Committee, of the twelve Sectional Committees, and of the twenty-four Sub-Committees, which represent the machinery that has been necessary to cope with this many-sided task.

A work of such magnitude could not have been carried out

without considerable funds, and though in the first instance these funds were provided by the Institutions named, the far-reaching benefits, which it was speedily admitted would result from Standardization to manufacturers and users alike throughout the country, impressed the Government with the importance and magnitude of the advantages of the movement. It is gratifying to be able to say that substantial support, both financial and other, has been afforded by the Treasury, by the Indian Government, and also by Manufacturers, Railway Companies and others who profit directly or indirectly by Standardization as applied to their particular trades or businesses. The Standardization Committee has throughout its labours been fully alive to the dangers which might result from any overdoing of Standardization; but between the limits of no Standardization at all and Standardization carried to the extreme length of hampering invention and impeding improvement, there has existed a very large field for the operations of the various Committees appointed to deal with the many subjects considered and still to be considered by them.

It is admitted that the waste which the old order of things involved in time, labour, material and of course capital, had become a reflection upon the British manufacturing community; and I feel that we may look with considerable pride and satisfaction upon the share which this Institution has taken in initiating, organizing and helping to solve this problem of Standardization, which is undoubtedly of great national importance.

I should like to allude also to the assistance which The Institution has given of late years to engineering investigation and research work. I would allude to the exhaustive inquiry into the "Thermal Efficiency of Steam-Engines," and to the like treatment of the important subject of "Methods of Conducting and Tabulating Engine and Boiler Trials;" also the work of the Committee on the "Education and Training of Engineers," to which last all the leading engineering societies lent their assistance. The published Reports and findings on these subjects bear witness to the attention and labour devoted to them.

With regard to the encouragement of experimental research work, the Council have thought it could best carry out that particular duty by grants, from time to time, to the National Physical Laboratory. This national institution is carrying out and has carried out experimental investigations on engineering matters, in a way which could only be done at fully-equipped and extensive establishments. The application of the grants made by The Institution towards investigations of engineering interest, is subject to the review and

approval of the Council, and the results achieved are undoubtedly of great importance and value. I mention the foregoing merely to show that The Institution recognizes that the elucidation and settlement of engineering principles, and incidentally provision for original research on engineering subjects, is in a direction of usefulness, and that this phase of its activity will undoubtedly become more and more important as time goes on.

This brings me, with your permission, to say a word or two about The Institution itself and its founders. In 1818 The Institution was founded by a small coterie of enterprising young engineers always understood to be six in number, although their account-book, which came into our possession lately and may be seen in the Library, indicates that their number was actually seven. It has grown and developed until now in the year 1908 (90 years since its commencement) it has arrived at an important point in its history, as the members are aware. On the 24th April last, an agreement for the disposal of its present home was concluded with the Government, who require the site in connection with the completion of the Imperial buildings now partly erected, and on the 1st August the Bill of the Government providing for its acquisition and the provision of a new site received the Royal Assent.

The members owe a debt of gratitude to Sir William White, as Chairman of the Building Committee, as also to Sir William Matthews, Sir John Wolfe Barry, and to Mr. Galbraith and others who have acted with them, in conducting the delicate negotiations extending over a period of 3 years, which have resulted in this preliminary step to the provision of a future home on a scale commensurate with the growing activities and prestige of our Institution. This impending change will undoubtedly have an important influence on the future of our Institution, and although the present building is only 12 years old, it has, from the associations of these busy and eventful years, endeared itself to all of us in many pleasant and beneficial ways, the memories of which cause a chord of regret to be struck as we contemplate leaving its hospitable roof. Its graceful proportions, and comfortable accommodation for our corporate body, will guide us in making provision for the requirements of the near, and, let us hope, distant future.

The changes which have taken place in our housing arrangements must always possess an interest for those who have The Institution's welfare and progress at heart, and when we look back upon the small beginning in the shape of accommodation, which was made when some hired rooms at No. 15 Buckingham Street, Adelphi, formed our home, and then glance into the future and picture the commodious

and handsome structure which our members far and near will possess, there is presented to our minds a tangible proof of the development of The Institution no less forcible than the statistics of its growth and multifarious activities.

It may be interesting to review the successive steps by which we are now within measurable reach of a home of the character of the building which we hope soon to see commenced. For 16 years our predecessors contented themselves with the rooms in Buckingham Street; but the increase in membership had by 1834 rendered larger accommodation inevitable, and in that year a small house in Cannon Row, Westminster, was taken. Shortly afterwards the further increase in members made another change necessary, and after an unsuccessful application to the Government for the allotment of premises—which would not have been an unprecedented action—in Somerset House, a fortunate opportunity presented itself to The Institution of obtaining premises on this present site in Great George Street, which premises were entered upon at Christmas, 1838. Ten years later the difficulty of insufficient accommodation again presented itself, and a proposal was made that a site should be secured upon which The Institution might erect a building; but as it was found impracticable to obtain any ground so advantageous as the existing position of The Institution, except upon heavier terms than could have been wisely entertained, it was decided to carry out some works of improvement and enlargement of the then existing building. By 1865 the membership had outgrown the accommodation once more, and after consideration it was recommended by the Council that Nos. 15 and 16 Great George Street should be purchased and a new building erected upon that site, but in view of the heavy cost involved the matter was not proceeded with then. The question, however, assumed such importance that, in 1867, it was revived, and resulted in measures being taken to acquire and adapt to the Institution's needs No. 25 Great George Street, with a portion of No. 24, and in 1868 the necessary work was carried out at a cost of between £17,000 and £18,000.

The next stage in this matter of accommodation occurred in the early nineties, when, in order to meet the increasing requirements, it was decided to rebuild the premises, according to designs prepared by Mr. Charles Barry, F.R.I.B.A., utilizing the sites of Nos. 24, 25 and 26 Great George Street, of which the freeholds had been acquired. The work was carried out by Messrs. Mowlem and Company, and in March 1896, was sufficiently advanced to admit of the transfer of The Institution's effects into the new building.

Even then it was seen plainly that finality had not been reached,



and the Council anticipated that future extension of the new building might be effected on the adjacent property, of which a lease had been acquired, and negotiations for its purchase took place, but they were not pursued in the face of the growing uncertainty of the Government's intentions in regard to the new public offices. I have referred to these incidents because they mark epochs in the history of The Institution, and are valuable as a means of enabling members to measure the progress which has been made between the several changes.

To carry the point a little further, with your indulgence, I will give some figures of the growth in the number of Members, Associates and Students at the various epochs in question.

In 1836 there was a total of 238 Members of all classes, 91 of whom were "corresponding members," a class which was merged in that of Ordinary Members two years later. In 1846 the total membership was 600, including 44 "graduates," which class was virtually abandoned in that year.

Twenty-two years later, in 1868, when the third change in the housing of The Institution took place, the number of Members had more than doubled, being 1,681, made up of 16 Honorary, 637 Members, 895 Associates, and 133 Students.

In 1896, an enormous increase appears, the total having reached 6,906, including 1,891 Members, 3,822 Associate Members and 839 Students. In a further period of 12 years (1908) the figures have still largely increased—Members to 2,276, Associate Members to 4,514, and Students to 1,482, the number of all classes being on the 1st October last, 8,555.

In another direction the Council, I submit, have shown care for the future, and that is in regard to the great question of the training of those embarking upon the profession of Engineering. The movement to secure definitely the better education of engineers, which was initiated in 1889, has developed into a system of examination on a large scale; and although here there may be room for differences of opinion, yet, on the whole, the fact cannot be controverted that the examinations for the admission of Students, and to test the scientific qualification for election to Associate Membership, are of a high order, and are widely recognized as standards of general education and technical knowledge.

The test of practical attainments is, perhaps, a more difficult matter to deal with, and the mode of acquisition of such attainments, as you all know, has undergone and is undergoing a great change, arising from the altered position of pupilage in the engineering and allied professions generally. Undoubtedly further expedients and

efforts will have to be made by The Institution to secure a standard of test for practical knowledge as satisfactory and definite as that which now obtains for technical and scientific knowledge. In addition to the candidates who have qualified by the examinations of The Institution a large number have qualified by means of other examinations ; and it is a cause for satisfaction that while The Institution has so firmly established its own examinations, it has broadened the basis of qualification by recognizing as exempting therefrom, examinations of all British Universities and Colleges which comply with the requirements that have been laid down by the Examinations Committee of the Council. This policy of recognizing places of learning both at home and in the Colonies cannot fail to have an important influence upon the standardization of preliminary, general and technical training of engineers ; and it has undoubtedly promoted in other and distant quarters a more carefully co-ordinated scheme of education leading up to the examinations for entrance into The Institution.

The Student class—the future members of our Institution—continues to extend, and the Council have, with the experience of our Secretary, Dr. Tudsbury, assisted, guided and developed in various directions the interests of this class. While London, of course, remains the headquarters, there are, in six of the most important industrial centres in the kingdom, strong local Associations of Students maintained by The Institution, and supported by members interested in its educational work. An addition to the ordinary proceedings of the Students' meetings has been made recently by arrangements for special lectures on practical professional subjects both in London and at the country centres ; and the Council have been so fortunate as to secure Dr. Unwin, one of our Vice-Presidents, and Sir Whately Eliot, as the Lecturers this year.

The Advisory Committees of the Council established in our distant Colonies of Australia, New Zealand and South Africa form a very direct and useful link between the members attached to this Institution in the Colonies and its organization at home ; and what is no less important, by means of representative Members of the Council resident in India, Australasia, Canada and South Africa, the views of those in distant parts are enabled to be made known directly to the Council by members of recognized position in their respective localities. It may be fairly claimed that by these means The Institution of Civil Engineers is doing what it ought to do in keeping touch with the vast dependencies of this Empire ; and by so doing, is assisting materially in the work of building up and linking together the various parts of our Empire—a function which forms

a creditable example of imperial work, and no doubt as time goes on will be largely developed.

The process of strengthening the profession by protecting the entrance to it is necessarily the first great operation in improving the general status of the engineer; and naturally following, whilst to some extent concurrent with it, is the further necessity of regulating the business involved in the practice of the profession of a Civil Engineer. Of course, in approaching questions which relate to the personal and individual interests of the members, it has to be borne in mind that such interests must be always subservient to the particular objects for which The Institution was founded and received its Royal Charters. Our primary object is to make The Institution strong and efficient in the promotion and dissemination of engineering knowledge, and thereby to advance the status of engineering as a profession. It cannot be gainsaid, however, that when a body becomes so numerous and so diverse in its activities as our own, questions are involved in the promotion of its professional status which concern its members personally, and apart from their support of The Institution as a scientific organization. The subject has received a large amount of attention from the Council, but chiefly on account of the transition period through which, I do not hesitate to say, the profession has been passing, difficulties have been encountered which have prevented the full exercise of such discipline as a great body like The Institution of Civil Engineers should possess: but I venture to hope that having done so much to secure the proper training of its new members, there must assuredly be subsequent attention given to the control of the practice of civil engineering.

I have set out, I hope at no undue length, the position of our Institution, and also some of the directions in which the Council are endeavouring to broaden and strengthen its power and usefulness, and in this way to serve the interests of our Members, Associate Members and Students. As an indication that these efforts are producing results, I may allude to a fact, possibly known to many, that several important departments of State rely to a considerable extent upon the work of the Council, and in some cases upon advice given by it, with respect to questions of the qualification of engineers and of their selection for public services. The result of all this strengthening of the efficiency of The Institution is that a higher average technical proficiency is undoubtedly attained by the young engineers attached to it than was formerly the case, and this state of affairs has been notably marked by the action of the India Office with respect to engineering

appointments in the Public Works Department; and very recently by the War Office, which has entrusted to the Council of The Institution the important function of selecting and recommending young engineers for nomination to the newly-organized Reserve of Officers for the Royal Engineers.

With reference to the last-mentioned matter, I take this earliest opportunity to make it known to The Institution that the War Office proposes to establish a Special Reserve of Officers for the Royal Engineers by means of the appointment of young Civil Engineers specially selected for the purpose. Such officers will receive a year's probationary training at the School of Military Engineering and otherwise, and on subsequently receiving their commissions will be required to attend for 15 days' training annually with their corps.

The terms of service and retirement therefrom will be such as may be fairly contemplated by young engineers in regular civil employment; and they may be called up for army service at home or abroad at a time of national emergency.

With respect to the conditions of rank and pay during probationary training and subsequent service, the Reserve Officer will be placed practically on all fours with the Regular Officers of the Royal Engineers.

Fuller particulars of all these arrangements will be communicated to you shortly.

The War Office has assigned to the President of The Institution the duty of selecting men for nomination to this Reserve, as may be required from time to time.

I need not dwell upon the importance, from a national point of view of the step thus taken to utilize the special knowledge and experience of Civil Engineers in the direction indicated, and I look forward with confidence to the support which the Council will receive in the furtherance of this scheme from all the members of The Institution, as well as from the Students, from whose ranks must be drawn the material of this future Reserve of Officers.

The engineering profession is, as I have said, like most commercial interests, passing through a period of rapid development and change, and from its very nature must be more susceptible to changes than its fellow professions of the Law, Medicine, etc. I do not contend that membership of this Institution is the only criterion of engineering competence, but if the India Office and other great departments of the State are alive to the desirability of public moneys applied by these well-organized departments to engineering purposes being administered by

definitely qualified engineers, I hope it will not be considered as going too far to suggest that in this year 1908, it ought to be laid down as a principle that all public money derived from rates and taxes should be, so far as it is applied in engineering construction, expended under the direction or control of definitely qualified engineers, as is already the case in many countries.

The establishment of any such principle is clearly a matter for practical politicians and economists. The Institution has ever aimed at justifying rather than inviting confidence in its members, and it may be assumed that this attitude represents the general sense of the engineering profession. Such a position as I have suggested would, however, be mutually advantageous to the public on one hand, and to the profession on the other. It would promote efficiency and economy in much public expenditure, and would immensely strengthen the practical side of the profession in Great Britain; and, by strengthening the body of engineers, from whose ranks must be drawn many of those who have to serve the needs of the Empire and British interests all over the world, would equally benefit the State.

Another, and somewhat consoling consideration, I would venture to place before you, and then I have done. The ideals of nations are different, as we all know, but I was hardly prepared for so precise a statement on the British and German ideals as that made recently by an eminent German professor lecturing on economic subjects. He said :—

“The aim of the German was everywhere to leave as little as possible to chance in the great struggle of the twentieth century, not to allow people to muddle through somehow, but to eliminate as far as possible the element of the unforeseen, while carefully training the mind to cope if necessary in an intelligent way with any emergency. While the British had, as a rule, a violent suspicion of the expert, and a strong belief in the untrained unpaid amateur as the right source of wisdom, allowing the expert to advise and the amateur to decide, the German had no fear of the expert. He well saw the possible danger of red-tapeism at the hands of highly-trained officials, but he found them less than the dangers arising from the decisions of well-meaning but untrained and inexperienced amateurs.”

If these principles were more acted upon in this country, as in time they must be, I think you will all agree with me that many members of this Institution would find increased scope for their energies, and added interest in the engineering problems they have to deal with, while, without doubt, better results would, on the whole, ensue for capital.

The Civil Engineers of to-day enjoy the great inheritance of experience which this Institution has largely helped to make available for them; and one of their chief concerns must be to make such provision for those who in turn will succeed them, that there may be no failure or want of continuity in the work of The Institution.

Mr. J. C. HAWKSHAW, Past-President, was sure it would be the wish of the members to accord their thanks to the President for the able Address to which they had listened. All of them were interested in railways as travellers, some as engineers, and some as investors; and there was nobody better qualified than the President to enlighten them on the subject. He therefore had much pleasure in moving: "That the best thanks of The Institution be accorded to the President for his Address, and that he be asked to permit it to be printed in the Minutes of Proceedings."

Sir WILLIAM H. WHITE, K.C.B., Past-President, in seconding the resolution, said there was one passage in the Address which as the President read it possibly did not appeal to the members as it did to those who were Past-Presidents. The Address contained a statement that each President in turn had to deliver an Address, and that Mr. Inglis regarded these Addresses as "deliverances." He thought the President had used that word in a special sense, but he was sure Mr. Inglis felt, as all those who had passed the Chair did, that the term described very correctly a Presidential Address. It was a thing to which each President must look forward, and as most of them were busy men it was not an easy task to prepare an Address, even when a man was full of matter and of experience, in a form which one would wish to place on record as a worthy successor to the Addresses of his predecessors. So that when it was over it was in a sense "a deliverance," although at the same time it was a deliverance recording the mature experience of such men as those who, by favour of the members, were successively placed in the Chair. He was sure he spoke the mind of every member of The Institution when he said that this Address was worthy of a place in that great collection, and that the President united in himself the qualities which he had put before them as those which should adorn the ideal modern British Engineer.

The Resolution having been carried by acclamation,

The PRESIDENT thanked the members for the compliment paid him, and presented the Telford, Watt, George Stephenson and James Forrest Medals. The other Awards made by the Council in respect of Session 1907-8 were announced.

A reception was held subsequently in the Library.

[APPENDIXES

## APPENDIXES.

### APPENDIX A.

REPORT MADE BY MR. ISAMBARD K. BRUNEL, DATED SEPTEMBER 15TH, 1835.

I beg to submit the following observations upon the subject of the width of the rails as explanatory of the grounds upon which I have recommended to you a deviation from the dimensions adopted in the railways hitherto constructed.

The leading feature which distinguishes railways from common roads is the great diminution of that resistance which arises from the friction at the axle-trees, and more particularly from obstruction on the road; this latter is almost entirely removed in a well-kept surface of the railway, and friction may be considered as the only constant resistance.

The effect of gravity when the load has to ascend any inclination is, of course, the same whatever the nature of the road, and depends only upon the rate of inclinations.

In the present state of railways and railway carriages the constant resistance, which we will call friction, amounts generally to about  $1/250$  or 9 lbs. per ton, although under favourable circumstances it may be reduced to  $1/280$  or 8 lbs. per ton. Assuming the latter as being the least favourable to the view which I purpose to take of the necessity of further improvement, I will apply this to the case of the Great Western Railway.

Upon the Great Western Railway from Bristol to Bath and from London to the Oxford branch, a total distance of about 70 miles, including those portions upon which full two-thirds of the traffic will take place, there will be no inclination exceeding 4 feet per mile, which will cause a resistance of only 1 lb. and seven-tenths per ton, calling it even 2 lbs., while the friction is taken at 8 lbs. it appears that the latter will constitute 80 per cent. of the whole resistance. The importance of any improvement upon that which forms so large a proportion is obvious, but nevertheless, according to the present construction of railways, a limit has been put to this improvement, which limit is already reached, or at all events, great impediments are thrown in the way of any material diminution of the friction, and this serious evil is produced indirectly by the width of the railways.

The resistance from friction is diminished as the proportion of the diameter of the wheel to that of the axle-tree is increased; there are some causes which in practice slightly influence this result, but within the limits of increase which could be required we may consider that practically the resistance from friction will be diminished exactly in the same ratio that the diameter of the wheel is increased; we have here, therefore, the means of materially diminishing this resistance.

The wheels upon railways were originally much smaller than they now are as the speed has been increased and economy in power become more important; the diameters have been progressively increased and are now nearly double the size they were but a few years ago—even upon the Liverpool and Manchester Railway I believe they have been increased nearly one-half, but by the present construction of the carriages they have reached their limit.

The width of the railway being only 4 feet 8 inches between the rails, or about

4 feet 6 inches between the wheels, the body of the carriage, or the platform upon which the luggage is placed, is, of necessity, extended over the tops of the wheels, and a space must also be left for the action of the springs; the carriage and load is raised unnecessarily high, while at the same time the size of the wheel is inconveniently limited.

If the centre of the gravity of the load could be lowered the motion would be more steady, and one of the causes of wear and tear both in rails and carriages would be diminished.

By simply widening the rails so that the body of the carriage might be kept entirely within the wheels the centre of gravity might be considerably lowered and at the same time the diameter of the wheels be unlimited.

I should propose 6 feet 10 inches to 7 feet as the width of the rails which would, I think, admit of sufficient width of carriages for all purposes. I am not by any means prepared at present to recommend any particular size of wheel or even any great increase of the present dimensions. I believe they will be materially increased, but my great object would be in any possible way to render each part capable of improvement, and to remove what appears an obstacle to any great progress in such a very important point as the diameter of the wheels upon which the resistance which governs the cost of transport and the speed that may be obtained so materially depends.

The objections which may be urged against these alterations are: (1) the increased widths required in the cuttings, embankments and tunnels and consequently the increased expenses; (2) a greater amount of friction in the curves; (3) the additional weight of the carriages; (4) the inconvenience arising from the junction with the London and Birmingham Railway.

First, as regards the increase of the earthwork bridges and tunnels. This would not be so great as would at first sight appear; the increased width of each railway does not affect the width between the rails or on either side as the total widths of the bodies of the carriages remain the same, and as the slopes of the cuttings and embankments are the same, the total quantity would not necessarily be increased above  $\frac{1}{12}$ th and the cost of the bridges and tunnels would be augmented about in the same ratio, and such addition has been provided for in the estimates. Secondly, the effect of the friction upon small curves. The necessary radius of curvature will be increased in the ratio of the widths between the wheels, viz. as 5 to 7, but the portions of the total length which is curved to such a degree as to render this effect sensible is so small (not being above  $1\frac{1}{2}$  miles upon the whole line except immediately at the entrance of the depots) that it is not worth considering when a great advantage is to be gained upon a total distance of 120 miles. Thirdly, additional weight of the carriages; the axle-trees alone will be increased and then form but a small part of the total weight of the carriages. The frame will indeed be simplified and I believe this will fully counterbalance the increased lengths of axle-trees. If the wheels are materially increased in diameter they must of course be stronger and consequently heavier, but this weight does not affect the friction at the axle-trees and not sensibly the resistance to traction, while their increased diameter affords the advantages which are sought for.

Fourthly, the inconvenience in effecting the junction with the London and Birmingham Railway.

This I consider to be the only real obstacle to the adoption of the plan, one additional rail to each railway must be laid down. I do not foresee any great difficulty in doing this, but undoubtedly the London and Birmingham Railway Company may object to it, and in that case I see no remedy, the plan must be abandoned. It is therefore important that this point should be speedily determined.



# APPENDIX B.

## GREAT WESTERN RAILWAY BROAD-GAUGE LINES AND BRANCH LINES CONVERTED TO NARROW-GAUGE.

Name of Line or Branch.	Date Opened.	Date Converted.	Mileage Approx.
Oxford, Worcester and Wolverhampton railway (West Midland) . . . . .	1850-54	1858	92½
Aylesbury branch . . . . .	1863	1868	7
Basingstoke branch . . . . .	1847-8	1869	
Bordesley junction branch . . . . .	1861	"	
Grange Court to Hereford . . . . .	1853-5	"	
Oxford to Oxley sidings, Wolverhampton, including Swan Village and Stratford branches . . . . .	1850-4	"	131½
Victoria Basin branch (Wolverhampton) . . . . .	1849	"	
Walsall Street branch (Wolverhampton) . . . . .	1854	"	
Wednesbury junction branch . . . . .	1859	"	
Hammersmith and City railway . . . . .	1864	"	
<i>Wycombe branch—</i>			
Maidenhead to High Wycombe . . . . .	1854	1870	
High Wycombe to Kennington junction . . . . .	1862-64	"	36½
Abingdon branch . . . . .	1856	1871	5½
Uxbridge branch . . . . .	1856	"	
Bristol and South Wales Union railway . . . . .	1863	1872	
Bullo Docks branch . . . . .	"	"	
Bridgend to Coegnant . . . . .	1861	"	
Bute Docks . . . . .	1858	"	
Bwlfa Dare branch . . . . .	1861	"	
Carmarthen and Cardigan branch . . . . .	1860-64	"	
Cirencester branch . . . . .	1841	"	
Cheltenham and Gloucester railway . . . . .	1847	"	
Cwmamman branch . . . . .	1855-8	"	
Didcot to Oxford . . . . .	1844	"	
Forest of Dean branch . . . . .	1854	"	
Forest of Dean Central railway . . . . .	1868	"	335
Gloucester Docks branch . . . . .	1853	"	
Merthyr branch . . . . .	"	"	
Milford Haven branch . . . . .	1863	"	
Neath loop . . . . .	1851	"	
Porthcawl branch . . . . .	1861	"	
Swansea North Dock branch . . . . .	1852	"	
<i>Swindon to New Milford—</i>			
Swindon to Kemble . . . . .	1841	"	
Kemble to Gloucester . . . . .	1845	"	
Carried forward . . . . .			608½

## APPENDIX B—continued.

Name of Line or Branch.	Date Opened.	Date Converted.	Mileage Approx.
Brought forward			608½
Gloucester to Chepstow East . . . . .	1851	1872	
Chepstow East to Chepstow . . . . .	1852	"	
Chepstow to Landore . . . . .	1850	"	
Landore to Carmarthen . . . . .	1852	"	
Carmarthen to Haverfordwest . . . . .	1854	"	
Haverfordwest to N. Milford . . . . .	1856	"	
<i>Vale of Neath line—</i>			
Middle Duffryn to Canal Head . . . . .	1856	"	
Canal head to Aberdare . . . . .	1853	"	
Aberdare to Neath . . . . .	1851	"	
Neath to Swansea South Dock . . . . .	1863	"	
Calne branch . . . . .	"	1873	5½
<i>Berks and Hants branch—</i>			
Southgate Junction to Hungerford . . . . .	1847	1874	
Hungerford to Devizes . . . . .	1862	"	
Devizes to Holt (Wells, Somerset and Wey- mouth railway) . . . . .	1857	"	
Bradford to Bathampton . . . . .	"	"	203
Bridport branch . . . . .	"	"	
Clifton May Bank branch . . . . .	1864	"	
East Somerset branch . . . . .	1858-62	"	
Marlborough Branch . . . . .	1864	"	
Radstock to Frome . . . . .	1854	"	
Salisbury branch . . . . .	1851-56	"	
<i>Wilts, Somerset and Weymouth Line—</i>			
Thingley Junction to Westbury . . . . .	1848	"	
Westbury to Frome . . . . .	1850	"	
Frome to Yeovil . . . . .	1856	"	
Yeovil to Weymouth . . . . .	1857	"	
Brentford branch . . . . .	1859-60	1875	21½
Cheddar Valley branch . . . . .	1869-70	"	
Henley-on-Thames branch . . . . .	1857	1876	4½
Faringdon branch . . . . .	1864	1878	
West London railway . . . . .	1844	"	11
West London Extension railway . . . . .	1863	"	
Weston-super-Mare branch . . . . .	1842	1879	2
Clevedon branch . . . . .	1847	1879	
Yeovil " . . . . .	1853	"	23½
Portishead " . . . . .	1867	1880	
Barnstaple " . . . . .	1871-3	1881	42½
Minehead " . . . . .	1862	1882	
Windsor " . . . . .	1874	"	8½
	1849	1883	
Carried forward			943

APPENDIX B—*continued.*

Name of Line or Branch.	Date Opened.	Date Converted.	Mileage Approx.
Brought forward . . . . .			943
Tiverton branch . . . . .	1848	1884	4 $\frac{3}{4}$
Chard „ . . . . .	1866	1891	12 $\frac{3}{4}$
<i>Main line, Paddington to Penzance—</i>			
Paddington to Bristol . . . . .	1838-41	1892	415 $\frac{1}{4}$
Bristol to Exeter . . . . .	1841-43	„	
Exeter to Plymouth . . . . .	1846-49	„	
Cornwall Junction to Truro . . . . .	1859	„	
Truro to Penzance . . . . .	1852	„	
Ashburton branch . . . . .	1872	„	
Bridgwater docks branch . . . . .	1845	„	
Brixham branch . . . . .	1868	„	
Falmouth branch . . . . .	1863	„	
Hayle Wharf „ . . . . .	1852	„	
Launceston „ . . . . .	1859-65	„	
Moretonhampstead branch . . . . .	1866	„	
St. Ives branch . . . . .	1877	„	
Sutton Harbour branch . . . . .	1869	„	
<i>Torquay branch—</i>			
Newton Abbot to Torre . . . . .	1849	„	
Torre to Kingswear . . . . .	1859-64	„	
Totnes Quay . . . . .	1874	„	
Total statute miles . . . . .	. . . . .	. . . . .	1,375 $\frac{3}{4}$