

THE  
INSTITUTION OF AUTOMOBILE ENGINEERS.

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PROCEEDINGS OF SESSION 1911-12.

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The Influence of Detail on the Development of  
the Automobile.

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(President.)

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GENTLEMEN,—I wish to thank you for the signal honour you have conferred upon me in selecting me as your President, an honour which is greatly enhanced by the illustrious names of those who have preceded me in this office, Crompton, Dugald Clerk, Hele-Shaw and Lanchester. Before, however, proceeding with my address, there are some matters connected with the policy of the Institution which I think should be mentioned at the commencement of the Session.

In the first place, it has been frequently urged that it is desirable that meetings of a less conventional character should be held, meetings at which Members would feel less restraint, and at which an extempore discussion should take place on a debatable matter rather than an elaborated discussion of a Paper which has taken much time and thought in its preparation and requires a similar expenditure of thought and consideration in the framing of questions and in the direction of criticism in the discussion. Steps have been taken for providing that at least one such extra meeting shall be held during the session at which the proceedings will be of a less formal character, and at which a debate or discussion on a technical matter of general automobile interest will take place. It is to be hoped that these meetings may prove popular with those Members who have hitherto refrained from taking part in discussions on the Papers read at our regular meetings, whether from feelings of nervous-

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ness or from an objection to seeing in print a verbatim report of their spoken words. In this connection, I may add that the remarks even of the most experienced speakers in this Institution, are, before they go to press, carefully edited by those Members themselves. For this there is good reason, as in public speaking on general topics one frequently and unconsciously repeats oneself, and in speaking on technical subjects it is often more difficult still to order one's thoughts and frame one's sentences in such manner that they are clear without being tautological, whereas in writing, matter and phraseology can be easily re-read and corrected. To those Members, therefore, who have felt these reasons to be an obstacle in the way of joining in the discussions, I would emphasize the fact that their fears are really groundless, and that ample opportunity will be afforded to them for putting into what they consider proper shape any remarks which they may make.

A second matter which has been raised is that of holding meetings at centres other than London. This question has been carefully considered by your Council, and it does not appear possible to arrange for ordinary meetings outside the London area until such time as our membership shall have increased very considerably. At present we have flourishing Graduates' branches in Coventry and Birmingham, in addition to that in London, and these, in their own centres, have held meetings and also organised excursions to Works and places of interest in their respective neighbourhoods. I am sorry to say that the attendance at these meetings and excursions has not been so good as it should have been, but all three branches shew signs of re-awakening interest, and steps are being considered for assisting this.

An excursion made by the London and Birmingham Graduates by invitation of the Coventry centre to the Coventry district was, however, very successful. Numerous Works were visited, and from the success of this visit, it has been proposed that, in the summer of next year, a visit of the whole of the membership, including the Graduates, shall, if possible, be made to Paris to inspect some of the French automobile factories, and it has been suggested that it should take place in June, 1912. It is expected that should this scheme meet with general appreciation, satisfactory arrangements may be come to so that the expense to Graduates, who do not expect to see the whole of the sights of the city on the Seine, may be sufficiently low to enable a large number to take part in the excursion.

The question of a Summer meeting of the Institution to be held in some Provincial centre at which Papers could be read or debatable subjects discussed, has also been considered by your Council, but for various reasons, not least amongst which is the desirability for awaiting the result of the "extra meetings," it has not appeared to them advisable at present to depart from the usual procedure in respect of the ordinary meetings of the Institution.

The "special meetings" are largely due to the criticism of a number of members as to the general theoretical nature, and the want of practical information in the papers that we have had before the Institution; that a number of the papers that have been read have been over the heads of a large number of workers, who perform a great share of the work of advancement of the automobile industry; and further, that it is desirable that these members should be able to get into touch with immediate progress in specialised portions of the industry, and benefit by the interchange of opinions from the partisans of the different appliances, accessories, and systems which may be brought forward.

Last winter, at the request of Mr. Henry Hess, of Philadelphia, who is now one of our Members, a reciprocal arrangement was made between this Institution and the American Society of Automobile Engineers, whereby a Member of either body finding himself in the country of the other is welcomed as a Member of that body *pro tem.*, from which it is hoped that good may result.

In furtherance of this object, when it was learnt by chance that several of the Members of the Society were proposing to come across for the Olympia Show, your Council thought that it would be a good opportunity to shew them some hospitality and arrange a friendly meeting, and it was proposed to invite the visitors to a dinner, the arrangements for which have now been made.

For the purpose of entertaining our guests, an ample guarantee fund has been raised among the Membership of the Institution.

#### THE INFLUENCE OF DETAIL ON THE DEVELOPMENT OF THE AUTOMOBILE.

In every class of machinery, no matter how well known it may appear to be, either to those engaged in its manufacture or

in its use, there are a large number of details of which many of the individuals connected with the construction have usually no knowledge, and of which the user frequently has less, in other words, he believes them to be quite different from what they actually are. From the ignorance of the small boy who thinks the boiler of the locomotive is completely filled with works, to that of the fireman who thinks the discolouration of his gauge cocks is due to the analysis of the metal—having heard that word used and believing it to be one of the ingredients in it—there are many other forms of ignorance which have contributed throughout to cause delay in the development and use of every class of machinery, and even at the present time many of these factors are still at work delaying that progress which might take place more rapidly were greater consideration given to the minutiae of machinery.

To examine this subject systematically, we shall find that most detail has its origin in design, but that the design is frequently marred in execution, and that the executed work is subjected to abuse by the user and to wear by the conditions under which it works, and it is from the latter end of the story that the cycle of design must recommence, since it must take account of the possibilities involved in use and abuse, and of the certainties involved by wear and tear. The subject, of course, is one which does not admit of being dealt with in general terms for all classes of detail, but it is one which it is easy to illustrate by examples.

To take the first example which comes to hand, that of the steering gear, it is well known that the ordinary Ackermann axle affords a fair compromise for obtaining the intersection of the axes of the front wheels at a point on the axis of the back wheels.

This gear as usually made is fitted with a number of pin joints, all of which are liable to wear, and as wear proceeds, the two front wheels of the vehicle when it is travelling in an approximately straight line, which, after all, represents by far the greater portion of the distance it runs, will, whether the steering bar be in front of or behind the front axle, take up positions such that the horizontal diameters of the steering wheels would intersect behind the car. After a certain stage of wear has taken place, it is thought necessary to put the wheels in gauge again, and most mechanics, if left to themselves, would set the wheels properly and truly parallel. At this point we should ask ourselves whether this is the right thing to do; whether making things “exactly

right" is after all the proper course to adopt, and whether the present example is not an illustration of a distinct advantage to be gained by making adjustments incorrectly in the first instance. If the limit for error in parallelism, determined by experience based on the wear of tyres, is half a degree (or, in the language of the shops, the wheels should not be more than one quarter of an inch out of parallel in a length equal to their diameter), and if, when this error has been reached, it is time to put them right, then why not set them half a degree (or a quarter of an inch) inwards to start with, so that they will start with a negative error no greater than the positive error permissible, and thus double the life will be given to the steering before it becomes necessary to take it up, assuming that want of parallelism is the only reason for the taking up?

Take another case: the bearings of an engine are made and fitted so that there is no shake or knock when the engine is turned round without the ordinary amount of lubricant. Such an engine will run very stiff until its bearings have become sufficiently worn to admit of the proper thickness of oil film for supporting the load. Under present conditions, with the limit gauges and more accurate machine tools available, some of these factors are being incorporated in the design, as recorded by the drawings, but there are many factors which still escape and are not recorded, and it is left to the shops to do as their unwritten experience suggests to them may be right. The tendency in the bigger factories is to diminish the amount of responsibility left to the individual worker in respect to the employment of what, for want of a better term, may be termed "shop knowledge," and the reason may be found in the fact that whereas in the earlier days of engineering the same man both constructed and repaired, now, under modern conditions of output, the man who constructs is of a class quite different from the one who repairs, and the two classes are rapidly becoming almost out of touch with each other. Consequently that form of shop knowledge which was of such use to the mechanic of some years ago and which enabled him to put through work on the imperfect instructions of not very definite drawings, must to-day be replaced by positive information supplied by the designer and embodied in the detail drawings, figured with limiting dimensions and supplemented by specifications.

In the broad and general consideration of detail, the first and

most important point to be dealt with is that of standardisation, and, consequently, interchangeability. In spite of all the efforts of Whitworth and others in creating standards of size and form for screw threads and for other details, there are still numbers of manufacturers in the country who work almost as though such standards had never existed. That is to say, there are firms who will make  $\frac{1}{2}$  in. bolts  $\frac{1}{8}$  in. large or  $\frac{1}{32}$  in. large because the user will get a stronger bolt although he is buying the same size. This will account for the fact that many coach bolts and nuts are not interchangeable. Again, there are numerous makers of screws who claim that their product is within  $\frac{1}{1000}$  in. or  $\frac{1}{500}$  in., as the case may be, but the accuracy of which does not run beyond the written or verbal statement, the actual bolts or screws having an error many times as great. The fit of screws between proper limits is quite as important as the accuracy of pitch and of shape of thread. A loosely fitting screw in machinery subjected to so much vibration as is common with automobile vehicles will ultimately cause waste of time and trouble to the user, if not damage to other parts of the machine, whereas the too tightly fitting screw has its obvious disadvantages.

Standardisation is looked after by committees who formulate very excellent rules which should be followed by the manufacturer, but in many cases there is a want of uniformity in the resulting product which calls for better inspection at the start of operations and for the checking of the gauges to which the work is made. The admirable work now being done by the National Physical Laboratory in connection with all classes of standardisation cannot be overrated; but the importance of the independent checking of commercial standards by such an impartial central authority is not so fully appreciated by manufacturers as it might be, that is to say, standards ought to be stamped, or the equivalent.

Again to take an example, the ordinary pneumatic tyre is supposed to be interchangeable, that is to say, the same rims will do for any of the tyres made by the leading makers. The same pump connection serves for pumping up the inner tube, but it will be found that the same uniformity does not apply to the other details which go to make up the complete tyre on its rim. Security bolts, for instance, have various threads, causing the expenditure of much bad language on the road. The diameters of covers are not always in agreement with the rims within the usual limits, with the result that a cover may prove

to be tight on the rim and may give considerable trouble in getting it into place. The checking of any of these dimensions is beyond the ordinary purchaser or consumer besides being outside his province, and the trouble caused by too great deviation from the standard dimensions is only discovered at a time when it gives great inconvenience. The question again is one of the various limiting dimensions of the rim and of the limits permissible in the cover under normal conditions.

In the wheels of pleasure vehicles ball bearings have been used for some years with increasing success, but their application was delayed through failures, in some cases due to over-loading, and in many others through imperfect provision being made in the casing of the bearing against the entry of water and mud. In fact a considerable period of time elapsed before the various causes which contributed to the failure of ball bearings in road wheels were appreciated at their proper values; the several factors of the provision for taking end-thrust, the amount of the permissible radial load, the exclusion of water and dirt, and the want of uniformity in the quality of the manufactured ball bearings all tending to complicate the commercial solution of the problem. This matter of wheel bearings is essentially one of design, because the ball bearing, when worn, is, in general, beyond repair, so that the question of the prolongation of the life of ball bearings is one which can only be referred back through the repair departments, who effect the renewal, to the designer. The presence of moisture, which has resulted in the failure of ball bearings in the road wheels, has also been found to affect those ball bearings which have been fitted to the crank shafts of some engines, and it has been found that a small amount of water in the lubricating oil will cause a sufficient pitting of the surface of the ball races and of the balls to result in premature failure.

In the engine many improvements in detail have been made, resulting in an enormous advance in respect to silence, speed of revolution, and power for piston area. Apart from such questions as multiplication of the number of cylinders, these improvements, however, have been confined to reduction in the weights of reciprocating parts, alteration of the arrangement and types of valves, modification of the shape of cams and of the size of the cam rollers, care in the selection of the materials and teeth of the gears used for driving the cam shafts, the replacement of low-tension by high-tension magneto ignition, and in general by improvements of details.

It is, however, in the carburettor that the main problem of advance in the internal combustion engine appears at present to lie. Carburettors have been made giving over 50 ton miles per gallon on ordinary touring cars when running at speeds up to 40 miles per hour, and there appears to be no reason why such results should not be easily and regularly obtainable when the carburettor has attained a development as far advanced as that of the high-tension magneto. At present the tuning up of the carburettor is still frequently effected by the expensive method of running the car on the road, involving a considerable expenditure of the time of a skilled tester, the wear and tear of the whole machinery of the car, and the wear and tear of the tyres, which, even if only old tyres are used, must be added to the other costs. It is true that on the road the conditions under which the carburettor is working are quite different from those of the testing bench. The forward movement of the car may give increased air pressure at the intake of the carburettor; the vibration of the car may appreciably alter the mean level in the float chamber and the amount of petrol which flows through the nipple. Usually these matters are adjusted by the tester by varying the size of the orifice in the nipple, but from an examination of the conditions which lead to the necessity for this adjustment, it would appear that it is frequently the level in the petrol chamber which requires adjusting quite as much as does the size of the orifice, and in but few carburettors is any provision made whereby the tester can set the level of the petrol to the desired height otherwise than by filing down the nipple or adding solder to the float.

In the clutch there is less complaint than was formerly common, in fact the peculiarities of leather, cone, and disk clutches have become sufficiently well understood by designers to render this detail one of those which now causes but little difficulty; in the case of metal disk clutches, the difficulties first met with in their use were mainly due to the imperfect knowledge on the part of the user of the proper conditions under which to work them, and, in this case, it is the improvement in the mechanical education of the user that has permitted their continued employment.

With disk clutches, if the plates are allowed to slip, and the throttle is not slightly closed after the drive is taken up, the slip will generally continue when the clutch spring is only slightly stronger than is absolutely necessary for driving the car; and if the slip be allowed to continue, the metal will get abraded into



small particles which act as rollers between the disks. When this occurs it is possible to wear out the disks very rapidly. Practically all owners who use disk clutches now realise that they must close the throttle after they have put the drive on, so that the plates get the larger value of the stiction of the surfaces instead of that of the friction.

In the last few years the question of the reduction of the noise on motor vehicles has been almost entirely dealt with in the engine and gear box, apart from the change from chain drives to live axles. In the gear box noise was found to be produced by errors in the shape of the gear teeth, which caused irregularity in the velocity of the driven shaft accompanied by separation of the driving surfaces at speeds beyond a certain minimum. The improvements in gears have entirely been improvements in detail; the involute form of tooth has been retained and the angle of inclination to the tangent of the path of the point of contact has seldom been varied; on the other hand, not only have the cutters been made of greater accuracy than those employed for the construction of other classes of machinery, but methods have been adopted, such as those for developing gears by hobbing, which of themselves produce a much more accurate approximation to the true form of tooth than was obtainable by older methods. Again, the distortion of the gear wheels which may occur in cementing and in case-hardening has been more thoroughly appreciated, and precautions have been taken by manufacturers which have resulted in a much smaller error in the finished product. In the back axle a source of noise has remained in the bevel gears, which even though made on developing machines, are liable to the introduction of more error than is the case with spur gears. Machines have already been devised, and some are obtainable, for correcting the errors in spur and other gears by grinding, and, should it become necessary to run gearing of light weight transmitting large powers at still higher linear speeds, it may be necessary for manufacturers seriously to consider the subject of grinding the bevel gears as well as the spur gears to the final degree of accuracy required. The back axle difficulty can of course be overcome by the use of a properly designed worm gear, and here again it is detail of design which fully determines the difference between the unsatisfactory and the satisfactory.

In the ordinary touring car there is still one detail which looks

as though it should be altered before long, and that is the want of alinement between the propeller shafts and the shafts in the gear box when the car is under its normal load. It would appear that a simple modification should be possible by which the whole length of shaft would be in alinement from the front of the engine to the centre of the back axle when under normal load. At present the chief difficulty is supposed to lie in the lubrication arrangements for the engine. Now the angle of inclination of the shafting, if it is made lineable, is but small, and is in fact much less than that of any of the gradients up which the engine is required to work at full load. If the uniform lubrication of the engine were assured for a larger range of angle, covering the total inclination of the engine to the frame added to that of the maximum gradient to be ascended, this difficulty would disappear. In the case of the transmission on commercial vehicles, the chain has been found far from unsatisfactory, especially since it has been possible to obtain chain cases which are at the same time simple and sufficiently oil-tight to ensure the chain running continuously in an oil bath. Under such conditions the chain is much more silent, its life is increased to such an extent that the cost of chains as a factor in the running becomes negligible, and chains running in proper oil-tight chain cases can now be guaranteed for a life of over 25,000 miles.

In the case of public service vehicles, the improvements made in detail are immediately noticeable on the London streets, where some of the earliest taxicabs are still running side by side with the latest types. In motor-omnibuses the contrast between the old pattern with the chain gear and the new pattern with the worm drive is still more marked, and here we have a paradox, for some of the more silent omnibuses, though they have no chains in the transmission from the gear box to the back axle, yet have a greater number of chains running at much higher speeds continuously within the gear box itself. The chain itself, therefore, should not be held to blame for the noise, but the cause should be attributed to the faulty method of application of the chain.

Provision for wear and tear is now made more ample than it was in the early days of the self-propelled vehicle, when the motor was frequently constructed in the form which may be called the "sandwich" engine. In this a single plane joint divided the upper from the lower half of the casing, with the half bearings

contained in each of the respective casing halves, so that when it was required to take up such wear as had taken place, it was necessary, after dismantling the engine, to take a cut over the whole surface of one half of the casing, or else entirely to replace the whole of the brasses in the bearings. This arrangement, which would not have been tolerated for a moment by a constructor with ordinary engineering experience, had, however, one great advantage, and that was that it ensured oil-tightness in the casing. Later, when engine cases were first designed so as to make provision for taking up the wear of the main bearings, difficulties in securing oil-tightness were met with which required to be overcome by various arrangements of detail for preventing the loss of oil, or for ensuring its return to the crank-chamber, and, amongst others, in many engines it was found necessary to provide a vent for the escape of such gas as leaked into the crank-chamber, a provision seldom necessary with the sandwich engine. The provision of this air vent might with advantage be adopted in some gear boxes and back axle casings, in which the warming of the lubricant which unavoidably takes place when power is being transmitted causes sufficient expansion of the air contained in the casing to force a small quantity of oil continuously along the shafts, and to cause not only wastage, but, in some cases, the unintentional oiling of the brake surfaces.

Experience has now determined the amount which should be provided for wear in the brakes; brake surfaces have been increased, and provision has been made for an ample range of adjustment in the brake gear. In the earlier designs of automobiles, the designer seldom compared the new or maximum form of the brake shoes or drums with the worn out or minimum thickness, with the result that it was frequently necessary, when adjusting the brakes, to cut the rods for length and re-thread the ends, or to set the levers in order that the necessary adjustment could be effected.

*The Safety of Automobile Traffic.*—The popular denunciation of mechanical traction on account of its alleged danger, usually based on the single factor of its speed, is contradicted very effectively by the figures given in the police statistics for the total number of accidents caused by vehicles which have occurred in the metropolitan area within the last three years for which the returns are available, that is, from 1907 to 1909. During this period the total number of street accidents caused by all

classes of vehicles involving injury actually shows a slight decrease, while the population is estimated to have increased by 1·5 per cent per annum, and the number of automobile vehicles registered has increased by about 19 per cent per annum. Considered on the basis of the population, the accidents per million increased by 50 per cent in the last six years (1891 to 1897) prior to the advent of the automobile; they attained their maximum in 1907, and have decreased by  $2\frac{1}{2}$  per cent in 1908 as compared with 1907, and by nearly 5 per cent in 1909 as compared with 1907.

Accidents, caused by automobile vehicles, excluding those due to the human fallibility of drivers and others, may arise from neglect, from defective material or from defective design. The elimination of the first of these causes is largely a question of management and of the responsibility carried thereby; defective material may be guarded against by proper specification and efficient supervision, but questions of defective or inadequate design, especially in regard to such vital details as the steering gear and the brakes, call, in certain cases, for examination by an independent body. There are many public vehicles now on the road covering long distances from their base, and though these may have passed the local police inspection and be considered adequately fitted for local conditions, yet outside the area of operations of the local authority they may be required to run under very different conditions of maximum gradient and of road surface. From some of the serious accidents which have occurred to such vehicles it would appear necessary that the approval of the design and the inspection of these vehicles prior to their going on the road should be performed by a staff having special technical knowledge. The experience of this staff, as in the case of others appointed to examine into boiler explosions and railway accidents, should be supplemented by an inquiry into the cause of all fatal automobile accidents due to mechanical failure, as in the case of the above-mentioned classes of fatality. These enquiries and inspections should be carried out by a department of the Board of Trade represented by an expert official.

Accessibility is a question which has had a great influence on the design of the automobile, and in some instances may have determined the type which has set the fashion, and fashion in the automobile vehicle plays a more important part than it does in any other class of machinery within my experience. The

necessity for frequent access to the engine, to its ignition gear, to its carburettor and to its valves has ensured the placing of the engine in the front of the car where it could be quickly and most easily reached with the minimum of disturbance to the main portions of the vehicle. This fashion in position of the engine is likely to die very hard, so accustomed have we become to giving up the front of the car to the engine.

Another point is that the early cars were evolved from racing cars, and in racing the driver was naturally given the most comfortable seat on the car, which he retains to the present day. This has influenced design very largely, and I believe it is still an important factor, because those responsible for the design of cars generally test them from the driver's seat, and if the car proves comfortable from that position, the rest is easily accepted as correct.

Accessibility may be divided into two main heads; first, accessibility to those parts which frequently require adjustment requiring no special skill, such as the adjustment of the brakes, of the strength of the clutch spring, of the spark of the ignition devices, and the like, most of which have already been dealt with by the designer in arranging them, and second, accessibility to details requiring skilled attention. In the latter class come the overhauls of engines, gear boxes, axles, etc., and the influence of commercial and public service vehicles on this branch of the subject is only now commencing to make itself felt. The importance of being able to remove parts of a car, unit by unit, that is, engine, gear box, back axle, etc., has now become recognised by those responsible for public service vehicles such as those of the motor omnibus and cab companies, since the conditions of working such services are much more closely allied to those of the railway and the tramway than are the conditions of the private car or even the commercial vehicle. The easy removal of these units complete, and their interchangeability with other similar units on the same class of vehicle are large factors in economically keeping a fleet of public service vehicles upon the road.

Apart from the two broad questions just mentioned, a third and very important factor is that of accessibility to the various parts by those tools used in making the adjustments. With the necessity for keeping down weight has come the reduction in the sizes of nuts below those selected by Whitworth for a material the use

of which in automobiles only occurs in body work—reduction in the size of nuts has been accompanied by reduction in the width of flanges—so the whole of the work has become more cramped and the clearance between the faces of the nut and other adjacent surfaces has been greatly reduced. To put the parts together in the first instance may require the use of special spanners, owing to the fact that the designer has not laid a scale tracing of an ordinary spanner on his drawing and ascertained that it can be effectively used, that he has not tried the clearance between the corners of the nut and the adjacent surfaces to ascertain whether a box spanner will overcome the difficulty, or, if so, that he has not allowed for the height of the box spanner. Ignorance of these factors contributes heavily to the repair bill, especially if such inaccessibility is assisted by the super-imposition of small details, and particularly piping, which requires removal before the main parts become accessible. If these features were considered in design, bolts would often be substituted for studs, long bosses would be cast on parts to enable the nuts or bolt heads to be reached; channels would be milled across faces into which bolt heads could fit to prevent them from turning, and such parts as guardings and covers would be so made that their detachment would be dependent on very few devices, and those of kinds easily secured and readily locked.

The difficulties connected with lubrication in the engines of cars have already been briefly alluded to, but far more important is this subject in the case of the marine motor, in which continual changes of inclination are taking place, and even greater still is its importance in the case of the aeroplane engine, in which the engine shaft is inclined considerably from the horizontal for long periods of time, and in which the question is often further complicated by the use of engines with fixed crank shafts and revolving cylinders.

In the case of engines employed for locomotion on the water or in the air, we come again to the carburettor question as one of the greatest importance for the immediate future. It is a question of such moment that a large proportion of the energy of research workers might well be devoted to it, and if their efforts were assisted by the loan of modern engines adjusted by the makers and supplemented by details of the power and consumption obtained on the test bench, the work would be much facilitated. The work done on steam engines by Willans in the

testing house at Thames Ditton has left its mark on high-speed steam engine design. It is therefore reasonable to hope for similar results from well-directed research on the modern petrol engine.

The existence of the automobile as a practical commercial machine has been shown by others to be largely dependent on materials previously neither readily obtainable nor extensively used, such as rubber, aluminium and petrol; Mr. Lanchester dealt with this subject at very great length, and in so admirable a manner, in his Presidential Address last year, that I have very little to add, except that the same applies to the steels used in construction, which, though previously known, were not only difficult to obtain in the necessary commercial forms, but their proper heat treatment was but imperfectly understood owing to lack of research and of experimental data. In the early days of engineering steel was steel, that is to say, there was wrought-iron or cast steel (tool steel), and mild steel is a comparatively recent product, but with the large number of special steels used in the construction of the automobile, it has become difficult to distinguish by simple tests any one quality from another. Under these circumstances it is necessary that the automobile manufacturer should adopt a system in his works for marking the different qualities of steel (as by painting them a different colour at one end of each bar, for instance), in order that a store-keeper or other unskilled worker may be able to issue or receive the proper quality for any detail required.

Leaving the vehicles of the present, and the position which detail has taken in their development, we may pause to ask ourselves what are the possible detail improvements which will influence the future evolution of light automobile machinery, whether for transport by earth, water, or air, and what effect will they have on the design and construction of the vehicles of the future.

*Fuels.*—Regarding fuel as a storage of energy, we have in petrol nearly 50 per cent more energy per unit weight than is stored in coal, and, moreover, we have it in a more convenient form, owing to the advantage which a liquid possesses over a solid.

Among so-called improvements may be cited solidified petrol, but it is difficult to imagine what possible advantage a solid which is troublesome to handle can have over a liquid which can

be readily led through a pipe from its reservoir to its destination by gravity, or by pressure if gravity will not suffice.

Among gaseous fuels, acetylene has been proposed, and though this compound is to some extent endothermic yet it has not a sufficiently high thermal value to render it a competitor of petrol, particularly as it is unsafe when compressed. It gives, however, a wider range of explosive mixture when mixed with air than the other well known hydrocarbons, and the mixture of acetylene and air fires at a lower temperature than is the case with other gases. In considering the applications of such gases of high calorific value as acetylene or hydrogen, it is only necessary to make a rough calculation to realise that at present no saving, but, on the other hand, a great increase of weight would result were they generated on the vehicle owing to their small weight relatively to that of the compounds used in their production. Moreover, the same applies to the storage of compressed gases, which can only be considered commercially practicable in the case of town gas applied to heavy vehicles engaged on runs of but short mileage between fixed charging points.

The fact that acetylene gives a larger range of explosive mixture than other well-known gases, and that the mixture fires at a lower temperature would point to a possible saving in the weight of the ignition apparatus. This saving would, however, be but small, and affects but little the question of the total energy obtainable within a limit for the combined weight of fuel and engine.

*Lubrication.*—In the desire to reduce the weight of the transmission gear, the diameter of shafts in the early vehicles was reduced to the minimum, and, in order to obtain the requisite area of bearing for carrying the load, the bearings in the gear box were of necessity made long. The spring of the shafts under the heavy loads to which they were subjected resulted in bending to such an extent as to reduce the thickness of the oil film locally below that necessary for efficient lubrication, with the result that in many of these earlier cars, difficulties arose in maintaining the bearings in efficient order. This difficulty has been largely overcome by the use of the ball bearing, which, as it takes up less length of the shaft, reduces the effective span between the supports and diminishes the spring. But this is not the only advantage given by the ball bearing; still more important is the fact that it is capable of working satisfactorily with a greater error of alinement than is possible with a plain bearing. The ball



bearing working under suitable conditions, and provided it is not overloaded in the first instance, appears to be capable of running almost indefinitely when immersed in an oil bath and kept free from small pieces of abraded metal. In fact, in the gear box, ball bearings generally give less trouble than on other portions of the car. Although the ball bearing has such marked advantages when treated in a suitable manner, yet under conditions less favourable, such as those of the road wheels, where a bearing may be called upon to stand excessive and obliquely applied loads, failure is much more easily produced, especially if accelerated by the penetration of water even without dirt, into the bearings as previously mentioned. The effect of water in destroying the smoothness of the surfaces leads to rapid disintegration, and once the ball bearing has begun to fail either by the breakage of the balls, or of the race, its end comes more rapidly than is the case with the plain bearing.

*Increased Motor Efficiency.*—The improvements in the efficiency of motors have been almost inseparably linked with improvements in carburettors; nevertheless improvements in the motor itself have to no small degree contributed to the advance in the amount of power obtainable per unit of weight of motor and in the efficiency of the motor itself as a thermodynamic machine. The consumption of fuel per brake horse-power per hour in the petrol motor has now been reduced to 0.63 lb. Allied to the question of efficiency is the question of obtaining small commercial motors capable of working with a less highly inflammable fuel, such as ordinary paraffin oil. Many attempts have been made to effect this by slight detailed modifications of the engine or of its carburettor, but the problem is one on which mechanical engineers have already spent vast quantities of time and money, the Priestman and the Hornsby-Ackroyd oil engines being examples.

The problem has, however, been tackled recently in a different manner by a method which combines the carburettor with a gas producer. It is well known that if a candle be blown out, the gas which rises from the wick is inflammable, and that a light held some distance above the wick will ignite the mixture of gas and air resulting from the incompleteness of combustion, and that the flame will travel down the ascending column of gas, re-igniting the candle. A similar principle underlies the action of the suction gas producer now used on many gas engines.

A paraffin carburettor has now been produced which resembles

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a gas producer in so far that a portion of the oil supplied to it is partially burnt, but, unlike the case of the ordinary producer in which anthracite or other coal is used, a portion of the heat generated in the partial combustion may be utilised to vaporise an excess of the fuel so that a mixture of producer gas enriched with oil vapour can be admitted to the engine. By keeping the percentage of vapour sufficiently low it is possible to avoid the difficulties, which occur by the clogging of rings and the deposition of carbon when paraffin oil is used direct in the ordinary petrol engine.

Further hope of using heavier and cruder fuel lies in the adaptation of the Diesel principle to the ordinary form of automobile engine. The efficiency of the Diesel engine has now been brought to so high a pitch that engines of 500 horse-power are built with a guaranteed consumption of crude oil as low as 0.42 lb. per brake horse-power per hour at full load. The Diesel engine, however, as at present constructed, is unduly heavy, and some time must elapse before it has been sufficiently modified to be of suitable weight without having lost the efficiency obtainable in its heavy form. Not only is the Diesel principle in its 4-cycle modification a possible rival to the ordinary Otto cycle engine, but the same may occur with the 2-cycle Diesel, to which some considerable amount of attention is being devoted at the present time. Another rival in the field to these engines at some future time will undoubtedly be the internal combustion turbine. In 1884, in a lecture on turbines given by Professor Unwin before the Institution of Civil Engineers, the difficulty in the way of the construction of a steam turbine was tersely summed up by him in the following words:—

“So soon as we can find a material strong enough and durable enough to stand an excessive speed of that kind (1,000 feet per second) so soon we may have steam turbines much smaller and cheaper and not less efficient than ordinary steam engines.”

After the successful progress made by the steam turbine since that date, and its development as predicted by Professor Unwin, it has gone on until it has passed the reciprocating steam engine in economy. A very similar prediction could be made at the present date in regard to the internal combustion turbine, modified in this respect, however, that temperature as well as velocity is a factor to be considered, and that it is to a great extent dependent on the evolution of the turbine gas pump.

*Improvements in Transmission.*—Many attempts have been made to obtain transmissions which are either variable in speed, or which are not merely variable in speed, but also give facilities for storing excess of energy in the motor, and utilizing this stored energy when required. The latter class has been fully dealt with by my predecessor in the Chair, and the former is being developed at the present time by another Past President of this Institution on lines which promise immediate fruition.

*Improvements in Materials of Construction.*—Not only have steels and aluminium alloys been improved in their ultimate tensile strength and in those other physical qualities necessary for the safe employment of such materials in constructional work, but increased knowledge has been obtained as to the proper treatment which these materials should undergo in order to give the best commercial results. The heat treatment of steels, whether for oil tempering or case-hardening, the proper treatment of aluminium alloys in order that the properties of the original mixture may be retained in the castings, and the diffusion of knowledge of rubber treatment and vulcanising outside the highly specialised tyre factories, are instances in point.

In the introduction of mild steel a number of years ago, when it was first used for boiler making, Mr. Daniel Adamson, a mechanical engineer, who was one of the pioneers in this work, made a special study of it as if it were an entirely foreign material, unconnected with iron, before he would trust it, and found out the special points in the treatment of it which were not thoroughly understood, and which had to be mastered, before it could be adopted for boiler making. Going back to that period, we have the classic paper by Stromeyer, read before the Institution of Civil Engineers in January, 1886, on the working of steel at a blue heat, in which he showed that quite apart from the phosphorus, sulphur and silicon in the steel, a steel might be perfectly good, yet by hammering it just below a red heat, it could be made so brittle that if it were given a sharp knock it would drop in half like a piece of very weak cast metal. Apart from Stromeyer's tests, there had been very many other experiments made in the heat treatment of materials. This subject was mentioned in Mr. Martin's paper before this Institution,\* in connection with the machining of drop forgings, and automobile manufacturers

\* See Proc. I. A. E., Vol. I., p. 120.

continue to find it necessary to anneal their drop forgings, so as to be perfectly sure that the heat treatment has been normal before the parts are machined. Again, they are obliged to specify that certain classes of steel should not be used. For instance, drop forgings of basic steel made by the Bessemer process may, with a very light blow from a hammer, break as if made of ordinary crockery-ware, with a finely crystalline fracture, and yet the same stamping put in a vice and twisted with a spanner will be quite as strong as an ordinary piece of mild steel, and will shear with a silky fracture.

There are, however, certain possibilities in the case of steel which may yet have to be considered. It has been found that metallic tantalum has very great hardness and power of resisting wear by abrasion; it is recorded that an attempt to drill a tantalum sheet by means of a diamond drill run at 5,000 revolutions per minute for 72 hours resulted in a penetration of the metal to the extent of  $\frac{1}{4}$  millimetre only, and was accompanied by considerable wearing of the diamond tool. It sounds incredible, but we have it on the excellent authority of Siemens, of Berlin. Now, if we suppose that the surface of a prepared piece of steel could be treated with tantalum in the same way as it can be treated with carbon in the ordinary case-hardening operation, and that, in fact, it could be superficially covered with a firmly adhesive coating of metallic tantalum, it should be possible to reduce any bearing surfaces so treated to dimensions hitherto unapproached under the heaviest loading. In other words, whereas the ball-bearing may be narrower than the plain bearing carrying the same load, a bearing dependent for its rubbing surfaces on a material so much harder could be made still narrower, and accompanying the narrowing of the bearings a large reduction in weight could be effected in many instances.

In respect of bearings carrying very heavy loads, I do not know whether it is generally known that the big lathe centre has the greatest intensity of load carried by any bearing in the ordinary way, and in the very biggest work, the lathes for turning the largest work, it is necessary to look after these centres most carefully and see that they are lubricated, otherwise the small ends of the centres would be apt to shear off and let the work drop. In fact, it is necessary to make special provision for ensuring the continuous lubrication of such centres, and to carefully watch them on account of the slow linear velocity of the bearing surfaces.

*Constructional Material.*—The treatment of ductile materials has up to the present taken the form of drawing into wire and tube, and rolling into plate and bar, so that the forms available have been those of uniform cross-section or of uniform thickness. For many purposes the tube is an extremely efficient constructional factor; the ordinary bicycle affords one of the best examples of its utility in obtaining a light and rigid structure capable of carrying a heavy load while subjected to considerable shock; but nearly half the difficulties in bicycle construction, apart from those of the bearings (solved, as in the case of the motor car, by the ball-bearing) were encountered in the difficulties of making tubes of sections other than cylindrical, of making them tapered, and, above all, of joining the various elements in such manner that strength was not sacrificed at the joint. Attempts to use tube for heavier and larger constructional work have also been made, and a company was formed for producing tubular frame railway goods wagons. The facilities at present existing for preparing and joining the ends of channel sections and the absence of such facilities in the case of tubes, militated greatly against the success of the type. For the standards carrying the trolley wires of the electric tramway, tapered steel tubes are used, and it is a matter probably only of a few years before tapered tubes will become more generally available as constructional material. The instances to which their use would apply are numerous and obvious.

*Cellular Structures.*—The distribution of a given mass of metal into that form in which it will carry the greatest load in bending when employed as a beam of given span, or the greatest load in compression when employed as a strut, is in each case dependent on ability to resist buckling due to failure under compression rather than to actual failure under compressive stress. The stiffening of beams and struts against such failure is a matter studied by the big bridge builders, and it is in large bridge work that one finds the problem of tubular construction seriously considered. In the case of light struts and structures, particularly the parts of aeroplanes, were it possible to construct such parts of cellular form and of metal of high tensile and compressive strength, it is obvious that the weight of many structures could be reduced greatly below that which is at present attainable. The difficulty in the problem lies in the joining of one piece of thin metal to another without sensibly impairing its physical qualities. For certain classes of work of large section, electric

welding has been available, and by its aid good work has been done; for others acetylene welding is being tried at the present time, and it would appear that there is a field open for research on the construction of beams and struts of minimum weight in which the elementary forms are produced from thin sheet or tubes joined by such methods as are commercially available.

In concluding this broad and imperfect survey of recent progress and the possibilities of the immediate future, it appears to me that the development of the automobile vehicle for the next decade lies most largely in the hands and heads of the younger members of the profession who are engaged in the design of vehicles and their accessories. Along the lines laid down by their observation and the intelligent conclusions drawn therefrom, the evolution of the vehicle will in a great measure take place. Broad and striking advances in any particular direction appear likely only to affect certain classes of vehicles, and it is not probable that such advances will come into general use until they have been tried by the test of time and found commercially proved.

ORDINARY GENERAL MEETING *attended by members of the American Society of Automobile Engineers on a visit of inspection to Europe.*

THE PRESIDENT: Gentlemen, I wish first of all to express, on behalf of all of you, our welcome to the American Society of Automobile Engineers on the occasion of this, their first, visit to our country. It is not very many years since this Institution was formed, but I think the Americans have been equal with us, if not slightly before us, in the formation of their own Institution, which surpasses ours in strength of numbers. Certainly I think they are ahead of us in some respects, one of which is their manner of conducting their meetings by holding impromptu discussions. To-night we are to have a paper which none of us have had the opportunity of reading, and this will enable us to see how their plan works.