NOTES ON MOTOR CARS.

Owing to the unavoidable absence of Mr. H. L. Wilkinson, the discussion on the "Deep Leads of Victoria" was deferred until next meeting.

After Mr. C. W. U. Adamson had supplemented his reply to the discussion on "Impure Feed-waters in Boilers," the meeting closed at 10.15 p.m.

PAPERS.

INTRODUCTORY NOTES ON THE MOTOR CAR.

By Prof. W. C. Kernot.

The constantly increasing number of motor cars seen in our streets, coupled with the tidings that reach us of the enormous development of the motor-car industry in Europe and America, suggests that this mode of locomotion is well worthy of the careful attention of a body like ours, which professes to be interested in all new mechanical developments. Consequently, I have endeavoured to put together a few notes of a purely introductory nature that may lead to a discussion which I hope will be far more valuable and instructive than the present short paper can possibly aspire to be. Personally, I confess myself in this subject a beginner, a learner, an inquirer, having many questions to ask, answers to some at least of which I trust my fellow-members may supply, while those unanswered may suggest lines of investigation to be usefully followed by such as possess special facilities for so doing. When steam railways first began to extend widely in Europe and America, many predicted that the horse—that useful friend of man through thousands of years past—would find his occupation gone. Great outcry arose from those engaged in breeding horses and supplying horse feed, harness, and other requisites, and strong opposition was evinced in many quarters to railway extension. But experience soon proved the futility of these anticipations. It was found that railways could not be brought to each man's door, but only to definite depots or stations, whence distribution of both passengers and goods must take place by road, and consequently, largely by horse traction. The augmented traffic due to the superiority of the railway train to the stage coach or waggon led to such an increase in the local use of horse flesh as to more than counterbalance the cessation of the long-distance transit on the main roads. This was 60 to 70 years ago, and since that time the horse and his friends have had no rea-
son to complain of lack of employment. But now a new and apparently most formidable competitor has entered the field. The horseless carriage, or motor car, is doing exactly the same work as the horse-propelled vehicle, and in some cases doing it better. The mechanical motor hitherto confined to the railways is taking possession of the roads and showing speed and power unattainable by animal means. Will horses shortly become extinct, and their skeletons be shown in museums alongside the megatherium? I hardly know what to say. It certainly looks possible. The change, however, will necessarily be very gradual. In rough, mountainous, and roadless countries, the horse will continue to enjoy his monopoly, and even where roads are fairly good, districts where horses, horse feed, and horse knowledge abound will be slow to abandon their time-honoured methods of transit. Further, there is a great deal of history, sentiment, and aesthetic feeling circling round the horse that will long cause him to be retained for purposes of ceremonial, luxury, and as a pet or object of affection. My own hope is that this will be the future lot of a beautiful and gentle animal, while the motor car will take the heavy and exhausting work, and terminate much hardship and cruelty that at present distresses every kindly and sympathetic mind. Although the great and striking development of motoring is of the last five years, the motor vehicle has a long history—longer, indeed, than that of the locomotive, and has more or less been in evidence for nearly a century and a-half. In 1769 a French engineer named Cugnot made a steam motor waggon capable of carrying several tons weight. It travelled, however, very slowly, and was, I believe, condemned as dangerous by the city fathers of Paris. At present it may be seen in the Conservatoire des Arts et Métiers in that city, where I have repeatedly examined it, and considering the state of knowledge at that date, regard it as a very intelligent design. In 1784 Murdoch, who had been assistant to James Watt, made a steam motor tricycle of diminutive size, which is said to have escaped from its maker, and madly careered down a dark and lonely lane in Cornwall. This little machine, after passing as an heirloom to Murdoch's descendants, was bought by Sir Richard Tangye, of Birmingham, and exhibited by him in the Melbourne Centennial Exhibition of 1888, where I had the opportunity of examining it. It corresponded exactly with the diagram given in D. K. Clark's "Railway Machinery," and was a creditable specimen of design and workmanship. Its driving wheel was 9½ inches diameter, its cylinder ¾ inch diameter and 2 inches stroke, its boiler a copper tube, and its furnace a spirit lamp.

In 1802 that erratic and unfortunate genius, Richard Trevethick, made a full-size steam coach on four wheels that actually ran and carried passengers, both in Cornwall, where it was made, and in London. About thirty years later Hancock and Gurney were interested in lines of steam omnibuses that ran in the suburbs of London, and proved a mechanical but not ultimately a financial success. During the latter half of the nineteenth century, the road locomotive, or motor car, has been represented by the steam traction engine, which in various forms has been used in all parts of the world for the con-
NOTES ON MOTOR CARS.

veyance of goods, and in a few rare instances for passengers also. Oppressive legislative requirements, and the difficulty of overcoming the objections of horses and their owners, appear to have limited the use of these machines; nevertheless, they have had a considerable vogue in some countries. Both New South Wales and New Zealand have given them much employment, and I have been astonished at the wonderful way in which a traction engine in the latter country forded rapid rivers, climbed steep and rough ascents, and travelled miles along narrow shelves cut out on the sides of precipitous hills, where the slightest error in steering would have precipitated engine and train hundreds of feet into the valley below.

At the Great International Exhibition in London in 1862, two steam motor cars for passenger service were shown. The most notable was made for Mr. G. Salt, of Saltaire, Yorkshire, by Carrett, Marshall and Co., of Leeds. It weighed six tons, carried twelve passengers, and professed a maximum speed of twenty and an average speed of twelve miles per hour on ordinary roads, carrying coal for 30, and water for 12 miles. From the drawings given in D. K. Clark's "Exhibited Machinery of 1862," I should consider these claims as to performance reasonable. These engines do not appear to have been imitated by others. The circumstances that have led to the great recent development of swift cars for passenger use, intended to fill the role of a gentleman's private carriage, have been—First, the development of the internal combustion engine with oil fuel; and secondly, the invention of the pneumatic tyre. Prior to this the steam engine, with its heavy boiler, its coal, cinders, smoke, and heat, was the only available motive power, whilst solid, iron-tyred wheels caused noise and heavy vibration, unpleasant to passengers and injurious to the mechanism. Now, in the modern oil engine we have a motor that is not one-fourth of the weight of a steam engine of conventional type, which is ready to start at a moment's notice, and which has no furnace or boiler, and which, if in good order, will work for hours without human attention or assistance. True, it has its defects, of which more will be said later in this paper.

The pneumatic tyre, with its perfect elasticity, due to the cushion of air within, was first applied to bicycles by Dunlop about 1890, and the increase in speed and comfort was a revelation. Made on a larger scale, it was found equally effective on motor cars, reducing resistance, and enabling railway speeds to be maintained on ordinary roads, without that vibration which, were such speeds attempted with rigid wheels, would speedily lead to their destruction. The enjoyment to the passengers when the car bounds along the road is also a distinctly pleasant sensation.

The oil engine is really an internal combustion air engine. Air is taken into a cylinder, compressed, then heated to a temperature of probably 2000 degs. Fahrenheit by the ignition of vapourised oil distributed through it. The result of this is a great intensification of pressure. Then the air is allowed to expand, doing work, and finally is exhausted to the atmosphere. The temperature limits between which such an engine works are several times wider than in the case of the
steam engine, and hence, by a well-known thermodynamic law, the oil
engine ought to obtain three or four times as much power from a given
number of units of applied heat as a steam engine. As a matter of
fact, even with all its present practical limitations and defects—which
are many—it is at least twice as efficient as the best steam engine of
similar power.

Successful internal combustive engines date from the discovery of
the cycle of four strokes by Beau de Rochas in 1862, which was first
practically applied by Otto and Crossley in 1877. This at once gave
us the gas engine, which speedily displaced the smaller steam engines
in towns having a gas supply; the inducement to change being not so
much absolute economy in cost of fuel as convenience, saving of skilled
attention, absence of smoke, coal, cinders, and, by no means least, sav-
ing in insurance, the gas engine being far more favourably regarded by
insurance companies than its predecessor.

The gas engine was in a few years followed by the oil engine, the
change from one to the other not being large. The oil engine is simply
a gas engine in which the gas is replaced by an oil spray or vapour, the
economy of fuel and simplicity of working being a great recommenda-
tion. In the early days oil engines were much used in Coolgardie and
Kalgoorlie, as much as 50-horse power in one engine-room being not
unknown.

The extreme lightness of the oil engine, with its supply of fuel in-
cluded, soon attracted the notice of manufacturers of bicycles, and by
attaching a small engine to a bicycle great increase of speed was ob-
tained. Motor bicycles first made their appearance as pacing ap-
pliances in cycle races, but before long came into somewhat general use
by those who desired greater and more sustained speed than they could
accomplish by muscular power. About the same time oil-engine motor
cars gradually came into vogue, especially in France, whence they
spread to other lands. A further and most interesting application of
the oil engine is to flying machines. A cigar-shaped balloon, driven by
a screw propeller actuated by an oil engine, has, in the hands of Santos
Dumont, accomplished results in aerial navigation far beyond anything
previously effected. But whilst the oil engine has accomplished all
this, giving us the motor bicycle, the high-speed motor car, and a fairly
successful flying machine, it has many limitations, defects, and incon-
veniences, which have led to other Richmonds entering the field. Spe-
cially-built steam engines, with oil fuel and automatic regulation, have
been, and are still, advocated by at least a respectable minority of
motorists, whilst electricity has many champions. How, then are we to
decide between the three competitors—the oil engine, steam, and elec-
tricity?

Many competitions have been held in Europe, America, and of late
in Victoria: races from Paris to Berlin, at speeds of 50 miles an hour
and over; hill-climbing competitions; and here an Easter tour a few
week ago, and a gymkhana at Moonee Ponds. Now, while by no means
denying the utility of these contests, I cannot regard them as at all con-
clusive. The best performance of a specially-prepared car under ex-
extreme and unusual conditions may be far from coinciding with the best average performance over a long duration of ordinary conditions. No one would, I suppose, advocate the use of the winner of the Melbourne Cup to draw the vehicle used by a medical man in his every-day practice. A racing yacht such as Sir T. Lipton's "Shamrock" is not likely to be a comfortable cruising boat for a party of tourists.

To tell which is the best car in average hands, under average conditions, is another and much more difficult problem. Racing cars tearing over hundreds of miles of road, killing, maiming, roasting alive their drivers or innocent spectators, I cannot regard as either useful or desirable. I have no doubt as to the possibility of attaining a speed of even 100 miles an hour over a fairly good road, but I feel the strongest disapproval of attempting it, except on a specially enclosed roadway from which the public are excluded. Legislation is proposed, and in some places already exists, limiting the speed to 20 miles per hour in the country, and 10 miles an hour in town, and some such limit I heartily approve of, both in the interests of the public and the motorists themselves.

My own idea of a good motor car is this: It should be the car which could make the best average speed over an average road, without ever exceeding a given maximum of, say, 20 miles per hour. A car which crawled up hill, and made up for time thus lost by going at a breakneck speed down hill, I would utterly condemn. Further, it should be safe, convenient, comfortable, reliable, and easily operated. It should be economical, not merely in the one item of fuel consumed, to which many people seem to attach such an exaggerated importance, but in its whole maintenance charges over a series of years. It is quite possible that one type of car might be the best for one road and average length of journey, and another car the best for another road and length of journey. Let us now look at the various types of cars in the field, and see how they compare. Firstly, everyone who has carefully considered the question agrees that for convenience, comfort, safety, and ease of operation, the electric car is unsurpassable. The driver has nothing to do but move a small handle, and the car at once responds. There is nothing else to distract his attention, which can be fully concentrated on the steering. The mechanism, consisting merely of a few rotating parts, is of the simplest, smoothest-running, and most durable character. Why, then, seek any other motive power? The answer is that the field of action of electricity is very limited. The accumulators or storage cells are heavy, costly, and of doubtful durability. The process of recharging them when exhausted is tedious, occupying hours, during which the car is not available for use, and this recharging can be effected only where electric current of a suitable kind is available. These limitations, and especially the last one, will for many years prevent the use of the electric car in Australia, except in certain favoured localities. We are left, therefore, to the direct internal combustion oil engine and the up-to-date motor steam engine as our two alternatives, and how to make a wise choice between these two is a problem that has for some time oppressed me as a prospective owner of a horseless vehicle; and
with the view of arriving at a solution I have made a number of personal observations upon no less than four oil engines and four steam motor cars, involving travelling about 250 miles over roads of the most varying character, besides seeking such information as others could supply. First, as to the oil engines. These I find to be complex, delicate, and tricky. They are not self-starting, and cannot be reversed. To adapt them to the various conditions of the road and requirements of the journey, a complex system of clutches, brakes, and epicyclic nests of wheels has to be brought into action, interesting in the extreme as a kinematical problem, but unless carefully looked after and adjusted frequently, likely to cause trouble. In my very limited experience I have already seen serious difficulty arise with this mechanism. Further, the cycle of the engine being one requiring four strokes to complete, the driving is very irregular, and this irregularity can be minimised only in one of two ways, both open to objection. The first is to load up the vehicle with an enormous fly-wheel weighing often a fourth of the total weight of the car; the other is to multiply cylinders, with all their attendant complications. To obtain as steady a driving force as an ordinary locomotive does with its two double-acting cylinders, we should need no less than eight oil engine cylinders, each with its full complement of valves and electric igniters. Most makers adopt a middle course, having either two or four cylinders, and a moderate fly-wheel, but whether this is better or worse than one cylinder and a large fly-wheel may be questioned, in view of the complication and the fact that it is often very difficult to get all the cylinders of these multiple engines to act in unison. I read recently of a British submarine which had sixteen cylinders in her oil engine, that it had never been known for all these cylinders to work at the same time, there always being one or more inactive, and constituting a drag on the rest. The usual experience with a single-cylinder oil engine is this: You carefully see that the fuel supply, the air supply, the electric ignition, and the lubricating arrangements are right, and then you turn a handle. If in a good humour the engine at once catches on with a vigorous snort. You then mount, and by the appropriate lever gear the engine on to the wheels, and proceed rejoicingly on your way. But not infrequently the engine makes no response. You turn and turn, you get hot and weary, you adjust one thing after another, but without avail; the brute mocks you. I have known this to continue for an hour. At last, suddenly, and without any discoverable reason, the thing starts and works beautifully, leaving you in utter ignorance of what was wrong, and totally without means of finding out how to prevent a similar occurrence in future. On these occasions I have been irresistibly reminded of the poet's description of the little girl who,

"When she was good she was very, very good,
And when she was bad, she was horrid."

In this respect multi-cylinder cars seem to be better than single cylinder, I suppose because if one cylinder is in a bad humour there is some chance of another being more amiable.
Should it be said that I have been unfortunate in my cars or drivers, I would reply that in two instances at least the cars were by extremely eminent makers, who had turned out hundreds, if not thousands, of similar vehicles, and were in the hands of persons of fair, and even large, experience as drivers; but, nevertheless, I have yet to make a journey of over 25 miles on an oil-engine car without some annoying and perplexing stoppage of from ten minutes to an hour's duration.

The fuel used for these engines is petrol, a light, highly inflammable, hydro-carbon oil, which will flash and burn at ordinary temperatures. It is expensive, and cannot be obtained in the country. On the recent Easter tour, special petrol depots had to be made before the cars could set out on their journey. In the event of upset or collision, involving the spilling of many gallons of this material, it might easily be ignited, and lead to appalling consequences, such as caused the death of a driver in a recent French road race. Further, this material is very volatile, and in a long journey in hot weather the loss by evaporation might be serious.

On the other hand, it is only fair to state that the oil consumption is very moderate. A car carrying two passengers easily, and three or even four at a pinch, has travelled with the writer on board 100 miles over by no means first-class roads at a fair speed with a consumption of only one gallon to 25 miles. There would have been little difficulty in carrying oil for 100 miles on this car with a little special arrangement.

Amongst minor defects in the oil-engine cars under observation may be mentioned, first, the unpleasant shuddering or vibration when the car is at rest and the engine running, the loud snorting noise and the smell, though this was rarely perceptible to the passengers, however offensive it might be to others; and, lastly, the fact that the speed and power could not be varied gradually, but only by considerable jumps, so to speak. Thus it often happened that when a hill was just too steep to be negotiated at full speed, it was necessary at once to drop to less than half-speed, which was unpleasantly slow and tedious. This was specially noticeable in a small car having only two speeds, and the need of a third or intermediate speed, could it have been obtained without undue complication, was evident.

To perform a journey in good time without at any part running at a rate inconveniently or dangerously high, it is absolutely necessary to have a fair speed up hill and over rough pieces of road. Far more can be gained this way than by running at breakneck rate down hill, or on easy portions, as the subjoined simple calculation will show. Suppose a road, one mile long, half up hill and half down hill; let one car have a uniform speed of twelve miles an hour throughout, it will perform the journey in five minutes. Now, let another car have a speed of eight miles per hour only up hill, it will take $3\frac{3}{4}$ minutes to do the up-hill half-mile, leaving only $1\frac{1}{4}$ minutes for the down-hill half-mile if it is to hold its own with the first car, and this means a speed of no less than 24 miles an hour, or double that of the first. The importance of good speed up hill is now universally recognised by railway men, and for this reason great power is insisted upon in modern express locomotives. In
this respect oil-engine cars, in my experience, are apt to be defective. They are slow up hill, and so lose time that cannot be recovered except by employing a dangerously high speed down hill.

With respect to the durability of the mechanism of these cars, it is difficult to speak, but the very high speed of rotation of the engines and epicyclic gears, and the rapidity with which a cylinder has been known to be utterly ruined by a temporary failure of the cooling and lubricating arrangements, does not lead me to be optimistic.

Turning now to the steam cars, we find these to consist of mechanism identical with that so well tried and proved by long years of service on railway locomotives and elsewhere—Two double-acting cylinders, with cranks at right angles, slide or piston valves, and link motive gear for reversing and varying power, running at a moderate speed and totally free from epicyclic complications. This seems in every respect superior to its competitor. It is self-starting directly steam is turned on, has a continuous and fairly uniform driving force, having no dead points, and needing no fly-wheel. It is thoroughly reliable, very durable, and cannot possibly fail to work so long as its mechanism is intact. When the car is at rest, it stops absolutely, so that there is no unpleasant shuddering vibration or waste of fuel. Should cylinder lubrication fail no great harm is done. Engines have run for years with no cylinder lubrication other than that provided by the steam itself, though, no doubt, with some augmentation of friction and wear. It is adapted with the minutest delicacy of graduation to every variation of grade or road surface, responding to the most minute movement of the reversing lever. Owing to the thermal storage of the water in the boiler, there is a reserve of power, which can be always called into action to ascend a steep hill without loss of speed. In illustration of this fact I may say that I have ascended the noted steep hill of Heidelberg from the lower road past the Incurable Hospital, in a steam car, with hardly any loss of speed, and have done the same on Curly Hill, Keilor. The steam pressure, it is true, dropped by about 40 per cent. while doing so, but soon recovered on the level or down-hill road following. Its smoothness of running gives it a charm that no petrol car can aspire to, while the certainty of its action relieves the mind of the driver from the harassing fear of absolute stoppage owing to some minute and hardly discoverable lack of adjustment. The steam engine may not work quite as well at one time as at another, it is true. One day it may be a little slower than another, but for it suddenly and absolutely to stick fast for some almost undiscoverable reason, as the oil engine so often does, is impossible.

Why, then, does it not come into universal use? What is the utmost that can be said against it from either a practical or a sentimental point of view? What are its defects, and how far are they serious?

Well, first: The steam car requires about fifteen minutes in which to raise steam. If, after lying unused for some hours or days, it is urgently needed for some sudden emergency, it is not ready at once; the petrol car is.

Second: It uses at least twice as much fuel to do the same work.
small petrol car will consume less than one pennyworth of petrol per mile, while a steam car of equal size may consume double as much, and for a given journey require to carry double the weight. On the other hand, the steam car will, I am assured, work well with kerosene, which costs per gallon about half as much as petrol, and, further, can be obtained in any little country township, which petrol cannot. Further, in the event of accident, kerosene is much safer from risk of sudden conflagration. This I have proved by actual experiment. Apart from the objection of some extra weight to carry, the kerosene on the steam car is little, if any, more expensive than the petrol on the oil car, is much more easily replenished, and unquestionably safer.

If the steam engine proves, as I believe it will, lighter in the way of repair charges than the other, it may, fuel and repairs taken together, easily beat it.

Third: The steam car consumes a large quantity of water, unless provided with a heavy, costly, and troublesome condensing apparatus. This is a point of considerable import. The steam cars with which I am acquainted, carrying a maximum of four passengers, need fully 10 lbs. weight of water per mile, and cannot, with their full load, carry water for more than about 20 miles, and at intervals not exceeding this supplies of really good water must be available. With the small and delicate boilers, any impurity in the water would soon do most serious damage, and the use of these cars, in limestone countries for example, might be disastrous. In and near Melbourne, however, the Yan Yean water is available, and my own experience with large boilers is that it is an almost ideal water. Hence Melbourne should be a favourable place for steam motor cars.

The principal reasons that cause me to hesitate in at once ordering a steam car are vague predictions of boiler troubles and burner troubles, the burner being practically what is known as a Primus stove. Are these predictions worthy of regard, or should they be at once brushed aside? That is the question.

In conclusion, I submit what appears to me a conservative estimate of the cost of running a petrol and steam car, based upon inquiry and experience with bicycles and small machinery, the cars to carry two adults easily with luggage, or two adults and two children without luggage, to be of about 5-horse power, and capable of maintaining an average speed of at least twelve miles per hour on such roads as we have in and near Melbourne:

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Or about 1½d. per mile per passenger, which is, I think, satisfactorily low.

In conclusion, I would quote from a paper read by Mr. Clarkson at the Society of Arts, London, in February last, and published in abstract by the "Argus" recently, giving the results of nine weeks' constant work of a steam-motor omnibus, carrying fourteen passengers, burning paraffin or kerosene, having hard rubber tyres:—Cost per mile in pence: Fuel, 1.42; lubricant, .16; tyres, .96; general, .39—total, 2.93; or, per passenger carried, .21 penny per mile; total distance run, 3032 miles; in view of which my preceding estimate will certainly appear not too low.
AIR IN RELATION TO BOILER-FEEDS.

In conclusion, very simple means suffice for proximate commercial analysis. The gases may be bubbled into a piece of ordinary glass tube sealed at one end—a plugged gauge-glass, for instance, or even an ordinary phial—filled with water, and inverted into a reservoir of the same fluid. When the gas has been collected, the tube should be lowered until the water levels within and without coincide, then closed with a well-fitting soft rubber cork and inverted, and the position of the water noted or marked. Temporary variations of level due to the insertion of the cork are of no consequence; the subsequent procedure rectifies them. Replaced in the original position, the cork is removed, a piece of stick potash \( \frac{3}{4} \) in. x \( \frac{1}{4} \) in. in diameter inserted, and the cork replaced—all under water. After agitation the variation of level—if any—due to the absorption of the carbon dioxide is noted, as before.

Next, a 2-grain pyro tabloid (stocked by all photo chemical dealers) is inserted, and a similar procedure followed; absorption of oxygen results.

Finally, the several volumes are ascertained by filling the tube from a graduated measure and noting the volumes between the several marks, and to the lip of the tube.

A little practice with a mixture of known composition—air for instance—will impart the necessary dexterity and confidence.

DISCUSSIONS.

INTRODUCTORY NOTES ON THE MOTOR CAR.

After the reading of the above paper, Professor W. C. Kernot expressed a wish that it might be freely discussed.

The President thanked Professor Kernot for his interesting contribution to a live subject. The time for discussion was limited, but perhaps some present might wish to make a few observations. His own experience of petrol cars led him to form the opinion that there was decided room for improvement, but he remarked that the British army authorities had adopted petrol cars for transport and observation purposes; therefore, presumably the steam car had not yet arrived at their standard of efficiency.

Mr. J. H. 1. Bilton desired to know whether in his experience with steam cars Professor Kernot had met with leaky tubes, burst gauge-glasses, etc. These seemed to him to be the sort of difficulties to be anticipated.

Prof. Kernot said his experience had as yet been restricted to some three hundred miles of travelling; therefore, his own opportunities to en-
counter difficulties had been limited, but he could quote two quite extended journeys by others in which none of the accidents alluded to by Mr. Bilton had occurred. A gauge-glass had given way, but that was due to an improper tightening of the gland. In such a case it was easy to substitute a new glass, and the automatic ball valves at once cut off the escape of both steam and water; the boiler could then be worked by the try-cocks.

As to the selection by the military authorities cited by the President, much depended upon where the cars were to be used, and for what class of work. Thornycroft claimed that the Admiralty had awarded him a first-class prize for a large steam motor car for heavy work.

If the quality of the water supply were doubtful, that would be a grave argument in favour of petrol, but the water in and around Melbourne was so excellent that here this need not be taken into consideration.

The President inquired whether the Admiralty fire-tube boiler was used in the cars referred to?

Professor Kernot said that in Melbourne there were two forms in use: one, multitubular boilers, something like the vertical boilers of ordinary hoisting engines; the other, with spiral tubes in the fire-box. He had made two very successful trips on cars fitted with boilers of the latter type. One such car had run 3000 miles with no other mishap than that the boiler had run dry on one occasion. If the spiral tubes became scaled through the use of impure water, it would be necessary to take the boiler to pieces to remove the incrustation; being bolted together this could easily be done.

Mr. J. A. Smith presumed that a more extended opportunity for discussion would be afforded at next meeting, after the paper had been perused at leisure.

The discussion was then adjourned.

IMPURE FEED-WATERS IN BOILERS.

(Continued).

Mr. C. W. U. Adamson thought in the first place there was no doubt that the most important point of all was the oil question, and he fully agreed with Mr. Rossiter as to the value of a Green's Economiser in a surface condensing plant. There seemed to be no certainty as to what would happen, and results varied very materially in plants working under apparently similar conditions. This applied whether the boilers were water-tube or shell, but he had observed in cases where economisers were installed a distinct improvement in the condition of the heating surfaces of the boilers.

He noted Mr. Clements' experience, but could hardly agree with him, as he (the speaker) found that oil was deposited where evaporation took place—viz., over the furnace in a shell boiler, and in the tubes nearest the fire in the water-tube type.
pose to expend, and shall neither incur any liabilities nor enter into any contract on behalf of the Institute, except as authorised by the Council”—

and called upon Mr. Smith to speak to the question.

Mr. J. A. Smith said there was no need to labour the point. The proposition was to extend a rule, at present only relating to one Committee, to all. It would ensure a complete check upon expenditure, not at present existing. He proposed the motion in the above words.

Professor W. C. Kernot, in seconding, said it gave additional security, and the Institute could not be too careful. Carried unanimously.

Professor W. C. Kernot's paper, "Introductory Notes on Motor-cars," was discussed, and the discussion closed. The President thanked Professor Kernot and others for the interesting contributions to the question, and said that, owing to the lateness of the hour, perhaps consideration of Mr. J. A. Smith’s paper on “Air in Relation to Boiler Feeds” had better be postponed.

Mr. W. C. Rowe said that Mr. Smith’s paper deserved leisurely consideration. He moved, and Mr. W. J. Newbigin seconded, that the matter be postponed to, and take precedence at, the next meeting. Carried.

At 10.10 p.m. the meeting adjourned.

DISCUSSIONS.

INTRODUCTORY NOTES ON THE MOTOR CAR.

Referring to Professor W. C. Kernot’s paper, the President said perhaps there was no class of machinery at present demanding such perfect workmanship and materials as did the motor-car.

Probably an important side-issue would be a great improvement of roads. Possibly, in the future, the light traffic—motor-cars, etc.—would be confined to a special section of the road, the heavier vehicles to another; this would certainly be desirable.

He (the speaker) had enjoyed a trip in Professor Kernot’s car, and considered the steam-car infinitely more comfortable to ride in than the petrol-motor. The former was also efficient even on steep grades.
He would like a more definite definition of "ordinary temperature," in regard to Professor Kernot's remarks in reference to the inflammability of petrol.

The opening historical sketch given in the paper was valuable. He had travelled in such steam-cars, running very successfully in the neighbourhood of Glasgow thirty years ago. After a fatal explosion in one case they were taken off the road.

As to speed, Professor Kernot suggested ten and twenty miles as the maxima for the town and country respectively. He (the speaker) quite agreed that ten miles was a fair rate for the town, but thought the average speed might exceed twenty miles per hour upon little-frequented country roads.

He was impressed by the great care the manufacturers exercised in utilising waste heat. After a run of a few miles the feed water-tank was almost at boiling-point, the exhaust then escaping almost inaudibly into the atmosphere.

Professor W. C. Kernot said that, in respect to the definition of "ordinary temperature," he had placed a tablespoonful of petrol in a saucer upon the ground during an ordinary cold winter's day; it instantly flashed when a match was brought within eight inches; evidently it was highly inflammable. He did not doubt it could be stored with safety, if proper precautions were taken.

As to permissible speed: he found a maximum of twenty miles upon country roads enough for himself. Over that speed the steering became somewhat wild. However, speed on country roads was of minor consequence. Ten miles should suffice in towns; with a powerful car, one was sometimes tempted to run too fast. He had some further notes that, if read now, might be useful in discussion.

They were as follow:

**ADDITIONAL NOTES.**

I had hoped to obtain valuable criticisms and suggestions to guide me in the choice of a car from the members of the Institute; but the reading of my paper being unavoidably delayed, I was compelled, by circumstances, to act on my own initiative, and have, in consequence, purchased a small steam-car of American make, by a firm who in years past have had a very high reputation for their bicycles, and with this I have made a number of experiments involving travelling about 350 miles, and am well satisfied with the results. The particulars are as follow:

**Weight.**—Empty 1050 lbs.

Roadworthy 1450 lbs.

**Boiler.**—Steel shell—19 in. diameter, 18 in. high—with internal fire-box 15 in. diameter, filled with long convoluted water-tubes about \( \frac{1}{4} \) in. diameter. Test pressure, 600 lbs. per sq. in. Safety-valve blows at 250 lbs. per sq. in.; claimed to combine the
thermal storage of the shell with the rapid action of a flash-boiler. Contains 4 gallons of water, and is provided with a super-heating chamber.

**ENGINE.** — Two double-acting inverted cylinders, 3 in. diameter and 4 in. stroke, with cranks at right angles. Piston-valves and link motion; an exact model of our latest passenger locomotives; connected to driving-wheels by sprockets and chain of ample size, and proportioned so as to be equivalent to direct driving on a wheel 12 in. diameter. Calculated tractive force, allowing mean effective pressure in cylinder to be \( \frac{3}{4} \) of boiler pressure, 561 lbs. A rough experiment, pulling against a spring-balance, confirms this.

**WATER SUPPLY.** — A tank holding 31 gallons, and lasting for a journey of thirty to thirty-five miles, according to state of road, etc. Feed-pump actuated by engine with an effective feed-heater. Auxiliary hand-pump that can be actuated while car is in motion, to use in case of failure of engine-pump.

**FUEL SUPPLY.** — Benzine, gasoline, or kerosene; the latter said to make more soot than the others. I am using benzine at 1s. a gallon. Fuel-tanks hold 9 gallons, and suffice for eighty miles. Air pressure of 40 to 50 lbs. per sq. in. kept on fuel by pump worked off engine. Burner on principle of Primus stove. Spare hand-pump can be worked while car is travelling, in case of failure of engine air-pump. Gets up steam in fifteen minutes, easily; has done it in nine minutes. Fuel cut off by adjustable diaphragm device at any desired pressure of steam, so there is no waste, and safety-valve comes into play only if diaphragm does not act properly.

**PERFORMANCE.** — A similar car to mine carried me fourteen miles in fifty-eight minutes with considerable hindrance from bad road and other causes.

My car did one and three-quarter miles, easily, in 6 min. 43 secs., returning to starting-point without losing steam pressure. It did the great Heidelberg hill in 3 min. 50 secs., easily, and I believe could have done it in half a minute less with more practice in handling. This places it in a good position amongst the cars recently tested there.

It also did 15 chains of 1 in 33 ascending grade at 15.4 miles per hour, and 6 chains of 1 in 20 at 15.8 miles per hour, under disadvantages from other traffic, etc., and from a standing start. It also did \( \frac{1}{2} \) mile in 2 min. 10 secs., ascending 145 ft., on average grade of 1 in 18. A duplicate car to mine went to Geelong (45 miles) in 3 hours running time, over inferior and rough roads. All these were with heavy load of passengers, water, and fuel.

**ACCOMMODATION.** — Carries two adults easily; three with a crush; and has carried four on one occasion.
Exhaust Steam.—Extends about 10 ft. back in cold, damp weather; in dry, warm weather, will be invisible. Is no nuisance to passengers.

Smell.—Very little.

General.—For quietness and smoothness of running, and ease and simplicity of manipulation, is simply perfect. Revised estimate of running cost per mile:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>1.30</td>
</tr>
<tr>
<td>Lubricant</td>
<td>0.25</td>
</tr>
<tr>
<td>Tyres</td>
<td>0.60</td>
</tr>
<tr>
<td>General, say</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.15</strong></td>
</tr>
</tbody>
</table>

With a fair allowance for interest and depreciation, say 5d. to 6d. per mile.

[The boiler was illustrated upon the blackboard.]

Four cars of this type were in use in Melbourne, two fitted with condensers. Admittedly those with condensers could go further on a given supply of water, but the condenser added to the weight. He preferred the non-condensing type.

Petrol-cars were much the more economical in fuel, but it must be remembered that this was one item only.

Including a fair allowance for interest and depreciation, he thought 5d. or 6d. would cover everything, and did not think that a horse and vehicle could compare with this for the same work.

The President asked how the burners were cleaned.

Professor Kernot said a little turpentine might be used, but after 410 miles' running only one had required this treatment.

In reply to the President: He could not say whether the small super-heater was efficient or not, but after running a few yards with the draincocks open there was no sign of water from them, nor was there any thumping in the cylinder after standing five or ten minutes; apparently there was a good deal of super-heat in the steam.

Although weighing only 50 lbs., the engine exerted about 8 h.p. The lubrication was on the splash system, and after 4,000 or 5,000 miles' run, similar engines did not show signs of wear.

The reversing lever was connected to the throttle, and controlled both functions; if left free, it assumed a central position, and the car stopped.

To sum up, he knew that the steam cars were less popular and less used here than the petrol type; but in America, the former were very largely used, and apparently liked; though in Europe they did not seem to have been extensively adopted.

In reply to the President: He thought that if a thoroughly
reliable light storage battery and means of recharging were available, no car other than the electrical need be thought about.

Mr. J. A. Smith desired to touch upon a few points of detail. First, the combined reversing-lever and regulator. He remembered a similar arrangement fitted to a "Rowan" steam railway-car running on the Victorian railways about twenty years ago.

Next, in the car described the proportion of tractive power to load was about one to three. On a railway an engine having about 12,000 lbs. draw-bar pull would haul—moderate speeds and grades—240 tons gross, equal to about 50 lbs. per ton, or about sixteen times less engine ratio than that provided in the car; therefore the latter would appear to be very heavily engined, although it had to negotiate far heavier grades than the locomotive.

He had had a short run on Professor Kernot’s car, and had never travelled on one before that ran so sweetly. On petrol cars the engines were often very much in evidence, and after the present novelty of motoring had passed, that would demand, and no doubt receive, attention. The absence of jar and throb in the steam car was nearly perfect.

He thought simplification might, perhaps, be possible by direct driving and the utilisation of relatively long stroke oscillating cylinders, permitting of compactness of design, consequent upon the elimination of the connecting-rod.

Professor Kernot: Did he understand that the disuse of gearing was suggested?

Mr. Smith: Simplification would seem to point in that direction.

Another point was the exhaust, in a super-saturated condition, of the atmosphere. He had observed the complete envelopment, by the exhaust, of a car in a Melbourne street on a foggy morning. Probably that was abnormal.

Professor Kernot: The exhaust should not be perceptible, except at full speed on a steep hill.

Mr. Smith: As to the relative efficiencies of internal combustion and steam-engines. It must be remembered that in the former available B.T.U.’s were wasted by the water-jacket necessary to ensure working conditions, and that the high initial temperature could not therefore be fully utilised. Therefore the relative efficiency would not be so great as the theoretical thermal range would imply.

In the petrol motor the intensity of the stress, and the number of reversals of stress, in the moving parts, in unit time, as compared with the steam-engine, was considerably increased. Wear would be found to increase in very rapid ratio as the number of reversals increased.
In the case of steam, there would be some delay in preparing for a run.

Professor Kernot: We have got ready in nine minutes, easily in fifteen.

Mr. Smith: When the question of comfort was taken into account, he thought that steam might share the future with petrol.

Mr. W. J. Newbigin thought the statement in the paper—"The temperature limits between which such an engine works are several times wider than in the case of the steam-engine, and hence, by a well-known thermodynamic law, the oil-engine should obtain three or four times as much power from a given number of heat units"—misleading. The assumption seemed to be that it was range of temperature that affected efficiency; really, the final temperature was far more important.

For instance, compare oil 2,000 deg. initial, 1,000 deg. final and steam at 500 deg. initial, 100 deg. final. The range in the former was nearly two and a half times as great as in the latter, but the theoretical thermal efficiency was almost the same. This question of temperature range was frequently misstated, especially in regard to the adoption of high initial temperatures. In general practice thermal efficiency was largely a function of the terminal temperature, and if this could be materially reduced the value of high initial temperatures was comparatively unimportant.

Mr. A. G. M. Michell said the discussion had been, so far, somewhat one-sided.

In regard to Professor Kernot's remarks characterising the oil-car as "complex, delicate, and tricky" [p. 6], and the further statement in the paper that the "oil-car cannot be easily reversed," it might be asked whether these strictures referred to the engine or to the car; if the former, then there was no more difficulty than with the steam engine. The reversal could be effected by extremely simple means, as, for instance, in the Pétréano engine.

Professor Kernot spoke of the driving being "very irregular because there was only one working stroke every two revolutions, . . . ." and said that, "To obtain as steady a driving force as an ordinary locomotive does with its two double-acting cylinders, we should require no less than eight oil-engine cylinders . . . ." Such a position was dynamically unsound; he would point out that the regularity of driving depended only on the number of impulses per second, not on the number per revolution.

For instance, he had heard Mr. Newbigin say with regard to the Parsons steam turbines, that there was only one impulse in a large number of revolutions, and the turbines were not remarkable for unsteadiness.
Professor Kernot: Did Mr. Newbigin specify the number of revolutions per impulse?

Mr. Newbigin: About fifty.

Mr. Michell: Most decent oil-cars had two cylinders at least; therefore in the case of a locomotive running at the speed of a motor-car, there would be only about half the number of impulses as compared with the oil engine.

With the oil-car there was no fore and aft motion, such as was felt on the footplate of a locomotive, or on a steam car, when going slow up hill.

On the next page it was said of the steam-car, that "the mechanism is identical with that . . . on railway locomotives." He wondered, if that were the case, what that chain was doing that connected the engine shaft with the rear axle in common steam-cars; also whether there was not a set of differential gearing on the driving axle of the car.

The things mentioned in the historic introduction had taken place before the present development for motor-car purposes; so that all criticisms based upon them were quite invalid.

He thought the author quite singular in disparaging high-power racing machines. He (the speaker) considered them to be the machines of most interest to the mechanical man. The designing of one of them required the application of a larger number of physical principles than any other machine he knew. The drawings formed indeed, quite an encyclopaedia of mechanical engineering.

Mr. W. C. Rowe expressed regret at his absence during the reading of Professor Kernot's additional notes. Sixpence per mile appeared a very large cost. For practical purposes the Professor's car-load was nearly one ton. In comparison, steam lorries, under favourable conditions of use and loading, could be run in Australia at twopence per ton-mile, inclusive of fuel, labour, wear and tear, and interest upon investment, based upon a minimum loading equal to 1,000 ton-miles per week.

If the difference was accounted for by cost of fuel, steam lorries could run upon an average of from 10 to 12 lbs. of coke per vehicle-mile. The comparative efficiencies of large and small cars was a matter of some interest.

In answer to inquiries, Mr. Rowe stated that interest was based on British figures (about 4 per cent.). The engines were compound 4 in. and 7 in. cylinders x 7 in. stroke, running up to 500 revolutions per minute.

Mr. W. R. Rennick said the tractive force of the car equaled about one-fourth of the total weight, and as it was driven by two wheels only, not four, the tractive power was about half the load, unless the driving wheels were the most heavily loaded. In
railway practice a tractive force equal to about one-fourth of the adhesive weight would be about the maximum.

In reply, Professor Kernot said, did he understand that Mr. Smith referred to non-expanding oscillating engines?

Mr. J. A. Smith: No, external cut-off.

Professor Kernot had seen some very intricate valve mechanism for this purpose; it would be more complex than the present system.

He remembered the oscillating engines on the “Great Britain”; they did very well with low pressure steam at 10 lbs. per sq. inch, but there were difficulties in lubricating the trunnions at high temperatures. They were things of the past.

The direct driving alluded to by Mr. Smith would mean heavier engines, and a longer contact of the steam with the cylinder walls. The modern tendency was towards a fairly high speed; and since the smallest wheel that could be used was about 30 in. in diameter, gearing down was required.

As to Mr. Newbigin’s examples it was plain that wide ranges could be got by assuming a high or low limit, but was it common to find a final temperature as high as 1,000 deg.?

Mr. W. J. Newbigin: In the examples the range was two and a half times as great, with about the same efficiency.

Professor Kernot did not think that fitted the actual case. On what were the conclusions based?

Mr. Newbigin had taken it from the statement in the paper.

Professor Kernot assumed that all were acquainted with the thermo-dynamic formula \( \frac{T_1 - T_2}{T_3} \) = thermal efficiency. He had assumed that the final temperatures were not inordinately greater than atmospheric temperatures. This was an academic point; he knew the petrol motor could do the work with about half the fuel, as compared with steam.

Of course, he had assumed that the temperature limit was in the usual position.

In reference to Mr. Michell’s criticisms. A single-cylinder steam engine gave two impulses per revolution. Then assuming a second engine, with its impulses crossing the first—as in a locomotive, for instance—and neglecting compression and assuming a long connecting rod, the forward effect would vary from 1 to 1.4.

In the internal combustion engine there were short sharp kicks, with intervals of inefficiency.

Next was the question of non-reversibility.

Mr. Michell asked whether most small gas engines were not provided with the means of changing the direction of revolution.

Professor Kernot replied in the negative.

Mr. Michell said that he had seen them.
Professor Kernot: Were they on the Otto cycle, and reversible when running?

Mr. Michell: Yes.

Professor Kernot said it was the first time he had ever heard of it. It was, of course, conceivable that it could be done, but there were great complexities involved.

In regard to Mr. Michell's remarks on complications. Chain and differential gear both existed in the steam-car. The differential was necessary, to enable a car to negotiate a curve, and was an essential part of it, and also of every traction engine. All petrol cars had either chain or bevel gears, therefore they were on an equality with steam in that respect.

In reply to Mr. Rennick's remark re adhesion. He had known the wheels to slip part of a revolution when bogged in very slippery ground, but was unconscious of slip on dry, ordinary roads; under these conditions it was practically absent.

In reference to the steam waggon comparison. Was the fuel referred to by Mr. Rowe coal?

Mr. Rowe said it was; 120,000 B.T.U.'s for one penny.

Professor Kernot said that using benzine, at 1s. per gallon, the rate was 13,000 B.T.U.'s for one penny, so that the car fuel cost about nine times more than that used by the waggon. A small car could not carry a sufficient load of a poor fuel.

AIR IN RELATION TO BOILER-FEEDS.

Mr. Smith said discussion at that late hour was hardly possible. He, however, desired to point out that he had discovered an inaccuracy in Bunsen's formula (p. 12 of paper). There had evidently been a clerical inadvertency—Bunsen was too great an authority to err in such a matter, the context of his investigations fully corroborated this—but the formula given for the absorption of gases from air by water had been based upon the volumes of the atmospheric components, instead of their weights or partial pressures. The figures should be (O. coef.) $\times 0.232 + (N. \text{ coef.}) \times 0.768$, in place of (O. coef.) $\times 0.2096 + (N. \text{ coef.}) \times 0.7904$. For sixty years text books had continued to perpetuate the inaccuracy.