gas per Brake Horse power, and 95 to 100 cubic feet at half full power. If set to drive any form of pump, the gas consumption, reckoned on the pump horse power, would be considerably greater. The Humphrey pump when lifting water works with about the economy of a gas engine driving itself only."

A gas engine driving a simple centrifugal pump required to do 16 pump horse power on a lift of 33 feet would require 120 to 127 cubic feet of gas per pump horse power per hour; the consumption of the Humphrey pump is 83.1 cubic feet.

Trials of steam pumping engines in the highest class in Professor Unwin's experience have shown a coal consumption per pump horse power per hour, varying from 1.62 to 1.996 lbs.; the coal consumption of the Humphrey pump is 1.06 lbs. "The fuel consumption in the trials of the latter," Pro. Unwin says, "reckoned on the work done in lifting water was less than in any pumping arrangement either by gas or by steam hitherto recorded."

Since this report was published, numbers of further experiments have been made, new types of pumps developed, and at the present time a 1,000 horse power high lift pump is in course of construction, the results from which will be looked for with the greatest interest.

Referring to the thermal efficiency of the Humphrey pump.

With a compression pressure of 11 atmospheres absolute, the theoretical thermal efficiency is 52.5%, as compared with the maximum of 40% with the Otto cycle, when all corrections for varying specific heat are allowed for.

These high compressions have yet to be tried, but are being utilised in the 1,000 h.p pump now being built. Up to the present an actual thermal efficiency of over 23% has been realised with a compression of under 50 lbs. per square inch. This corresponds to 0.95 lbs. of Anthracite coal per pump horse power hour, and the result was realised on a pump with only a 35 feet lift. It has been claimed by well known pumping engineers that whilst the Humphrey Pump gives remarkable results on low lift work it will not be suitable for high lift pumping. The inventor disagrees with this, and high lift pumps are now being built, the results from which should prove of immense interest to all engineers.

Passing now to other phases of engineering work.

On no question in the profession is there more controversy than that of steam versus internal combustion engines as prime movers. Steam has long reigned supreme, and in the field of both large marine and stationary works still leads. But its position with regard to small plants —land and marine—has been challenged by the gas and oil engines.

The result has been, redoubled effort on the part of steam engineers to still further improve their plant in an endeavour to retain the supremacy.

With very small units up to say 50 H.P., the Internal Combustion engine undoubtedly leads both in simplicity and efficiency. But above that power the question is, I think, still in doubt.

The efficiency of a plant involves not merely its thermal efficiency, that is to say its output of work realised per pound of combustible, but also includes the important item of reliability and durability. There can be no doubt that steam is the more reliable medium of the two. Your steam engine plant can be allowed to get into a deplorable condition before she refuses duty. Not so with the gas engine. Its condition must be maintained up to a certain standard if it is to work without continued trouble. So far as efficiency is concerned, the results realised with high class gas plants are practically unattainable with steam plants. Some very remarkable results have, however, been recorded, and I propose just to mention a few typical cases.

The Turbo-Alternator sets recently installed at the Ultimo Tramway Power Station, have each a nominal capacity of 5,000 K.W. at 6,600 volts, but their overload capacity is phenomenally high, being 7,600 K.W., or 50% above full load.

The steam consumption realised on tests "in situ," was 16 lbs. per kilowatt hour, using steam without superheat.

It may incidentally be mentioned that at the date at which these machines were ordered, there were no larger turbine plants running on stationary work.

On the new 4,000 K.W. sets now in hand for the City Council station at Pyrmont, the guarantees call for a consumption of steam at 100 degrees superheat of not more than $15\frac{3}{4}$ lbs. per K.W. hour at full load, and $17\frac{1}{2}$ lbs. at half load. Practically speaking, these figures correspond to a consumption of 1.1 lb. of good Newcastle coal per Brake Horse power, or reduced to the British standard, 1.03 lb. of best Welsh steam coal per Brake Horse power hour, which again gives a figure of approximately 260 B.T.U. per B.H.P. minute, a result directly comparable with the data already given for the Humphrey pump. It must, of course, be remembered that the 250 B.T.U. expended in the case of the latter appliance was expressed at per pump horse power minute, i.e., it is inclusive of both engine and pump losses, whereas in the steam plant the 260 B.T.U. includes losses only up to the turbine shaft. The result is, however, an excellent one.

On very large modern high duty steam pumping plants the heat expenditure usually lies between 300 and 360 B.T.U. per pump horse power minute. Taking, however, another class of steam plant, some very excellent results have been achieved. I refer to the small semi-stationary combined engine and boiler, in which highly superheated steam is used and the steam cylinders are mounted either in the boiler steam space or in the smoke-box, with arrangements for re-heating the steam on its way from the H.P. cylinder to the L.P. cylinder.

These machines developed in England by Garrett's Ltd., and on the Continent by Wolfe of Magdeburg, where they are known as Locomobiles, have been most carefully tested by various reliable authorities, and have given results varying between 1.04 and 1.21 lbs of coal per B.H.P. hour on plants of 50 H.P. and under. Taking into account the calorific value of the coals used on these tests, the heat expenditure per B.H.P. minute was from 245 B.T.U. to 280 B.T.U. and this was with engines of very small power.

Taking the general reliability of steam plants into consideration, it is evident that to materially excel plants of the above nature will severely tax the abilities of the gas engine builders. I under stand that more than one of these machines are on their way to Sydney and their subsequent behaviour will no doubt be watched closely.

On high class Diesel Oil Engines the heat expenditure lies between 155 B.T.U. and 130 B.T.U. per B.H.P. minute for engines of from 30 B.H.P. to 250 B.H.P., results so far unobtainable with steam plants. With high class gas plants figures closely approximating these are realised.

Time will not allow further consideration of this most interesting question, and I next would draw your attention for a moment to some recent developments in the application of Turbine Machinery to Marine practice. One of the problems exercising the minds of Marine Engineers is the possible application of Turbine machinery to slow going ships. Two years ago or more, one partial solution was devised, in the combination of reciprocating engines and turbines, the latter utilising the lower portion of the expansion of the steam between the low pressure cylinder of the reciprocating engine and the condenser. This system, as no doubt all of you are aware, has been applied to several ships, and to some extent also in utilising exhaust steam in collieries.

Recently, however, some information has been published by the Hon. C. A. Parsons, relative to another possible solution of the question, and one which promises good results.

No scheme has as yet been evolved to so reduce the speed of the turbine on the one hand, or modify the design of propeller on the other, to allow of the direct application of turbine drive to slow going ships without high initial cost and a sacrifice of steam economy.

Mr. Parsons has, however, carried out some very elaborate experiments with a slow speed cargo boat, in which the propeller shaft was driven by a normal speed turbine through mechanical gearing. The results were very remarkable and may possibly be new to some of you.

In the latter part of 1909, the Parsons Marine Steam Turbine Company, purchased a tramp steamer, the S.S. "Vespasian," built in 1887. The length of the boat is 275 feet, beam 38 feet 9 inches, and displacement 4,350 tons.

She was fitted with Triple Expansion Engines which were sent to the builders for thorough overhaul before the tests were commenced. After the overhaul the vessel was chartered to carry a load of coal from the Tyne to Malta, and careful records were taken of all coal and water consumption, speeds, etc., by a staff of experts, who made the trips on the boat. On her return the reciprocating engines were removed and replaced by turbine machinery. Two turbines were employed, one on either side of the vessel; and at the after end of each turbine shaft, a driving pinion was connected by means of a flexible coupling, these pinions gearing direct into a wheel attached to the propeller shaft. The boilers, propeller, shafting, and thrust blocks remained unaltered. Trips were again run under similar loading conditions as before with the result that the geared turbine arrangement showed an overall economy of approximately 20% over the reciprocating engines.

No trouble was experienced in the least with the gears, which were of the double helical type running in oil with very little noise, and showing a loss of less than 2% in transmission. The boat has experienced very heavy weather since the turbines were fitted, and no trouble whatever has been experienced with the equipment.

Such a result is of far reaching importance and cannot fail at least to be of interest to sea going Engineers.

One cannot in any resume of Engineering Progress during the past 12 months pass by the launching of the mammoth White Star liner, the "Olympic." This vessel, built by Messrs. Harland and Wolff, of Belfast, has a length of 882 feet, breadth of 92 feet, with a displacement of 60,000 tons, and with combined reciprocating engines and low pressure turbines of 47,000 Horse Power, designed to give a speed of 21 knots.

It is to be noticed that the speed is below that realised by the two Cunard liners, the Lusitania and Mauretania, which with a displacement of 43,000 tons and a horse power of 80,000, attain a speed of 26 knots. The contrast is very marked. We see in the more modern vessel a marked increase in displacement, and therefore carrying capacity, a vastly decreased power of machinery, and a relatively small reduction in speed. In the new vessel building for the

Hamburg-American Line the same tendency is noticeable, her dimensions, speed and horse power being almost identical with that of the "Olympic" and "Titanic."

The Cunard Company are apparently following the same policy, though not so markedly, in their new boat, of which specifications have recently been issued. She will have the following leading dimensions:—Length, 850 feet between perpendiculars, 885 feet overall, full breadth, 95 feet 6 inches, displacement, 50,000 tons, and she is to be equipped with turbine machinery of from 60,000 to 65,000 horse power, operating quadruple propellers to attain a speed of 23 knots. Her total cost will be somewhere in the vicinity of £2,000,000.

It is to be noted that the White Star Company, apparently thoroughly satisfied with the behaviour of the combined high pressure reciprocating engines and low pressure turbines, with which the "Laurentic" is equipped, have adopted the same combination in their two new liners, the "Olympic" and "Titanic." The Cunard Company, on the other hand, are adhering to the direct multiple propeller turbine driven system.

The question of speed and power in these monster vessels is of paramount importance, since even a relatively small variation in coal consumption involves a considerably increased first cost, and a vastly greater one in annual cost. It has been estimated that to increase the speed of the Olympic from the contract 21 knots up to 25 knots, that is one knot slower than the Lusitania and Mauretania, would involve an increase in the capacity of the propelling machinery from the present 47,000 H.P. up to 115,000 H.P.—an impossible proposition commercially. The carriage of cargo on such a ship would be impossible on a paying basis, and it is apparent that very high speeds with these mammoth liners are only commercially justified where heavy Government subsidies are available; hence the policy of increasing dimensions and decreasing speeds, thus bringing maintenance charges within reasonable grounds.

In another sphere of engineering work, development is proceeding with rapid strides. I refer to the steady displacement of the horse by motor vehicles for business and commercial purposes.

Mr. F. W. Lanchester, the present President of the Institution of Automobile Engineers, dealt largely with this question in his recently delivered Inaugural Address. Whilst recognising that the pleasure or passenger motor car status is well assured, and that the many years of development have resulted in standardisation along one general plan, yet Mr. Lanchester is not very sanguine at present as to any saving to be effected in the application of the motor vehicle to heavy commercial traffic. His reasons for this opinion are the present high cost of fuel, and such material as rubber, aluminium, and mineral lubricating oils, which now largely govern both the first cost and running charges. But he anticipated an early reduction in the price of these items, and concurs in the general belief that a very big expansion in the automobile industry is to be early expected in the application of the heavy motor vehicle for commercial purposes.

The number of such vehicles already in use is very great, particularly in those centres such as Sydney, where the contour of the country involves excessively heavy work on the horse vehicle; but one of the main features in bringing this type of motor into universal use is good roads, and in this direction the Road Engineer controls the situation.

One might go on for hours enumerating and discussing the engineering developments of the past year, but the time at my disposal will not so allow.

In the realm of aeronautics the advance has been phenomenal not so much in the development of new principles in the design of aeroplanes, but chiefly in the perfection of existing types, in improvements in details, in the application of more suitable materials, and in the elimination of unnecessary parts.

There is no doubt that the main problem to be faced is that of "stability," that is the maintenance of equilibrium against the action of the various disturbing forces encountered in flight, and in this respect the hundreds of pioneers now practising flights on various machines and in all parts of the globe, are doing great service, although the percentage of aviators who have met with fatal accidents is unhappily very great.

The recent many successful flights accomplished by Mr. Hammond in and around Melbourne are particularly worthy of note.

We here are also steadily availing ourselves of the advantages offered by wireless telegraphy, chiefly as a result of the great improvements which have been realised during the past 12 or 18 months.

Already several of the coastal steamships are equipped with modern apparatus, and others are now taking the matter in hand.

The Governments of both Australia and New Zealand are also installing plants and there is no doubt that shortly it will not be necessary for a passenger on any of the mail or larger coastal steamers to be out of touch with land. Such a position adds greatly to our sense of security in travelling at sea, but whether the unhappy business man away for a real holiday will have cause to bless the innovation, is quite another matter.

In this State many large engineering works are in hand. The great Barren Jack weir is steadily growing, the North Coast Railway is advancing section by section to shortly link up with civilisation the isolated dwellers on the Northern Rivers who are now dependent upon the vagaries of wind, weather, river bars and small coastal steamers.

One cannot also overlook the building up of the Torpedo Destroyer Warrego at the State Government Dockyard, which work is, I understand, rapidly approaching completion.

Of still more importance, in my opinion, are the advances being made in the development of large private undertakings, such as that of Messrs. G. and C. Hoskins, at Lithgow, the Commonwealth Oil Corporation at Newnes, and many others, but unhappily there has been and is associated with all these great private and Government undertakings a general spirit of unrest in the relationship between employer and employee.

The question of wages is the one of greatest import in the industrial life of to-day. Education, form of Government, and similar questions are not nearly so important. No subject is so disturbing as that of wages, and because the question is a dangerous explosive, because any stray spark, concussion or blow may fire it, it should be as far as possible standardised, and as many as possible of the opportunities for clash should be eliminated.

I think the present situation has been well summed up in a recent article by a well known American writer:—

"The individual is born with the instinct of self-preservation, of race preservation, of acquisition and hoarding, the latter probably merely a specialised development of the squirrel's nut hoard, the wolf's buried meat. We have interposed the device of wages between basic need and its satisfaction. Wages therefore acquire the importance of both, and wages are also the question between anarchy and civilisation. Men and women 24 hours without food become wild beasts; the human baby becomes fretful and then an anarchist if there is ten minutes delay, instinctively knowing that nature gave it a mother able instantly to satisfy its craving."

"We have societies for the suppression of our natural instincts, societies for the prevention of cruelty, for the preservation of birds, for safety appliances, for art collections and for libraries; we have in our legislature, endless debates over insignificant matters; but where is there any rational study of wages, much less any society to enforce fair wages or any legislation in favour of fair wages, that is, fair to both employer and employed."

"Labour unions use the big stick to force wages up, employers make secret combinations to keep wages down, as if a clock, either too fast or too slow were any good."

"As at present paid, wages come neither under status, contract, nor individual effort. Like many other innovations, wages have preserved some of the worst features of all three systems and avoided the best."

"The worker is in status when he comes, stays, and goes under the orders of the employer. There is, however, no status when he is laid off without pay or his hours are cut down. He contracts his time for a fixed sum per hour, but he does not, like other contractors, agree to deliver an equivalent in output for the pay received."

"The worker is selling time, and the equivalency between operation and time is of transcendent importance in the solution of the present unsatisfactory state of affairs."

"There can be no industrial peace until such times as this problem is settled by the revision of equivalents, employing scientific methods and specialists, revising solely in the interests of accuracy and truth, never to give either party an unfair advantage."

This already overlong address must be brought to a close.

Let me ask you to carefully consider the views that I have endeavoured to set before you regarding the status of this Association, accepting my proposals in the spirit in which they have been made, that is with the one aim, the well being of this Institution, and the upholding of the Engineering Profession in that position to which it is entitled in the life of the community.