INSTITUTE OF MARINE ENGINEERS

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SESSION 1902-1903.

President—D. J. Dunlop, Esq.

Local President B.C. Centre—Sir Thos. Morel.

Volume XIV.

ONE HUNDRED AND SEVENTH PAPER

(OF TRANSACTIONS).

THE

SPEED REGULATION OF STEAM ENGINES, STATIONARY AND MARINE.

BY

Mr. W. WELBURY (Member), of Leeds.

READ AT

3 PARK PLACE, CARDIFF,

On WEDNESDAY, JANUARY 14th, 1903.

Chairman: Mr. W. SIMPSON (Member).

AND AT

58 ROMFORD ROAD, STRATFORD,

On MONDAY, FEBRUARY 9th, 1903.

Chairman: Mr. W. LAWRIE (Member of Council).

PREFACE.

3 Park Place,

Cardiff.

January 14th, 1903.

A meeting of the Bristol Channel Centre of the Institute of Marine Engineers was held here this evening. Mr. W. Simpson (Member) presided. It was stated that the Council of the Institute had nominated Sir John Gunn as President-elect of the Institute. The choice of the Council was a compliment and an honour which the Bristol Channel Centre cordially appreciated, and one in which recognition was indicated of the practical services rendered to the Institute by Sir John. A paper on "The Speed Regulation of Steam Engines, Stationary and Marine," was read by Mr. W. Welbury (Member), and illustrated by lantern slides. A brief discussion ensued.

George Sloggett,

Hon. Local Secretary.

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It is impossible within the limits of a paper of this description to give the history of and thoroughly discuss such a subject as "Speed Regulation." To go right into the matter would take more time than we have at our disposal, and necessitate many references to and quotations from various authorities.

The writer's intention is to go so far as may be necessary, keeping, with some few exceptions, within the limits of his own experience, to show you at what a high state of efficiency the regulation of stationary engines has arrived, to give you some examples of that regulation both from diagrams and specifications, and then ask you why, if it has been found possible for the stationary engine maker to reach such a condition of excellence with his regulation, the marine engineer, the leader in almost all improvements so far effected in the steam engine, has, up to the present, made no serious attempt to deal with this most important matter? Nay, more, it is said his mind is so firmly made up that the marine engine is incapable of regulation, that he declines further discussion of the subject.

The writer trusts to be able to convince some of you, if only a few, that the subject is not so hopeless as it may appear to those who have attempted to deal with it, that it is something on which time and thought may be profitably employed, and that so far from being an hopeless matter, the speed regulation of marine engines is quite within your reach, if you will only take the trouble to investigate.

STATIONARY ENGINES.—There are two different methods of governing in general use for stationary engines, viz., the throttling and the variable expansion.

The former, of course, is the more simple, and is also less expensive to the maker, but there can be no question, although some few makers of throttle governed engines hold the contrary opinion, from actual results in ordinary work as well as from tests, that the latter is not only the best regulator, but with an engine on which the load varies to a great extent, it shows an average economy of about 12 per cent. in steam consumption, the saving being more apparent at light loads. In large plants this is a consideration that should not be, although it often is, overlooked.

The quickness of the action of the throttling governor is not only dependent upon its design, but also on the position of the throttle valve with respect to the distributing valve, for whatever volume of steam may be between these valves when the load comes off is beyond the control of the governor, therefore it must pass through the engine, with possibly serious momentary effects. Hence the throttle valve should be placed as near to the distribution valve as convenient; the smaller the steam space is between the two the quicker will the effect of the governor be felt by the engine.

As the variable expansion governor acts on the distribution valve direct, variations in speed can be more quickly met, for the valve is only opened sufficiently to admit the steam necessary to cope with the load, or in the case of all the load being thrown off, the governor is so arranged that the steam is cut off entirely at the steam port, or no more is admitted than is required to overcome the friction of the engine, and so keep it running at its normal speed without load. Therefore, the only steam not under control of the governor is that already in the cylinders.

In engines designed without separate exhaust valves, the quicker cut-off causes the compression to increase, and this has a retarding effect on the engine.

It will thus be seen that the variable expansion governor is the more prompt to act in answer to a change of load, therefore, where sudden changes of load have to be faced, or where the load is liable to be thrown off entirely, it is to be preferred.

It is not possible to keep the speed exactly constant under varying conditions of load, no matter how sensitive the governor, for the speed must change before the governor can act, and thus alter the amount of steam being supplied to the engine sufficiently to keep the normal speed. The more sensitive the governor, and the finer its range, the less will be the variation in speed.

It is quite possible to make a governor so fine as to be able to keep the variation of speed within 1 per cent. of normal, but it is not advisable to do so where sudden and extreme changes of load have to be dealt with, as, with a light fly-wheel, you are liable to set up governor hunting.

As some of you may not be aware what governor hunting is, it had better be explained. The finer a governor is made—that is, the smaller the range of speed it is made to control the engine within—the less stability it has, so that its operations are the more easily upset.

If sudden changes of load take place the governor is apt to be set vibrating, somewhat like the action of a pendulum, the weights working in and out with a regular swing, and causing the engine to race away and then to slow up. The same thing will also take place when the governor has not sufficent power to overcome the friction of the governing mechanism.

The writer's first experience of governor racing was with a " Silvers " governor, crossing the Atlantic. It happened when the vessel's stern was thrown out of the water more quickly than usual; the governor acted, but instead of keeping the throttle shut until the engine speed was reduced it opened and closed the valve rapidly two or three times, letting steam to the engine, of course, at a time when it was least required. It may be noticed that this paper does not deal largely with figures.

Besides, figures, except for settling general principles, are not of great value in this case. The governor is more a subject for experiment than for mathematics, the friction of a joint, or a stuffing box, is liable to upset the most careful calculation. The following practical hints when designing governing mechanism should not be overlooked.

The governor must have a good margin of power over the work it is required to perform, and be so situated that there may be few connections between it and the valve it operates; the whole of the working parts should be made free, to minimise friction as much as possible. The power of the governor, even where fairly powerful, may be largely taken up in overcoming friction, leaving little for governing the engines, so that a powerful governor under these conditions becomes practically useless for the purpose for which it is designed. It is sometimes necessary to introduce friction in a governor, but where this is done it is usually in the form of a dashpot, or other regulateable device, so that the amount can be controlled. The valves now most generally used for throttling are of the double beat equilibrium type; the old butterfly or wing valve, owing to its many disadvantages, is now rarely seen in stationary engine work, while the equilibrium valve, being balanced, is practically frictionless, and will remain steam-tight for long periods. The writer heard some time ago of a steamer's engines being fitted with an equilibrium throttle valve. Not being satisfactory, it was replaced with a butterfly valve; the reason was due to the valve and seat being cast iron instead of gun-metal or bronze; consequently, it stuck fast, a result not at all surprising, but it led to the idea that equilibrium valves were not suitable for marine engines. What was really required to make the valve a success was that those concerned in the making and fixing of it should have had some previous experience of this class of work.

With variable expansion gear the governor acts directly on the steam distributing valves, either through trip gear, as with Corliss or drop valves, on an expansion valve, or on the main slide valve direct. It may be mentioned here that the piston valve has not been found suitable for use with variable expansion gear, as it cannot be kept steamtight for any length of time.

For Corliss or drop valves, the governor most generally used is of the improved pendulum type, mounted on a pillar, and driven either direct off the shaft by gearing or through a belt or chain drive. This type is also used occasionally with slide valves, the governor acting on the valve through a link and die, varying the travel of the valve to suit the load, but the best and most simple form has the slide valve or expansion valve working on the back of the slide valve, driven direct by a shaft governor.

To save the governor being made unduly large and powerful, also unduly costly, the general practice when slide valves are used, particularly with large engines, is to balance the main slide valve and couple it direct to the governor. This arrangement with a shaft governor gives the simplest and one of the most efficient means of stationary engine governing known. Engines up to 3,000 I.H.P. are working with shaft governors coupled direct to H.P. valves, and giving results that cannot be excelled at the present time, either for economy in steam consumption or speed regulation.

While on this part of the subject it may be as well to relate the origin of the shaft governor, as many engineers are under the impression that it comes to us from the United States, although the Americans have many more variations of this governor than we have, and they recognised the advantages to be gained by its use more fully than was generally done in this country till recently.

Mr. Wilson Hartnell, of Leeds, makes the following statement in a lecture on governing given some three or four years ago:

"Previous to the year 1862 the pendulum governor was in general use, and governed sufficiently well for general purposes. It was, however, not powerful enough to act direct upon a variable expansion valve without the intervention of more or less complicated or delicate gear. In that year the Porter governor was introduced, which was a form of pendulum governor with a central weight. It was not more sensitive than the older Watt pendulum governor but more powerful.

"The desirability of a simple automatic expansion gear that could be applied to a portable engine was pressed on his (Mr. Hartnell's) attention by the successive engine trials of the Royal Agricultural Society, particularly by those held at Bury St. Edmunds about the year 1867. It then occurred to him that a governor of sufficient power to act in a direct and simple manner on the slide valve could be placed on the fly-wheel. Thus the crank shaft governor was not invented for the sake of more sensitive and prompt governing, but for the sake of making it so powerful that it could act direct on the expansion valve, and so simple that it could be applied to an agricultural engine. The patent for this was taken out in 1868. The first of such governors was placed in horizontal engines in the fly-wheel, the eccentric for working the valve being outside the fly-wheel.

"It was not until some six years later that it was applied to a portable engine, the second of which was subjected to a series of careful experiments preparatory to sending it to the Royal Agricultural Show at Cardiff, where it obtained a silver medal for excellent governing. It was during these tests that the governor showed itself, by comparison with other governors, extremely sensitive and prompt. As applied to high-pressure engines it showed an average saving of something like one-third of the fuel, and it came much into request. However, it was not until after electric lighting was well established that the special qualities of promptness and excellent governing were demanded; and the patent having expired this governor soon became a favourite with all the manufacturers of quick-running engines, both in England and abroad."

In large engines used for the generating of electricity, in the manufacture of which the writer has been engaged for a number of years, it is now a known fact that to make engines govern too finely is a mistake, particularly where the alternating current is in use, and generators have to run in synchronism; the governor must not be too susceptible to very slight changes in load, for the reasons given in the specification that follows shortly. In order to make clear what is meant by alternators running in parallel, it will be well to give a simple illustration. The alternators may be considered to be spur or cog wheels with a certain amount of slackness between the teeth to agree with the permissible allowable variation on either side of rotation. The wheels are free to be moved into and out of gear; one is set in motion, say on the Town mains delivering current, the other, as the load comes on, is also run up to speed. These two wheels have now to be brought into gear with one another; when this is accomplished the two are what is termed in parallel. Before this can happen the wheels have to be in step, or in such position that the teeth of one must coincide with the spaces in the other; if the teeth should touch ever so slightly there ensues a fluctuation in the light, but if they come in direct contact, point to point, or nearly so, the wheels would be wrecked, in like case so would the electrical apparatus receive serious damage. The alternators also must run during the whole time they are running in step with each other, and be taken out of parallel under the same conditions. You will perceive that the speed regulation to accomplish this object must be excellent and under very close control. But the people who issue the specification already referred to omit to mention that certain forces which materially assist parallel running vary in each machine, and deal entirely with the characteristics of the engine, or the effect of the engine on the generator, and not the action of the generator on the engine. That it has such action is a well-known fact. But the electrical engineer does not admit that this has any influence on the speed regulation; he simply says that "if the alternators are run at the same speed and the frequency is the same there will be no difficulty in paralleling." This, of course, is obvious, but does not assist the engine builder, who, to a certain extent working in the dark, has to alter his governor to suit the generator, often so much so, that in two sets of steam alternators off the same patterns, after they have been got into work, and everything is running satisfactorily, were the governors to be changed from one engine to another there would probably be trouble. The engine builder in this class of work has often to sacrifice the excellence of his governor, as a regulator pure and simple, and introduce into it various features—which under ordinary circumstances would be considered defects—to meet the exigencies of this work. The present state of excellence has not been attained without considerable research and experiment. Perseverance has overcome what at one time seemed unsurmountable difficulties, and the stationary engine builder has now the satisfaction of being able to regulate his engine at any desired speed under almost all circumstances.

The specification previously referred to is issued by a well known firm of electrical engineers for the information of, and assistance to, engine builders, and is as follows :

FOUR CHARACTERISTICS OF ENGINES.

(*a*) The engine governors should be so constructed that there is no tendency to cause a periodic transfer or surging of the load between one engine and another. This tendency may originate in the angular variation of velocity in different parts of the revolution which is common to all reciprocating engines, or to a sudden variation of load, which will affect each governor in a slightly different manner, or to other causes that lead to a non-uniform speed. The engine governors should not be sensitive to such disturbances, nor maintain or increase them. The effect on the engines of a periodic transfer of load, occasioned by hunting between two engines running in parallel, is somewhat similar in effect to throwing the load on and off a single engine at short equal intervals, which may be measured by one or several pulsations in the combined turning efforts applied to the engine shaft. In some extreme conditions the pulsations of load may amount to more than the normal capacity of either engine. With no external load one engine may then alternately drive the other, which will evidently be a more severe condition than if the load were only applied and removed from a single engine. If under any case of pulsating load the engines do not tend to accentuate the pulsations in turning effort and speed, then a load favourable to parallel running is attained.

(*b*) Variation of the rotating part of the generator through the revolution at any constant load, not exceeding 25 per cent. overload, should not exceed one-sixtieth of the pitch angle between two consecutive poles from the position it would have if the motion were absolutely uniform at the same mean velocity. The maximum allowable variation, which is the amount the rotating pole forges ahead, plus the amount which it lags behind the position of uniform rotation, is therefore one-thirtieth of the pitch angle between the two poles. Generally this is obtained by the use of a heavy fly-wheel. In a two-pole machine this variation is equivalent to three degrees as measured on the circumference of the rotating part; in a four-pole machine it is $1\frac{1}{2}$ degree; and in a six-pole machine one degree, or as the number of poles increases the permissible angular variation decreases.

(*c*) The engines should have practically the same characteristics of speed regulation, that the power delivered to their respective generators may be proportional to the load—that is, the same load on any engine should produce the same percentage drop in its speed. This is most readily obtained in engines in which at full load the speed drops from 3 to 5 per cent. below the no-load speed, as a slight change in adjustment of the governors will have less relative effect than in engines in which the speed drops only 1 per cent. under the same variation of load.

(*d*) The use of governors which are adjustable while the engine is running is recommended.

Slight adjustments of speed may then be made, which will facilitate synchronising the alternators or changing the load carried by the engines.

MAXIMUM PERMISSIBLE VARIATION ON EITHER SIDE OF UNIFORM ROTATION.

Poles.	Angular Degrees.	Per cent. of Circumference.
2	3·000	0·83333 1-3
4	1·500	0·41666
6	1·000	0·27777
8	0·750	0·20833
12	0·500	0·13888
16	0·375	0·1041
20	0·300	0·0833
24	0·250	0·0693
28	0·214	0·0594
32	0·187	0·0520
36	0·167	0·0462
40	0·150	0·0416
44	0·136	0·0378
48	0·125	0·0347
52	0·115	0·0320
56	0·107	0.0297
60	0·100	0·0278
64	0·094	0·0260
68	0·088	0·0245
72	0·083	0·0231
76	0·079	0·0219
80	0·075	0·0208

The conditions of this specification show the high condition of efficiency the speed regulation of high-class stationary engines has reached. Attention is particularly drawn to the table at the end of the specification, and also to the fact that the authors of this specification do not state how these results are to be arrived at; that is left to the engine builder to solve.

Referring to paragraph (*d*) in this specification: "The use of governors which are adjustable." To illustrate this we will suppose a case—our engines have a variation in speed of 5 per cent. from full load to no load, which means that if our engines run 100 revolutions at full load they will run 105 revolutions with no load, each position of the governor weights, from right in to right out, having its corresponding speed. This is not quite correct, but is sufficiently so for illustration. If we have one engine already running, say, with full load on it at 100 revolutions, to get the other in parallel we must reduce its no-load speed from 105 revolutions to 100 revolutions to get it in phase. This is accomplished by varying in some way the controlling power of the governor while the engine is running. Some makers have a special spring on the governing mechanism for this purpose, others vary the main springs, which is the simplest and most direct way. The operation consists in tightening or slackening the spring or springs. We will suppose our engines are now in phase, but we find that the second engine does not take any appreciable load from the first engine; to cause it to do so we must increase the speed slightly on the second engine, immediately we do this it commences to take load, and we go on increasing the speed until the engine takes the load we desire. By these means it is possible to regulate the load as required on the engines.

Fig. 1 is an illustration of the McLaren shaft governor and speed adjusting gear from which most excellent results are obtained. This governor has been fitted to a large number of engines both in this country and abroad with highly satisfactory results.

Fig. 3 is a copy of a Moscrop diagram taken to show how the speed of the engine can be varied.

As there are several very interesting diagrams taken from the Moscrop Recorder used to illustrate this paper, a few words on this most sensitive of speed variation measurers may be of interest.

It consists of a clock, steam gauge, and pendulum governor working in conjunction. A roll of paper is so connected to the clock that its mechanism unwinds it, a hanging weight connected to a drum rolling it up as it is unwound by the clock. The steam gauge is coupled up to a pen which draws a line on the paper as it passes on the drum, indicating the variations in pressure of steam at the boiler.

DRAWING No. 2185. McLAREN'S PATENT AUTOMATIC EXPANSION GOVERNOR.

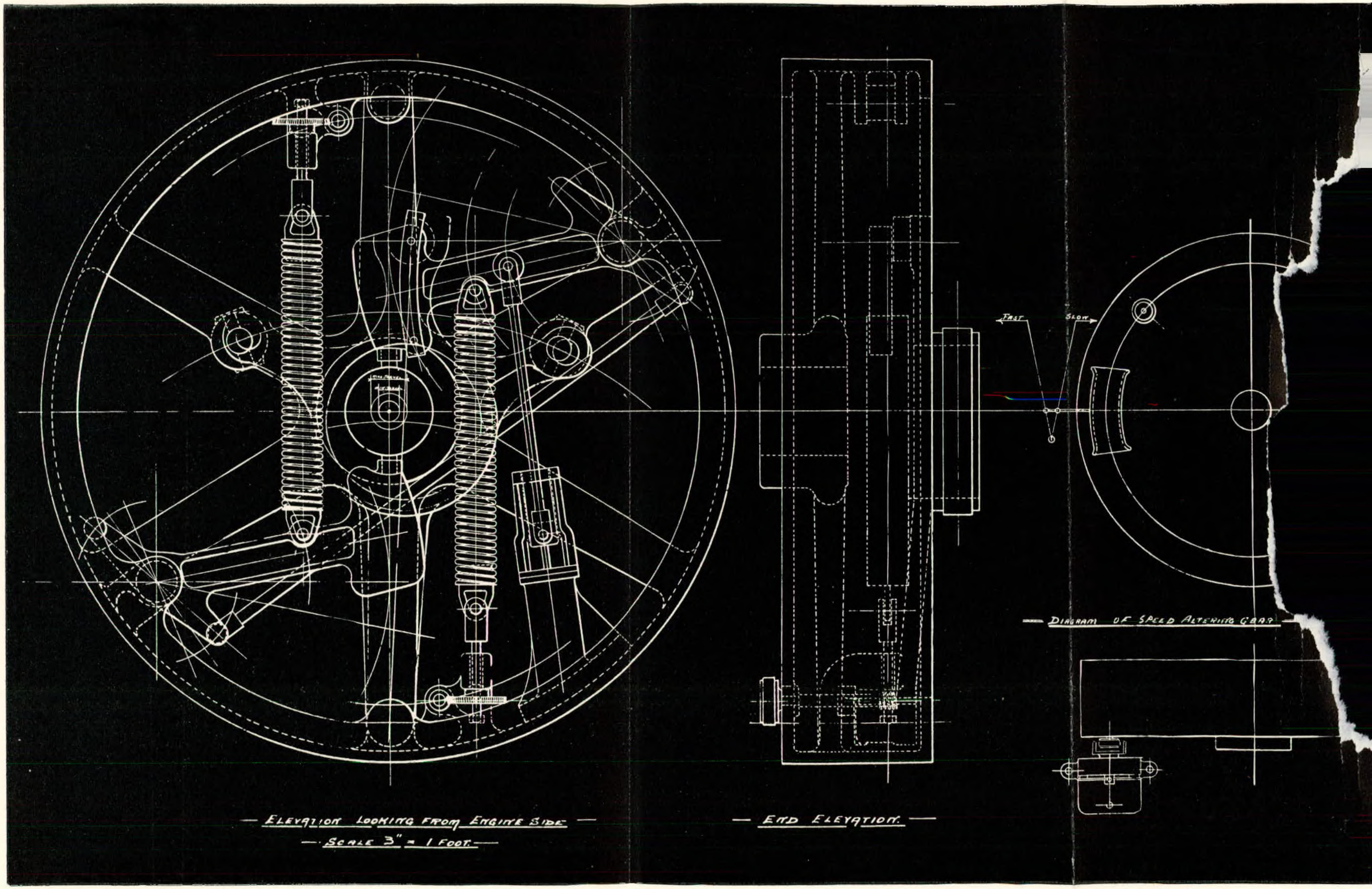


FIG. 1.

MOSCROP RECORDS.

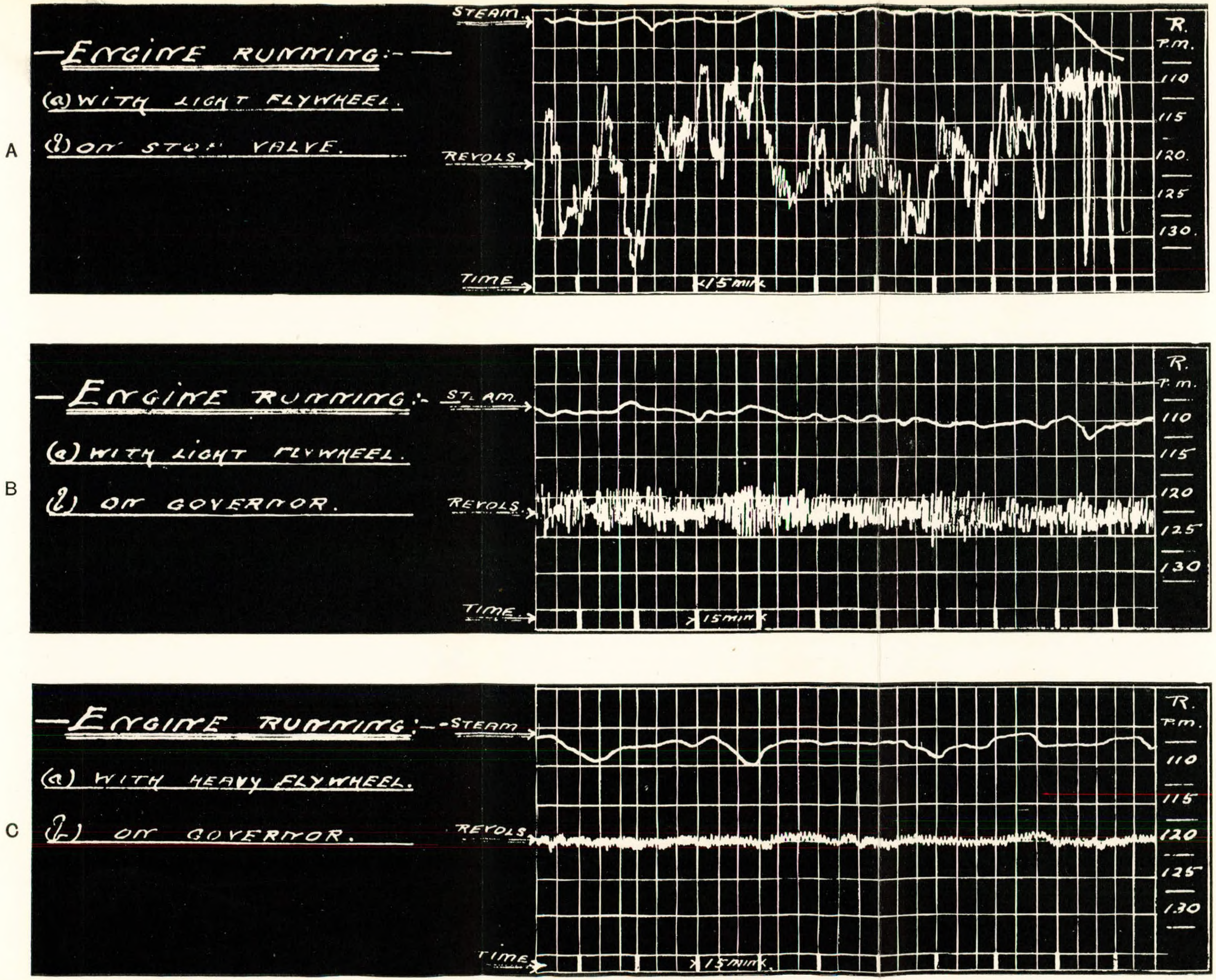


Fig. 3.

The pendulum governor also has a pen connected to its mechanism, which marks on the paper the slightest variation in speed indicated by the rise and fall of its weights; as the governor has no other work to do—being practically frictionless—but move this pen, it is very sensitive.

The marks you notice across the edges of the diagrams represent time, this being divided into periods of five minutes each by the lines. The other lines lengthwise of the paper are to measure the speed variation, and are set off in percentages, showing a difference of 5 per cent. between the lines.

The Moscrop diagrams (Fig. 3) are taken from a stationary engine driving an engineering works.

Fig. *b* was taken some years ago, and shows a speed variation of about 5 per cent., and was considered a good diagram, this regulation for the class of engine being held to be highly satisfactory.

Fig. *c* was taken after a heavier flywheel had been fitted. A comparison of the two diagrams shows at a glance the effect of flywheel inertia on speed regulation.

Fig. *a* was taken when the governor was out of action during the time some trifling repairs were being made to it. It shows the variations in speed which took place with the engine running on the throttle valve without the governor, and with what may be considered a fairly steady load.

From these diagrams we see the effect of light flywheel with a good governor; heavy flywheel and good governor; and flywheel without governor.

Fig. 4 is indicator diagrams taken from engines regulated by throttle, and variable expansion governors.

Fig. 4 is a curiosity, and is probably the only indicator diagram ever taken under such conditions. It was taken from a McLaren type triple expansion, surface condensing, electricity generating engine of 1,500 indicated horse-power, fitted with a McLaren shaft governor. The high pressure piston was removed, the high pressure slide valve coupled to the governor direct being left as before, and the engine was started up as an ordinary compound, with the medium pressure and low pressure cylinders. It was put on the load in this condition and governed well, the variable expansion governor acting as a throttling governor, and regulating the flow of steam to the medium pressure cylinder, which was in this case, of course, actually the high pressure cylinder.

(Fig. 5).—This illustration is a set of indicator cards taken from a 1,000 h.p. engine with a variable expansion shaft governor. Your attention is directed to the receiver pressure shown and to the slight drop between it and the cylinder; note also the throttling action shown on the diagrams of the lower powers.

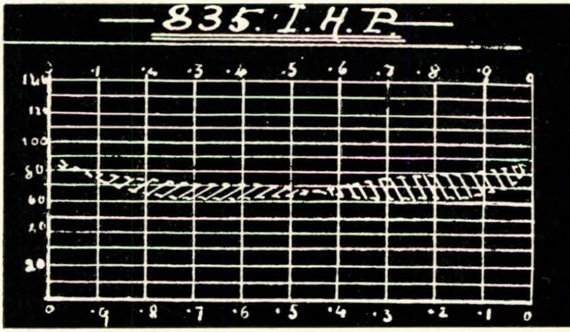
MARINE ENGINES.—What follows may appeal more to the marine engineer, but it was necessary to show you what has been and is being done with the stationary engine, and try to deduce from that, what it is possible to do with the marine engine, than which no engine requires a good governor so much—the changes of load it is subject to being so very great. In a moment, the load varies from no load to full load continuously often for days together; it seems strange, therefore, to find this engine, which requires a good governor, put to its work without one.

All engineers with sea experience can doubtless recall the uncomfortable times passed through during heavy weather, how the terrific racketing seemed to be more than any structure made by man could possibly withstand, also how heavy their engine repair bills were after an experience of this sort, even if nothing worse befel.

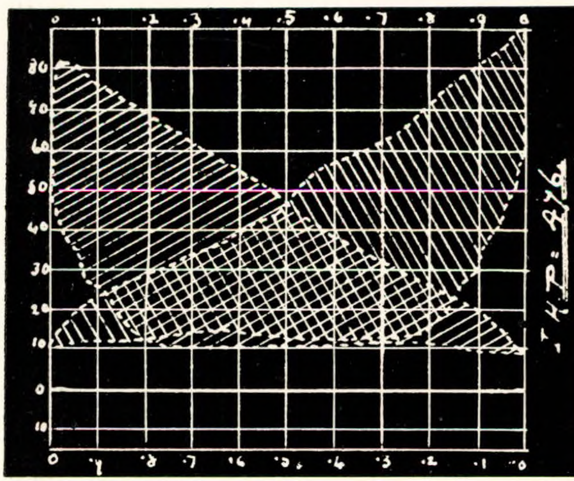
At a meeting of the Institute some years ago, racing was described very fairly as follows: "When an engine suddenly attains a speed double its normal and is suddenly brought up again to below its standard rate, and much worse racing is common enough, the whole strain of the sudden check of the engines caused by the extra resistance offered by the water to

Sliing condensing at 165 revolutions per minute) running

H.P. Cylinder.

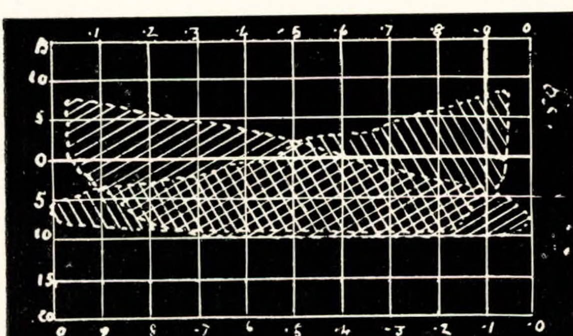


M.P. Cylinder.



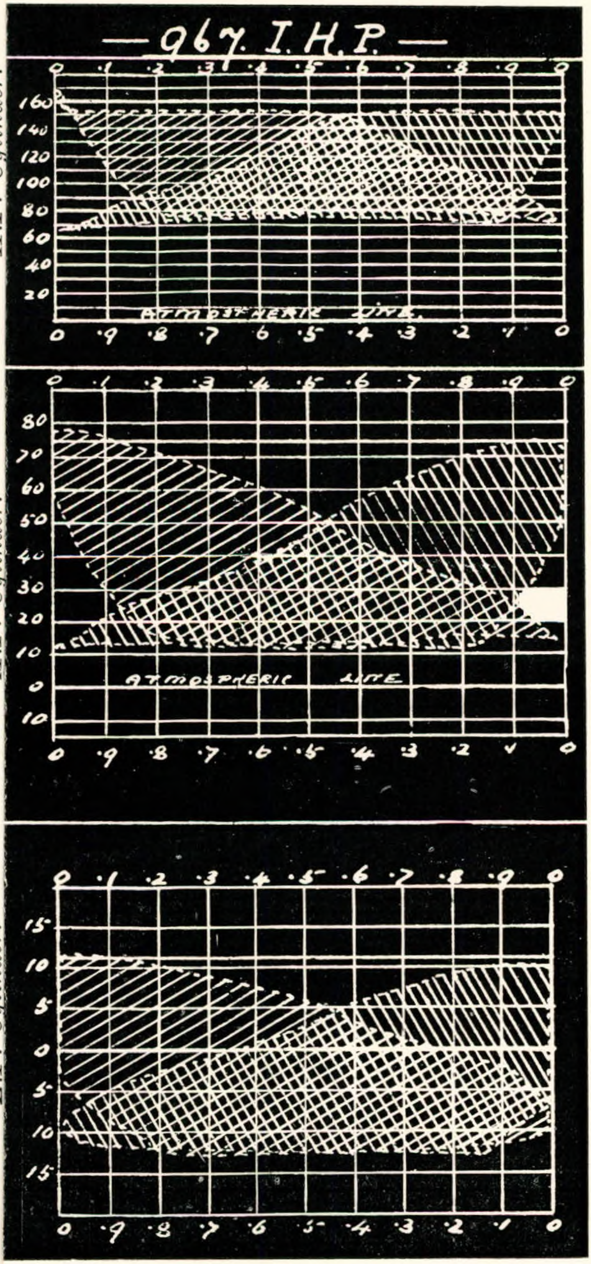
I.H.P. 476.

L.P. Cylinder.



I.H.P. 359.

nning condensing at 125 revolutions per minute.



H.P. Cylinder. 213 I.H.P.

M.P. Cylinder. 345 I.H.P.

L.P. Cylinder. 409 I.H.P.

the propeller as it dips, after being practically or wholly lifted out of the water, must necessarily be transmitted through the whole length of shafting and coupling bolts, to the crank shaft. There is also severe straining of the pumps, pump rods and links, caused by the racing, the pumps being unable to deliver the water quickly enough, the buckets coming down heavily on the water in the barrels, destroying the valves. The feed pumps being only partially filled with water, the rams coming suddenly in contact with it, give shocks to barrels, pipes, valves, crosshead, links, etc.

A continuance of these vibrations loosens first one part and then another from the bedplate fastenings right throughout the structure ; indeed, it is difficult to say where the evils due to racing end."

Doubtless the worst moments in a race are those when the propeller comes out of the water with the heavy jar which attends this operation; again, when it is entering the water, the blades strike with great force on the surface. The greater part of the mischief is done during these periods.

Notwithstanding the immense amount of damage which results from the lack of efficient speed regulation, what is being done to remedy this state of affairs? What is the marine engineer doing? Why has he not done more? Whatever reasons may be advanced in excuse, unquestionably those responsible have not taken the interest in the subject that it merits.

The following extract from an article on steam engine governors, which appeared in one of the technical journals in 1895, is interesting as an expression of the feeling of an expert towards the attitude the marine engineer has taken up on speed regulation :

" Under these circumstances, one would think that every steamship of any importance would be fitted with an efficient governor. But we have heard it said, in reply to such a statement, that such a governor does not exist. Well, if this be a fact, that such a governor does not exist, this state of things is a disgrace to the marine engineering talent of Great Britain and Ireland."

Generally the marine engineer takes up on this subject an attitude with which reason can have no sympathy. He is mostly sceptical as to the success of any efforts in this direction, and the arguments he uses to defend his position may be summed up as follows: That the marine engine working mostly at full load does not require regulation. That the tri-compound engine is so well balanced that it does not race, or at all events does not race very much. That having tried various governors in the past, of which none have been successful, there is nothing further to be done in the matter.

These contentions are not justified by facts, for it is notorious that breakdowns of steamers' machinery are on the increase, becoming more numerous year by year. That this is so does not mean, of course, that all are due to the racing of the engines, but that a very high percentage of them can be traced to this source is more or less generally acknowledged. It would be interesting to know the actual cost for one year of the repair of defects in steamers which are directly due to or influenced by racing.

Certain parts of the machinery have been strengthened from time to time, but still the waste goes on. In making these changes the fact has apparently been overlooked that to eradicate a disease it is first of all requisite to remove the cause. That the tri-compound or quadruple engine is so well balanced that it does not race, or races very little, is also opposed to actual facts, for really it races more than the ordinary compound engine, which, again, raced more than did the simple engine it replaced. This is easily proved, for the greater the number of cylinders, steam chests, and passages the steam must pass through between the throttle-valve and the condenser the less control has this valve, for it can only produce effect during the admission of steam, owing to the large quantity of steam confined in the engine which is not under control. Thus hand throttling, which was so effective with the simple engine, fairly so with the compound, is now so ineffectual that it is rarely resorted to. In a seaway the engines are linked up, the boiler pressure is reduced, and racing, with its racket and consequent dangers, goes on unchecked.

The man who takes the engines to sea, however, never makes the assertion that there is little or no racing with modern engines. His testimony is certainly to the opposite effect.

That many of the governors offered in the past have been tried is no doubt correct; but were measures taken to prove that these means were sufficient for the purpose, or that the principles on which the design and action of these governors were based were such as to promise success?

Seeing that the speed of the stationary engine has been under control for a long period certainly gives a sufficient ground on which to base inquiry, but it would seem that the marine engineer has never inquired thoroughly into this question, or made a special study of it, such as it deserves, and which it certainly would repay. If this had been done some effective method of control would now be in general use.

The position the marine engineer has taken up on this important question is not a healthy one. He appears to have given up all hope of a satisfactory solution, ceasing further thought or action; he has forgotten—for a time only, let us hope—that the engineer can never know sufficient of any subject in engineering to justify him ceasing inquiry.

During the writer's seagoing days governors in the engine-room were not made quite so conspicuous by their absence as they are at the present time; generally speaking, there was no serious attempt made at speed control except in the earlier types. All that was attempted was to make a mechanism that would imitate hand throttling. Yet the most absurd claims were and are now, in fact, made for some of these appliances regarding the limits within which they will keep the speed.

Had the marine engineer made inquiries he would have learned that the results so absurdly claimed can rarely be excelled in stationary engines that have a load which varies considerably; yet these engines have a good flywheel allowance, while the marine engine has none. The absurdity of these claims should excite suspicion and cause inquiry, for such statements must either be wilfully misleading or made without knowledge of the subject. It would certainly be interesting to witness the performance of some of these governors on a stationary engine. Of the marine engine governors which came within the writer's experience some were driven by a rope from the shaft, others were of the types in which the motion of the ship or of the waves is used to act on certain mechanisms; these, again, acted on the throttle valve. There were also pumps used in a similar manner acting through gears, lever rods, etc. The first named of these governors had faulty drives, the single rope was constantly breaking, they also hunted considerably; still, when working on the old simple engine they did fairly well, although there was no reliable means of adjustment for various speeds—the same apparatus being supplied to all engines irrespective of number of revolutions per minute. Had the drive of these governors been improved, and a speed adjustment been added, it would have increased their efficiency to a great extent.

For those governors which got their movement from the motion of the vessel, or from the motion of the waves, it was generally claimed that they would anticipate a change of load. The writer considers this contention opposed to reason, except when the propeller is immersed to some distance below the surface of the water, under which conditions a governor is not so often required. But when the tips of the blades are level with or above the surface, it is only natural to think that the engine, which is taking the load, will feel the influence of a change before an outside mechanism which has no connection with the load whatever, and which, moreover, derives its action from a source which is too variable to be sufficiently reliable for the purpose.

If a governor could be endowed with brains it would not be certain to anticipate a change of load every time, as anyone who has had experience at the throttle can testify. But this is not all, for on the one hand there is an engine with a fairly high mechanical efficiency; on the other a mechanism, or series of mechanisms, which is not always at work, and therefore liable to get out of order to the extent that it, from this cause alone, will not work without considerable friction. Hence, it will have a lower mechanical efficiency than the engine, even if it has not this to begin with, and thus will indicate a change of load later than the engine itself, which certainly should feel the effect of the propeller rising out of the water as soon as, if not sooner than, any other appliance.

It is a mistaken idea that when a governor is driven from an engine the engine must first race before the governor can act—a properly-designed governor will move as the engine moves, and its speed vary as the engine speed varies, not after. It is not a question of time, but of speed, so that a sufficiently sensitive governor may close the throttle during, say, the time an engine is travelling 2 in. or 3 in. of its stroke, if it travel quick enough, and on a marine engine, with the least sea swell, it would never be entirely at rest, but be for ever on the move. This is simply a matter of arrangement.

The idea generally entertained by marine engineers, that an engine must race before a governor driven by it can act, may be due to the fact that their experience has been with a class of mechanism which cannot govern—it can only keep the throttle valve in one of two positions, full open or dead shut; therefore it cannot be made very sensitive, or it would be simply banging the throttle to and fro, open and shut continuously under very slightly varying loads, like a hunting governor on a stationary engine; thus it has to be made so rough that it is not affected by slight changes.

This type of governor came in after the compound engine began to be generally used. It was found that those governors used with the simple engine did not act so satisfactorily with the compound; competition then set in to see who could close the throttle valve the quickest, speed regulation was not considered, and a class of governor came into use that was unsatisfactory in every respect. All, or most, of the fundamental principles of governing were thrown to one side, with the result that although the throttle valve was closed quickly once it commenced to move, yet it is questionable whether some of the older governors did not close the valve just as quickly, for they commenced to close it as soon as the speed commenced to increase, whereas the mere throttler did not commence to close until the other was nearly, or quite, shut. This type also acts erratically; on certain occasions it will open the throttle while the propeller is out of the water, for where driven from the engine, as soon as the speed falls below a certain point the valve must be opened, and as it can only be opened wide the consequences are such that one might be pardoned for considering the remedy worse than the disease.

There can be no doubt that to regulate the speed of an engine automatically the governor must be driven by the engine it is desired to control; any other means of driving is safe to be uncertain, with a liability to act at the wrong time, or in a diametrically opposite direction to what is required. There are also the considerations that a governor driven by the engine has a safe and reliable source of motion, that it will be ready for action so long as the engine is moving, and that it will need no changes or reversals of its movements such as are required by some appliances, either going head to, or running before a sea. As the most potent factor in the speed regulation of the engine is the flywheel, and as we cannot make use of the inertia of this part to assist in controlling the marine engine, it would seem that the marine engine is the more difficult to control. If this be so, then a governor to control the latter must first be able to control the former, for it is a simpler task. If this contention be granted there is some justification for the plea that the marine engine governors tried in the past have been found wanting, for there are—as far as the writer is aware—very few, if any, marine engine governors that fulfil this condition; but that the means tried have failed does not justify the conclusion that the case admits of no remedy. Probably some good method of dealing with this weak point in the speed regulation of the marine engine may have been passed over by the marine engineer in his present sceptical condition.

That it is possible to control the speed of the marine engine within such fine limits as the stationary engine is controlled does not seem feasible to the writer, no matter what means are employed, neither does it seem necessary. What is really required is such control that the risk of derangement to the machinery shall be reduced to a minimum by entirely eliminating all heavy shocks. To do this it is necessary to find some means which will in a measure replace or reproduce on the marine engine the influence the fly-wheel has on a stationary engine; for to control the speed of any multiple expansion engine having a varying load, and not being subject to this influence by regulating the flow of steam to the cylinders only, is impossible, but there are several ways of replacing this influence which promise success.

First, the variable expansion principle may be employed by so arranging a governor to act on the reversing gear. Second, the power bottled up in the engines beyond the influence of the throttle valve may be reduced.

In the first method the governor should cause the reversing gear to move into such positions as are necessary for the valves to admit sufficient steam to deal with a varying load, while keeping the engines at or near the normal speed.

The second method is for the governor to close the throttle valve, after which, when necessary, the steam is allowed to flow from one or more of the steamchests direct to the condenser. By this latter means the power developed by the engine after the steam is shut off is effectively dealt with. The writer is aware that certain means of obtaining similar results have been tried, such as throttling the exhaust and fixing by-pass valves to allow both sides of the low pressure piston to be placed in equilibrium, but the type of governor employed to operate these means was of the sort already referred to, which admits of only two positions for its purpose of controlling the speed, so that under all conditions of varying load its operations must be the same, both for large and small variations. With such governor no good result can be expected, because it is not purely automatic.

The principles of speed regulation do not appear to have been recognised in connection with these appliances, as with most other marine engine governing apparatus. In the writer's opinion the wrong end of the engine was chosen for the purpose of reducing the power; the end where the steam is admitted, where the highest pressure is and where the volume is the smallest, offers the best and most economical facilities for carrying out this purpose. It may be there were good reasons why the low pressure end of the engine was chosen. But whatever is attempted on this matter must be on the lines of speed regulation, not on those of hand throttling, if successful control is expected. In the writer's opinion the principal characteristics of a marine engine governor should be as follows: It should be driven from the engine it has to control, it should be purely automatic in its action, and whether fitted with a relay or working on the throttle valve direct, its action should be such that the position of the throttle valve shall coincide with the engine speed, varying as the speed varies. Its design and construction should be such that it will keep the engines at practically the same speed if running either with or without a propeller on the shaft, that is to say, the revolutions should only vary to the extent required by the governor weights to take up fresh positions. It must be strong, so as to withstand the excessively rough work it has to perform, and simple, having no more parts than are absolutely necessary for the due performance of its duty, so that it shall not only offer few risks of derangement, but be easily understood by the engineer in charge. It should be sufficiently sensitive to answer to slight, as well as great, variations of load, yet not so sensitive as to court unsteadiness. It should be purely mechanical, without any electrical features, for if this power were sufficiently reliable for these purposes it would be in general use at the present time in connection with the governing apparatus of engines used for generating electricity. The marine engine governor should be constantly connected up to the engines, so that it will be in motion when they are, and be ready for work at any time, for although a governor may not be constantly required at sea, when it is wanted it is badly wanted. A governor can be of no practical use if, when it is required, it is not in good working condition. Governing mechanisms being necessarily somewhat delicate, it should be protected from dust, water, etc., and from the danger of external injury, while no marine engine should be considered complete without it, nor should it be looked upon with suspicion by the sea-going engineer, considered as an unnecessary part of his outfit, to be neglected and allowed to get out of order when not in actual use, and then, after this treatment, be blamed for not fulfilling its duties when required. It is well worthy of an honoured place in the engine-room, will be found always watchful and ever ready for duty, and no part of a vessel's equipment will give a better return for a little attention.

DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, JANUARY 14th, 1903.

CHAIRMAN:

MR. W. SIMPSON (MEMBER).

MR. JOHN FLEMING said, while he had a favourable recollection of one of Palmer's governors in the days of compound engines, he had not yet come across a governor which could control a triple expansion engine. There was no comparison between the varying load of the marine engine and the conditions of the stationary engine. In his experience of triple expansions in Transatlantic trade, all they could do was to reduce the pressure to 100 lb. and reduce the vacuum to about eighteen inches, then let her go. Hand throttling was no good. They had no governor which could control a triple expansion engine at sea, especially when the boat was in ballast.

Mr. MILLS said some years ago he had great faith in the variable expansion method of governing stationary engines, but he had read of experiments which seemed to prove that there was not the economy which was claimed for it, due probably to the superheating of the steam.

Mr. J. CHELLEW said he had seen only one marine engine governor, and that was now in a dry dock stores. What struck him as absurd was that this governor was fitted against the engine-room bulkhead, and the controlling rod weighed nearly half a cwt. How this could act on the throttle valve was beyond his comprehension. No doubt, the more sensitive the machine was the greater the efficiency, but it was a difficult matter in the engine room of a cargo boat to take sufficient care of so delicate a piece of mechanism.

Mr. BOYD did not see any real necessity for this delicate governing for the marine engine, the mere fact of an engine running away under a light load did not do much harm. The author seemed to lay some stress upon the circumstance that the doubling of the size of the flywheel should minimise the variation. There was nothing surprising in this, because if they had a big enough flywheel they could do without a governor at all. The question became one of convenience, expense, weight, etc. Some of the China steamers ran with a very big flywheel, and the effect was the engines did not race, so that the application of the flywheel to a marine engine was quite practicable. There was perhaps nothing to be said against it except what the owners might have to say as to its weight. In considering this subject of governors, credit should be given to Mr. Willans, a pioneer in the matter, and to Mr. Parsons, who controlled all his turbines by an electro-magnetic arrangement within one per cent.

Mr. LE LUBEZ stated that the Brown governor fitted to a couple of South-Western boats' engines, between Southampton and Havre, had worked very successfully. In another boat an Aspinall governor was fitted, and he believed acted satisfactorily.

Mr. ROBERTS said there was no necessity to regulate a marine engine anything like an electrical engine, for in the latter case the load might not be constant but the speed must be. He thought a general reduction of steam pressures was more towards the practical idea than the introduction of a fine, delicately adjusted apparatus. If the engineer was careful to reduce the steam in time he could get the same effect. They could govern cross-channel steamers of fixed draught, but it was different with cargo boats of varying draught.

Mr. GEO. SLOGGETT asked Mr. Welbury if he could cite instances where governors had been successfully adopted on board cargo boats.

Mr. STEEVES (Liverpool) asked for information as to the "thunderbolt" governor.

Mr. WELBURY said it was a very simple matter to take care of the governor on board ship. All the delicate parts should be enclosed in a box partially filled with oil, and no dirt could get near it. With regard to the results accruing from the larger fly-wheel, there was nothing surprising about them. He simply drew their attention particularly to these diagrams which showed so plainly the effect of the fly-wheel on speed regulation. With regard to electrical governors, so far as he could learn there was no such thing on any electrical generating engine in this country. Willans governed their engines by a centrifugal governor, designed on the Hartnell principle. Parson's turbines were controlled by Proell pattern governors. As to the speeds, a governor could be so constructed that it might be varied to suit any speed—it was only a mechanical arrangement. His object in preparing the Paper was to try to induce marine engineers to take an interest in this subject of governors. It had been said there was no necessity for them on marine engines. In his opinion there was greater necessity now than ever. In these days everything on a ship was of the most approved pattern to attain economy with efficiency, and if the marine engine builder had been subject to the same demands and conditions as had been the stationary engine builder, there would have been efficient governors on marine engines long ago. If the stationary engine builder did not put a governor on his engine to-day he could not sell it,and they had only to say to the builders of marine engines that they would not have them without governors and the builders would quickly find a means of control. Also if the underwriters were to say they would not insure unless the engines were governed they would soon have them effectively governed. The subject formed a most interesting study, and would well repay anyone taking it up. A question had been asked by Mr. Sloggett as to the ships on which a governor had been tried. He could only say that his own governor, which he had shown them on the lantern screen, and which he called the Racing Check, was fitted on eleven ships, and was doing remarkably well. It was notorious, however, that no more money was spent on a ship's equipment than could possibly be avoided; but if they were prepared to pay a reasonable price, there were lots of makers who would supply and guarantee governors and would not ask for payment until they had proved their utility. One gentleman had said that flywheels had been tried on board steamers and acted well. But the smallest flywheel allowance to keep the engines within ten or twelve per cent. of normal was one foot-ton per I.H.P., and if they took a 3,000 I.H.P., what sort of wheel were they going to have on an engine making seventy revolutions?

Mr. BOYD, interposing, said this was an extreme case. The object of the flywheel on a marine engine was to resist the racing and variation of speed when running light.

Mr. WELBURY had always understood that the flywheel was adopted on Holt's boats in order to keep them off the dead centre.

Mr. BOYD: That was an incidental effect.

Mr. JOHN FLEMING, in proposing a vote of thanks to Mr. Welbury, said he agreed with Mr. Boyd as to the object of the flywheel where adopted for marine engines.

The vote was seconded by Mr. BOYD and supported by the CHAIRMAN, who expressed gratification that the paper was also to be read in London, and suggested that those B.C.C. members who were not present at this meeting should send written remarks to the Hon. Secretary in London.

In acknowledging the vote, Mr. WELBURY said if he had succeeded in interesting members in the subject he was amply rewarded. He should be glad to contribute at some future time another paper on this or some other topic.

The meeting closed with a cordial vote of thanks to the Chairman.

PREFACE.

58 ROMFORD ROAD,
STRATFORD.
February 9th, 1903.

A MEETING of the Institute of Marine Engineers was held here this evening, when a paper on "The Speed Regulation of Steam Engines" was read by Mr. W. WELBURY. The paper was illustrated by means of lantern slides, as well as by several diagrams taken from the Moscrop Recorder—printed along with the paper—which had previously been read at the Bristol Channel Centre Rooms in Cardiff. The chair was occupied by Mr. W. LAWRIE, Member of Council.

JAS. ADAMSON,
Hon. Secretary.

DISCUSSION

ON

THE SPEED REGULATION OF STEAM ENGINES, STATIONARY AND MARINE.

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, FEBRUARY 9th, 1903.

CHAIRMAN:

MR. W. LAWRIE (MEMBER OF COUNCIL).

THE CHAIRMAN said they were met to hear an interesting paper on "The Speed Regulation of Steam Engines, Stationary and Marine" by Mr. W. Welbury (Member), resident at Leeds. They were very fortunate in having Mr. Welbury with them to read his own paper, and be on the spot to answer any criticism that might be passed on it.

The paper was then read.

MR. W. E. FARENDEN (Associate Member) said he thought the author had been rather severe on the marine engineer with regard to not having proper governors to control his engine. He was of opinion that there was one that met the requirements put forth by the author in the latter part of his paper. He referred to the governor known as Aspinall's, which gave very good results, and was quick in action. The Aspinall governor was usually fixed on the pump lever at a given distance from the centre of the pump shaft, being connected with levers direct to the throttle valve. This governor could be regulated to make it more or less sensitive, so as to shut off at any required revolutions of the engine. Emergency gear was also fitted to this governor which came into play in case of excessive racing, or a broken shaft, the gear of the governor being arranged to shut the throttle, and prevent it being reopened. The Aspinall governor consisted of a hinged weight operating two pawls carried on a frame, which was bolted to the air-pump lever or other reciprocating part of the engine.

Mr. G. SHEARER (Member) said he had had no experience with Aspinall's governor. He had, however, been very much impressed with the governor invented by their president, Mr. Dunlop, which he had always considered to be the ideal marine governor. In all other governors that he was acquainted with it had been necessary to have acceleration of motion before they could act. A great mistake was made in many ships in having the opening to the connection at the stern carried too far forward. It was generally put into the after end of the tunnel close to the stern gland. In large ships that would be from 25 ft. to 30 ft. forward of the propeller. Now if the opening were taken right into the run of the ship close in to the stern frame, say 25 ft. further aft, a rod connection could then be used for the shut-off valve; the Board of Trade would enforce a shut-off valve in the skin of the ship. He had noticed in the working of the Dunlop governor where they were fitted in that way with the inlet too forward, not so much perhaps in the heavy seas of the Southern Ocean, but in the Atlantic, where they got a more jumping, and comparatively shorter sea, that it did not act very well, because if the water got away from 25 ft. to 30 ft. from its work the acceleration of speed became great before the action took place—the inlet valve was too far away from the propeller. He could not agree with the author when he said that the tri-compound or quadruple engine raced more than the ordinary compound engine. The racing of the old compound engine was enough to startle any man at times, but the racing with a three or four crank engine, he considered, was nothing in comparison to the shocks that were caused by the racing of the old compound engine. With regard to a compound engine with which he had been engaged, there were the ordinary starting valves on high and low pressure cylinders, and he could always throttle off the high pressure engine, but there was such an amount of steam between the throttle valve and the condenser that the racing was minimised certainly, but not to the extent he would have liked. The starting valves of that engine were very large. So far as he could remember they were 5 in. valves at the top and bottom of the low pressure engine, and he connected them very simply by turning round the levers of one of the valves and connected the two together with the throttle valve on the starting platform, so that by moving the handle one way (they had the up-and-down motion of the old starting valves) to open both valves at the same time and thus threw the piston into equilibrium. Owing to the arrangement of the throttle gear on the middle platform the governor worked the handle, which was right in line with the starting gear, and they had no trouble whatever. He lengthened out the throttle valve lever, which was right opposite the gear, by a tube, and connected the handle to the starting gear by means of a piece of rope, so that he had full control of the engine under those circumstances. Thus the governor was working the throttle valve and both starting valves on the low pressure cylinder at the same moment, and he found that it made an enormous difference.

Mr. W. McLaren (Member) said that an engine in which he was interested had been tested before leaving the workshop. They tried her with a full load and no load. Her full load revolution was 450, and with no load she only increased to 470 revolutions. He considered this a remarkable performance for any engine, with which anyone would be pleased. The author had claimed that the triple and quadruple engine raced much more than the old compound. The speaker's opinion was that the build of the ship had a great deal to do with the racing. The author had also described a remarkable performance with a governor, which seemed so sensitive in its action that there was not time to wink one's eye before the governor acted.

Mr. WELBURY, interposing, said: You cannot notice the variation in speed when the full load is pulled off.

Mr. McLAREN, continuing: He did not think it was a question of governing between 10 and 15 per cent. on marine engines; the main thing wanted was an emergency governor that would act when the propeller was out of the water. He remembered being on board a little steamer about 140 ft. long, and in a heavy sea they seemed almost to be standing on end. He would like to see a governor that would keep the engines going steadily in such a vessel. The question of the fly-wheel was quite out of the consideration of the marine engineer. The fly-wheel had been adopted, or was the style, on some of the Holt Line steamers, as the author had mentioned, but those fly-wheels had been fitted mainly to carry the engines over the dead centre.

Mr. JOHN SINCLAIR said there was one statement that the author had made to the effect that the triple engine raced more than the compound, and the compound more than the simple, with the result that a large number of shafts were broken. He considered that statement open to question, as if carefully gone into it would be found that Lloyd's Rules and the Board of Trade Regulations allowed more power to be passed through the shafting of triple-expansion engines. The breakage of shafts might be due to the fact that they could pass more power through the same shaft when using triple-expansion engines than they could when using compound or single engines.

Mr. K. C. BALES (Member) said the most satisfactory governor he knew of was the one mentioned by Mr. Farenden. He remembered that some seven or eight years ago the Aspinall governor was first noticed, and was very little known. The superintending engineer of steamers he knew was rather difficult to move in respect to innovations, and he believed that gentleman was now very considerably impressed by the results obtained from the governor named. As Mr. McLaren had remarked, he did not think the governing of marine engines was required to the extent that was obtained in stationary engines, such as those used in connection with the production of electric light. Possibly, without going into calculations, a margin of 10 per cent. would give very satisfactory results as regarded marine engines, although the governor which Mr. Farenden had partially described was of a type which the author disagreed with, namely, on or off type; it was used by several large lines of mail steamers and so far had given great satisfaction. It was not controlled by any other means except the engine itself. It was bolted direct on the engine, and was not driven by belting or cotton ropes.

Mr. G. SHEARER said he wished to mention one point. He had said that the Dunlop governor was his ideal governor, and so it was so far as the racing of engines in a sea-way was concerned. It was, however, of no use in the event of losing a propeller, or breaking a shaft.

Mr. J. H. SILLEY (Member) said he had had experience of the Aspinall governor, and at first had thought a good deal of it, but his experience of more recent years caused him to feel there was room for improvement. Taking, for instance, steamers leaving a colonial port with a light cargo and about 2,000 tons of coal on board, by the time they were in the N.E. trades the draught was greatly altered, and the ship perhaps down by the head. In such a case he had found it necessary to reduce the speed considerably, when the engines were racing badly, to prevent damage to the machinery; he could not rely on the governor shutting off before an excessive speed was reached, and consequently he had lost a good deal of his faith in it.

Mr. JOHN McLAREN said he could not agree with Mr. Silley. He had had some experience with the taking out of new steamers, and from that experience preferred this governor. He thought it would be found that the Cunard and White Star steamers used it. He was of opinion that the breakdown of the *City of Paris* would not have occurred had they had such a governor. He had been with the Dunlop governor and also with the Durham-Churchill governor, and had always found the Aspinall governor to do its work when required if kept in thoroughly good order and looked after. The makers claimed that they could regulate them to within 5 per cent., and he had found that to be true.

Mr. JAMES HOWIE (Member) said he did not see why the piston valve should be discarded for a flat valve if the valve acted quickly on the body of the steam, and as it was not required for a shut-off valve, but a throttle-valve, the same action ought to be obtained. It had been remarked that breakdowns were on the increase. He would not say they were on the increase in the ratio of the shipping afloat, as shipping had also increased. A question had been raised with regard to tail shafts. It was an old question. Lloyd's had been increasing their shafts a little. The number of cranks and the balancing of the present day engine had a considerable effect on its revolution and momentum. Mr. Welbury had told them what he wanted to do, but he was not quite sure that he had said what they ought to have. The speaker once heard Mr. Milton remark that water-tube boilers were very good, but they had not got the right one. He told them what the water-tube boiler ought to be, but said he would leave it to a mind of greater power to invent what he wanted. That seemed to be the idea of Mr. Welbury. He knew exactly everything that was required, and what a good many more engineers had been requiring for a considerable time, but he was not sure that this governor or any governor would act with the same efficiency on a marine engine at sea. That brought up the question that Mr. Welbury mentioned, namely, that it would act immediately. That was just where the crucial point came in. He was afraid the governor had not arrived at that perfection yet; he doubted if the governor would act immediately at the moment when the engines required to be checked. The momentum of the engines was so great that by the time the speed had been reduced in a heavy sea the governor would cease to be of any use, as the engines would have got back into the sphere of the propeller being immersed. One could not say that governors were of no use. If they got an idea from a land engine, and saw that it was all right, why should the governor when applied to a marine engine not also be all right? There must be some sensitive point in the marine engine where the governor ceased to be effective at sea, and that point may be found out, either in leaky piston and throttle valves or otherwise, as mentioned by Mr. Welbury.

Mr. T. A. McKenzie (Member) said he thought they ought to adopt the idea suggested if it were proved to be of any good. He thought rather too light a view was taken of the difficulty in regard to the racing of marine engines. There were a great many more difficulties in regard to throttling in the modern than in the old engines. He did not know any case of land engines that underwent so many variations as the marine engine, especially in light ships in a heavy sea-way.

Mr. A. H. Mather (Member of Council) said the strictures in the author's paper did not apply to the designers of marine engines and governors so much as to the men who took them to sea. He had been with two different governors in two different ships. In one instance he was a junior, and had no chance of doing what he would have liked, but that particular governor was never used all the time he was in the ship. It was one of the type that worked from the stern of the ship, and he understood that the pipe connecting the stern to the governor was choked somewhere, but whether the stoppage was in a place that could be got at or not no one seemed to know. In the other ship the governor was placed on a bracket up on the bulkhead in a place where it could get no attention, with the result that it was painted all over about a quarter of an inch thick and left to its fate. He thought it would be found that many men have governors, but take no interest in them, because they considered that they could throttle quite as well. With regard to racing, the balancing of the engines made the effects of the racing less plainly felt, but the racing went on all the same. A good many people asserted that the four-crank engines in the navy, with small diameter propellers well below the water, did not race, but he could tell them that those engines did race. He had been out with one or two warships in heavy weather, and the engines had raced very severely. There was no special means of throttling with these engines—indeed, throttling had no effect. The result of the racing, even during a thirty-hour trial, was such that all the crank pin and crosshead brasses had to be adjusted, so the statement that racing did not occur with three- and four-crank engines did not, in his experience, hold good at all.

Mr. A. O. WALKER (Member) said he believed there were good governors in the market; he had had experience with two or three himself. The Dunlop governor was a good governor, but the india-rubber diaphragm was, he thought, a weak point. He believed the more modern ones, fitted with a smaller diaphragm, were better. Another governor, manufactured by Messrs. Durham & Churchill, could regulate the speed of the engine to a nicety, even when not required to prevent racing. These governors were good, but they were always looking out for improvements.

A MEMBER said it was some time since he had anything to do with governors, but he considered their use far better than standing by the throttle valve. As to marine governors, he had not had occasion to use them for some years, but he had found them very effective.

The CHAIRMAN remarked that he had not had much to do with governors during the last few years. He had not been trying to reduce or control the speed of engines. There was no doubt that Mr. Welbury in his paper had made some very serious statements, and he thought that they might take it for granted that what he had said was about right. Mr. Welbury had told them that marine engineers had not closely considered the question of marine governors. He had also said they had not thoroughly inquired into the matter, and he had spoken of the damage to machinery, a great part of which might be reduced. They had been strengthening some parts of the machinery, but the author had told them that the cause of the disasters had been overlooked. That was a very serious statement to make against what was usually considered a progressive body of men. He thought that Mr. Welbury quite recognised the difficulties engineers had to contend with, and had said they must find something to replace or reproduce the fly wheel. That was a tall order, and a very difficult thing to do. The fly-wheel was a very big and a very important thing, and it would be a very difficult matter to find something to replace it, and he did not follow that the author's explanation quite found that out.

Mr. WELBURY, replying, said his experience of the racing of engines commenced with the old two cylinder engine, and ended with the triple expansion. He had been in the Atlantic trade, going backwards and forwards in a steamer of 700 tons register, and he had seen them double banked for thirteen or fourteen days at a stretch, and at the throttle valve for twelve hours each day. After they got to the triple expansion engine it was no use to throttle, for the reason that it had no effect unless they could shut off the throttle three or four revolutions before the vessel's stern began to rise. His attention had been first called to the matter of trying to improve the speed regulation of the marine engine by seeing what could be done with the stationary engine. The electric lighting engines were all subjected to very severe tests, from a quarter load to 25 per cent. over load, thrown right off at the main switch, and the variation of speed must not exceed from 4 to 6 per cent. Although the engine had a flywheel they would admit that was a very severe test. If a land engine could be controlled like that should not something better be done with the marine engine? He had heard a good deal of the Aspinall governor: it was a governor on the same principle as the "hit or miss" governor on gas engines. He knew three things about the Aspinall governor: (1) It would only cut off the steam once during a revolution; (2) It would only open the steam once during a revolution; and (3) owing to its having rigid gear they dare not allow the throttle valve to be closed entirely, it had to be left so far open in case some accident to the gear might happen through vibration. He knew it was claimed that the Aspinall governor would control the speed within 5 per cent., but it was not stated that this was within 5 per cent. of any specified engine revolutions. Regarding the speed of the stationary engine mentioned by Mr. W. McLaren, the results he gave were very good indeed. The higher the speed of an engine the easier it was to control. Referring to the size of shafts, there was no doubt that Lloyd's allowed a smaller shaft with 3-crank than with 2-crank engines. That might be a reason why there had been so many breakages of shafts in triple-expansion engine ships, or it might be due to the more balloon-like shape of the ships that the shafts were fitted into now. Breakages ought to be less in number; they should improve. They ought not to be content to sit in the same hole all the time.

They congratulated themselves that breakages were not more frequent, but really they should get less. In stationary engine work, if a maker found that his shaft broke within a certain time he increased the size of it. If there were some other cause he removed that cause. He did not think that the marine engineer took such care of his engine as the stationary engineer did. Who paid for all the breakages and damages? They did not have stationary engines insured the same way. There were certain corporations which took up the insurance of them, but the matter of damage was very closely inquired into. The crux of the matter was this, that until the men who had breakage to pay for demanded that the engines should be controlled in speed, they never would be, except by a few men who took a pride in their engines and were anxious to improve all round.

The CHAIRMAN observed that owners paid for damages, not the underwriters; the latter body paid for the damages out of the premiums which they received from the owners, and lived very well by their losses. That was a point very much overlooked.

Mr. WELBURY said he had an idea that the price of the Aspinall governor was about £30. He had shown them a governor on the screen that evening for which his firm got orders from stationary engine makers, and the prices went as high as £250. If they could get a governor that could control the marine engine—which was a more difficult task than to control the stationary engine—would the stationary engine builder not prefer to pay the £30 instead of £250 if the governor could do the work as well?

The CHAIRMAN said in his young days he was connected with the "Silver" governor, an invention of Mr. Silver, an American. That gentleman did a very good business on the Clyde for a long time. - A finer governor was wanted when the compound engine came into use. Mr. Silver set to work and invented another governor. They called it the tangential governor. Instead of the fly-wheel he had a four-ball governor worked on the cross-head on the centre of the shaft. They tested the governor in the works, and found it worked beautifully. There was not an atom of racing, and it absolutely controlled the engine. That governor went out on board a big liner, but it would not work at all, and it came back to the shop. He remembered standing alongside the man who was to put it right according to the maker's instructions. The maker had every joint eased, because it was thought that easing the bearings to a certain extent might improve the working of the governor. Still, when made freer, it would not control anything. Perhaps they had not thought the matter carefully out, but it seemed to him that there had been a lot of brain-power wasted, or at all events expended, on governors.

Mr. WELBURY remarked that the higher the speed at which the governor was run the more sensitive it would be in its actions.

Mr. W. MCLAREN proposed, and Mr. SOAR seconded, a vote of thanks to Mr. Welbury for the trouble he had taken with his paper. He understood that Mr. Welbury would be willing to give them another paper later on.

Mr. SOAR seconded the proposition, which was cordially agreed to.

A vote of thanks to the Chairman for presiding, proposed by Mr. J. HOWIE, seconded by Mr. G. SHEARER, concluded the meeting.

Mr. C. W. BARNES (Associate Member)—communicated—I hope the author will allow me to congratulate him on his practical and painstaking paper. The addition of the diagrams enhances the value of it twofold. Owing to the large field covered by his paper, Mr. Welbury has omitted to mention the Parsons' electrical governor which is fitted to their turbo-generators. Quite recently it was observed that all the machines at the Manchester Square Station, Oxford Street, W. (Metropolitan Electrical Supply Company), were fitted with them. This governor is really the only successful electrical governor in practice. The governing is accomplished as follows: Steam is admitted to the turbine in a series of gusts by the periodic opening and closing of a double beat valve. This spindle is operated by means of a steam relay in mechanical connection with the turbine shaft. The duration of each gust is controlled either by an electrical governor—which consists of a solenoid connected as a shunt to the field magnets, the core of the solenoid being hung from the end of the long lever—or by a centrifugal governor driven from a worm on the turbine shaft. The fulcrum of this lever is periodically moved up and down by means of a link connecting it with an eccentric, which receives its motion from the worm on the sleeve coupling; the eccentric also serves to work the oil pump. The short end of the lever controls the valve of the steam relay. Each periodic movement causes a gust of steam to be admitted to the turbine, the duration of the gust depending on the position of the solenoid in the case of the electrical governor. With alternate current generators, when governed electrically, an additional series solenoid is placed above the shunt solenoid, the core of the series solenoid being connected to the top side of the long lever. Thus, as the load on the dynamo increases, the lever rises, and increases the duration of the gusts of steam, and the governor is thus compounded for constant voltage.

Mr. WELBURY, in reply to Mr. Barnes's communication, adhered to the statement made on page 25. This is a general statement, and was not meant to include isolated cases, which probably are more or less of an experimental character.