regulate the speed finally. But where perfect steadiness is desired it is probably better not to cut off much before half stroke, especially if a single-cylinder engine is used. The use of accumulators as regulators would of course prevent a great deal of the fluctuation, and would permit of the steam being cut off much earlier without causing any apparent unsteadiness in the light.

The electric governor was fixed on the engine and worked for the first time on January 13 last. The improvement was remarkable, the lights remaining steady, without the sudden alternations of brightness and dullness which had occurred before. But it was still found that with any considerable variation of boiler pressure or of load the electromotive force in the mains varied more than was thought conducive to long life in the lamps. As however it was found that, by augmenting or diminishing the weight suspended from the core bars, the electromotive force could be brought back to its normal amount, it occurred to the author to fix an upright cylinder in direct communication with the boiler, and to make its piston-rod press upwards on the core-bars: the diameter of the cylinder being experimentally determined by observing the weight necessary to be added or removed for certain variations in boiler pressure. This arrangement caused a very great improvement; and when the load was approximately the same it maintained the electromotive force constant under very considerable variation of steam pressure. When, however, the load was varied very considerably, say from one lamp to a hundred, it was found that more variation took place in the electromotive force than was desirable.

The arrangement was accordingly modified by causing the piston-rod to act upon a lever, and by introducing a second cylinder supplied with steam from the steam-chest, the second piston-rod acting not upon the same lever but upon the other side of the fulcrum. The end of the lever was furnished with a steel knife-edge, bearing against another knife-edge set at right angles to it upon the prolongation of the core-bars. The cylinders were also both of them made larger, and were placed so that they could either of them be moved nearer to or further from the fulcrum of the lever, whereby the resultant effect of their differential power could be easily adjusted. This arrangement answered very well indeed, and it was found that the lights could be varied from 1 to 100 and the boiler pressure from 30 lbs. to 60 lbs. with but very slight variation of electromotive force in the mains: provided of course there was sufficient steam to do the work required. It is also quite easy to cause the electromotive force to rise as the load on the engine increases—or in other words as more current passes through the main—by simply giving greater leverage to the piston connected with the steam-chest. In fact with this arrangement the electromotive force can be maintained practically constant, or can be made to vary in any desired manner with variations of steam pressure or of load.

Several experiments were made by Mr. Richardson and the author on the action of this regulator, the results of which were as follows:—When the load on the engine was allowed to remain constant, with only one lamp alight, it was found that while the steam pressure was allowed to vary between 31 lbs. and 55 lbs., the electromotive force remained constant at 90 volts. Afterwards, with the same extent of variation in steam pressure, and with the load also varying from 1 lamp to 91 lamps, the electromotive force varied only 2 volts—from 91 volts to 93 volts. The introduction of this governor has, in the author's opinion, contributed very largely to the duration of the lamps also. The discussion of this paper, which was very full, was mainly upon the governor described and the governing of engines for electric work, the necessity of an electric governor being maintained on the one side, whilst on the other it was held that all that was required was an ordinary mechanical governor of great sensibility.

The Rev. E. Venables, at the conclusion of the discussion, invited electrical engineers to advise the Cathedral authorities, as they should like to see, as a practical result of the visit of the Institution of Mechanical Engineers to Lincoln, the lighting of Lincoln Cathedral by electricity.

A VOLTAIC CELL WITH A SOLID ELECTROLYTE

I BELIEVE that there has never hitherto been made a voltaic cell with a solid electrolyte which was capable of generating the smallest sensible current—at least at ordinary temperatures. Sir William Thomson found that when warm glass was placed between plates of zinc and copper, the existence of an electromotive force was indicated by an electrometer in connection with the metals, and Profs. Ayrton and Perry extended the observation to the cases of paraffin-wax, gutta-percha, indiarubber, and shellac. But it is needless to say that with electrolytes of such enormous resistance no current could be generated of sufficient strength to be detected by any galvanometer, however delicate.

On June 27 I exhibited to the Physical Society a little cell consisting of plates of silver and copper, between which was contained a mixture of 1 part of copper-sulphide with 5 of sulphur. When this cell was connected with a reflecting galvanometer it produced a current by which the spot of light was at once deflected off the scale, copper being the positive pole. The electromotive force was found to be '07 volt, and the internal resistance 6537 ohms. The current, therefore, though far more than merely sensible, was small. Attempts were made to reduce the internal resistance by diminishing the proportion of sulphur contained in the mixture, but it appeared that as the sulphur was diminished the electromotive force was also diminished, until, when there was no free sulphur at all, the cell failed to produce the smallest measurable current.

It occurred to me that the sulphur owed its efficacy to the fact that it formed a film of silver sulphide upon the surface of the silver plate by direct combination. I therefore made a cell thus:—A thin layer of copper sulphide was spread upon a copper plate and compressed into a compact mass against a surface of polished steel. A layer of silver sulphide was then spread upon the copper sulphide, and the cell was completed by pressing a silver plate upon the silver sulphide. The current which this cell produced through the shunted galvanometer was considerably stronger than that generated by the cell first described; but still the result was not quite satisfactory, and there seemed to be indications of short-circuiting, which I thought might possibly be due to the penetration of particles of copper sulphide through the layer of silver sulphide. The silver plate was therefore removed from the cell, and, having been brushed over with a weak solution of sulphur in bisulphide of carbon, it was heated over a gas flame, and soon became covered with a uniform and continuous coating of sulphide. The heating was continued until all the free sulphur was evaporated. When the cell was reconstructed with this prepared plate it produced a current of 6800 micro-amperes through an external resistance of '2 ohm, and was able to deflect the pivoted needle of an ordinary coarse galvanometer.

The dimensions of the cell are as follows:—The copper and silver plates measure $2\frac{1}{2}$ inches by 2 inches; the thickness of the two layers of sulphide (strongly compressed) is about 1-20th inch; the E.M.F. is '053 volt, and the internal resistance is therefore about 7 ohms.

This cell seems to be exactly analogous in its action to a Daniell cell in which plates of copper and zinc are immersed in solutions of copper sulphate and zinc sulphate. Silver is probably the best (or only) possible metal for the positive plate, but some other metal might perhaps be substituted for the copper with advantage.

SHELFORD BIDWELL