crease of speed was accomplished by field control, the rheostats were of sufficient capacity that the speed in the main motor might be reduced below 450 r.p.m. by armature control. Both motors and the ratchet worm and wheel were mounted together on a common cast iron sub-base forming a single and compact unit. The ratchet wheel was made in two parts, one part carrying the worm and ratchet teeth ran free on the shaft, the other part carrying the pawls was keyed to the shaft. Each pawl was provided with a small spring which held it against the ratchet teeth. On starting the small motor the ratchet teeth engaged the pawls and turned the motor armature shaft until the main motor was thrown in when its speed was such that it overhauled the ratchet, at the same time the small motor was disconnected from the circuit and the worm wheel came to rest. As the main motor speeded up centrifugal force threw the pawls entirely out of mesh.

The R—73—A, controller was especially designed for operating printing presses with two motors and had nine points for the operation of its smaller motor by resistance control and five points for the operation of the larger motor by resistance control and fifteen points for the operation of the larger motor by field control. The controller was provided with a finger designed to lift up when the controller was turned backward from any of the notches for the operation of the large motor so that the circuit of the small motor would not be completed in turning the controller to "off" position. The controller was provided with a finger for operating contactor switch, the circuit being opened and closed through this contactor. With each equipment there were furnished push button switches which short circuited the solenoid coil of the contactor so that the press might be shut down from any one of these buttons, the buttons themselves being placed at different places on the press. There was also an interlocking device on the contactor which after the press had once been shut down from a push button the operator was required to turn the controller to the "off" position before the press could again be started. The arrangement of rheostats used in the armature circuits of these motors was such as to secure smooth acceleration using the same rheostat for both motors. On turning the controller handle to the first notch the contactor energising coil was given current and closed the main circuit. The first nine points successively decreased the resistance in series with the small motor armature until on the ninth the latter had full voltage. The change from the ninth to the tenth notch was that the large motor armature was given current through its highest block of resistance and the circuit of the small motor besides being interrupted at the ends of the segments was also opened by the finger which automatically lifted. The next five points successively decreased the resistance in series with the large motor armature until it was running at full voltage, after which the next fifteen points inserted resistance into the shunt field circuit for speeding up.

There were a number of other machines running under different conditions, but he was afraid of trespassing on their time. He would, however, before closing these remarks like to mention that he considered it most necessary to put up a good switch board containing circuit breakers, irrespective of those on special machine panel boards, meters etc., The current for the "Daily Telegraph," plant including lighting only cost 2.3d pence per unit.

He might mention that they had forty five motors running at the present time, and that their saving by the conversion to electricity from steam amounted to nearly four figures per annum.

Mr. McNamara said with reference to the author's strong advocation of direct current machines for factory and shop purposes there were arguments for and against this. There was no doubt that without the extended use of the carbon brush as now supplied for direct current work the use of this class of machine would be considerably curtailed. The C.S.R. Co., in 1903 when considering the installation of electrical power at the Pyrmont Refinery, went very carefully into this question, and after the various merits and demerits of the two systems were discussed, the 220 volt direct current was finally decided upon, with the dust proof type of motor as a standard. (The plant now by the way had increased to nearly 1000 electrical h.p. counting generators and motors), and it was a fact that not withstanding the sticky and also dusty nature of the material handled, the commutator troubles so far had been practicably nil. This might be owing to the system of attention adopted (costing in the aggregate perhaps 15/- per week, and also in the first instance to the fact previously mentioned—of the adoption of the dust proof type of motor. Against these and the many other good points for the direct current motor brought forward by the Author and others, might be laid the following on behalf of those who advocated an alternating current system of transmission.

1st. The cheaper first cost of the induction motor (this being a motor in which currents were induced from the fields into the armature, these currents in turn reacted upon the fields and produced the motion so giving the name to the motor). The cost of the squirrel cage type being about 20 per cent. per h.p. less than for the shunt wound direct current type.

2nd. The elimination of even casual attention while running, due to the absence of the commutator, pointed out by the Author

3rd, Also to the fact that the induction motor might be used in a variety of situations where a commutator motor would be advisable, for example, in powder, cement, coke or cotton factories, and other gritty or dusty places, where if a direct current motor were installed it would have to be either a dust proof or totally enclosed type, more likely the latter, when of course a higher price per h.p. would result on account of the loss in efficiency due to the enclosure of the motor causing a rise in temperature which brought down the said efficiency anything from 30 to 50 per cent, according to the type of motor used, be it dust proof or totally enclosed.

The use of the synchruous motor. These motors belonged to another class of alternating current machines and were so called on account of their running in step or "synchronism" with the impulses of current supplied by an alternating current generator. They could not be very well advocated in opposition to direct current motors as they had their fields excited from a direct current source which entailed the use of a direct current exciter close handy. Again they would not start very well against a load therefore they must first be speeded up and the load gradually applied, but they possessed an advantage over the induction motor inasmuch that they did not set up lagging currents and so increased the resistance of the circuit which of course threw more work on the generator.

Reverting to speed regulation of alternating current motors, it might be of interest to know that motors were now being placed on the market for which the makers claimed the same ease of regulation as on the shunt wound direct current type and the same efficiency when using the armature resistance method of control Another method was resorted to viz, by placing resistances in the various phases of the field windings and various speed might be also attained by altering the number of poles of the motor which would cause a corresponding change in the strength of the magnetic field and likewise a difference in the speed—either up or down as the case might be.

A comparison of points like these was necessary before determining upon the system which a user was likely to adopt, and proved that under certain conditions both systems had their own respective fields of utility.

Mr. A. J. Arnott said he would like to say a few words. With the exception of one or two points he agreed generally with the remarks and advice given by the Author in his paper; but he would not agree that there was a loss of 50 per cent, with steam plant under ordinary workshop conditions as compared with motor driving; that seemed to him to go over the mark. It would, he thought, be an exceptionally badly arranged workshop in which the actual loss in shafting amounted to 50 per cent.

From estimates he had seen he thought the difference was from 15 to 30 per cent, but an exceptional case of 50 per cent. as mentioned by the Author could be no criterion to go by. The reference to Mr. Williamson's paper was rather interesting, where he pointed out that the latter stated that electric energy cost, 5d per horse power. That was, of course, electric horse power, which had been transmitted through the dynamo, so that there was a percentage of loss in generating; which gave 20 per cent, to come and go upon with steam plant shafting. He should like to say that he had paid a very extensive visit to the Continent some few years ago, and visited most of the large workshops He did not think he saw one workshop that was driven by direct current. One particular workshop in Berlin, employing 17,000 hands, would take weeks to go over, and there were installed alternating current three phase motors. The generating plant was quite a powerhouse in itself. While alternating current motors had some advantages—cheapness being one—specialists—men of high position in the electrical world—would not have them in their workshops. He congratulated the Colonial Sugar Company on the success of their direct current motors. He knew of cases where accumulators had given a great deal of trouble, and had repairs costing from £10 to

£20 done to them in a short time. Accumulators had been advocated by the Author, but he was inclined to doubt the advantage of installing a battery of accumulators, for workshops. They might be an advantage and run all right in large places where the efficiency was not high and they were not overcharged, but the chances were that in five years' time it would be found that a new battery would be wanted; and a new battery cost money—from £500 to £1000. As to the matter of gearing raised by Mr. Williamson, after all was said and done the cost of maintenance was the great point, and he had it on good authority that 25 per cent was good in running a workshop; even if they went to 50 per cent. that was not a big mouthful after all, considering the interest on the more expensive plant that would have to be installed. He had nothing to gain in advocating any one system more than another. There were many advantages with electric driving with special machines, but these advantages would have to be carefully considered and the cost compared so as to see whether it was advisable to make the change. The points raised by the Author about refrigerating plants was a good one, and ought to strongly appeal to those interested in that question.

Mr. James Shirra, considered that the author had put the advantages and limitations of the electric drive very fairly and reasonably before them. Evidenty there was a great field for it where only a small power was required, and current could be obtained from an electric supply at reasonable rates, also for driving machines at a distance from the prime mover, and for travelling and other cranes. To drive a detached punching or drilling machine in a ship-yard for instance either by a long length of shafting, steam pipes and an independent engine, or hydraulic power, involved such losses in the resistance and capacity of the conductors, to use electrical terms, and the work was done at least so uneconomically, that it might well be more profitable as well as far more convenient to use electric transmission. But where we had the machinery in a compact workshop there must be some exceptional circumstances if it would profit to submit to the inevitable loss in a double transformation of energy, first from work to electric current, and then back to work again.

He remembered talking over quarter of a century ago, to a gentleman who was interested in and enthusiastic about, the use of hydraulic power on shipboard. He predicted that in a few years steam winches would be obsolete, their place being taken by hydraulic lifts. The electric motor was then just begining to be thought of, and he suggested that one might have electric cranes instead. But he said the potential of the electric current was so low that motors would need a great deal of gearing up to do any useful work, and the frictional losses would be too great for any success to be obtained. The heavy currents and high voltages we were now familiar with, were not dreamt of then, but there was still much in the objection unless we used large and expensive motors. If indeed we could get gears which gave a reduction of 10 to 1, with only 2 per cent. was, as the author said, there was not much in it, but such efficiency would hardly ever be common or cheap.

Mr. Williamson's paper from which he quoted might be found in full in the June numbers of "Engineering" for 1903, and it was worth the study of those interested. The quotation with which he concluded was from an editorial in the same paper of July 3rd, but it must be taken as an oratorial peroration rather than as scientific facts.

1. If you get your current from an electrical supply and your main cut-out fires, your servant was very much out of the way.
2. A motor needed more than two wires, it must have switches, controller, resistances, and fuses, for starting gear, or you risked burning it out.
3. The simile was rather unfortunate, theoretically it was obedient, but no doubt many could say how such obedience worked out in practice.
4. This statement was contradicted in page 26, where it was admitted that there were cases where the electric drive had been abandoned.

It was satisfactory to find the cost of motors was going down, and their efficiency, he believed, was being increased, but it was doubtful if they were as reliable as the shaftings, etc., they displaced. Mr. Longridge, Chairman of the British Boiler, Machinery, and Electric Insurance Company, stated last March, that out of every twelve dynamos or nine motors insured with his company, one of either had broken down in the preceding year. He had little doubt but with care in design and elaborate attention to details, motors might be made almost insure from breakdowns, but such elaboration had to be paid for. Any amateur in electricity could make a motor, but not one to stand the usage of a boiler shop. The horizontal high-pressure engine was about the simplest and cheapest form of steam engine, but if we applied it to a locomotive we must not only use the very best materials, but bring to bear the highest talent in design and construction, with special attention to apparently minor details, and this cost money. So with electric plant, it must be made practicably impossible to have any short circuit, defective insulation, loose connections or serious overload, and this could only be done by having all the details of the circuit and its fittings carefully thought out and substantial, as well as the motor itself. In the United Kingdom there was quite a literature and legislation on these matters, Board of Trade regulations, city building Acts, etc, but here the crave for cheapness might prevent us profiting by it, there was all the difference between failure and success between an installation that seemed just good enough, to the contractor, and one that would be a joy for ever to the user.

The Author recommended the direct current motor, but if the commutator even with carbon brushes, was got rid of, so would a great source of trouble. There was something fascinating in the alterating or induction motor revolving under the influence of a rotating magnetic field without any mechanical contact or connection with the wires, and the starting difficulties with such motors would yet be easily surmounted.

The application of motors to textile factories was an interesting one, but for full success, the electricians must go further, and not merely drive the first motion shaft of a power-loom for instance by a motor, but perform all the complicated work of the loom now done by cams, springs, pickers, and kickers, by direct-acting electro-magnets; it should be possible, and would lessen the horrible din of the weaving shed, which, as he once heard an old workman say, would "deave a devil."

Why should it be necessary in such a machine as a punching machine to use a rotary motor at all? A powerful solenoid or electro-magnet acting on a lever or toggel arrangement might do the work economically, dispensing with gearing and flywheel altogether. There was a great field for electro-mechanism, besides that of providing rotative power, and mechanical engineers should press the electric current into their service.

The President (Mr. W. H. German), considered that the subject had been fairly thrashed out, and he thought Mr. Arnott had put the case before them from a sensible standpoint, namely, that the necessity of understanding the limits of electricity for workshop and general factory driving they as mechanical engineers, most of us could not be expected to understand all the details of electrical machinery, or which was really the best type of current to use in every case, but if we had sufficient knowledge to know generally the conditions under which motors should be applied, and those under which they should be let alone, a discussion such as we had had would have served its purpose. A good many remarks had been made about electrical driving in sugar factories. Supposing a sugar refinery, about the size of this room, having pans and pumps in the centre, he was perfectly certain it would not pay to provide a dynamo and a motor. With the loss of 10 per cent. in the dynamo, and 10 per cent. lost from the motor to the machinery, how was it going to pay? It was only going to pay under the heading of cleanliness, convenience, accessibility, or something of the kind. Now, at Pyrmont Refinery, some three years ago, the question was considered, because the works had so extended, they spread across many acres of ground, and it was found that, as Mr. Shirra remarked, that the cost of the distributing power over hundreds of yards, up many flights, and across streets, either by belting or by steam, was not only inconvenient, but expensive in coal, and particularly in maintenance. So that when the authorities were recommended to incur a very considerable expenditure in putting down electrical plant, they were not promised any very distinct saving under the head of coal-saving; what they were promised was a great saving in maintenance, in oils, and particularly in convenience. In the refinery sugar stores there must be no oil or dirt about, no belts or wheels to endanger men, and in these respects the change had been satisfactory. It had also been satisfactory from the coal-saving point of view, because he might almost say that miles of steam piping had been cut out, wherein it was a difficult thing to calculate the former loss due to condensation. In the case of a large engine pounding away in the workshop, steam had to be sent to it from the boiler; certainly the exhaust steam was supposed to be used again, but in that case there was no exhaust steam, as it practically returned to the vacuum pans as water. With these remarks he would call upon Mr. Price to deal with the points that had cropped up, if he thought them worthy of his notice.

Mr. A. W. Price, in replying on behalf of the author, referred to the installation of electric driivng at Tooth's Brewery, where, since the change, the output had been largely increased, the machinery driven had been added to. lighting had been extended, "and something like £400 per annum has been saved by the storage of electricity and the cutting off of the gas supply besides the saving in general repairs. In that particular business there had been a tremendous saving, and since the motors had been put in many buildings have gone up. The buildings covered 8½ acres; and in hundreds of yards of steam piping, steam being generated at 120 lbs. per sq. inch, and after being conveyed many hundreds of feet generally used to arrive at the point of usage at about 60lbs. so in that instance alone the saving has been very great. With regard to paper-wetting machines, at the "Evening News it had been reckoned with steam power a reel of paper took 40 minutes; with motor power 28 minutes. The great saving was where paper was wavy, the speed of the machine was controlled by a speed regulator or controller, and after the adjustment of the paper high speed was quickly obtained and time therefore saved. He had had the opportunity of seeing the current account of the "Evening News," and it worked out at 2.7 pence, which was a little higher than in the "Daily Telegraph" case.

Regarding accumulators, his opinion was that they lasted three or four years. At Carrington Hospital they had been a wonderful success. They were installed four years back, and he could safely say that the man in charge was practically an uneducated man, who did a bit of gardening, etc., and he had no trouble whatever. No one had been there but himself in five years time. The battery at Tooth's Brewery was in a most satisfactory condition, but he was unable to obtain the efficiency at the present time. Regarding the change from steam to electric driving, and going back to steam again, although this had occurred in the city with a large engineering firm, his opinion was that they had been wrongly advised in the matter. Instead of grouping their machines they had put down one large motor wherein they had been wrongly advised.