DISCUSSION.

Mr. G. Fischer said it was more by accident than desire that he found himself at the conclusion of the last meeting the seconder of the motion for adjournment of discussion on Mr. Selfe's valuable contribution, with the concomitant obligation to offer some remarks thereon.

As regarded the comparison of Hydraulic Power with Compressed Air, he would leave this matter in the hands of those gentlemen who had recently taken a prominent part in the introduction of Hydraulic Power to our city; but he certainly must take exception to the concluding sentence in Mr. Selfe's Paper in the paragraph, under the heading, "The Electric Current," which reads thus:—"Therefore, we may dismiss electricity from our present consideration as the medium for a power company in such a case as Sydney." Mr. Selfe wisely admits that the electrical distribution is "both theoretically and practically the most efficient system known so far as the percentage of useful effect which the power given off by the secondary motor bears to the prime mover." Qualifying this by stating "if it were not for several serious drawbacks attending electricity which there does not appear to be any likelihood of being overcome."

As one of these serious drawbacks, Mr. Selfe instances the great danger to human life, illustrated by an accident which happened some four or five years ago. Now accidents to attendants of machinery of *all* classes happen daily, and are in almost all cases simply traceable to carelessness. However, during the last few years the practical application of electricity has made enormous strides, and appliances had been devised which made the occurrence of similar accidents almost impossible so long as those entrusted with the machinery will only carry out their instructions. A current of 500 volts, for example, was not dangerous; it would certainly prove unpleasant. No man, woman, or child had ever been seriously injured by a 500 volt current; consequently, by transforming the high tension current before entering the place where it is used to 500 volts or less, the objection of danger to human life was dispensed with. The risk of fire was absolutely less than in the case of any other illuminant, and certainly not more so than in the stove for heating the compressed air used in the "Popp" system.

As regarded Mr. Selfe's objection to electrical power transmission on account of "the enormous expense of the conductors if a current of a low potential is used," this did certainly not appear to prevent the marvellous spread of Central-Station Lighting and Power Transmission by means of Electricity in Europe and America. Let us compare the two European cities next in population to London, viz., Paris and Berlin. The distribution of compressed air from a central station in Paris dated as far back as 1870, or about nineteen years, and the total power of the generating plant was now about 3000 I.H.P. The first Central Station for Electric Lighting was established in Berlin about five years ago, and it was expected that the total plant would reach by the end of the current year, 18,000 I.H.P., both for lighting and power. Judging by this development, it did not appear as if the drawbacks attending electricity were so serious as Mr. Selfe appeared to think. But the most striking example of the advance of electricity was to be found in the fact that a plant was nearing completion in London intended to supply two million incandescent lamps, requiring 140,000 I.H.P. to drive the generators. The Board of Trade was noted for the stringent conditions it imposed on all parties catering for the public, so as to obtain a maximum of safety to all concerned; but even this was no obstacle to the triumphant advance of the application of that latest power of Nature laid under contribution to the service of mankind. He would not extend his remarks in this direction, as no doubt there would be many other speakers to follow him, and he hoped that his remarks would not be regarded as disparaging of the good work done by M. Popp. On the contrary, he gave that gentleman all possible credit for the admirable manner in which he had worked out the details of the extensive works under his direction.

As regarded the application of the Popp system to Sydney, he wished to express his doubts as to its success. Mr. Selfe acknowledged that the pipe-joints were the great trouble with compressed air. The joints used in Paris were no doubt well designed, as the pipes were suspended in the sewers and always accessible. How this joint would answer were it buried in the ground he would not like to predict. Again, the pipes in Paris were provided with self-acting drain-valves at every 330ft., which would have, in our case, to be connected with the sewers. These details would have to be designed and practically tried before they could be recommended for Sydney, and would most probably increase the first cost of the air mains by almost 100 per cent., thereby upsetting nearly all the calculations on which the comparisons between hydraulic power and compressed air were made.

Mr. Cruickshank asked Mr. Fischer what was the actual amount which could be taken off an electric motor? He would like the answer to be expressed in percentage. Mr. Selfe admitted that electric power was the most effective if it were not for serious drawbacks, which were detailed in his paper.

Mr. Fischer said the latest figures gave 92 per cent. as the efficiency of the motor.

Mr. Cruickshank: Ninety per cent. given off the steam engine?

Mr. Fischer: Ninety per cent. off the dynamo.

Mr. Selfe: Results as high as 95 per cent. have been stated.

Mr. Swinbourne remarked that he had not had much time to go into the question thoroughly, having been travelling continuously since the last meeting. The comparisons made, in the paper, between compressed air and hydraulic power were hardly fair, inasmuch as the expense of supplying hydraulic power was taken at maximum figures, and these figures could be reduced to one-sixth or one-seventh, as he could prove, not by theory, but by the actual work of the Company he was connected with. In Melbourne they were supplying power at a very much lower rate than that mentioned in the paper, in fact from 2s. up to 8s. Mr. Selfe also stated that water was non-elastic, and urged this as a reason why compressed air would be a better motive-power for the conveyance of loads varying in weight; but in this city the Lawrance lift had partially overcome that difficulty by having two cylinders, one enclosed in the other. The same system was also in operation in cranes, which allowed of the expenditure of power being adjusted to the weight of the loads carried. The Paper also referred to the damage that might be done if a main, being worked under high pressure, were to burst, the inference being that this possibility would be averted by the use of compressed air; but he might say that in his experience such a thing had never happened.

All the pipes his Company were putting in were tested for 700lb. pressure, and they had never yet had a broken pipe, and their experience, as far as damage was concerned, had been very slight. In Melbourne, London, and America, machinery was being driven at high pressure. In Melbourne they were supplying a high pressure for driving domestic machinery, including organ-blowers. Mr. Selfe also said that it would be very difficult and costly to introduce the high-pressure hydraulic system into Sydney; but there were many instances in which it could be introduced in Sydney under favourable circumstances. If compressed air were used for such machinery as lifts, for instance, it might cause many accidents, owing to the contraction and expansion, thus allowing the grips to slip which would otherwise be steady under the standard power of water. In London a little engine working under high pressure was at present driving electric dynamos, and to a very great extent the motors were of American automatic action, by means of which the power was developed to suit any load. The objection that Mr. Selfe had raised would be overcome by this invention. The improvement was being largely adopted for hoisting variable loads. According to Mr. Selfe, compressed air could be used for driving refrigerators; but they were being effectually driven in Melbourne now by hydraulic power.

Mr. Selfe: This paragraph meant that the exhaust in compressed air acted as a powerful refrigerator.

Mr. Swinbourne, resuming, said that Mr. Selfe also stated that compressed air could be applied to the propulsion of tram-cars. But the same operation could be effected by water-power. In Highbury, near London, an attempt had been made to run tram-cars by compressed air; but the essay was found to be unsatisfactory, and he believed that some other machinery had to be substituted. As to sewage, the Shone system had an automatic pump worked by compressed air, and was now in operation at a great many places in England. Professor Latham was a strong advocate for hydraulic power to be employed in connection with sewage. At present, however, a patent was being taken out for a pump similar to the Shone pump, but adapted to work by hydraulic high-pressure. At Mortlake gasworks the machinery in connection with the charging of the retorts was being driven by compressed air. Mr. West had told him (Mr. Swinbourne) that he had discarded compressed air in favour of wire-rope and hydraulic power. There was one way, however, in which compressed air could not be applied, and that was in the extinction of fires. Captain Shaw, of the London Fire Brigade, recently witnessed several trials of the hydraulic injector, and had expressed an unqualified opinion of its great merits. It was being supplied in Melbourne, ready for use at a moment's notice. One pipe being led from the low-pressure, and the other from a high-pressure main, the application in a case of fire was simplicity itself, the two combined throwing 180 gallons per minute to a height of 100 feet. He supposed that the figures given by Mr. Selfe would be the exact cost of applying the system, and did not include the cost to which the consumer would be put if he adopted the system of heaters to his engines. Heating the air to obtain the higher power would greatly increase the cost. In Melbourne, at the present time, gas-engines were being done away with, as the owners had found it cheaper to work directly from the hydraulic power. The value of space, in many cases, made it incumbent upon the proprietors of buildings to economise, and they did so, with the result that the replacement of the gas by the hydraulic power effected a saving of £100 per annum in some instances. A case has been mentioned where a gas-engine was doing certain work for £220 per year, and he would be glad to do the same work with hydraulic power for £150 per year. Hydraulic at present was cheaper than any other power, and if business increased at the same rate as it had done during the last two months, it would become cheaper still. He felt sure that prices would be lower eventually than in London.

Mr. Houghton considered that compressed air could not compare with hydraulic power. In such a place as Birmingham, for instance, compressed air could be used much more economically than in London, on account of the number of small industries in the former city. So economical was hydraulic power in London that at the "Tower," where they had large services to fulfil, they had an hydraulic installation of their own. The price of the water would make a great difference, because any one using 6,000 gallons per day would get it for 2s per 1,000 in London, while the price here would be 10s. The statement in the paper anent the getting water from the Thames, should be qualified by the admission that the water so lifted had to be filtered, and this filtering processs would add to the cost. On a farm at Glynde, England, they had electric power for the purposes of the farm. The tension of the current was about 100 volts, and the danger from this was, as a matter of fact, *nil*.

Mr. Fitzmaurice said the Paper commented upon the danger of touching the terminals, but the mere touching of a terminal would not kill a person unless the circuit were completed. The light at the Circular Quay was run by a current of 1,200 or 1,300 volts, and no accidents had occurred, although the installation had been in operation for more than eight years. A thousand volts, with a ten amperes current, would transmit a current equal to

13 horse power, with a 12 or 14 B.W.G wire. The hydraulic high-pressure system would be very effective in cases of fire.

Mr. Diamond thought the advocates of the different systems should give the actual cost per horse-power for a specified time.

Mr. Cruickshank was pleased at the discussion evoked by the paper; still, he considered none of the speakers had touched the real point involved, and that was the great power which could be obtained from compressed air compared with the results obtained one or two years ago. It appeared to him that all the speakers had one object, and that was to devise machinery whereby skilled labour could be done away with. The value of an invention seemed to be gauged by the amount of manual labour it displaced. The elasticity of air and its power of expansion was perhaps a difficulty when air was used for certain purposes. Mr. Selfe had dismissed in a summary manner the joint used in Paris. He (the speaker) would suggest that at some future time a full description should be given of this ingenious and clever contrivance. All the high-pressure engines in the colony were working in a most wasteful manner. Their efficiency could be increased 12 or 14 per cent. This could be effected by heating the water by the exhaust steam or waste gases. Mr. Selfe some time ago read a paper on compressed air, but since then it appeared, from the present paper, that the efficiency of air had been practically doubled. From a given qnantity of heat we could obtain a given amount of work, but as we gained the one we lost the other; or, in Rankin's words, "Heat and mechanical work are mutually convertible, and heat required for its production produces by its disappearance mechanical energy in the proportion of 772 foot-lbs. for each British unit of heat." This first cause, the elastic force of steam, is entirely due to the heat energy it contains, and when any portion of this heat is lost or converted into work, liquification and loss of pressure or volume follows. The heat in steam is disposed of in three ways: First, in raising the temperature; second, in overcoming internal résistance; third in performing external work. A pound of steam, no matter how produced, contains a given and invariable quantity of heat energy corresponding to its pressure and temperature. But the heat expended in producing the steam is greater than that contained in the steam by an amount equal to the actual work done. And, conversely, no matter how we use the steam, assuming no heat is lost by radiation, the total heat expended, minus the heat left in the steam after performing work, is the thermal value of the work done. The proportional amount of heat actually converted into motive power, or work compared with the entire quantity of heat expended, is the true measure of the efficiency of the process.

Mr. Selfe, in reply, said he had taken figures, the results of recent trials by independent experts sent from Germany to Paris to inspect the compressed air systems, and had compared these figures with electric and hydraulic power. His experience of hydraulic power extended over a period of twenty-eight years. With many of Mr. Swinbourne's remarks he concurred, but he (Mr. Selfe) had shown that compressed air possessed greater advantages, and nobody had refuted his deductions in any way whatever. Some of the speakers had stated that the power of the future would be electrical transmission, but they could not cite a single practical case at present in existence. Another of the speakers had cited an experiment which was being carried on in England, upon a farm, but this was merely in a tentative stage. In Paris nearly all the theatres had their dynamos driven by compressed air. The Paris Company had over 300 customers, and owing to the stress of business they had been obliged to get engines from England. If compressed air were applied to the hydraulic lifts, it would be for the purpose of working the pumps only. He made his deductions from figures and data put forth by the most eminent authorities in the world. In addition to the ingenious joints described in the paper, there were self-acting valves which would shut of their own accord in the event of a main bursting. He could hardly understand how the Hydraulic Company could do work in Melbourne for 1s. 6d. which in London would cost 2s. A further advantage, which could not be too strongly insisted on, was that in a hot climate like this, ventilation was a necessity, and compressed air, after it had done service in furnishing power to supply fresh air, would give off cold, which would be available for reducing the temperature. Professor Robinson had recently published a valuable book having regard to the proper working of hydraulic installations, compiled from the best authorities and figures from England and France, and this book threw a great deal of light on the subject at issue. For domestic purposes compressed air would be a desirable power, and if the tap were accidentally turned on, the only result would be a little wave of wind which would not be likely to cause any damage. A recent report on the compressed air tramway plant, mentioned by one of the speakers as having been used in England, stated that there were two reasons for discontinuing its use, one being that six of these trams were used in connection with 20 horse trams, and it was found undesirable to have the two systems on the same line; another reason was that the Tram Company were told that they would be responsible for the efficient state of the road, and they could not see their way to accept this responsibility. Compressed air trams were successful in Nantes and Paris, where they had been working for eight years. With regard to the extinction of fires, such pumps as the Worthington or Blake could be operated by means of compressed air. However, that did not affect the question of using compressed air. He was as great a believer in water power as ever for certain purposes; in fact he was at present putting up lifts to take their power from the Company's mains. With regard, then, to the operation of a Power Company in Sydney, it so far appeared that the summary of the whole matter amounted to this:—Persons who require small powers for their business operations can obtain it by means of a gas engine for about 2½d. per horse-power per hour, or for 3d. with gas at 5s. 8d. a thousand. By means of a small steam-engine, including attendance, a horse-power will only cost 2·08d. per hour. With compressed air on the basis of the Birmingham and Paris tariff, including the heavy rental of the engine, a mean between ·593d. and 7s. 6d. equals 4·09d. for the air (the charge for the engine being perhaps double what is necessary), the mean total cost would be, say 5d. per effective horse-power; but, as already shown, it can be done for 2½d. With water-power, however, the first cost of the material (that is, the water itself) at 1s. 6d. per 1,000 gals. comes to 2·2d. for the equivalent of a horse-power, that is allowing the most efficient engines to yield 66 per cent., the water alone will cost 3·3d., and in the case of ordinary engines when 50 per cent. is all that could possibly be expected, 4 4d. per horse-power per hour would be the price. In other words, if any Hydraulic Power Company pays here 1s. 6d. per 1,000 gals. for their water (the regular price charged by the Sydney Water and Sewerage Board) and then finds the site, the engines, coals, stock, mains in streets, engineers and attendance for nothing! and only charge their customers the bare 1s. 6d. paid for their water, it would still be more costly to the consumers than air power supplied at a fair profit, and will be quite double the price of steam-power. It therefore appears that the day for an Hydraulic Power Company in Sydney has now passed by, and that something better must be found, which, so far as present experience goes, seems to be compressed air

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