Discussion.

Mr. Arthur J. Hart said that he had very much pleasure in rising to propose a vote of thanks to the Author for his paper. He thought they were especially indebted to him because he had brought before them that night a paper which he believed contained a great deal of original research on a subject which until recently was little known, but to which a great deal of attention and experiment was now being devoted all over the world. The paper had been particularly interesting to him because it dealt with problems with which he himself was sometimes faced.

The most notable instance which he had ever seen of the electrical disintegration of reinforced concrete was the case of a jetty at Southampton, England. This jetty was constructed with piles and decking entirely in reinforced concrete, exactly the same as might be seen in Brisbane, New Zealand, or, for that matter, at ports all over the world. After about five years' service this jetty was found to be getting into a bad state. In some of the piles the concrete covering the reinforcement had spalled off, and the steel bars were exposed in various parts of the structure in exactly the same way as the Author showed in his photographs that evening. The concrete itself seemed to be of excellent quality, and the cause of the decay could obviously not be attributed to the action of sea water on the concrete, as within a mile of this jetty there was another constructed in precisely the same manner, which, although double the age of the first one, had not deteriorated in any way, but was perfect in every respect. After various theories accounting for the damage as simply due to shocks from vessels coming alongside had been disproved, a closer investigation was

made of the whole structure, and it was then found that the return of the electric lighting circuit was earthed to a steel bridge connected to the jetty, and this was proved to be the sole cause of the deterioration which had taken place.

The Concrete Institute in London appointed about this time a special committee to enquire into the effect of electric currents on reinforced concrete work, and one interesting fact brought to light by them, and which was indeed in some measure to be expected also, was that while direct currents would set up decomposition, alternating currents had no effect upon the material. They also established the fact that the corrosion, when it existed, took place always at the positive pole, and that there was no corrosion at the negative pole. The tests also proved that the spalling off of the concrete from the reinforcement was due to the formation of insoluble salts of iron round the bars, the expansion of these salts bursting away the concrete outside the bars from the main bulk of the member.

The United States Bureau of Standards had just issued a very full and comprehensive report on similar investigations conducted by them. Their experiments had confirmed those just mentioned, and had also proved that the current had no action whatever on the concrete itself or on unreinforced concrete. They also established the fact that the amount of damage to reinforced work was regulated, not solely by the quantity of electricity passing through the specimen, but also by the rate at which the current passed, and that the corrosive action decreased much more rapidly than did the voltage. On specimens subjected for a length of time of two years to slight currents, no damage was sustained. The speaker, therefore, saw no useful purpose that would be served by the periodical testing of reinforced concrete structures by instru-

ments capable of measuring very small differences of potential, as suggested by the Author, since the tests showed great weight of evidence that reinforced concrete structures were in very little danger from small leakages or under normal conditions.

The Author had stated in reading his paper that most modern American buildings were stated on good authority to suffer from electrical corrosion. The speaker would very much like to know on whose authority that statement was made, since so far as he knew exactly the opposite was the condition of affairs.

Referring to the tests of corrosion in salt solutions, the speaker stated that other experiments had shown that reinforced concrete specimens in which salt had been mixed with the concrete had corroded more quickly than had specimens free from salt, thereby corroborating the Author's observations.

While thanking the Author for having brought forward such an interesting paper, the speaker thought that the risks anticipated by him in reinforced concrete construction were very much greater than actually existed, since cases in which damage had been caused were exceedingly rare, and since it had been established that small currents had no deteriorating effect. The speaker was further of opinion that, on the Author's own showing, a reinforced concrete building did not offer the same risk to the constructor as did a steel frame structure, in which a slight chemical difference in the quality of two steel plates used might result in speedy and very great corrosion of a whole member, necessitating its complete removal, as such chemical difference would be absolutely undetected in even the best shop practise of the day.

Mr. JAMES SHIRRA, in seconding the vote of thanks, remarked that the paper gave some insight into the ultimate composition of matter, the molecules and the atoms,

and the migration of the ions. Engineers were more familiar with iron and metals in mass, but the former aspect must be studied in considering corrosion. The Author referred to experiments that had been attempted to render the surface of iron or steel plates passive to chemical action. He thought the solution of the problem of preventing chemical action would be obtained in this direction. It was well known that the iron drums in which strong commercial sulphuric acid was transported were not attacked by the acid, whereas if it was diluted they were rapidly corroded. The Cumberland process of keeping the iron positive by electric currents promised well, but before it could be used in such plant as marine boilers much more investigation would need to be made. The experiments referred to in the paper all seemed to have been made at ordinary temperatures and atmospheric pressure, but the temperature and pressure in modern steam boilers were potent factors in chemical action, and could not be ignored. He had read lately that ammonia was being made by the direct combination of its constituent gases, nitrogen and hydrogen, heated together under very high pressure, which showed the influence of these agents in producing chemical combination.

He noticed that in the Tables given the sulphuric acid was qualified as 4N/100. He would like the Author to explain what this symbol meant.

Mr. R. SYKES remarked that Mr. Hart, in his remarks, laid particular stress upon the voltage used in certain experiments and its effect upon reinforced ferro-concrete columns, etc. He did not agree with him altogether, inasmuch as he had left out a most important point, viz., the amperage of the circuit employed. He would find that the Order in Council of Electrical Units and Standards stated that "the ampere was represented by the

unvarying electric current, which, when passed through a solution of nitrate of silver in water, deposited silver at the rate of 0.001118 gramme per second." The voltage, therefore, did not have any appreciable bearing on the question of the deposition of the metal at all.

Mr. W. SINCLAIR said that the Author referred to the loss of weight of different metals when immersed in calcium brine, but he must say that in his experience with refrigerating plants this had not been the case. He must admit, however, that the comparatively high temperature (73 deg. Fah.) at which the experiments were carried out would, no doubt, cause the liquid to attack the metals mentioned on the chart.

Mr. J. L. WRIGHT said he did not agree with Mr. Sykes' statement that the voltage did not have much bearing on the question of electrical deposition. Where would the energy be derived from if there were no electrical pressure in the circuit?

He would also like to ask the Author what would be the effect of connecting, say, the negative pole of a lighting circuit to the City service pipe of the water supply system, for it was said to be often done by moving picture show proprietors?

THE AUTHOR'S REPLY.

Mr. MCNAMARA, in his reply, said that Mr. Hart stated that in the paper he (the Author) did not mention that corrosion took place at the positive pole, whereas he had definitely mentioned in several places that deposition always took place at the "anode" of the circuit. His reason for stating that periodical tests should be made for even small currents was based on the assumption that damage might occur at places where corrosion was going

on at zones free from observation, due either to dampness or small local currents, not necessarily extraneous currents. He apparently must have conveyed a wrong impression to Mr. Hart when he was explaining the illustrations of damaged members of some American buildings, and would refer him to Vol. VI., No. 11, of "Concrete" for further information on the subject of electrolytic action on ferro-concrete structures, one building mentioned therein having so much as 3,000 linear ft. of members attacked.

It was certainly the case that ferro-concrete structures were better protected from corrosion than those made from plain plates and girders, since the concrete served as an inhibitor to corrosion, at all events until cracks and segregation of the material took place, when moisture penetrated and corrosion naturally followed.

Mr. Shirra's remarks on the passivity of metals certainly were to the point, and it was to induce the passive state of the surfaces of iron and steel that many elaborate experiments had been conducted. The experiments relating to the Cumberland process were conducted under the conditions mentioned by Mr. Shirra, since it would have been impracticable to take the weight of a boiler under steam and then to ascertain the consequent gain or loss on the plates due to the application of the electric current.

The symbol 4N/100 sulphuric acid mentioned in the Table showed that 4 parts of normal strength sulphuric acid were added to 100 parts of water, in order to obtain a dilute acid for the electrolyte in the cell.

The Author agreed with Messrs. Sykes and Wright that before deposition of a metal could take place, both voltage and current must be present, for without the former the current could not flow, and without the latter, which

determined the rate per second, no transposition of material would occur.

Mr. Wright's query as to the effect likely to occur when one pole of an electric light circuit had been connected to a water pipe, would best be answered by reference to Figure 9 of the paper, where the projection on the side of the pipe clearly indicated that a current had passed from the pipe to the earth at that part, and that the material in the pipe had undergone a change, and. it must be admitted, to its detriment.