water over 200 feet deep. Will this gradually applied extra load produce a gradual depression? This might almost seem a crucial test, and it would seem as though a few well-placed and well-determined bench marks on projecting hills, or possibly triangulation tripods, in the area to be submerged would answer the question. And it is the hope of arousing interest and causing the necessary measurements to be made that has spurred me to write this note. ALFRED C. LANE.

THE GEOGRAPHICAL DISTRIBUTION OF STUDENTS.

IN the article on 'The Geographical Distribution of the Student Body at a number of Eastern and Western Universities and Eastern Colleges,' which appeared in the issue of SCIENCE for August 10, 1906, I neglected to call attention to the fact that the showing of a number of the state universities is somewhat misleading, for the reason that many students from outside the state in which the university is located endeavor to establish a state residence, in order to escape the tuition charged to outsiders. This is true particularly with reference to the University of California, on account of the isolation and the large size of the state. Families of students from outside often establish a temporary residence in Berkeley, and a similar state of affairs no doubt exists with reference to the University of Michigan and other state universities. At California not over one quarter of the students coming to the university from outside the state and from foreign countries are so registered. RUDOLF TOMBO, JR.

Registrar.

SPECIAL ARTICLES.

THE PRESERVATION OF SURFACE CONDENSER TUBES IN PLANTS USING SALT OR CONTAMINATED WATER CIRCULATION.[1]

THE prevention of electrolytic corrosion of condenser parts where they are subject to contact with condensing water that contains electrolytic properties has been a serious problem with condenser engineers at sea as well as on land, where the condensing water contains salts in solution. This action is especially destructive where the cooling water is contaminated further with chemicals or with sewage.

In the great steam plants of New York city where the water bills extend into thousands of dollars per annum, in fact, are approximately one tenth of the fuel bills, this is an important condition bearing upon the cost of the hourly power unit, but the attempt to use surface condensers in the past for the purpose of saving this waste has not been accompanied with any degree of success. The highest economy demands such precautions as shall leave the hot-well water coming from the condensers in a proper condition for feeding the boilers.

The waste incident to the inability to save this water in stationary generating plants has caused the construction of surface condensing apparatus at such plants as that of the Brooklyn Edison Company at Bayridge, and of the Metropolitan Street Railway Company at 96th Street, New York City.

At the time the design of the Long Island City Power House of the Pennsylvania Railroad was undertaken, it became evident that true economy in the operation of a plant which would have under ordinary circumstances an annual water bill of about $100,000, when the plant has been fully put into service, justified an attempt to save the water from the hot well for replenishing the boilers. This seemed to demand a thorough investigation of the matter of condenser protection where the circulation cooling water was an electrolyte as it was in this case.

The site where this plant was to be constructed was at Long Island City near the harbor front, and the plant was designed to contain, when fully constructed, fourteen 5,500 K.W. generating units. With such an equipment and with an ordinary loading, the amount of boiler feed water required per annum would cost in the neighborhood of $100,000.

In the investigation of possible methods for

[1] Read at the Ithaca meeting of the American Association for the Advancement of Science, June 29, 1906, before Section D—Mechanical Science Engineering.

preventing the rapid destruction of condenser tubes and parts, an effort was made to find out if the condenser engineers of the country did not have suitable information as to the nature of the action tending to destroy the thin tubes and preventing tightness in the condenser, or had not made trials to indicate effective methods of protection. The most competent opinion that we could get was that if we could adjust the difference of potential due to stray ground traction or other currents to a value of less than three volts, we should have no difficulties; that the trouble was all due to stray ground currents from electric railways and that stray currents from lighting plants had little or nothing to do with the corrosion. They further stated that all that was necessary was to insulate from the possible inflow into the condenser of stray currents from traction operations. It had been found that these currents were already destroying the city water pipes of the vicinity along which they were traveling and to which connection would have to be made.

With a view to discovering a method of protection, we carefully investigated this statement based on the action of a device at the Brooklyn Edison Company's Bayridge Plant caring for this condition, and found it had been an abject failure, ending in the abandonment of surface condensers, and the installation of elevated jet condensers at considerable expense, and consequent wasting of the water of condensation. Numerous other instances, more or less efficiently handled, were found. Some of the condensers in other steam plants were so designed and the connections so made that it was absolutely essential to permit the sea-water from the main spaces to pass into the steam space of the condensers by the actual removal of tubes, thereby preventing the re-use of feed water from the hot wells, even if they had been tight otherwise.

It became evident at once that there was really nothing accurately known about the destructive actions that were taking place in condensers and that a systematic study of the situation for Long Island City was demanded before we should decide on the type of condenser and the wisdom of trying to use hot-well water in the boilers.

To that end, we measured the stray currents and we found that the voltage of the railroad rails in the terminal freight yard of the Long Island Railroad at points between the power house and the river was at times as much as nine volts above the potential of the river; that this caused a flow of current to the harbor and a destruction of water pipes and other things in the railroad yards, and that anything that was done would have to be not only able to compensate for this nine volts but must further provide for the control to fit modifications thereof in such a way as to prevent reverse current actions and corrosion of other things. In other words, with the peak of the load on the Brooklyn Rapid Transit, the voltage would go to nine volts; and as the load sagged off it would decrease, until it was only a volt or two. Therefore, whatever was put in must be thoroughly controllable from time to time by switchboard appliances.

In order to properly study the real conditions a number of large glass jars were provided and various combinations of metals were immersed in samples of water taken from the river at Long Island City, of sea water from off Far Rockaway, as well as of pure water.

It became evident that the effect of samples of water from the East River was much more violent than that of ordinary sea water. It was further observed that there was a local action going on which was galvanic, and that the amount of stray currents had something to do with the polarization of the surfaces in galvanic action, making the galvanic action exceedingly violent and destroying thin copper tubes at a very rapid rate. There would be punctures of these tubes in four or five days' time which would be fatal to the commercial requirements, producing a very serious repair item in order to maintain the condensers sufficiently to permit their being used to return the reclaimed or hot-well water to the boilers.

In other words, it would render it impossible to keep them in a suitable condition, as the water would be contaminated with salt-water leakage.

It soon became evident by observation of the several combinations in these cells, that there was a violent local action between the zinc and the copper of the brass tubes which were in contact with the electrolyte, and that this increased in the reaction as it progressed in stagnant conditions.

It then became necessary to find a method more comprehensive than the proposed simple counter-electromotive force for the neutralization of the traction companies' stray currents. Further experiments with plates immersed in the cooling water samples showed that by interposing a counter electromotive force against the galvanic couple which should exceed in pressure the voltage of the galvanic couple, the actions of the electrolytic corrosion ceased. The difference in potential between the zinc and the copper for the Long Island City harbor water was found to be 0.4 of a volt. Zinc and copper were selected in these experiments because the condenser tubes were to be made of 60 per cent. copper and 40 per cent. zinc. It became evident that when unconnected, or electrically separated, plates were placed in this electrolyte, if they were of composite construction and had sharp projections into the fluid, raised by cutting and prying up with a knife, they would have these projections promptly destroyed, and that if an electric battery having a pressure exceeding that of the couple in the East River water was caused to act to produce a counter current, and having a pressure exceeding that of the galvanic couple, the capacity of this electrolyte to drive off atoms of the mechanically combined metals in the alloys used was overcome and corrosion was arrested.

It, therefore, became desirable to not only carefully provide the balancing quantity of current to equal the stray traction currents arising from the ground returns of railway and other service, but to add to this the necessary voltage through a cathode placed in the circulating water in such a way as to bring to bear electrolytic action which would prevent the galvanic action due to this current coming into contact with alloys of mechanically combined metals such as the brass tubes.

It became evident that the influence of various foreign substances in the East River water made the galvanic couple as between an atom of zinc and an atom of copper greater than for open sea water, and it was found to be at times as high as 0.42 of a volt. With this known it was planned to put a pressure of 0.6 of a volt on the anode in order to overcome this action and prevent the separation of the zinc molecule from the surfaces and the consequent breaking down of the tubes.

In order to accomplish these two things, it was first necessary to so install the condensers as to prevent undue amounts of stray currents flowing through them, thus tending to reduce the amount of power required to prevent injurious action of these currents and otherwise to neutralize them. This was done by insulating the joints in the piping and from ground connections and even lining the large water connections with glass melted on to the surface.

To furnish electromotive force, a 3-K.W. motor generator was provided. It was of the form used for electroplating. By means of a system of wiring, switchboard apparatus and appliances, together with ammeters and voltmeters for measuring quantities and pressures, and a connection to an outlying anode in the condensing supply intake at its harbor end, this generator was planned to provide current to neutralize the stray currents in the condenser structure to any extent that they had passed the insulated joints in the supports and connections, as well as through the columns of water in the pipe connections, and then to adjust the additional voltage needed to counteract and prevent the galvanic action.

This led to much discussion as to methods and the reasons why the corrosion was prevented; and it became necessary, in order to get at the facts in the matter, to review the history of electrolytic conduction. A reference to Faraday's Laws and to the results of the experiments of Helmholtz and Clausius, explained the nature of this electrolytic conduction and the reasons for its action. The best explanation is summed up in Professor Oliver J. Lodge's 'Modern Views of Electricity,' chapter four on 'Electrolytic Conduction,' as follows:

1. Electrolytic conduction is invariably accompanied by chemical decomposition, and in fact only occurs by means of it.

2. The electricity does not go through, but with the atoms of matter, which travel along and convey their charges something after the manner of pith balls.

3. The electric charge belonging to each atom of matter is a simple multiple of a definite quantity of electricity, which quantity is an absolute constant quite independent of the nature of the particular substance to which the atoms belong.

4. Positive electricity is conveyed through a liquid by something equivalent to a procession of the electro-positive atoms of the compound, in the direction of the current; and at the same time, negative electricity is conveyed in the opposite direction by a similar procession of the electro-negative atoms.

5. On any atom reaching an electrode, it may be forced to get rid of its electric charge, and, combining with others of the same kind, escapes in a free state; in which case visible decomposition results. Or it may find something else handy with which to combine, say on the electrode or in the solution; and in that case the decomposition, though real, is masked, and not apparent.

6. But, on the other hand, the atom may cling to its electric charge with such tenacity as to stop the current; the opposition force exerted by these atoms upon the current being called polarization.

7. No such opposition force, or tendency to spring back, is experienced in the interior of a mass of fluid; it occurs only at the electrodes.

The first three of these statements constitute a summary of Faraday's Laws of Electrolysis.

The claim was made, immediately upon the application of this apparatus, that the electricity coming from the anode, which in this installation was of cast iron but which ordinarily would be of carbon, would short-circuit on to the very ends of the tubes instead of passing through the tubes to the several points which might be exposed to galvanic action. This, however, does not seem to be the case, and in fact is entirely accounted for by the following remarks from the above-mentioned work on 'Modern Views of Electricity':

But it may be asked, 'If the atoms in each molecule cling together by their electrostatic attractions, and, as there are an enormous number of atoms between the two electrodes, how comes it that a feeble electromotive force can pull them apart and effect decomposition; moreover, how can the electromotive force needed to effect decomposition help varying directly with the thickness of the fluid between the plates?' It does not depend upon anything of the kind; the length of the liquid between the electrodes is absolutely immaterial. This proves that throughout the main thickness of the liquid no atoms are torn asunder at all. Probably, they frequently change partners, one pair of atoms not always remaining united but occasionally getting separated and recombined with other individuals. During these interchanges there must be moments of semi-freedom during which the atoms are amenable to the slightest directive tendency, and it is probably these moments that the applied electromotive force makes use of.

The reality of such a state of continual interchange between molecules has been forced upon chemists by the facts of double decomposition, such facts as the interchange of atoms between strongly combined salts where their solutions are mixed so as to form very much weaker compounds; the proof that such compounds are formed being very clear in the case when they happen to be insoluble.

The fact that the most infinitesimal force is sufficient to effect its due quota of decomposition has been proved most clearly and decisively by the experiments of Helmholtz.

Moreover, electrolytic conduction is perceived to be scarcely of the nature of true conduction: the electricity does not slip through or among the molecules; it goes with them. The constituents of each molecule are free of each other, and while one set of atoms conveys positive electricity, the other set carries negative electricity in the opposite direction; and so it is by a procession of free atoms that the current is transmitted. The process is of the nature of convection: the atoms act as carriers. Free locomotion of charged atoms is essential to electrolysis.

Professor Lodge also says:

For any element, whatever, the number of atoms liberated in any time is equal to the number of atoms of hydrogen liberated in the same time divided by the 'valency' of the element as compared with hydrogen. This law was discovered by Faraday; and appears to be precisely true: and inasmuch as the relative weight of every element is known with fair accuracy, it is easy to calculate what weight of substance any given current will deposit or set free in an hour, if we once determine it experimentally for any one substance.

By this means, we succeeded in properly adapting the sizes of the generating and other apparatus. All connections were made in a manner to insure a uniform voltage of the various parts of the condenser to prevent local action, each connection being so made and provided with such measuring instruments as to insure ready adjustment to effect this. The apparatus was designed in accordance with the above statements. Its operation has extended over a period of fourteen months, and with the exception of about ten tubes which have become pitted, the results have been satisfactory.

When the condenser was planned, the condenser manufacturer was instructed to slope the tubes down one inch in the direction of flow; but when he did so, it was forgotten that the middle inclination, if parallel to the first and third passes, would then be up-hill for the circulating water, and that when the condenser was shut down all the water would drain out of this middle section except that in the bottom tubes. These bottom tubes it has been found have become somewhat corroded, although not seriously.

The cause for this result having now been found, its prevention has been effected by perforating the diaphragm in the condenser head to permit prompt drainage of these tubes when the condenser is taken out of active operation.

The efficiency of the apparatus amply justifies the expense of its installation, while its operation is not expensive and the plant here described will now be followed by other protecting plants of the same character.

W. W. CHURCHILL.

QUOTATIONS.

THE NEXT INTERNATIONAL TUBERCULOSIS CONGRESS.

THE International Tuberculosis Congress takes place at intervals of three years, and the latest was held in Paris last autumn. The next, therefore, is due in 1908, and Washington has been selected as the place of meeting. It seems a far cry from now to the autumn of the year after next; but the American National Association for the Study and Prevention of Tuberculosis, which has general charge of the arrangements, evidently intends that this meeting shall be notable among congresses, and with laudable forethought has already got its plans something more than mapped out. As an initial step it set itself the task of collecting a sum of $100,000 towards the expenses, but resolved to get this amount in a fashion quite impossible in any country on this side of the Atlantic. In other words, the minimum subscription was placed not at five shillings but at five thousand dollars, in the belief that there would be no difficulty in finding at least twenty citizens of the United States ready for such an object to put their hands into their pockets to the tune of £1,000 each. Nor does it appear likely that these rose-colored expectations will be falsified, for about half the sum desired is already in hand. There is a double object, however, in this early collection of the sinews of war. A sum of $100,000 lying at interest at American rates for a couple of years will enable another scheme to be fulfilled. This is to award prizes of considerable value to the authors of the best papers sent to the congress on certain selected subjects, such as municipal control, bacteriological treatment and sanatoriums, as also to anti-tuberculosis societies which can show the largest increase in membership since the congress of 1905, and to the city, wherever situated, which can claim the greatest improvement in its phthisis mortality rates during a corresponding period. The exact subjects have not yet been finally determined, but it is understood that an announcement of them is to be expected before very long. A further novel suggestion which