In the presence of these disasters, all of which have happened during peaceful maneuvers or practice, it will require some well-fortified evidence that the submarine has done effective work in the Sea of Japan, before our confidence in this new engine of war can be re-established.

SELECTION OF TRANSMISSION VOLTAGES.

BY ALTON D. ADAMS.

Electric transmission is now regularly carried on over distances up to 154 miles, the length of line between Electra power house and San Francisco, and with voltages up to at least 50,000, the pressure on the circuit between Shawinigan Falls and Montreal. From these superlative distances and electric pressures the line lengths and voltages drop gradually to the numerous transmissions of ten miles and less at not more than 10,000 volts.

Between the transmission over ten and that over 150 or 200 miles, there is evidently a wide range in choice of practicable voltage, though such choice should turn on well-defined engineering considerations. Like many other engineering problems whose solutions depend on various conflicting factors, the relation of voltage and distance has been differently fixed in actual transmissions. A broad survey of the majority of transmissions, long and short, will show, however, a fair approximation to a constant relation between voltage and distance, in a great number of cases. Such a relation once established on sound considerations, and illustrated by numerous examples, is obviously very convenient in the selection of a voltage for any particular case.

By the fundamental laws of electric circuits, it is known that the weight of conductors varies directly with the squares of their lengths, when the power transmitted, the voltage, and the loss are constant, and that the weight of conductors varies inversely as the square of the voltage, when the power, loss, and distance are constant. From these rules follows the one so often repeated in connection with transmission problems, that the weight of conductors remains the same with constant power and loss for all lengths of line, if the voltage is increased directly as the length. Attractive as this rule appears at first sight, it is probably safe to say that no group of transmission systems can be found that illustrate its application over a wide range of distances, say 10 to 150 miles. Certain it is that if any such group of transmissions can be found it will exhibit poor engineering in either the shorter or the longer lines.

A rule of which much less is heard, though its important illustrations in practice are far more numerous, may also be drawn from the two fundamental principles first stated. This rule is that with constant power and loss on the line, the cross section of conductors remains the same if the voltage of transmission varies directly as the square root of the length. If these relations are maintained, the weight of conductors obviously increases directly with the length of line, whereas with constant voltage the weight would increase as the square of the line length. The increase of voltage with the square root of the distance thus gives the line structure a constant cost per mile whatever the length.

It requires but a glance to show that a direct increase of voltage with distance, so as to hold the weight of conductors constant for a given power and loss, would soon carry line pressures beyond the limits of present practice. A voltage of 10,000 has been so generally and successfully used on transmissions under a great variety of climatic conditions, is so easily insulated, and adds so little to the dangers of much lower pressures, that it is very seldom too great for transmissions of five to ten miles. If 10,000 volts is adopted for a five-mile line, and a proportionate increase of pressure is made for a 100-mile line, the latter must operate at 200,000 volts, or about four times the greatest pressure now in use for power transmission. Even if a line ten miles long at 10,000 volts is taken as the starting point, a line of 100 miles requires 100,000 volts, if pressure and distance are to increase at an equal rate, and this voltage is nearly twice that in regular use for practical work. With 10,000 volts for a five-mile line, and an increase of pressure at the same rate as the square root of the distance, a line 100 miles long requires about 44,000, and a line 150 miles long about 55,000 volts, and these figures do not exceed present working limits.

Various factors combine to make the use of very high voltages on short lines undesirable. It is frequently the case with a line less than ten miles long, that a voltage of more than 10,000 or 15,000 would either render the conductors too weak mechanically, or raise their temperature too much, even with a small percentage of loss. The most that can be saved by the high voltage is some part of the weight of conductors, all of which is not great, and this is more than offset by the higher cost of insulators, larger crossarms and poles, and the greater risk.

Data of a number of the longer and more important transmission lines in the United States and Canada show that their voltages vary roughly as the square roots of their lengths, taking a five-mile line at 10,000 volts as a basis. Between Canon City and Cripple Creek, Colorado, a distance of 23 miles, the transmission line operates at 20,000 volts, while the voltage on the basis just named would be 21,000. A 23-mile line connects Niagara Falls and Buffalo, and its voltage is 22,000, or just above the figures reached by a rise with the square of the distance from five miles and 10,000 volts. The line from Apple River Falls to St. Paul is 24 miles long and its voltage is 25,000, while the voltage that would be employed on the basis named is 22,000. Spier Falls is about forty miles north of Albany, and the transmission line between these places has a voltage of about 30,000, while 28,000 volts is the figure based on five miles and 10,000 volts.

Santa Ana River develops electric energy that is transmitted at 33,000 volts to Los Angeles, 83 miles away. Allowing for a rise of voltage with the square of the distance, on the basis indicated, the line in this case would operate at 40,000 volts. Between Colgate power house and Oakland, California, the distance is 142 miles, and the line pressure based on 10,000 volts for five miles would be 53,000 volts. This transmission operated at 40,000 volts during several years, but the intention is to raise the pressure ultimately to 60,000 volts. On the 154-mile line between Electra and San Francisco the actual voltage is about 60,000, while an increase with the square root of the distance from five miles and 10,000 volts would give this transmission a voltage of 55,000.

In a few instances rather long transmissions are operated at materially higher voltages than those indicated by the foregoing considerations. Perhaps the most notable instance of this sort is the line between Canon Ferry and Butte, which is 65 miles long and carries energy at 50,000 volts. Even this case does not show a rise of pressure as the distance from five miles and 10,000 volts, for that would carry the voltage to 130,000.

It may or may not be that five miles and 10,000 volts are the most desirable figures to use as a basis, but some such basis having been reached, there will seldom be any good reason for using smaller conductors on a long than on a short transmission.

NEW METHOD OF MILK ANALYSIS BY CENTRIFUGAL APPARATUS.

A new method of making analyses of milk has been presented to the Academie des Sciences by Messrs. Bordas and Touplain. The process is claimed to be much more rapid as well as more exact than the methods which are now in use. With some of these methods only a part of the elements are determined. With others all the constituents are found and estimated, but the analysis often requires two days to carry out, and the caseine must be estimated by the method of differences on account of the uncertainty of the processes which are used. In the process which is given here the authors sought exactness as well as rapidity and simplicity of the operations, by employing centrifugal apparatus. Drop by drop, they introduce 10 cubic centimeters of the milk under analysis into a graduated glass tube containing a solution composed of 65 deg. alcohol acidified by acetic acid. The solution is allowed to rest for a few minutes and is then treated in the centrifugal apparatus. After decanting, the precipitate is washed by adding 30 cubic centimeters of 50 deg. alcohol. This is again placed in the centrifugal machine and then decanted. The liquids which are thus obtained are collected, and the lactose is estimated by Fehling's solution. The extraction of the butter is carried out with the precipitate which comes from the preceding operation. Two treatments are made with 2 cubic centimeters of 96 deg. alcohol for the first and 30 cubic centimeters of ordinary ether for the second. Each time the matter is treated in the centrifugal machine for a few minutes, and the ether is collected in a graduated vessel where it is evaporated and the butter is weighed after drying. In the tube of the centrifugal apparatus there only remains the caseine in fine powder, which is quickly dried at the ordinary temperature. It is weighed in the tube itself, the latter having a known weight. The above estimates are completed by finding the ash which is given by 10 cubic centimeters of milk. This method suppresses all the filtrations and partial solutions as well as the long and tedious process of drying the caseine. By using a single test specimen we can make all the estimates in the same tube by successive solutions and precipitations. Besides, only a small quantity of milk is needed to make an analysis.

AN EXPLANATION OF ICE CAVES.

In many parts of the world caves are found which contain ice all the year round, though the average annual temperature of the air in the caves is far above the freezing point.

Years ago B. Schwalbe suggested, supporting his hypothesis by still older (1865) experiments of Jungk, that the refrigeration in this case is due to percolation of water through porous strata. The physical justification of this assumption, however, has since been apparently destroyed by experiments, in which the percolation of water through silica and other powders was found to be attended by a rise of temperature, in some cases of considerable amount.

G. Schwalbe has now made a series of experiments with pure silica and different kinds of sand, using water of various initial temperatures, and has found that water warmer than 4 deg. C. (the temperature of maximum density) is heated, water cooler than 4 deg. C. is cooled, and water at 4 deg. C. is unchanged in temperature by its passage through the porous stratum. The maximum change in temperature, equivalent to a development of heat of 6.16 gramme-calories, was observed when 20 grammes of water at 16.3 deg. C. were allowed to percolate through 10 grammes of silica.

These results are in accordance with deductions from the mechanical theory of heat, and are due to the fluid pressure caused by the attraction exerted by a solid body upon the film of liquid which adheres to it. As water expands with rise of temperature above 4 deg. C., and also with fall of temperature below 4 deg. C., compression necessarily causes heating in the first case and cooling in the second.

THE CURRENT SUPPLEMENT.

In double-tracking a part of the Illinois Central Railroad, it was found necessary to build a more substantial bridge across the Big Muddy River at Carbondale, Ill., than the existing steel structure. In the opening article of the current SUPPLEMENT, No. 1537, the concrete bridge, which took the place of the old steel structure, is very fully described and excellently pictured. The Lister Two-Cycle Gas or Oil Engine is carefully described and illustrated. Recent developments in Wireless Telegraphy are reviewed. Mr. Charles A. Mudge's paper on High-Speed Long-Distance Electric Traction is concluded. The English correspondent of the SCIENTIFIC AMERICAN gives a *résumé* of an interesting lecture recently delivered before the Royal Geographical Society of Great Britain on the subject of Tibet. Sir William H. White's scholarly review of Submarines is concluded. The origin of the craters of the moon has baffled selenologists ever since the mountainous character of our satellite was first recognized by means of the telescope. It has been thought that perhaps the many craters of the moon, which number not less than 250,000, and perhaps 1,000,000, were formed by the impact of countless meteors. Mr. R. S. Tozer in the current SUPPLEMENT seeks to prove the truth of this theory by describing some experiments which he made, which consisted in hurling projectiles against plastic clay. Although his miniature craters bear a striking resemblance to those found in the moon, the Editor differs with this conception for reasons advanced in a brief note to Mr. Tozer's article. Mr. Rossi concludes his brief study of the Ferro Metals and their electrical manufacture.

LOSS OF HEAT IN STEAM.

M. Maréchal, engineer of the Association Normande des Propriétaires d'Appareils à Vapeur, who has carried on interesting investigations on the steam engine and the proportion of calories actually utilized, has arrived at the conclusion that, even with the most perfect systems, as much as 59 per cent of the total heat developed goes to the condenser. When the motor is of free escapement, 63.6 per cent of the heat is dissipated in the atmosphere.

A VAGARY OF THE RUSSIAN PRESS CENSOR.

In our issue of April 15, Mr. Lodian described the compressed tea which is used by the Siberians and by the Russian army in Manchuria. The article was accompanied by an illustration of a tablet of compressed tea, bearing the imprint of the Russian government. The printer was not familiar with the Russian language, for which reason the engraving appeared upside down, so that the insignia of the Czar upon the tablet were reversed. This revolutionary proceeding proved too much for the censor. In every copy of the SCIENTIFIC AMERICAN that reached our Russian subscribers the unfortunately placed engraving was ruthlessly blacked out.

The Chicago & Alton Railway has announced that it has made all arrangements for the establishment of a wireless telegraph system on all its trains running between Chicago and St. Louis, and that eventually all its trains will be in wireless telegraphic communication with the larger cities. The announcement was the result of careful tests made on a limited train running between Chicago and St. Louis. The observation car was equipped with the wireless apparatus. Messages were received while the train was running at a speed of fifty miles an hour. Mr. Felton, president of the road, announced that this was the first time the wireless system had ever been used to communicate with persons on a moving train. In this he was wrong; for if our memory serves us, similar experiments were carried out two years ago in Canada with marked success.