into play. Using still the flood-terrain as above described, let it be supposed that the river is turned against it in such a manner that the whole mechanical energy of the stream is directed against it, and suppose further that as fast as the banks are torn down by the impact of the water and the sapping of the banks the material is promptly carried away through the agency of great declivity, then the whole terrain would be carried away in less than ten years.

Next, let the rate of transportation under maximum conditions be illustrated, and still let the described flood-terrain be used for this purpose. Suppose that the terrain could be loaded upon the Mississippi in such a manner that the waters are constantly supplied to their utmost capacity. Now it has been observed in Utah, and again in Colorado in the case of certain bad-land streams, that under most favorable conditions water is capable of transporting its own volume of load. The Mississippi River annually discharges into the Gulf an average of one million cubic feet per second. If this volume of water were loaded to its utmost capacity, as described above, the flood-terrain of the Mississippi would be discharged into the Gulf in one year.

The rate of corrasion is subject to many interdependent variable conditions, Only the laws of the first order have been presented. There is still a great number of conditions of a second order to be considered; but they do not in any material way vitiate the laws already stated. The facts and principles that have been presented are those which the engineer must use in planning and constructing irrigation works. They are also of importance in dealing with the regimen of rivers for the purpose of improving navigation, and for the still more important purpose of protecting flood-plains from overflow. It is proposed here to call attention to some of the engineering methods which have been used to control rivers for the protection of flood-plains. Those selected for mention in this manner are as follows.

The banks of the stream may be protected from lateral corrasion by revetment, but such protection will be sufficient only to the extent to which it is applied; for thorough protection both banks must be revetted throughout the whole length of the flood-plain reach. And further, the revetment must be carried below the level of possible vertical corrasion or the revetment will be undermined. By this method the channel is protected from the choking which arises from the deposition of materials brought in from upper reaches, lateral tributaries, and local erosion. In a bank-protected channel along a flood-plain reach there is a constant tendency to distribute the obstructing deposits evenly along the bottom, as the lower declivities are sites of deposits and the higher declivities present conditions of increased vertical corrasion. In a river with uniform channel and uniform volume of water the deposition is uniformly diminished from head to foot, and such a stream builds up its channel until a degree of declivity is reached sufficient to carry away all the supply of load. If the declivity is more than sufficient to carry away the load supply, vertical corrasion is inaugurated and the channel is deepened. If the declivity is insufficient to carry away the supply of load, the deposit of sediment will build up the channel, and destructive floods will be increased thereby. Revetment, therefore, is efficient only on the condition that the declivity is exactly sufficient to carry away the load and to produce no further corrasion; for if vertical corrasion be increased, the revetment will be undermined and destroyed, and if vertical corrasion is insufficient, deposits will be made and floods will result. The practical problem, therefore, is to decide whether the declivity is or is not sufficient to preserve the channel. This problem is always solved by nature, and its solution is made perfectly plain. If the declivity of the flood-plain reach is sufficient to preserve the channel, the channel will be preserved, and there will be no lateral corrasion. Every flood-terrain is such because the channel of the stream has an insufficient declivity for its own protection. The very fact that corrasion is wholly lateral is in itself an absolute demonstration that the declivity of the stream is insufficient for the protection of the channel. This arises from the fact that the load once deposited remains, as the channel does not present conditions for its reloading: revetment, therefore, is necessarily futile, except for local and temporary purposes.

If portions of the banks of a channel are revetted, the only result arising therefrom is to change the locus of lateral corrasion; for, the total deposits remaining the same, the total lateral corrasion will remain the same. If the whole channel is revetted, the whole channel will be built up thereby, and ever a greater volume of water will be distributed over the flood-plain, until the channel is entirely filled at its head, or built up to such a declivity that vertical corrasion will be sufficient to preserve the channel.

There are four other methods that have been presented by engineers and geologists still worthy of consideration, as they are more or less efficient, either separately or conjointly. These are as follows.

1. The channel of the stream may have its banks and bars removed, and it may be deepened by river ploughs. To be efficient, the clearing of the channel of its deposited obstructions must be complete. The effect of clearing a lower reach is not extended to an upper reach, but the effect of clearing an upper reach is to increase the obstructions of the lower. For this reason the channel must be cleared its entire length throughout the region to be protected from floods at one effort.

2. The channel of the river may be shortened. By this method the declivity of the stream will be increased, the velocity of the current increased, and the waters more rapidly discharged. At the same time the channel of the stream will be deepened progressively from the foot to the head of the reach, where the stream runs through alluvial formations; but wherever the stream has its bed in indurated rocks the progress of stream deepening will be retarded.

The shortening of the channel may be accomplished by two methods.

a. By establishing a nearer outlet.

b. By utilizing and promoting cut-off reaches.

3. The headwaters and tributaries may be impounded in reservoirs at flood time and held until low water, and the volume through the year may thus be more or less equalized.

4. The headwaters and tributaries of a river may have their waters drawn off into settling basins, and thus they may be caused to discharge the sediment they carry, which is the material which forms the deposits and chokes the channel, and also the instrument of lateral corrasion.

It is manifest that the storage of water and the discharge of sediment may be accomplished by the same agency.

It is the purpose here merely to mention the principal efficient methods of controlling rivers in their flood-plain reaches. Every river presents problems more or less peculiar to itself, and the application to special cases of the laws which have been set forth is one of great interest and of profound importance.

J. W. POWELL.

COMMERCIAL GEOGRAPHY.

The Care of our Forests.

IN the annual report of the Department of Agriculture, B. E. Fernow, chief of the forestry division, dwells most emphatically upon the necessity of adopting a sound policy regarding our forests. His interesting report is accompanied by a map showing the distribution of forests in the Rocky Mountains, where they serve the important purpose of regulating the flow of springs and streams. Mr. Fernow's weighty arguments and urgent demands for better care of our forests ought to attract the most speedy attention of our legislators. He says, —

"It has become evident, in spite of the enormous supplies which seemed to be available, that our natural forests are being rapidly reduced, both by an increased demand and by wasteful practices; and it is now safe to say that the annual consumption of wood and wood-products is at least double the amount reproduced on our present forest area. The forest, under proper management, is capable of furnishing continuous crops, and therefore, as a source of constant supply, demands national legislation.

"It has become evident, that with the unrestrained scourge of fire and the destruction by herding, and other malpractices now prevalent, and in the absence of all rational forest management, not only is the remaining forest deteriorated in material value, but large tracts of land are converted into absolute deserts or useless barrens. A sound land-policy, therefore, demands that the nation should give earnest attention to forest management.

"It has become evident that we are not to escape the consequences of disturbing the even distribution of water-flow by forest devastation, and denudation of mountains and hills, which have been experienced in other parts of the world, and which have reduced fertile lands to barrenness, prosperous communities to poverty. Regard, therefore, for the future welfare of the several communities which in their aggregate represent the nation, calls for a rational forest policy, a proper utilization, a proper distribution, and a proper management of the natural forest.

"Lastly, if the nation as such is interested in the proper development of the rich agricultural lands of the plains and prairies, it must be interested also — in that part of its domain, at least — in forest-planting as a means of ameliorating climatic conditions and making the region more habitable."

Mr. Fernow then proceeds to consider the most immediate needs and the most immediate duty of the general government in regard to the forestry question. "The general government still holds, as an individual, national property, a forest area the extent of which is unknown, but may be estimated between fifty and seventy million acres. The bulk of these lands is to be found on the rugged mountain sides and crests of the Western ranges, notably the Rocky Mountain, Cascade, Sierra Nevada, and Pacific coast ranges, mostly land not fit for agricultural use. The agricultural valleys at the foot of these ranges are not only destitute of timber, but they are dependent for their agricultural productions upon irrigation, the water for which is derived from the mountain-streams and more rarely from artesian wells, both of which sources are fed by the rains and snows which fall upon the forest-covered mountain-sides, and gradually find their way to the plain below. It has been proved not only by experience, but by actual experiment on a large scale, that forest cover regulates and beneficially influences the rapidity with which these precipitations are carried to the plain for utilization on agricultural lands."

In order to preserve these woods, a bill has been formulated, which has been submitted to Congress through the agency of the American Forestry Congress. Its essential features are the withdrawal from sale, or other disposal, of all woodlands still in the hands of the government, and the classification of the same into three classes; the regulation of the sale of timbered land which is fit for agriculture; and the management of the forests occupying land unfit for agriculture. To insure a proper administration of such a law, to prevent waste and loss by fires, a new bureau in the Department of the Interior is proposed, with a forest commissioner and four assistant commissioners acting as a forestry board.

"None but such a thorough organization can be expected to guard the national property, of which, under the present neglect, the nation is annually robbed to the extent of from five to ten million dollars, not counting the damage done by fires and fraudulent operations of speculators. But, as has been stated repeatedly, the forest-cover in the localities in which the bulk of the public timber-lands is situated, notably on the Rocky Mountains and the Pacific slopes, subserve a function which makes its material value of only secondary importance. It has become already evident that the denudation of mountain-sides in the region under consideration has impaired the regularity of water-flow, upon which irrigation in the arid valleys below depends.

"The interest of the nation, therefore, in properly administering this property, reaches beyond that of any material advantage; and certainly in these mountain forests, in this legislation for their proper administration, lies the immediate national interest in forestry."

ELECTRICAL SCIENCE.

The Heroult Aluminium Process.

THE Swiss Metallurgical Company, established close to the Rhine Fall at Neuhausen, has adopted the process of M. Heroult for the production of alloys of aluminium. The process resembles in some ways that of the Cowles brothers, which is so successfully employed at Lockport in the United States, and which has been recently introduced in England and the continent. In both the Cowles and Heroult processes an electric current is employed. In the former it is used simply to produce a very high temperature in a limited zone, the reduction of the ore being due to the temperature alone and not to any effect of electrolysis, so that an alternating could be used as well as a continuous current. In the Heroult process, according to the views of the inventor, the reduction of the ore is partly electrolytic and partly due to the heat of the arc. The furnace has a carbon pole at the top, and the current passes in by it through the melted aluminium oxide to the reduced metal at the bottom; the ore is decomposed, the oxygen passing upward and attacking the carbon, while the molecules of the metal travel downward and are merged in the metal bath.

The furnace used in the process is a large carbon block hollowed out in the proper shape and enclosed by a frame of iron. In the smaller furnaces a single block of carbon is used and the iron is cast around it; for larger sizes slabs of carbon are used, and are held together by wrought-iron bands. There is an opening in the bottom of the furnace for drawing off the reduced metal. The current enters the crucible through a carbon electrode which enters the top, and which consists of a bundle of carbon slabs, ten feet long, seventeen inches wide, and nine and a half inches deep. The distance of this electrode from the surface of the molten metal is regulated by an attendant. This distance is very small, preferably not over a quarter of an inch. One of the electrodes is consumed in producing about half a ton of aluminium. The crucible is covered by carbon slabs insulated from the body of the crucible; in the top, holes are provided for the introduction of ore and scrap metal. The ore generally used is alumina, free from silicon and other impurities, and the scrap metal is either iron or copper, according to the alloy which is desired. The process of smelting is a continuous one, the ore being introduced and the crucible tapped at regular intervals. The production of aluminium per horse-power hour varies somewhat with the percentage of the metal contained in the alloy, the average being thirty grams of aluminium and the maximum being forty grams. That is, to produce one pound of aluminium requires fifteen horse-power hours on the average, and eleven horse-power hours under favorable conditions. The present capacity of the crucible is four hundredweight of aluminium in twenty-four hours.

At the works at Neuhausen the current is produced by two dynamos driven by a turbine of three hundred horse-power. These dynamos are of the multipolar type, designed by Mr. C. E. L. Brown, and built at the Oerlikon Engineering Works. They are designed to give six thousand ampères each, at an electromotive force of twenty volts, and they can be worked up to thirty-five volts. The speed of the turbine is controlled by an automatic regulator acting upon a throttle in the inlet-pipe of the turbine. While the working current is normally twelve thousand ampères, it sometimes increases to twenty thousand ampères, because of a short-circuit in the furnace, caused usually by one of the slabs of which the carbon electrode is made burning more slowly than the others and touching the surface of the molten metal. This increase of current does not injuriously affect the dynamos. There is no sparking at the brushes of the dynamos. The process promises to be a successful one; from the figures given it compares favorably with the Cowles process in the amount of aluminium reduced per horse-power.

AN IMMENSE ELECTRIC LIGHTING STATION. — In the London *Electrical Review* is a description of the station of the London Electric Supply Corporation. At the Stowage wharf, Deptford, this corporation is laying down plant sufficient for the supply of 250,000 incandescent lamps, and there is space for three other sets similar to the first, giving a final capacity of one million lamps. The grounds of the corporation have a river frontage, with a wharf for landing fuel and heavy machinery. A fifty-ton derrick has already been erected. The buildings occupy a space of 210 by 195 feet, and the height will be 100 feet.

The boiler house is 195 by 70 feet, and is constructed to hold boilers of 65,000 horse-power, and of these, 13,000 horse-power are being erected. The boilers will occupy the two lower floors, with stowage room above for the fuel. The two engine houses are of nearly the same dimensions as the boiler house, and are very massive in construction. In the first of these houses a pair of 3,000