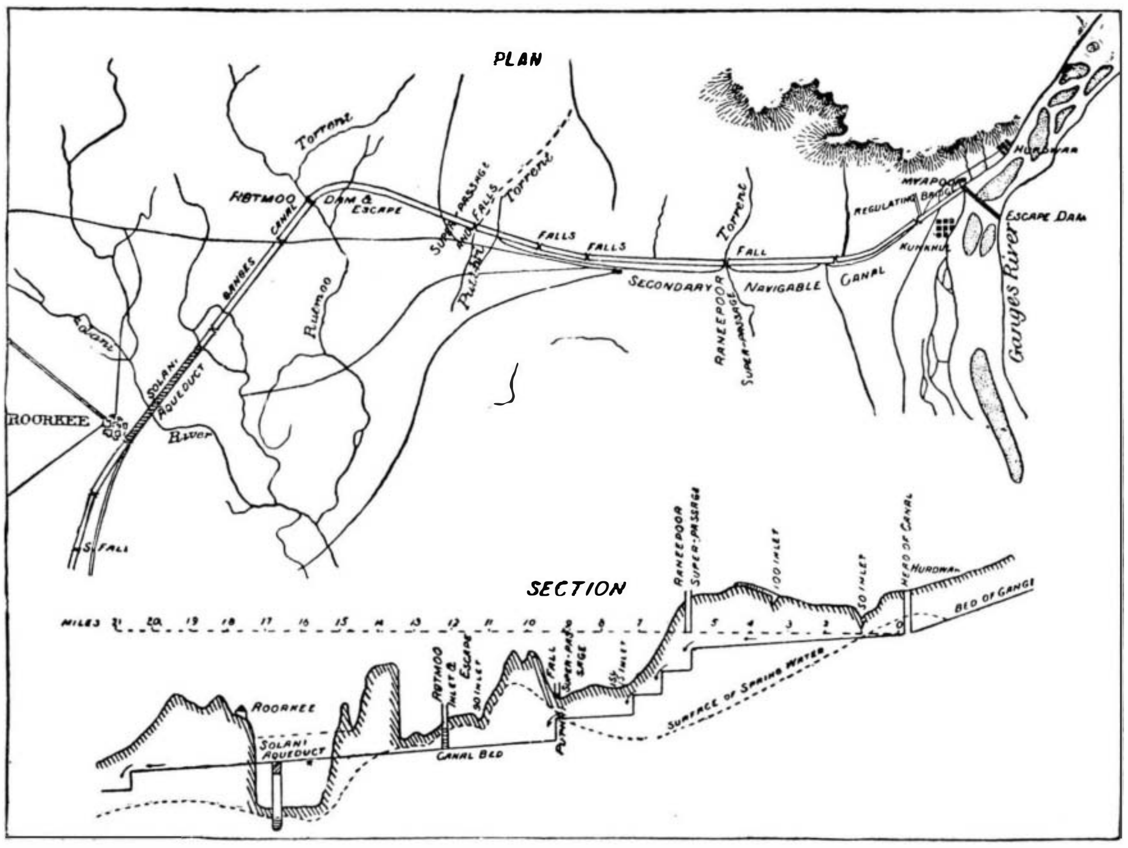
multipolar railway generator, three compound engines each of 750 horse power, one a horizontal, direct-connected to a Thomson-Houston multipolar railway generator of 500 horse power capacity, another a vertical engine direct-connected to a similar generator, and a third belted to one of these generators. There is also a four hundred horse power high speed compound engine direct-connected to a two hundred horse power Thomson-Houston railway generator. The switchboard is on the north side of the room, and from it the operator commands full view of all the machinery. The armature of the 1,500 kilowatt generator is probably the largest one in the Exposition service. It was built up on the engine shaft. The generator is fifteen feet in diameter, while the commutator is seven feet in diameter, and twelve clusters of carbon brushes with ten brushes in a cluster bear on it.

There are ten stations on the road. The first one is at the loop at the south end of the grounds, the others are in the following order: The Forestry building, the Colonnade, which is between the Palace of Mechanic Arts and the Agricultural building, the Railway Terminal Station, the Transportation building adjoining and connecting with the station of the elevated road from the heart of the city, the 62d Street entrance to the grounds, the 59th Street entrance to the grounds, the 57th Street entrance, the Iowa building, and at the loop at the north end of the line adjacent to the Fisheries building and the United States government building.



PLAN AND CROSS SECTION OF GANGES CANAL, HURDWAR TO ROORKEE.

IRRIGATION IN INDIA.

The twelfth annual report of the U. S. Geological Survey, J. W. Powell director, contains, among other most valuable matters, a paper by Herbert M. Wilson, C.E., entitled Irrigation in India. It is an account of his personal observations in that country in 1890, during a visit and inspection of some of the principal irrigation works made under the auspices of the survey. The paper forms a volume of some two hundred pages, illustrated with maps and photographs, over eighty in number. We are indebted to the author for a copy. It is full of most interesting and valuable information. We regret that our limited space prevents us from presenting the paper *in extenso*. We can only give a few abstracts, sufficient, perhaps, to convey to the reader an idea of some of the extraordinary works that have been constructed and are being built in India, by the British government, for the benefit of the agriculturists of that great empire.

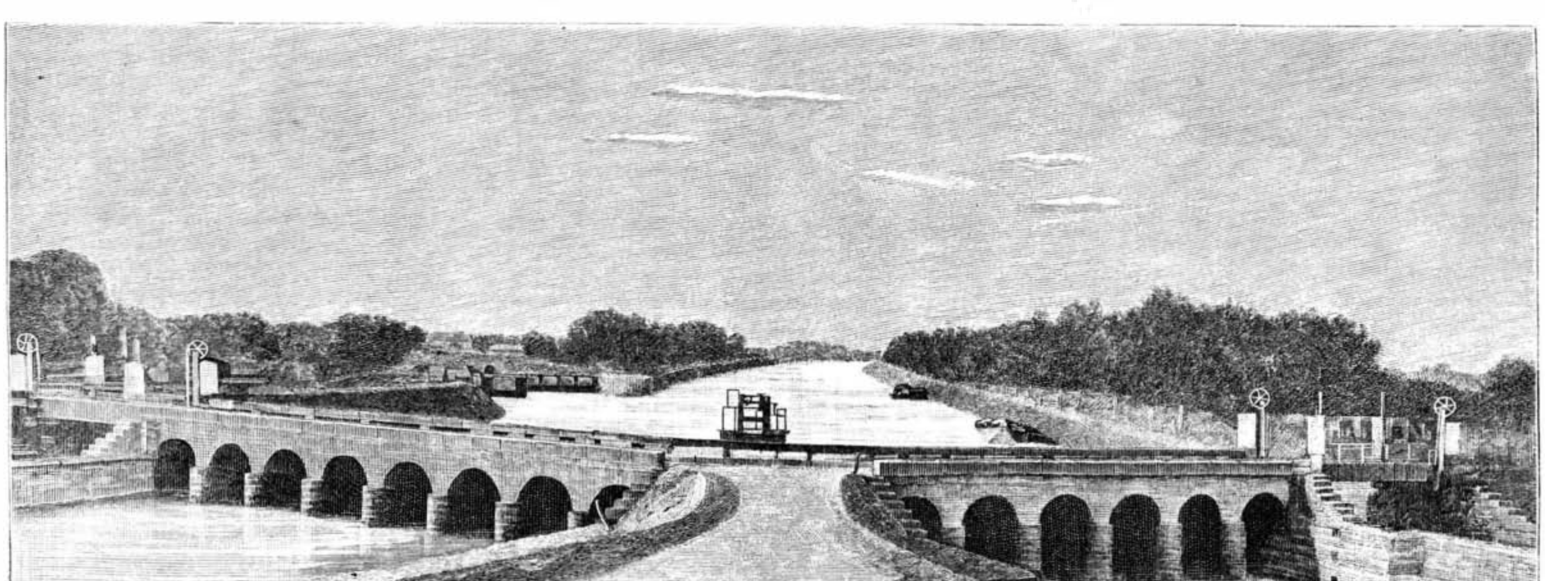
"India," says Mr. Wilson, "stands pre-eminent for her gigantic engineering undertakings. No other country has so vast and so fertile an expanse of territory, with such convenient slopes for the construction of canals, and at the same time such an abundant water supply. In general there is great similarity between the climate and topography of the great northern plains of India and portions of our arid West, especially the eastern slope of the Rocky Mountains and the great California valley. Central India and the Deccan have many features in common with the central arid Territories, particularly portions of northern Arizona and southern Utah. The climate is as similar to that of our central Territories as is the topography."

"The conditions under which Americans must undertake irrigation enterprises are not so different from those exising in India and southern Europe as would at first appear. Any works we may construct must depend for their utilization and revenue on immigration, as they will be largely undertaken in a sparsely inhabited country. A few of the great canals of the Northwest Provinces and the Punjab were undertaken in districts that were sparsely inhabited. These canals are among those of India that have paid the largest interest on the original outlay. Within ten years from their construction the country was fully populated, although the immigration was often from remote portions of India." In 1888 the area of British territory in India was 1,064,720 square miles and the population 269,477,728. The area cultivated was 144,000,000 acres, of which 25,000,000 acres were irrigated lands.

"The irrigation works of India are divided by the engineer into two great classes, (1) gravity irrigation and (2) lift irrigation. The former includes four great heads, namely, perennial canals, intermittent canals, periodical canals and inundation canals. The water supply for these may be supplemented by storage works. This will be treated as a third class. Perennial canals are taken from the rivers the discharge of which at all times suffices for the irrigation of the lands without the aid of storage. Intermittent canals are taken from intermittent streams, the water of which must be stored in order to furnish a constant supply. Periodical canals are taken from streams having an available supply during the rainy season only, and are used altogether in the cultivation of the summer crop. Inundation canals are taken from rivers having a constant discharge of some magnitude, but are fed by those rivers only when in flood. Lift irrigation is chiefly illustrated by wells. Of these there is little to say, although the area irrigated by them is considerable. They are used in a country where labor is cheap, and are valuable adjuncts of irrigation, catching the seepage water from the canals and irrigated fields which otherwise would be wasted. Owing to the cost of labor, it is doubtful if they will ever be used to any extent in America."

"Men, women, and children are engaged alike in the construction of all works. As common laborers women and children receive about 4 cents per day, and men from 8 to 10 cents. Skilled masons and machinists receive from 18 to 22 cents per day, and carpenters and blacksmiths nearly the same."

"There are 34 major works designed to irrigate, when fully completed and irrigation has been fully developed, something more than 10,000,000 acres. Of 5,520 miles of main and branch canals, no less than



THE GANGES IRRIGATING CANAL INDIA—THE GOPALPUR BIFURCATION.

2,250 miles are navigable. In addition to the 5,520 miles of main canals constructed in these 34 systems, there are 17,135 miles of principal distributaries."

"The gross value of the entire area irrigated in 1888 by all the four classes of irrigation works administered by the government reached the sum of $155,000,000."

Additional works to the value of nearly as much more are projected and in progress.

THE GANGES CANAL.

"This canal is the largest in existence. As at present constructed its head works are situated near the city of Hurdwar, about 20 miles above the railway town of Roorkee. At this point the Ganges issues suddenly from between the foothills of the Himalayas on to the broad level plains. In the first 20 miles of its course (see plan) the canal encounters a considerable amount of sub-Himalaya drainage, and the works for the passage of this drainage and for the reduction of the slope of the canal by means of falls are important. The slope of the river bed in this section is from 8 to 10 feet per mile."

"A short distance above Hurdwar a branch of the Ganges about 300 feet in width separates from the main river and hugging the Hurdwar shore rejoins the stream a half mile below Hurdwar. The discharge of the main river at this point in the dry season is about 8,000 second-feet, a majority of which is diverted by training works and temporary bowlder dams into the Hurdwar channel. This has been deepened and given a uniform slope of 8½ feet per mile to the canal head. At Myapur the canal is taken from the Hardwar channel, the water being diverted into it by means of a weir and sluices across the channel and a masonry regulator at the head of the canal. To the sixth mile the canal crosses several minor drainages, which are admitted by means of little inlets. At the sixth mile it is crossed by the Ranipur torrent, passed over it by means of a masonry superpassage about 195 feet in breadth. In the tenth mile the Puthri torrent, having a catchment basin of about 80 square miles, or twice that of the Ranipur, is carried across the canal by a similar superpassage 296 feet in breadth. The sudden flood discharges in these torrents are of great violence, the Puthri torrent discharging as much as 15,000 second-feet and having a velocity of about 15 feet per second.

"In the thirteenth mile the canal encounters the Rutmoo torrent, with a slope of 8 feet per mile and a catchment basin half as large again as that of the Puthri. This torrent is admitted into the canal at its own level. In the side of the canal opposite to the inlet is an open masonry outlet dam or set of escape sluices. In the canal just below this level crossing is a regulating bridge by which the discharge of the canal can be readily controlled; thus in time of flood, by opening the sluices in the outlet dam and adjusting those in the regulator so as to admit into the canal the volume of water required, the remainder is discharged through the scouring sluices, whence it continues in its course down the Ranipur torrent.

"In the nineteenth mile, near Roorkee, the canal crosses the Solani River and Valley on an enormous masonry aqueduct. The Solani River in times of highest flood has a discharge of 35,000 second-feet and the fall of its bed is about 5 feet per mile. The total length of the aqueduct is 920 feet. The banks of the canal on the upstream side are reveted by means of masonry steps for a distance of 10,713 feet, and on the downstream side for a distance of 2,722 feet. For 1¾ miles the bed of the canal is raised on a high embankment previously to its reaching the aqueduct, and for a distance of half a mile below it is on a similar embankment. The greatest height of the canal bed above the country is 24 feet. The aqueduct proper consists of fifteen arches of 50 feet span each. In addition to these great works there are in the first 20 miles of the canal five masonry works for damming minor streams and a number of masonry falls.

"Beyond Roorkee the main canal follows the high divide between the Ganges and the west Kali Nadi and continues in general to follow the divide between the Ganges and the Jumna to Gopalpur, a short distance below Aligarh, where the main canal bifurcates (see engraving), forming the Cawnpur and Etawah branches. The former branch tails into the Ganges at Cawnpur and is 170 miles in length. The Etawah branch is also 170 miles long and tails into the river Jumna near Humerpur. The Vanupshahr branch leaves the main line at the fiftieth mile and flows past the towns of Vanupshahr and Shahjahanpur. It formerly terminated at mile 82¼, emptying into the Ganges River, but it is now continued to a point near Kesganj, where it tails into the Lower Ganges Canal. The first main distributaries are taken from both sides of the canal a short distance below Roorkee. The nature of the country offers abundant facilities for escapes from the canals. Five are constructed on the main line, four on the Cawnpur branch, and three on the Etawah branch, besides numerous small escapes to the distributaries."

LOWER GANGES CANAL.

"The Lower Ganges Canal was undertaken as a means of relief or improvement of the Ganges Canal. It irrigates a part of the Ganges-Jumna interfluve that was originally intended should be commanded by the Ganges Canal proper. The work comprises a masonry diversion weir at Narora, about three miles below the railway crossing at Rajghat. It relieves the Ganges Canal of 128 miles of the Cawnpur branch and 130 miles of the Etawah branch. It is now considered as a work separate from the Ganges Canal.

"The weir is a substantial one, resting on masonry wells, usually 20 feet deep; the front and rear curtain walls rest on smaller wells. The weir is 3800 feet long and is 10 by 10 feet in cross section, having a vertical overfall to a paved floor. It is constructed chiefly of brick. The weir scouring sluices opposite the canal head are 42, each 7¼ feet wide. The regulator at the canal head is constructed of masonry and has thirty openings each 7 feet wide. The weir crest is 7½ feet above the sill of the canal, and this can be raised to 10 feet by means of shutters. For the first 26 miles of main canal the bed is 216 feet wide; the full supply depth is 10 feet and the slope one-tenth of a foot in 1,000.

"In the first portion of its line the canal is compelled to follow the low river bottom for some distance before its grade enables it to surmount the banks and reach the summit of the interfluve. In this low reach the canal is threatened constantly by the encroachments of the river, and extensive river training works are necessary to preserve its integrity. These extend for a distance of 4 miles above the canal head and 15 miles below, and consist chiefly of long earthen groynes or embankments, sometimes 2¼ miles in length, projecting into the stream at right angles to its course and protected at the end by loose rock noses. The total length of the main canals is 564 miles. There are 2,021 miles of distributaries and the total length, including escapes and drainage cuts, amounts to 2,992 miles."

Electricity and the Art of War.

This was the title of an able article in a recent number of the *Journal of the U. S. Artillery*, and in the last number, January, the comments and remarks of various officers upon the subject are given. Among them is the following by Second Lieutenant George O. Squier, Third Artillery, who says:

Some recent experiments abroad by Captain Charollois on the use of a field telephone outfit for military operations indicate that it has great possibilities as a means of communication in the field. Captain Charollois uses a bi-metallic wire, with steel core surrounded by copper. Thus it is not easily oxidized, and has great strength for a given cross section. This wire is unwound naked upon the surface of the ground, the earth return being completed through the operator himself, or his horse in case he is mounted. The small magnetic receivers can be used as the wire is being paid out on the ground, and this constant communication is kept with the starting point as the line progresses. By the use of such small wire the entire material for a line of one mile weighs less than five and a half pounds. Each reel carries 10,000 feet of wire, and is conveniently and compactly strapped to the soldier as a part of his equipment. On account of the extremely minute currents required in telephony, the only limit to the smallness of the wire, and its consequent weight for a given length, is the fear of breaking while it is being laid. Cavalrymen, or infantry on bicycles, could establish a line with great rapidity. In some recent experiments in the field, a 14 mile line was completed in five hours and taken up in one hour; and the passage of a division of cavalry over the wire did not interrupt the communication of a dispatch that was being sent at the same moment. No batteries are required; no poles of any kind; no heavy, cumbersome wire to be strung, and any one can operate.

In view of the above, and that we are now talking between New York and Milwaukee, there is but little doubt that the telephone is the instrument both for the field and for permanent lines.

The writing telegraph, when perfected, will undoubtedly have its important *role*, as by its use maps, plans of battles and fortifications, and drawings of all kinds can be reproduced with accuracy at any distance.

Passing to the use of railroads in the mobilization and supply of armies, those familiar with recent street railway progress believe that the steam locomotive must give way to the electric motor for passenger service, and also that with this change a speed of one hundred miles an hour will be the rule and not the exception. An electric line is now under construction between Chicago and St. Louis, which is to make the trip in three hours.

The suggestions of Lieutenant Parkhurst as to the applications of electricity to the modern sea coast fortification are excellent, and instead of being, as some may think, the predictions of an enthusiast, they are not as progressive as the present state of electrical science warrants.

In regard to the security of the main power plant against the long-range fire of the enemy's guns, it is remarked that there seems to be no limit as yet to the distance which electrical power can be economically transmitted. We have recently before us the Lauffen-Frankfort line in Europe, where 300 horse power was transmitted 112 miles at a tension from 16,000 to 30,000 volts, at an efficiency of 74 per cent. As soon as we obtain a perfectly satisfactory alternating current motor, I see no reason why electrical power cannot be transmitted and converted into useful work at distances much greater than the above.

Electricity threatens to revolutionize our whole heavy artillery organization. With an enormous engine of war, weighing many tons, costing thousands of dollars, which can, however, by the application of results *already accomplished* in the industrial world, be lowered, raised, aimed, and fired by the movement of simple levers in the hands of a gunner—does not this point to *fewer* men and *more skilled* men in our organization?

The dozen men in a detachment required for the doomed "heave and embar" system must be replaced by not more than half that number of carefully trained cannoneers. Each round fired from our new 12 inch rifles will cost $217, the gun itself costs $52,365, and these amounts in conjunction with the cost of the carriage, and the limited life of the weapon, compel us to adopt that means of control which insures the most rapid, accurate, and reliable service.

Granting that the modern fortification will be equipped with an elaborate electrical plant, ought we to rely upon civilian electrical engineers to design, install, and care for the same? This brings up a subject of policy of which I have been firmly convicted for the last five years, and which is strengthened more and more as time goes on. Electrical science has reached the theoretical stage—that, given the set of conditions which the motor is to fulfill, and which in sea coast matters the artillerist alone fully understands, the design of the machine to do this particular work can be made with accuracy, *e. g.*, speed under variation of load, field windings for perfect control, and the size of every minute part can be calculated in the office, and when assembled in the workshop it will do the work required near perfection.

We have only to look at our new navy for a practical illustration of the way things are drifting in this regard. Every modern cruiser now has its officer in charge of all electrical matters on shipboard, and the generators and motors already in use are specially designed for conditions afloat. In like manner each group of guns ashore, with its electric lighting system, search light system, range finding system, generators, and motors, will of necessity be under the supervision of an electrical engineer directly responsible to the senior artillery officer in command. If present conditions point to anything, they seem to me to point to the necessity of the following:

The War Department should speedily educate a limited number of officers as electrical engineers at our best institutions of learning. The word "speedily" is used because one cannot become an electrical engineer in six months, nor yet in one year, and he certainly cannot be created at pleasure by a general order from the War Department.

I am aware that objection would be made by some to such details; the applicant is supposed to desire to shirk his legitimate battery duties, and what not; but such reasons seem to me on too low a plane to merit serious consideration. The weeding process of requiring periodical reports of the work accomplished, and the efficiency reports already in vogue, would insure the details being given to those who would make the most of them for the department.

Thanks to the foresight of the General Commanding the Army, officers of artillery have recently been sent to our principal arsenals to co-operate with the Ordnance in the manufacture and testing of our modern guns. With half a dozen expert electrical engineers at Sandy Hook, and the sea coast gun carriage factory at the Watertown arsenal, co-operating and in perfect harmony with the ordnance experts already at these places, to design, test, and work out step by step the details of the plan, I doubt not that rapid progress would be made toward the selection of type carriages for our new guns and mortars, and we no longer would be threatened with the condition of possessing finished weapons with no carriages on which to mount them.

Inventor Harvey's Royalties.

Many who have speculated on the immense fortune which Mr. Harvey will realize from his process of treating armor plate will be surprised to learn that his profits from the United States government will be only about $100,000. The amount of royalty which Harvey receives for the right to decarbonize armor plates by his method of treatment is fixed at a half-cent a pound. Nineteen thousand tons of armor have been contracted for and less than half will be Harveyized. It is the intention of the Navy Department to increase the order for Harveyized armor plate as much as possible; this is the natural result of the remarkably successful trials recently held at Indian Head.