is 8 per cent., or 422.4 feet per mile. The whole line from Buenos Ayres to Valparaiso is 850 miles long, of which 701 miles were completed and opened at the last accounts, and the remaining 149 miles were under construction through the mountain section, involving very heavy work and a large number of tunnels, many of them in the region of perpetual snow, 10,000 feet above the sea. It is being constructed by English engineers and contractors.

THE HYDRAULIC SLIDING RAILWAY.

Among railroad novelties may be mentioned the Hydraulic Sliding Railway, a section of which has just been opened near the Crystal Palace, in London. This is the same "chemin de fer glissant" which was exhibited at the Paris Exposition of 1889, and there attracted much attention.

The principal feature of this decidedly novel invention is that it dispenses entirely with wheels, and substitutes therefor a series of iron shoes which carry the railway car, and rest upon a broad flat rail. The shoes are perforated with a very narrow annular orifice, or slit, through which water is forced at high pressure, so as actually to raise the shoes off the rail, and to float the cars upon a very thin water bed between the shoe and the rail. This, as may be imagined, reduces the resistance to forward motion to a minimum, experiment having shown that this hydraulic friction on the sliding railway is, on a level, less than one-fifth of the usual rolling friction of the wheels on an ordinary railway. As the whole train is thus afloat on this film of water, it may be asked how impulse is communicated to it from the motive power. This is ingeniously done by a series of water jets issuing from fixed nozzles along the roadway, which are opened and closed automatically by the train itself, and which impinge upon suitable pallets attached under the cars. As may be realized, the consumption of water is great, and other methods of propulsion have been proposed, but thus far without any practical results. This novel system has been mentioned more as a matter of curiosity than as one from which satisfactory results in transportation are to be expected, although the promoters of the scheme claim that speeds of 70 to 125 miles an hour have been obtained, and that no less than 94 per cent. of the fuel required to drive a train can be saved, giving actual experimental figures to prove it. Such data were evidently obtained upon a level line, and we all know that the resistance on a level is but a very small part of that to be encountered upon a railway. The wheel friction, for instance, is $4\frac{1}{2}$ to 5 pounds per ton, while that from gravity on a grade of $5\frac{1}{8}$ feet per mile is 20 pounds per ton; and there is in addition the resistance from curves and from the atmosphere—the latter at high velocities sometimes forming an important fraction of the whole. For journal bearings, however, for cranes, and possibly for drawbridges, this idea of supporting a weight upon a thin film of water, issuing at a great pressure, may be worth experimenting with.

THE SIBERIAN RAILWAY.

One of the great railways of the world, which is eventually to be over 5,000 miles long, is now under construction by the Russian Government across Eastern and Western Siberia. For the present it is to consist of two isolated sections of railway connecting the navigable waters of rivers in the interior. Beginning at the Pacific end, at Vladivostok on the Japan Sea, the first section is to extend 261 miles to the navigable waters of the Amour; there to connect with 1,590 miles of steamboat navigation. Thence begins another railroad section of 1,895 miles more, which again connects with 1,870 miles of steamboat navigation and thereby with existing railways extending some 1,600 miles further to St. Petersburg. Altogether there are 2,156 miles of railroad to be built now, at an estimated cost of \$103,000,000; and the work is expected to be completed in six years. Russia has now about 20,000 miles of railway for some 92,000,000 inhabitants. If it is about to enter upon increased activity in railroad construction, there may be an opportunity for the employment of the rapid and cheap American methods and tools in this as well as in other portions of the world.

THE RAILWAYS OF THE WORLD.

It may be interesting in this connection to inquire as to the relative railroad status of various continents, and having lately had occasion, for another address, to compile and estimate the number of miles of railway in the world on the 1st of January, 1891, the result is herewith graphically exhibited by a diagram. On this

diagram the length of the lines represents the aggregate number of miles on each continent, and the thickness represents the ratio of the number of miles of railroad for each 10,000 inhabitants. The actual figures are as follows:

North America is estimated to possess 187,425 miles, or 21.54 miles per 10,000 inhabitants. South America to have 16,000 miles, or 5 miles per 10,000 inhabitants; while Europe has 141,000 miles, being at the rate of 4.06 per 10,000. Asia having 20,000 miles, or only a ratio of $\frac{1}{5}$ mile per 10,000. Africa, with 6,000 miles of railroad, averaging $\frac{3}{10}$ of a mile per 10,000 inhabitants, and Australia, ranking nearly with Europe and South America, with 13,000 miles of railroad, and a ratio of $\frac{3}{42}$ miles per 10,000 inhabitants. Asia, therefore, and more particularly China, seems to present a field for railroad missionary work, for it cannot fail eventually

to ascertain how great a national economy will follow upon the substitution of railroad for other methods of land transportation.

There was occasion, in connection with the schedule of the world's railways already referred to, to estimate this national economy for the United States, and it was found that if we assume that there was a real necessity for the whole volume of the exchange of commodities and movements of passengers (which volume, of course, could not exist at the higher charges), the business done by our railroads in 1889, at the rates of freight and passengers which existed before the railway era, would have cost the nation not less than \$12,239,899,980, while the charges actually collected were \$992,856,856, thus leaving a difference, or national saving on that basis, of \$11,247,043,124, or more than the entire capital invested in our railroads, which, as represented by their stocks and liabilities, amounted to \$9,931,453,146.

The average cost of railroads in the United States stands at about \$60,000 per mile, while in Europe they are capitalized at about \$120,000 per mile, the difference being largely the result of the cheaper methods and designs which original scarcity of capital and labor have led our engineers to develop. The Americans are now the great railroad builders of the world, they execute such undertakings with less expenditures, as measured either in money or in day's work, than other nations, and it seems not impossible that firms of American engineers and contractors shall find it profitable to employ these methods in other countries, let the capital, the labor, or the materials come from whence they may.

(To be continued.)

THE ELECTROLYTIC PREPARATION OF CHLORATE OF POTASSIUM.

FOR the past ten months the manufacture of chlorate of potassium by the Gall-Montlaur electrolytic process has been successfully carried out at Vallorbes. The daily output now amounts to one ton of refined chlorate. According to *La Lumière Electrique*, M. Lunge states that one H. P. a day = one kilogramme of potassic chlorate, hence a daily production of one ton requires 1,000 H. P. The process is based on the transformation of a 25 per cent. solution of chloride of potassium (KCl) at a temperature of from 45° C. to 55° C., into chlorate (KClO₃) by the action of the chlorine and potassium liberated by electrolysis. The chlorate is precipitated, collected, washed, dried and purified. One of the preliminary difficulties was the selection of suitable connections for the electrodes, since the slightest trace of certain metallic oxides in the solution arrests the process. The vats are 270 in number (half being in use at one time), rectangular in shape, and arranged so as to permit of the rapid handling of the volume of liquid, amounting to 11,000 gallons per diem. A porous diaphragm separates the cathodes from the anodes, the former being of iron and the latter of platinum (four mils. thick). The solution is kept at the proper temperature by the current itself. Power is obtained from the falls of the Orbe, which can supply 2,500 H. P. At present there are installed at the generating station ten 150 H. P. Riether turbines, and 105-kilowatt Thury dynamos. The generating plant is at the foot of a mountain, the works themselves being 330 feet and the reservoir 230 feet above the station. This arrangement has the twofold advantage of obtaining a great head of water and of removing the machinery out of reach of the fumes given off in the process. The hydrogen liberated at the cathode amounts to 3,530 cubic feet per ton of chlorate turned out, and as this large volume of gas escapes into the air, carrying with it a certain amount of chloride of potassium, the vicinity of the works is covered with a thick, white saline deposit of a highly erosive character. With ample water power available, the electrolytic process can undersell the chemical process, although at present only 400 tons per annum is being produced by it, as against 8,000 tons by the older method. Some 5,000 tons of this total is produced by the works of the Chemical Union. The electrolytic process is cleaner, simpler, quicker, leaves no residue, and needs no coal for mere heating purposes.

POCKET ELECTROMETERS.

By C. V. BOYS, F.R.S.

As quartz fibers increase the delicacy and diminish the disturbing influences affecting instruments, much smaller controlling forces can be employed than when

FIG. 1.—Cylindrical "needle," with four insulated sections, containing a dry pile.

FIG. 2.—Cross shaped "needle," consisting of a strip of platinum and a strip of zinc, charged by its own contact difference.

FIG. 3.—Disc shaped "needle," with alternate quadrants of zinc and platinum, one of the enclosing quadrants being removed.

silk is used for suspensions. The author had, he said, pointed out some time ago the great advantages arising from making galvanometers small. Applying similar reasoning to electrometers, he remarked that making an instrument one-tenth the size of an existing one reduced the moment of inertia of the needle to $\frac{1}{1000}$, while the deflecting couple for given potentials would only be $\frac{1}{10}$ of its former value. The small instrument would, for the same periodic time, be 10,000 times more sensitive than the large one, provided the disturbing influences could be reduced in the same proportion.

This, however, was not ordinarily possible, for any method of making contact with the needle such as by a fine wire dipping into acid or mercury prevented very small controlling forces being used. Still, by suitable devices, a large proportion of the full advantage could be obtained. A freely suspended needle without liquid contacts was essential to success. The first instrument described was one in which the needle was cylindrical (Fig. 1), contiguous quarters being insulated and connected to the opposite ends of a minute dry pile placed within the needle; opposite quarters were then at the same potential, and at a different potential to the other pair of quarter cylinders. This was suspended within a glass tube silvered on the inside and divided into four parts by fine longitudinal lines. In such an instrument the needle and quadrants are reciprocal, and the deflection depends on the product of the difference of potential between the quadrants and that between the parts of the needle. Owing to the dry pile not being constant, the instrument was found unreliable, but when working at its best, a Grove cell would give 30 or 40 millimeters deflection. The next step was to make a cross shaped needle of zinc and platinum (Fig. 2), and rely on contact electricity to keep the parts of the needle at different potentials. This bold experiment proved remarkably successful, for the instrument was very sensitive. A disk-shaped needle, with quadrants alternately zinc and platinum, was then employed, and by this a small fraction of a volt could be measured. The weight of the disk was only $\frac{1}{10}$ of a gramme, and the instrument could be turned upside down or carried about in the pocket with impunity. Another small instrument with the quadrants of zinc and copper (Fig. 3) was exhibited, and by rotating them through an angle of 90 deg., so as to bring them in a different position relative to the parts of the needle, a deflection of several degrees of arc was produced. Mr. Boys made several suggestions relating to ballistic electrometers and electrostatic Siemens dynamometers, and pointed out the possibility of instruments such as he had exhibited being of use in elucidating the obscure points in connection with so-called "contact electricity."—*The Electrician*.

THE EDISON PATENT DECISION.

IN July, at New York, Judge Wallace filed his opinion in the United States Circuit Court in the patent suit of the Edison Electric Light Company against the United States Electric Lighting Company, owned by the Westinghouse Company. The argument was made before him a month ago on the Edison patent No. 223,898 for an incandescent electric lamp, and took eight days. The printed testimony fills seven volumes, or about 6,000 pages. The taking of the testimony had kept the lawyers on both sides busy almost continuously for two years and the printed briefs of the arguments of counsel on both sides are eight in number, covering about 1,000 printed pages. Judge Wallace's opinion fills 23 pages of typewritten legal cap, and sweepingly sustains the patent, a decree of injunction and accounting being ordered.

Edison's invention was made in 1879, and his patent was granted in 1880. The suit was begun in 1885, the subject in controversy being two claims of the letters patent No. 223,898, "for an improvement in electric lamps." These two claims were as follows:

1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described, and secured to metallic wires, as set forth.

2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted for the purposes set forth.

Judge Wallace decides that the defendant does not infringe the first claim, because the leading wires in its lamps are not secured to the filament according to the method of the patent, but, on the second claim, judgment is given for the plaintiff, that being in reality the essential feature of the invention claimed by the Edison Company.

The following is the most important part of the decision:

The second claim is broad enough in its phraseology to secure the real invention described in the specification, and can be read consistently with its language so as to import into it every essential limitation.

It was a remarkable discovery that an attenuated thread of carbon would possess all the long sought qualities of a practical burner when maintained in a perfect vacuum. The extreme fragility of such a structure was calculated to discourage experimentation with it, and it does not detract in the least from the originality of the conception that previous patents had suggested that thin plates or pencils or small bridges could be used. The futility of hoping to maintain a burner in vacuo with any permanency had discouraged prior inventors, and Mr. Edison is entitled to the credit of obviating the mechanical difficulties which disheartened them, but what he did in this respect was a matter of only secondary merit, and was no longer new in the art, because he had already disclosed it in his French and English patents.

What he actually accomplished was to unite the characteristics of high resistance, small radiating surface and durability in a carbon conductor by making it in a form of extreme tenuity, out of any such materials as are mentioned in the specification, carbonizing it, and arranging it as he had previously arranged his platinum burner in an exhausted bulb made wholly of glass and sealed at all points, including those where the leading wires entered, by the fusion of the glass. He was the first to make a carbon of materials and by a process which was especially designed to impart high specific resistance to it, the first to make a carbon in the special form for the special purpose of imparting to it high total resistance, and the first to combine such a burner with the necessary adjuncts of lamp construction to prevent its disintegration and give it sufficiently long life. By doing these things he made a lamp which was practically operative and successful, the embryo of the best lamps now in commercial use, and but for which the subdivision of the electric light by incandescence would still be nothing but the ignis fatuus which it was proclaimed to be in 1879 by some of the learned experts who are now witnesses to belittle his achievement and show that it did not rise to the dignity of an invention.