interesting it might be, but we may look at the types and trace the line of thought of the designers, and see what success has been attained.

Looking first at the old and still-used vertical hinged valve, we see at once that its weight hangs on the pivot, and has little effect in completing its closing. Obviously the way to improve it was to place the seat on a slope or make it entirely level, and this was done. But at best, a hinged valve can open at only one side and half open at its two ends. For instance a 4-in. square hinged valve would require a 2-in. lift to be fully open, but if (Fig. 1) opened equally all round (Fig. 2) only 1-in. would be required. If therefore a larger valve area be required without increase of lift, the only course is to increase the number of valves.

Circular and other valves having a parallel lift, obviously have four times the area of hinged valves of equal lifts, but in simple or single beat valves, the limit of area is also very soon reached.

To increase the effective, or discharging capacity of the parallel lift valve, without increasing its lift, an opening was made in its centre (Fig. 4), and it then became the annular valve with two beats on the same plane. A great improvement on this was the raising of the inner beat to a higher level, making the well-known Harvey & West's double beat valve, which not only secured, larger area, without increase of lift, but allowed of the reducing of the difference in the relative areas of the beats, and thus also of the weight or pressure of the valve on its beats. Carrying on the same principle, a step further produced the beat valve three and four, (Figs. 6 and 7). An example of the latter may be found at the Montreal Water-Works.

Pursuing in the same manner the line of thought which produced the simple annular valve and the grated flap-valve, brings us to a multiplicity of rings connected together and acting as one valve—an arrangement which obviously allows of the choosing of such size of opening and lift as the case requires, and then attaining the requisite area by merely multiplying the rings. Figs. 8 and 9 show examples in use at the Hamilton Water-Works designed by the author.

In all these examples the increase of valve area has been obtained by increasing the dimensions of the valve, but another method is to merely multiply the number of separate valves (Figs 10 and 12.) In order to pack the numerous valves into as small a space as possible—or rather into as small a diameter of pump barrel or chamber as possible—they have been arranged in superimposed rings and groups of many shapes.

(To be continued.)

THE ELECTRICAL TRANSMISSION AND STORAGE OF POWER.

BY DR. C. W. SIEMENS, F.R.S., M. INST. C.E.

The following is an abstract of a lecture delivered under the auspices of the Institution of Civil Engineers (London) on March the 15th:

Dr. Siemens, in opening the discourse, adverted to the object the Council had in view in organizing these occasional lectures, which were not to be lectures on general topics, but the outcome of such special study and practical experience as Members of the Institution had exceptional opportunities of acquiring in the course of their professional occupation. The subject to be dealt with during the present session was that of Electricity. Already Telegraphy had been brought forward by Mr. W. H. Preece, and Telephonic communication by Sir Frederick Bramwell.

Thus far Electricity had been introduced as the swift and subtle agency by which signals were produced either by mechanical means or by the human voice, and flashed almost instantaneously to distances which are limited, with regard to the former, by restrictions imposed ' the Globe. To Dr. Siemens has been assigned the task of introducing to their notice electric energy in a different aspect. Although still giving evidence of swiftness and precision, the effects he should dwell upon were no longer such as could be perceived only through the most delicate instruments human ingenuity could contrive, but were capable of rivalling the Steam Engine, compressed air, and the hydraulic accumulator, in the accomplishment of actual work.

In the early attempts at magneto-electric machines, it was shown that, so long as their effect depended upon the oxidation of zinc in a battery, no commercially useful results could have been anticipated. The thermo-battery, the discovery of Seebeck in 1822, was alluded to as a means of converting heat into electric energy in the most direct manner; but this conversion could not be an entire one, because the second law of thermodynamics, which prevented the realization as mechanical force of more than $\frac{1}{7}$th part of the heat energy produced in combustion under the boiler, applied equally to the thermo-electric battery, in which the heat, conducted from the hot points of juncture to the cold, constituted a formidable loss. The electromotive force of each thermo-electric element did not exceed 0.036 of a Volt, and 1,800 elements were therefore necessary to work an incandescent-lamp.

A most useful application of the thermo-electric battery for measuring radiant heat, the thermo-pile, was exhibited. By means of an ingenious modification of the Electrical Pyrometer, named the Bolometer, valuable researches in measuring solar radiations had been made by Professor Langley.

Faraday's great discovery of magneto-induction was next noticed, and the original instrument by which he had elicited the first electric spark before the members of the Royal Institution in 1831, was shown in operation. It was proved that although the individual current produced by magneto-induction was exceedingly small and momentary in action, it was capable of unlimited multiplication by mechanical arrangements of a simple kind, and that by such multiplication the powerful effects of the dynamo-machine of the present day were built up. One of the means for accomplishing such multiplication was the Siemens armature of 1856. Another step of importance was that involved in the Pacinotti ring, known in its practical application as the machine of Gramme. A third step, that of the self-exciting principle, was first communicated by Dr. Werner Siemens to the Berlin Academy, on the 17th January, 1867, and by the lecturer to the Royal Society on the 4th of the following month. This was read on the 14th of February, when the late Sir Charles Wheatstone also brought forward a Paper embodying the same principle. The lecturer's machine which was then exhibited, and which might be looked upon as the first of its kind, was shown in operation; it had done useful work for many years as a means of exciting steel magnets. A suggestion, contained in Sir Charles Wheatstone's Paper, that "a very remarkable increase of all the effects, accompanied by a diminution in the resistance of the machine, is observed when a cross wire is placed so as to divert a great portion of the current from the electro-magnet," and led the lecturer ' an investigation read before the Royal Society on the 4th of March, 1880, in which it was shown that by augmenting the resistance upon the electro-magnets 100-fold, valuable effects could be realized, as illustrated graphically by means of a diagram. The most important of these results consisted in this, that the electromotive force produced in a "shunt-wound machine," as it was called, increased with the external resistance whereby the great fluctuations formerly inseparable from electric-arc lighting could be obviated, and that, by the double means of exciting the electro-magnets, still greater uniformity of current was attainable.

The conditions upon which the working of a well conceived dynamo-machine must depend were next alluded to, and it was demonstrated that when losses by unnecessary wire-resistance, by Foucault-currents and by induced currents in the rotating armature were avoided, as much as 90 per cent, or even more, of the power communicated to the machine were realized in the form of electric energy, and that *vice versâ* the reconversion of electric into mechanical energy could be accomplished with similarly small loss. Thus, by means of two machines at a moderate distance apart, nearly 80 per cent. of the power imparted to the one machine could be again yielded in the