large units of gas or kerosene lamps have been used, and consequently it was not possible to produce the thorough diffusion of light which will be attained at the Pan-American Exposition by the use of well distributed small units. Instead of a few intense points of light, there will be myriads of these small but nevertheless powerful incandescent lamps outlining the towers, pavilions, caves, and other exposed points of the principal buildings surrounding the Court of Fountains. Upon and about the Electric Tower the lights will be, of course, most brilliant and glorious, while the basin in front of the Tower, the cascade falling into it from a height of 70 feet, and the basin of the Court of Fountains, with its fountains and cascades, as well as the Plaza and Esplanade and buildings surrounding, will be grandly illuminated with these same incandescent lamps used in a way to intensify the charm of the whole magnificent scheme.

The wiring of the Machinery and Transportation Building for the illumination has been completed. That of several other buildings is nearly so.

When the lights were turned on the Machinery building a few nights ago, the effect was awaited with much anxiety and expectancy. The result was all that could have been desired; indeed, it surpasses expectations, for the charm of this kind of illumination I am sure has never been brought out in such a way before.

The Machinery building is 500 feet long, and it is nearly 200 feet to the topmost points of the splendid towers surmounting it, which remind one so strongly of a campanile of some ancient Mexican cathedral. With rows of lights outlining all the architectural features of this great structure and bringing out the beauty of its colors, which can be seen to even greater advantage than under the light of the mid-day sun, the effect is charming beyond the power of any words one can think of for purposes of description.

Bear in mind that this is but one of a large number of buildings which will be thus illuminated next summer, and that the Electric Tower will be the most glorious spectacle of all, rising as it will to a height of 391 feet, and bearing upon its summit a statue of the Goddess of Light to crown the whole wonderful scene.

To give variety and novelty to the illuminations and increase the fairy-like effect at night, floating lights will be used in the fountain basins. In the basin in front of the Electric Tower there will be not only floating incandescent lamps, but also an illumination of most striking and fanciful character to be achieved by placing beneath the water of the basin 94 large-sized search lights, casting colored lights on the water effects, and also bringing out the fact that these colors are so arranged as to be constantly changing. This combination of electrical and hydraulic effects and introduction of ingenious devices for increasing the marvels of the scene will secure results such as are attained by experts in the production of spectacular scenes on the stage. But there will be this important difference that instead of being confined to a space like the stage of a theater, 50 feet wide, we will say, and possibly 100 feet in depth, the space thus illuminated will be about 2,000 feet in length by nearly 700 in width, while some of the scintillating lights will reach an altitude of nearly 400 feet in their ambition to outrival in beauty the twinkling stars of the firmament overhead.

The fountain display will call for the use of 35,000 gallons of water per minute, and the number of incandescent lamps used in producing the illumination in and about the Court of Fountains, Plaza, and Esplanade will be over 200,000. This does not include the arc lamps used in the buildings and at some points on the grounds, nor the many incandescent lamps used by concessionaires on the Midway and by private exhibitors.

One of the Midway concessions, the Thompson Aerio-Cycle, will alone use 2,000 incandescent lamps. Other Midway features will be profusely lighted, which will considerably increase the total number of lights used in the illumination of the buildings and grounds as a whole.

About 400 miles of wire will be used in the insulation of the lamps for the illumination in and around the Court of Fountains, which expressed in another fashion means about 250 tons of insulated copper wire of all sizes.

The electric energy for the production of this vast illumination will be obtained partly from Niagara Falls. From the harnessed Niagara 5,000 horse power will be furnished for Exposition uses, and about 5,000 more horse power will be generated on the grounds for the turning of the wheels and the lighting of the myriads of lamps. The service already arranged for contemplates the use of gasoline for motive power, of gas both under boilers, producing steam, and in gas engines, producing energy as well as the utilization of the water power of Niagara. Thus it can be seen that the Pan-American Exposition enjoys the advantage of a greater number of resources of power than has been possessed by any exposition of the past.

THE TELEGRAPHONE—A MAGNETIC SPEECH RECORDER.

By VALDEMAR POULSEN.

FOLLOWING is a description of the principles and the arrangement of my invention which I have called the telegraphone. A steel wire (piano wire), *AB*, about 1.5 m. (5 feet) long and 0.5 mm. (one-fiftieth inch) in diameter is stretched on a board, Fig. 1. Along it can slide the electromagnet, *E*, which embraces it with one of the poles, Fig. 2. The core of the electromagnet is a piece of soft iron wire about 8 mm. (one-third inch) long and 0.75 mm. (three one-hundredths inch) in diameter, and the electromagnet itself is in series with a battery and a microphone, or is connected to a transformer in the microphone circuit. At the beginning of an experiment the wire should be completely unmagnetized.

If, while the electromagnet is sliding along the wire with a velocity of about 1 m. per second, the microphone is spoken into, the current fluctuations produced register themselves by means of the electromagnet on the steel wire. If now the electromagnet is connected up with a telephone and made to travel over the wire again, the telephone repeats what was spoken into the microphone. Thus, owing to the great coercive strength of steel, there has been impressed on the wire in undulations, so to speak, of magnetization, a kind of writing which is permanent, and faithfully records the articulations of the voice. When *E* is put, now, in direct connection with a moderately strong battery and is made to pass once more over the wire the magnetic writing is obliterated under the influence of the constant magnetizing force, which is great compared with the intensity of the writing magnetic forces.

The wire, *AB*, is too short to contain many words. In order to obtain a larger capacity a very long piano wire is wound very firmly round a drum having a fine spiral groove on its surface, and the piano wire follows this spiral groove. Parallel with the axis of

FIG. 1.

the drum there is a rod upon which a kind of sleeve can slide. The electromagnet is fastened to this sleeve. When the apparatus is in operation, the electromagnet embraces with one of its poles, or with both, the steel wire, Fig. 3, and during the rotation this steel wire itself pushes the electromagnet and the sleeve along the rod. It is very easy to handle a drum of this kind, and the whole arrangement is very convenient for experiments. Of course, it must be borne in mind that in the various telephonic and telegraphic applications of the telegraphonic principle there are certain conditions which must be fulfilled. The nature, dimensions, and cost of the writing basis, and the velocity, the construction of the electromagnet and the magnitude of the current must all be considered. Without going into details here I only beg to direct the attention upon some essential points concerning the three proceedings, viz., the inscription, the reproduction, and the obliteration.

Most frequently the inscription is effected by means of a polarized electromagnet, but the polarization and the degree of the polarization must not be arbitrary. Let, for instance, the electromagnet, by means or which the writing is to be performed obliterate a prior mag-

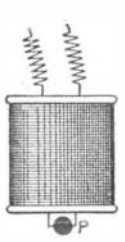

FIG. 2.

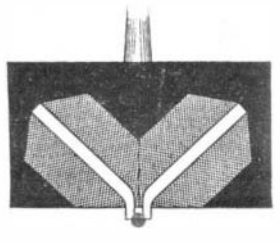

FIG. 3.

netic record and also simultaneously magnetize the writing basis. Then during the inscription the electromagnet is given the polarization opposed to that which it had during the obliteration. In this way a lively movement of the molecular magnets is obtained at the very moment of forming the writing. The susceptibility seems to increase very much in that magnetic status nascendi, and every shade of the writing becomes extremely perceptible. Ordinarily the polarization of the writing magnet is only a very small fraction of that of the obliterating one. The nearer its polarization approaches to the neutralization of that of the writing basis, however, the feebler may be, of course, the polarization of the obliterating magnet. The coercive force determines the degree of polarization which exactly neutralizes the magnetization of the writing basis. It is found that the writing is somewhat weak when the polarization of the electromagnet during the proces of inscription is just equal to that used in the preceding obliteration. In order to polarize the electromagnet a constant current or a permanent magnet may be used.

If the positive and negative curves of an alternating

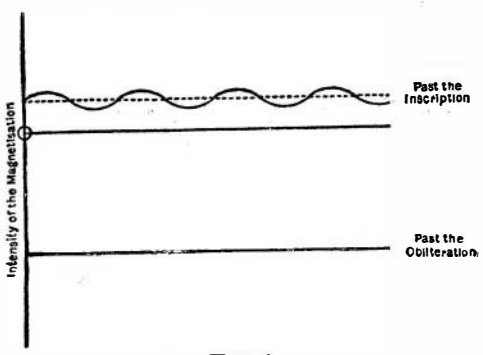

FIG. 4.

current differ, their faculty of producing the writing may equally differ. This explains the peculiarity that the direction of the primary current with a certain polarization of the writing basis may sometimes influence the writing which, in the secondary circuit, is performed by an unpolarized electromagnet. This is owing to the lack of uniformity in the manner in which the resistance of the microphone is increasing and diminishing. The inequality here spoken of is perhaps the more considerable the more the mobility of the carbon granules is considerable.

It seems that a speech (or a song) inscribed on the wire may be reproduced indefinitely without any perceptible diminution in clearness, the tone of the voice remaining perfectly distinct. Even when the apparatus is as primitive as that of Fig. 1, the reproduced voice is distinguished by the highest clearness and purity, and free from disturbing accompanying noises. The telegraphones of more recent date are able to reproduce with the greatest exactitude not only words spoken or sung into the microphone, but also whispers and even the feeble sounds of respiration.

The writing is completely obliterated by passage through a magnetic field of sufficient strength. Ordinarily it is sufficient to let the writing basis pass the writing magnet or another small electromagnet energized by a current from two or three cells. If a speech, however, be inscribed by means of an unpolarized magnet on a writing basis already written upon there results, as a rule, not an obliteration, but an interference.

Besides common piano wires, steel ribbons and nickel wires have been used as writing bases. The dimensions of the steel ribbons were 3 mm. by 0.105 mm. (one-ninth inch by one-fiftieth inch). The steel ribbon passes from a roll to a second receiving roll, where the layers of the ribbon may cover each other without the writing being destroyed. As to this last point, it has been proved by experience that the magnetism does traverse the ribbon, though as a rule, there is sufficient air space between consecutive layers to afford nearly complete protection. With a speed of about 1 m. (3 feet) per second, 0.154 liter (one-fiftieth cubic foot) of steel is needed for a speech lasting an hour. Instead of ribbon, a fine piano wire unrolling from one place to another may be used. In some cases nickel may with perfectly good effect be used as a writing basis, which fact is in accordance with the known properties of this metal as regards permanence for weak magnetizations, and demonstrated by A. Abt. The great dependence on mechanical influences which is characteristic of the magnetic state of nickel demands, however, careful handling of the nickel wire. It is not likely that the common steel used hitherto is exactly the most suitable for telegraphonic purposes; most probably other and better kinds are to be found.

I have no intention of speaking of all the various specifically phonographic applications of the telegraphonic principle nor of the constructive differences in connection with such applications. Nevertheless, I think that the following arrangement ought to be sketched: a long steel ribbon is stretched between two rolls which can rotate at a rather considerable speed. The ribbon passes a series of electromagnets of a speed regulated according to the circumstances. The electromagnet, *E*, inscribes words, music, etc.; the other electromagnets—"the reading magnets"—reproduce the communications in the telephone of each hearer; and, finally, the obliterating magnet, *V*, equalizes the mag-

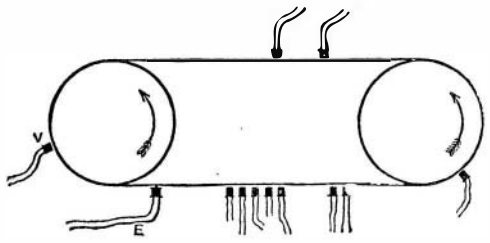

FIG. 5.

netic variations of the ribbon ("telephonic newspaper," Fig. 5). As using does not weaken the writing, we are able to intercalate any number of reading magnets.

Again, it is possible to use the telegraphone to increase the telephonic current (telephonic relay). The engineer, E. S. Hagemann, has proposed an arrangement which, theoretically at least, is very simple, and which I here describe. A drum is provided with a series of circular steel rings having their centers in the axis of the drum, their planes perpendicular to the axis. As the drum rotates, whatever is spoken into the microphone is inscribed on the first ring by means of a writing magnet. By means of a series of reading magnets placed on the first ring, the words are transmitted to the other rings, which synchronically carry their equally formed writings past their reading magnets, duly connected together, and afterward past obliterating magnets (Fig. 6).

An elegant method of compensation has been invented by the engineer, P. O. Pedersen, and allows several speeches to be intermingled, so that they can afterward be reproduced separately. As it is not feasible to describe this method satisfactorily in a few words, I shall not speak further of it here. Later,

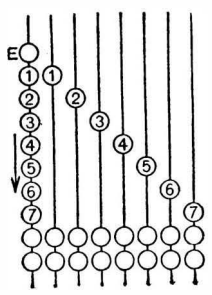

FIG. 6.

perhaps, Mr. Pedersen himself will make a communication about it.

In my endeavors to develop the telegraphone I have received the greatest assistance—first from Mr. P. O. Pedersen, and also from Mr. E. S. Hagemann. I owe them both my best thanks. I have, besides, to thank the Institution and experts abroad, as well as those of my own country, for the interest they have shown in the telegraphone. We are indebted to The London Electrician for the engravings and the description above.

THE Times states that the construction of the vessel designed by Mr. W. E. Smith, one of the chief constructors to the Admiralty, for the National Antarctic Expedition, is now in active progress at the yard of the Dundee Shipbuilders' Company. The ship, which is to be named the "Discovery," is to be barque-rigged and to have three decks. Accommodation for those