P. O. PEDERSEN & V. POULSEN.

ELECTROMAGNET FOR TELEGRAPHONES.

APPLICATION FILED APR. 9, 1902.

900,304. Patented Oct. 6, 1908.

Fig. 1.

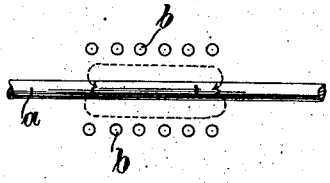


Fig. 2.

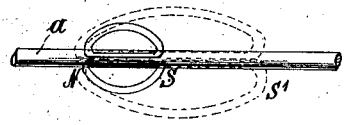


Fig. 3.

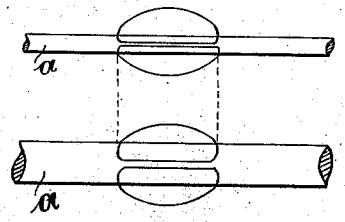


Fig. 4.

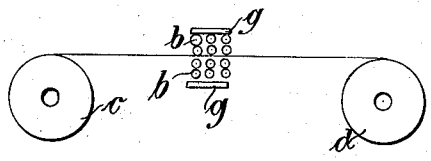


Fig. 5.

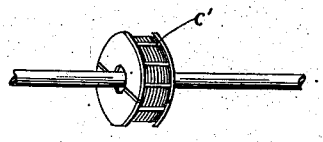
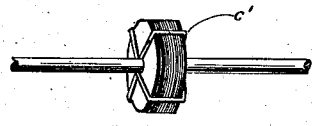


Fig. 6.



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UNITED STATES PATENT OFFICE.

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ELECTROMAGNET FOR TELEGRAPHONES.

No. 900,304. Specification of Letters Patent. Patented Oct. 6, 1908.

Application filed April 9, 1902. Serial No. 101,994.

To all whom it may concern:

Be it known that we, PEDER OLUF PEDERSEN and VALDEMAR POULSEN, subjects of the King of Denmark, residing at Vestervoldgade 2, Copenhagen, Denmark, have invented certain new and useful Improvements in Electromagnets for Telegraphones, of which the following is a specification.

Our invention relates to an apparatus for magnetically recording and reproducing sound, and ordinarily known as the telegraphone. The usual construction for this purpose makes use of a steel or similar record medium, which is moved in proximity to an electromagnet in a telephone or similar circuit. The iron core of the electromagnet is maintained either in direct contact with the record medium, or in very intimate proximity thereto during the movement or passage of said medium. So far as we are aware, an electromagnet having an iron core has always been found necessary in this class of apparatus.

The present invention comprehends the use of an electromagnet in the form of a solenoid, through the axis of which the steel body in the form of a wire, moves.

The invention is illustrated in the accompanying drawing, in which,

Figure 1 is a conventional sectional view of a solenoid and recording medium. Fig. 2 illustrates the path of lines of force under two different conditions. Fig. 3 illustrates the lines of force emanating from thin and thick recording mediums. Fig. 4 illustrates the relative arrangement of a solenoid, recording medium and storing reels for the latter; and Figs. 5 and 6 illustrate two forms of iron mantles for the solenoids.

Attempts to use a simple solenoid or wire helix without any iron core, in place of an electromagnet of the above character, have not hitherto proved successful in practice for the following reason: A solenoid in a medium of uniform magnetic permeability, such as air, produces lines of force extending in continuous curved paths through the helix in one direction and around the outside thereof in the other direction. But, as soon as a body of high permeability, such as iron or steel, is introduced into the solenoid, such body becomes strongly magnetized and develops north and south poles at its respective ends. In other words, when the core of the solenoid is straight like an iron bar, it necessarily develops a north pole at one end and a south pole at the other end, when magnetized. But lines of force always start from every north pole and flow as directly as possible toward the south pole. This condition is illustrated in Fig. 1 of the drawings, where the path of the lines outside of the core is shown by the dotted lines. It is evident that these lines of force flowing from the north toward the south pole, as above described, coincide in direction with the magnetic field of the coil exterior of the latter, but oppose the direction of the magnetic field of the coil within such coil. The resultant field within the coil is therefore weaker or less effective than it would be if not partly neutralized in the above manner. The problem therefore consists in causing as large as possible a proportion of the lines of force flowing from the north to the south pole of the magnetized core to return outside the solenoid where they coincide in direction with the field of the latter rather than inside where they oppose its field.

Now, by thorough study and experiments, we have ascertained that a solenoid can be employed for telegraphone purposes, and means and ways can be found by which the lines of force are caused to move in the greatest possible number outside the solenoid. In other words, means have been found to prevent the lines of force from the free poles produced in the iron or steel body from opposing or neutralizing the lines of force within the solenoid due to its magneto-motive force. This being accomplished, it is evident that an iron or steel body within the solenoid can be strongly magnetized, and it becomes possible to use a solenoid for telegraphone purposes. This result is secured by three factors as follows:

1. The adjoining poles of the steel wire within the solenoid must lie as far as possible from one another. In other words, that portion of the wire which is magnetized by a given current pulsation in the solenoid must be comparatively long and slender. In this way, the lines of force describe a longer path, or return through the air in paths more distant from the body than otherwise. This result is clearly shown in Fig. 2 of the drawings, where the dotted lines represent the lines of force when the core is comparatively long, while the full lines indicate the lines of force when the core is short. The same re-

sult can, of course, be obtained by moving the wire or record medium through the solenoid at greater speed, it being evident that a greater speed of the record medium spaces the magnetic poles which may be developed therein further apart from one another.

2. The record medium must have as small a cross section as possible. The reduction of the diameter or cross section produces, relatively speaking, the same result as increasing the speed; that is to say, it causes the magnetized body within the solenoid to be as relatively long and slender as possible. The conditions, with a slender record medium and a thick record medium, are indicated at the upper and lower parts of Fig. 3, where it will be seen that the lines of force are more distant from the thin wire than from the thicker wire. It is also of importance that the turns of the solenoid be kept as close as possible to the wire or record medium, since the more closely the wires surround the record medium, the more nearly does the exterior field thereof coincide with the lines of force developed from the iron body or core. Moreover, the solenoid is more efficient in its magnetizing action, or magneto-motive force if it closely surrounds the core or body to be magnetized.

3. Finally, if a mantle of iron or material more permeable to the lines of force than air, is fixed upon the exterior of the solenoid, a larger number of lines of force will be conducted around the exterior of the coil. This result follows, since placing an iron mantle or the equivalent on the exterior of the solenoid, tends to approach the condition of a complete magnetic circuit of uniform permeability around and through the solenoid. The more this condition is approached, the less will there be any neutralizing or demagnetizing action within the solenoid, as above described. With a complete magnetic circuit of uniform permeability throughout, there would be no free poles formed at any point, and substantially no demagnetizing or neutralizing action within the solenoid whatever.

By a suitable combination of the above described three factors, very favorable results can be obtained with the use of solenoid coils. The essence of the present invention, therefore, consists in providing by suitable means for a sufficient number of magnetic lines of force passing through the solenoid coil, so as to insure the efficient magnetization of the record medium, and the audible storing up of the conversation to be recorded and reproduced.

In the several figures of the drawing, *a* indicates the record medium and *b* the solenoid winding.

For the record medium, a thin steel wire may be advantageously used, of the form shown in Fig. 4, which, on account of the small cross section, not only is of special advantage for the use of solenoid coil for the above described reasons, but is also very advantageous in that a thin steel wire can be wound from one roller *c* on to another *d*, and possesses a very high retentiveness. This is a matter of great importance when it comes to the application of the telegraphone principle for telephonic purposes.

The solenoid coil *b* of Fig. 4 likewise consists of very thin fine spun copper wire which is so wound that between the steel wire and the inner wall of the coil only a very small space remains. The coil must not be too thick so that a sufficient number of lines of force can pass outside around the coil. In order to conduct the lines of force as much as possible outwards, around the coil is arranged an iron mantle *c'*, (Figs. 5 and 6) which to avoid eddy currents is advantageously made in a number of parts. As shown in Fig. 5, the mantle may consist of single bars insulated from one another which can be connected by front plates. The arrangement shown in Fig. 6 in which wires running radially and connected at the ends are used can be employed to advantage. The choice of the mantle is limited to no definite form; it is only of importance that it fulfils its purpose of guiding the lines of force outwards.

As for the above-mentioned reasons the speed with which the record medium is moved plays a considerable part, it should be mentioned that the less the speed, the thinner must be the steel wire and the smaller the exterior diameter of the solenoid coil.

Instead of guiding the lines of force outwards by means of an iron mantle surrounding the coils, in certain cases pieces of iron and in other cases magnet bodies may be provided at a certain distance outside the coil, as at *g* Fig. 4, so that they assist to draw the lines of force outwards.

In every case, in order to secure practical results, care must be taken that sufficient lines of force pass without the solenoid coil.

What we claim, is:

1. In telegraphones, the combination of a record medium and a solenoid coil through which the medium passes, said coil being of such dimensions, speed, form and position that an effective number of lines of force take a path outside of the coil, substantially as described.

2. In a telegraphone, the combination of a record medium and a solenoid coil surrounding said medium and through which the medium moves, said coil being of such position, form and construction that lines of magnetic force issuing from the magnetized record medium find a path in an effective number outside of the coil, substantially as described.

3. In a telegraphone, the combination of a movable record medium, a solenoid coil and an iron mantle surrounding said coil for di-

recting an effective number of lines of force outside of the coil.

4. In a telegraphone, the combination of a record medium, a solenoid coil surrounding the same and having an iron mantle constructed in a plurality of sections, substantially as described.

5. In a telegraphone, the combination of a record medium, a solenoid coil surrounding the same and a body or bodies of magnetic material located outside of the solenoid coil, for the purpose set forth.

6. In a telegraphone, the combination of a record medium, a solenoid coil surrounding the same, and magnets located outside of the coil, for the purpose set forth.

7. In a telegraphone, a record medium comprising a steel wire of comparatively great length and small diameter, a pair of spools from one to the other of which said wire is wound and unwound, a solenoid coil surrounding said wire and of sufficiently small diameter to enable an effective number of magnetic lines of force emanating from the record medium to take a path outside of the coil.

8. In a telegraphone, the combination of a record medium, and a solenoid coil through which the medium passes, the speed of said medium being such that a comparatively great distance between adjoining north and south poles in the record medium is maintained during the recording and reproducing of the speech.

In testimony whereof we have hereunto set our hands in the presence of two witnesses.

PEDER OLUF PEDERSEN.
VALDEMAR POULSEN.

Witnesses:
JENS HERMAN CHRISTENSE,
J. C. JACOBSEN.