

No. 873,541.

PATENTED DEC. 10, 1907.

E. S. HAGEMANN.  
METHOD OF RECEIVING AND STRENGTHENING THE REPRODUCTION  
OF SPEECH, SIGNALS, &c.

APPLICATION FILED APR. 29, 1902. RENEWED MAY 2, 1907.

2 SHEETS—SHEET 1.

Fig. 1.

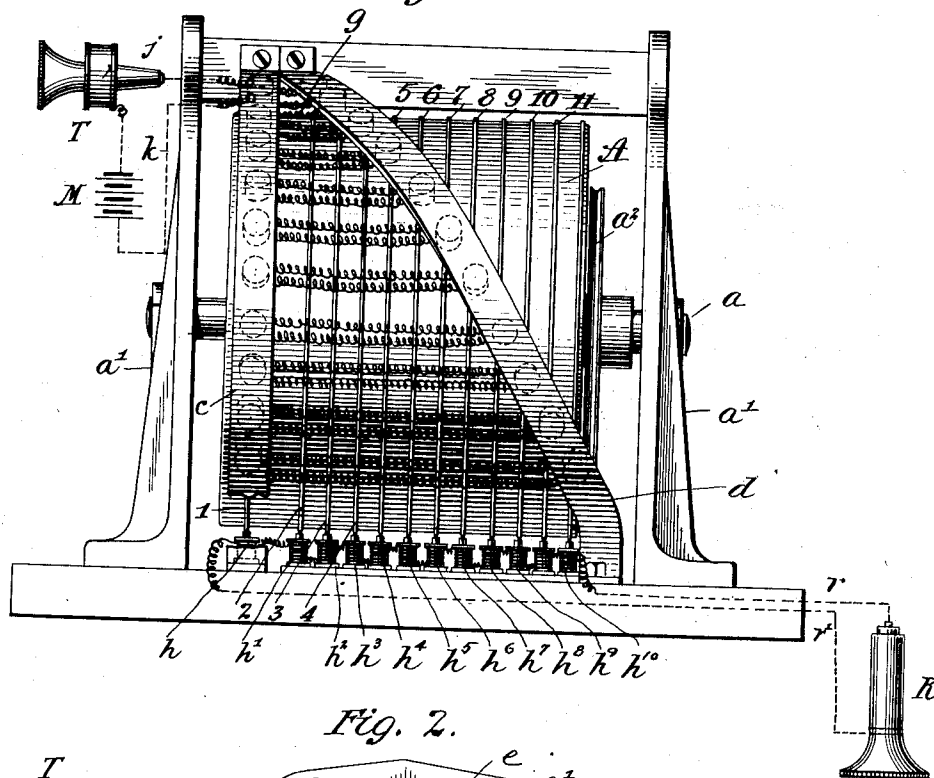
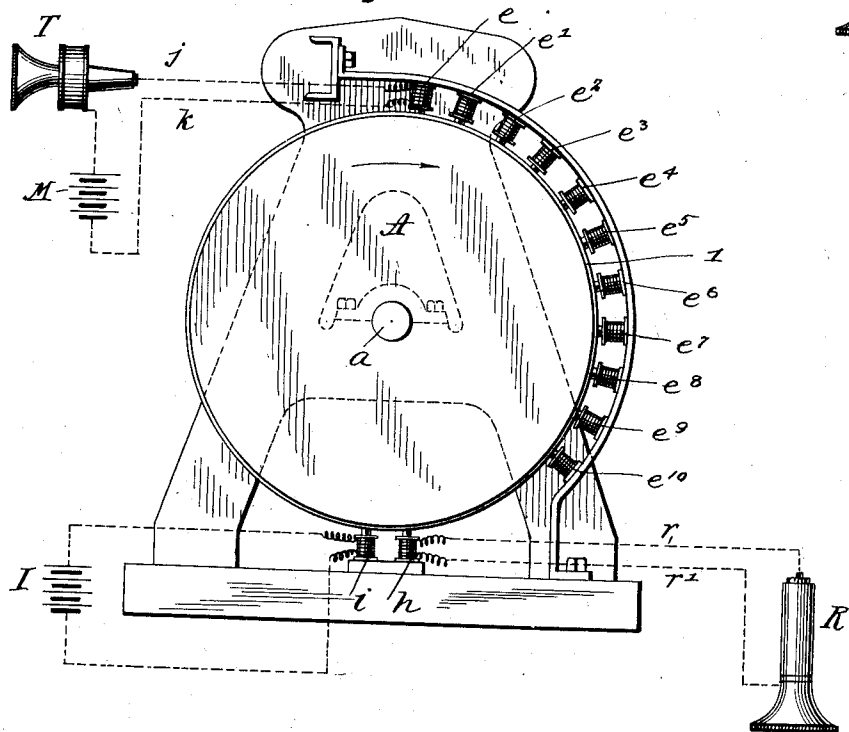


Fig. 2.



Witnesses  
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Fig. 7

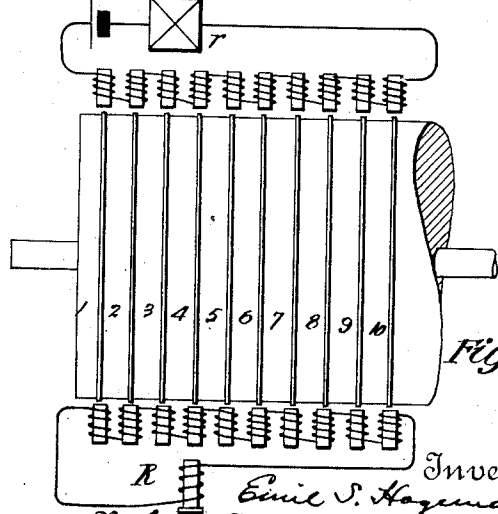
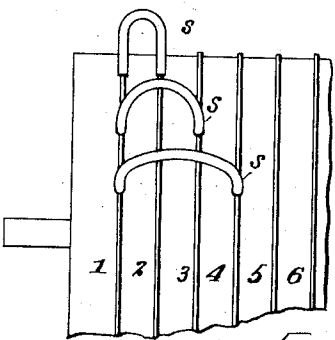
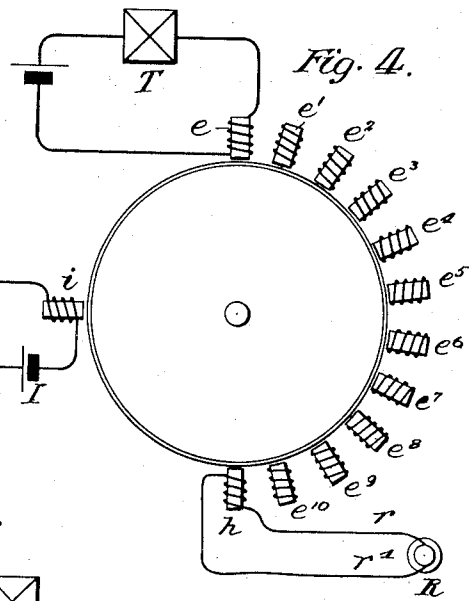
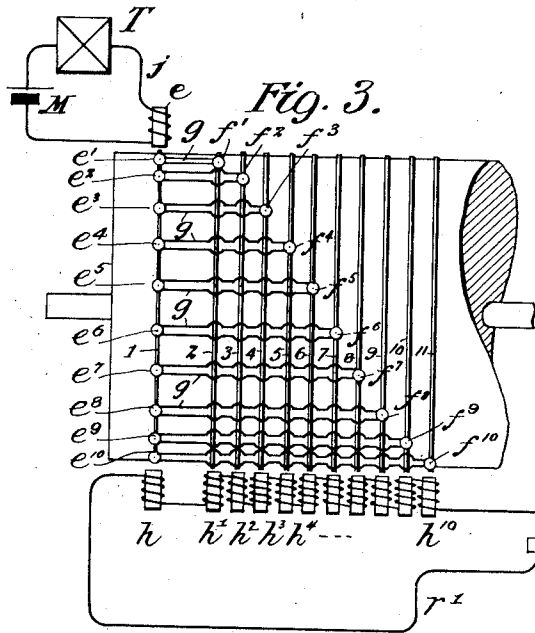
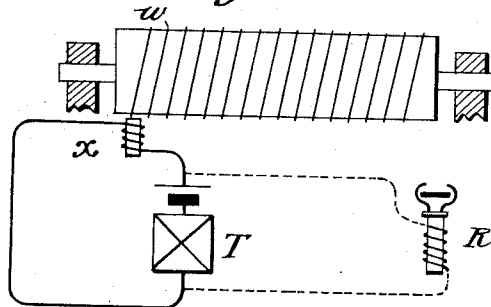


Fig. 5.  
Witnesses  
Frank J. Ober  
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Fig. 6.  
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# UNITED STATES PATENT OFFICE.

EMIL SCHACK HAGEMANN, OF COPENHAGEN, DENMARK.

## METHOD OF RECEIVING AND STRENGTHENING THE REPRODUCTION OF SPEECH, SIGNALS, &c.

No. 873,541.

Specification of Letters Patent.

Patented Dec. 10, 1907.

Original application filed June 19, 1900. Serial No. 20,816. Divided and this application filed April 29, 1902, Serial No. 105,249.

Renewed May 2, 1907. Serial No. 371,450.

*To all whom it may concern:*

Be it known that I, EMIL SCHACK HAGEMANN, a subject of the King of Denmark, residing at Copenhagen, in the Kingdom of Denmark, have invented certain new and useful Improvements in Methods of Receiving and Strengthening the Reproduction of Speech, Signals, and the Like, of which the following is a specification, being a divisional part of the application filed on the 19th of June, 1900, under the Serial No. 20,816.

This invention relates to a method of electro-magnetically recording speech or other signals, and reproducing the same, and has special reference to the principle disclosed in Letters Patent of the United States No. 661619, issued November 13, 1900, to V. Poulsen.

The object of the present invention is, primarily, to provide a method of amplifying or strengthening sounds or electrical impulses reproduced from the instrument and delivered to the receiving apparatus, to an extent more than can be done with the instrument as described in the said Poulsen patent. In accomplishing this, I produce a species of relay or repeater which may be used in transmitting telephonic and telegraphic messages over long distances.

The strength of the reproduced message in the receiving apparatus, largely depends upon the amount of resistance to the several electric circuits utilized in the recording and reproducing operations; for instance, a given record will be reproduced from the machine, more loudly or forcibly in the receiving apparatus over a short circuit than over a long circuit.

The present invention is therefore intended to amplify the sound or force of the reproduced speech or signal, with any given condition of resistance of circuits. In accomplishing this I record the message upon a plurality of different steel wires or bodies, and in reproducing, I joint or cumulate the effect in the circuit containing the receiving apparatus. The amount or extent of the amplification or increase in the reproduction is therefore theoretically limited only by the number of records made and simultaneously reproduced, and it is evident that for transmitting messages telephonically over long distances, unattainable in ordinary telephone practice, it is only necessary to insert at one or more

points in the circuit, an amplifying apparatus 55 of the character herein described.

My invention will be described with reference to the accompanying drawing, in which

Figure 1 is a side elevation of my improved relay apparatus; Fig. 2 is a diagrammatical 60 or conventional view, corresponding to Fig. 1. Fig. 3 is an end elevation thereof; Fig. 4 is a similar view corresponding to Fig. 2, and Figs. 5 and 6 show modifications of my invention. Fig. 7 is a diagrammatic view of 65 the ordinary Poulsen telegraphophone and circuits.

Referring to the drawing by letter, *a* indicates a cylinder or drum mounted on a shaft in bearings *a'* and fitted with a pulley *a*<sup>2</sup> 70 through which it may be rotated from any suitable source of power. On the surface of this cylinder, are applied a number of steel rings or bands, lettered respectively 1, 2, 3, 4, etc. Each of these is a completely closed 75 ring, so as to present a smooth endless surface. Facing ring 1 is an arc-shaped frame *c*, carrying on its inner face a series of electro-magnets respectively lettered *e*, *e'*, *e*<sup>2</sup>, *e*<sup>3</sup>, etc. The pole pieces of these magnets are presented to, and preferably rest in contact 80 with, the ring 1. *d* is another frame piece, extending diagonally around the face of the cylinder and properly secured above and below, to the main frame; this frame piece 85 also carries a number of electro-magnets *f'*, *f*<sup>2</sup>, *f*<sup>3</sup>, etc., on its inner face, whose pole pieces are presented to, and preferably against, the respective rings 2, 3, 4 etc. These magnets correspond respectively with the magnets *e'*, 90 *e*<sup>2</sup>, *e*<sup>3</sup>, etc. and the corresponding magnets are fixed in the same horizontal line on the face of the cylinder. Each corresponding pair are connected together in a closed circuit, by the wires *g*, said wires being connected to the 95 terminals of the coils of each magnet. *h*, *h'*, *h*<sup>2</sup>, *h*<sup>3</sup> indicate another series of electro-magnets, supported by a suitable part of the framework, as shown, being attached to the base of the instrument, and arranged in a 100 horizontal line with their poles presented to, and preferably in contact with, the respective rings, 1, 2, 3 etc. These magnets *h* are all connected together in series in the circuit *r*, *r'*. Beyond the series of magnets *h* is still 105 another series of magnets *i*, *i'*, etc. corresponding respectively, and in contact with the several rings 1, 2, 3, 4 etc. These mag-

nets are all connected in circuit with a source of constant current, such as a battery I.

The initial message is sent to the instrument through a circuit  $j, k$ , containing a transmitter T and the usual equipment of battery M, and may also contain an induction coil in the usual way, this, however, not being illustrated. The circuit  $j, k$  leads to and includes magnet  $a$ , which is the main recording magnet of the instrument. The circuit  $r, r'$  includes a suitable receiving apparatus B, which may be a telephone receiver.

Both the transmitting and receiving circuits may extend any distances from the relay instrument, whose operation is as follows: Let it be assumed that the cylinder is being rotated at a constant speed in the direction of the arrow in Fig. 2. Speech or other signal is delivered to the transmitting apparatus T and electrical impulses corresponding thereto, are thus created in the circuit  $j, k$  which includes magnet  $a$ . This magnet is therefore variably magnetized by the successive impulses, and its magnetic condition is imparted to successive portions of the steel ring 1, against which its pole or poles rest. These magnetic impressions are retained by the ring, and on the rotation of the drum, are carried successively past the poles of the magnets  $e', e^2, e^3$  etc. In thus passing the poles of these magnets a current is induced or generated in the coils of the said magnet  $e', e^2, e^3$  etc. in the well understood manner of a dynamo electric machine, the power being supplied by the motor which rotates the cylinder. The current generated in the magnet  $e'$  flows over the connecting wires  $g$  through the magnet  $f'$ , which is resting upon ring 2; hence the instant a magnetic impulse or impression in the ring 1, passes the magnet  $e'$ , it will be accompanied in its further movement onward, by an exactly similar magnetic impression in the ring 2, the two impressions traveling abreast, as it were, towards the receiving magnets  $h, h'$  etc. The impression in the ring 1 reaches the magnet  $h$  at the same instant that the impression in the ring 2 reaches the magnet  $h'$ ; hence magnets  $h$  and  $h'$  which then become receiving magnets, will have similar current impulses generated in their coils, and since these coils are connected together in the same circuit, their electromotive forces will combine and be theoretically double that which is produced by either magnet acting alone. After a given magnetic impression in the ring 1, has passed the magnet  $e'$ , it acts upon the magnet  $e^2$  and sends therefrom a current which energizes magnet  $f$ , which, in turn, impresses a corresponding magnetic impression on ring 3, hence the ring 3 will present the same magnetic impression to magnet  $h^2$  which rings 1 and 2 are at the same time presenting to magnets  $h$  and  $h'$ , and we thus have in the circuit  $r, r'$ , theoretically, three times the electromotive force

that could be reproduced from any one ring. In like manner the same magnetic impression in ring 1 will be communicated to ring 4 and act upon the circuit  $r, r'$  at the same time with the others, and so on throughout the entire capacity of the instrument, a given magnetic impression being conveyed and simultaneously presented to the magnets  $h, h'$  etc. upon respective rings 1, 2, 3 etc. The result in the receiving circuit  $r, r'$  is a current impulse having an electromotive force equal to the combined electromotive forces produced by the respective rings, the current impulses leaving the instrument and proceeding to the receiver B, are thus much stronger than could be obtained by the use of a single reproducing magnet only.

It will be understood that there will be some loss due to the resistance of the coils and circuits, and to the several transfers of the record, but a satisfactory increase can be obtained by using a sufficient number of rings and corresponding magnets. For instance, assuming that a message, when transferred to the ring 1 by magnet  $a$ , has only one-fifth of its original intensity, and further that in transmitting the message from the ring 1 to the rings 2, 3, 4 etc. only one-fifth of the intensity of the ring 1 is obtained on each ring 2, 3, 4 etc. then 25 rings will be necessary in order to reproduce the message with its original intensity.

On comparing the relay instrument with the instrument described in the Poulsen patent referred to, it will be seen that the ring 1 and the magnet  $a'$  correspond with the steel wire and magnet of the Poulsen instrument, and that instead of using the same magnet for reproducing as for recording I use a second, a third and a fourth etc. magnet of similar character, represented by  $a', a^2, a^3$  etc. placed on the same wire, so that the reproducing therefrom is obtained immediately after the record is made, the speed of the drum being such that the message is not perceptibly interrupted or retarded in traveling from the transmitting instrument T to the receiving instrument R. It will be seen that the magnet  $a$  is a recording magnet, the magnets  $e', e^2, e^3$  etc. are all reproducing magnets, the magnets  $f', f^2, f^3$  etc. are all receiving magnets, the magnets  $h', h^2, h^3$  etc. are all receiving magnets. Hence the instrument embodies a number of Poulsen instruments all working together.

In order to be able to use the instrument continuously for transmitting a message, it is necessary to eliminate the magnetic impressions from each of the rings after they have been utilized to repeat the message, and before the same portions of the rings again pass the poles of the recording magnets. To accomplish this, the magnets  $i, i', i^2$  etc., connected with the constant source of current I, are placed beyond the reproducing magnets

*h, h'* etc. in the direction of the rotation, and they wipe off the message and allow the rings to be presented clean and ready for the new message or another part of the same message.

- 5 It is not necessary to use a cylinder or drum with rings upon its surface, as described, since steel ribbons suitably mounted to move with respect to the poles of the magnets, can be used to produce the same result.
- 10 It is also obvious that since the function of the connected magnets *a'* and *f'*, etc. is merely to transfer magnetism from a magnetized body to one which is not magnetized, an iron bridge connecting the two bodies together, could also be used, this construction is shown in Fig. 5. The magnetic impression from the ring 1 magnetize the bridge *s*, which, in turn, similarly magnetizes the ring 2, 3 or 4, with which it is connected. It is also obvious that the transmitting circuit *j, k* could be made to act directly upon all of the rings 1, 2, 3, 4 etc. by simply connecting a number of the magnets *e* in the circuit *j, k* and applying one magnet to each of the rings. This
- 20 method, however, has its objections, from a practical standpoint, and is merely mentioned as a possible way of operating.

What I claim and desire to secure by Letters Patent of the United States is:

- 30 1. The method of reproducing electrical impulses corresponding to sound waves or signals, which consists in making magnetic records of such impulses in a plurality of para-magnetic bodies, then electro-magnetically generating corresponding electric impulses from each of said records and simultaneously impressing the latter impulses upon a receiving circuit.

2. A method of recording and strengthen-

ing the reproduction of speech, signals and so forth, which consists in impressing upon an electric circuit containing an electro-magnet, modulations of current corresponding to the sound waves or speech or to the signals or the like: simultaneously bringing successive portions of a magnetizable body under the influence of said electro-magnet and thereby establishing in said body successively varying magnetic conditions; communicating these magnetic conditions of the said magnetizable body to other magnetic bodies, subjecting electro-magnets connected in a circuit successively to the various magnetic conditions established in said bodies, and reproducing the speech, signals or the like in a receiver, substantially as described.

3. The method of operating electro-magnetic sound and signal recording and reproducing apparatus, which consists in making duplicate electro-magnetic records in a plurality of paramagnetic bodies and transferring the sum of such records to a circuit containing a receiver.

4. The method of operating electro-magnetic sound and signal recording and reproducing apparatus, which consists in producing electrical impulses corresponding to the sounds or signals, then making duplicate electro-magnetic records of such impulses and finally causing said duplicate records to simultaneously react upon a receiving circuit, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two witnesses.

EMIL SCHACK HAGEMANN.

Witnesses:

JH. MARDEN,  
LEICRER.