No. 641,147. Patented Jan. 9, 1900.

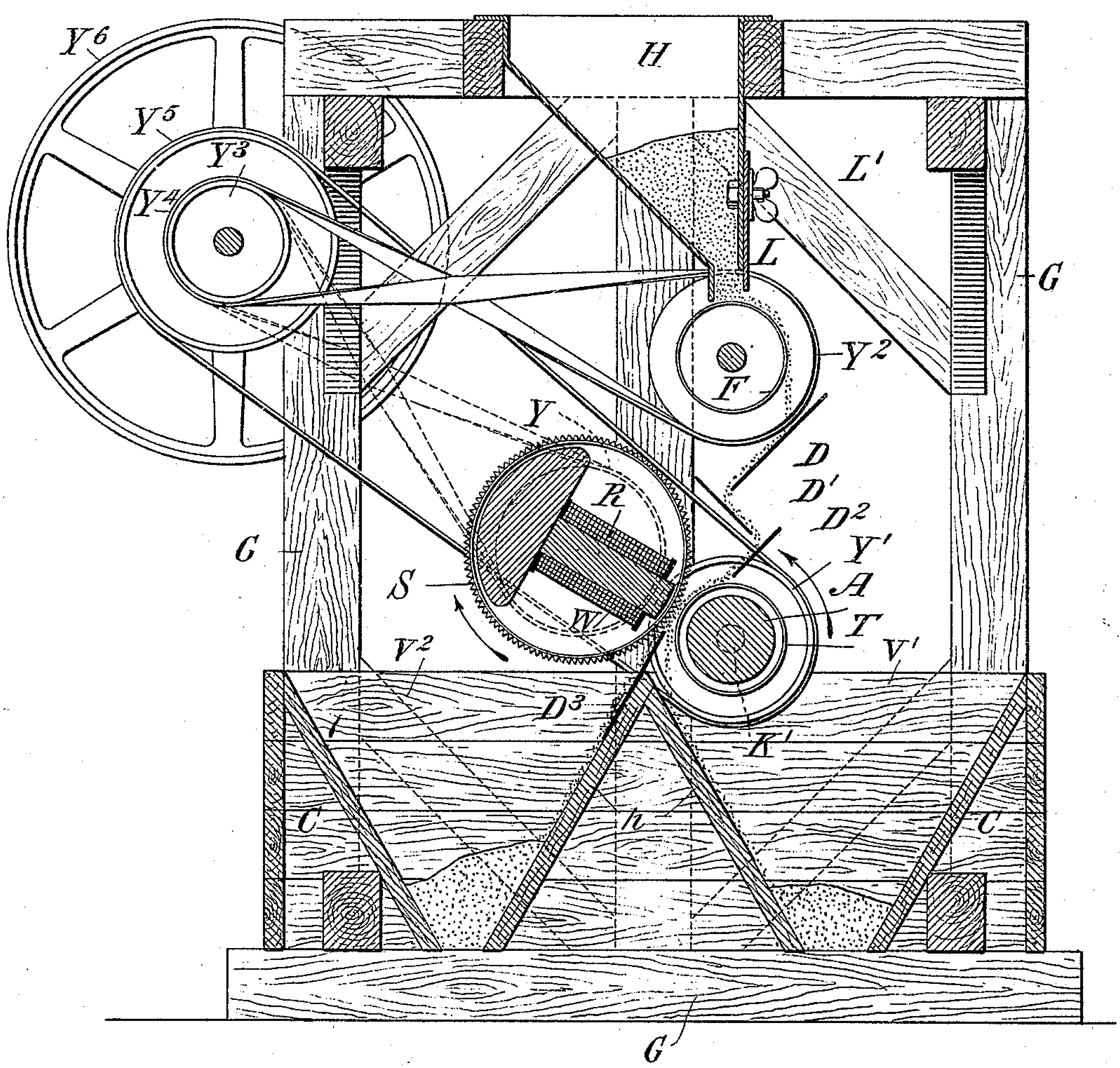
C. Q. PAYNE.

APPARATUS FOR MAGNETICALLY SEPARATING ORES.

(Application filed June 26, 1897.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1,



WITNESSES:

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H. W. Lloyd

INVENTOR:

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(No Model.) 4 Sheets—Sheet 2.

Fig. 2,

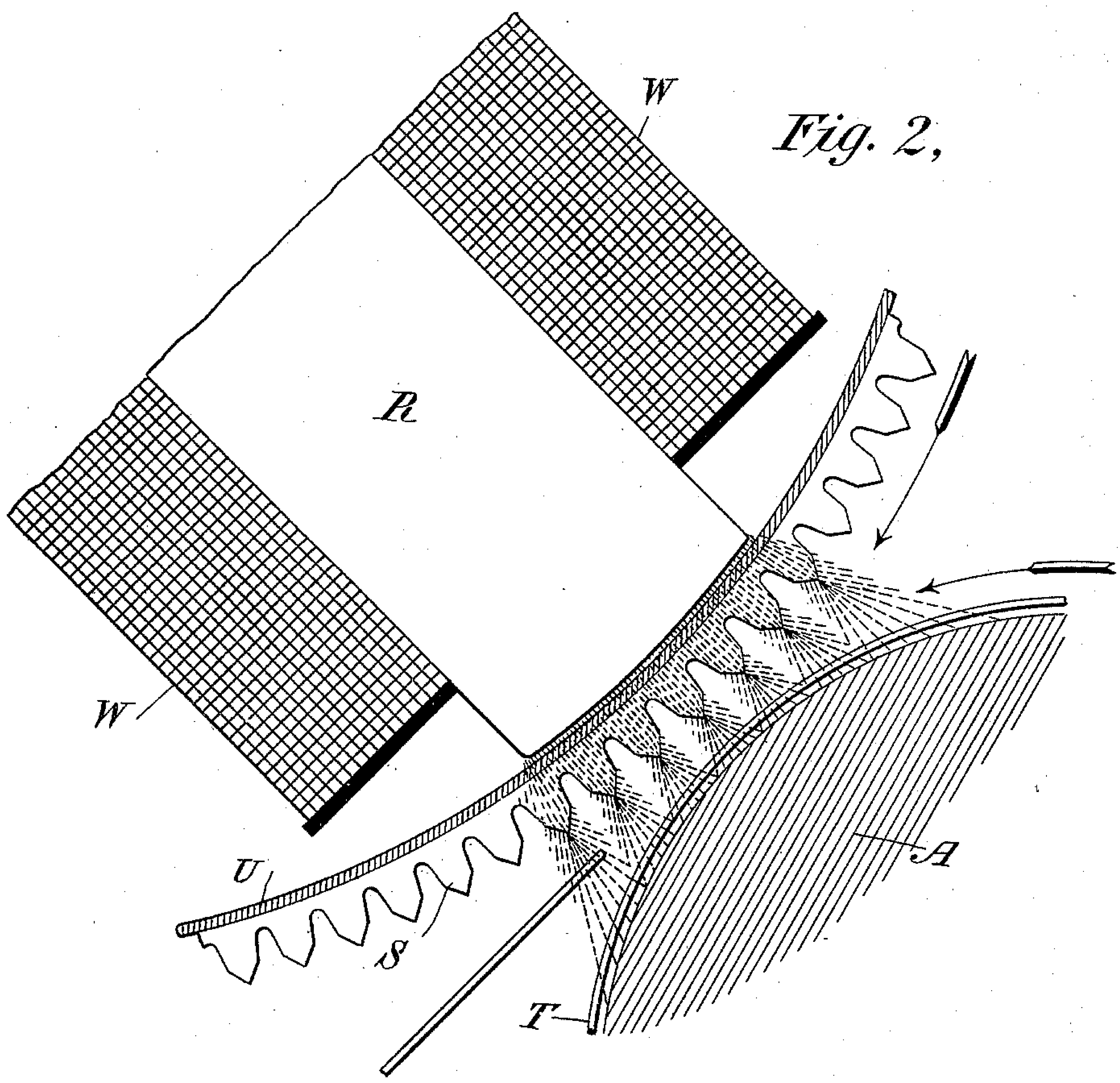


Fig. 3,

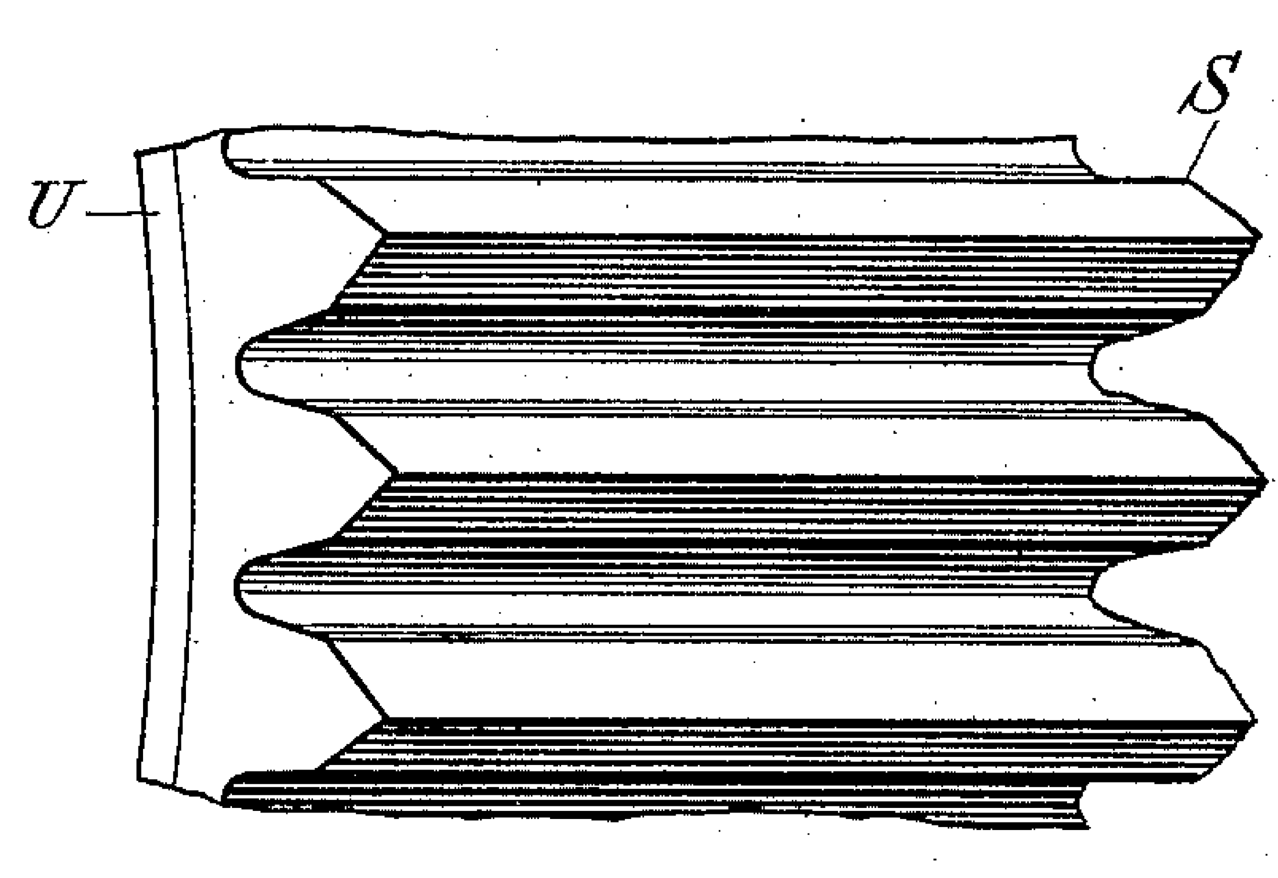
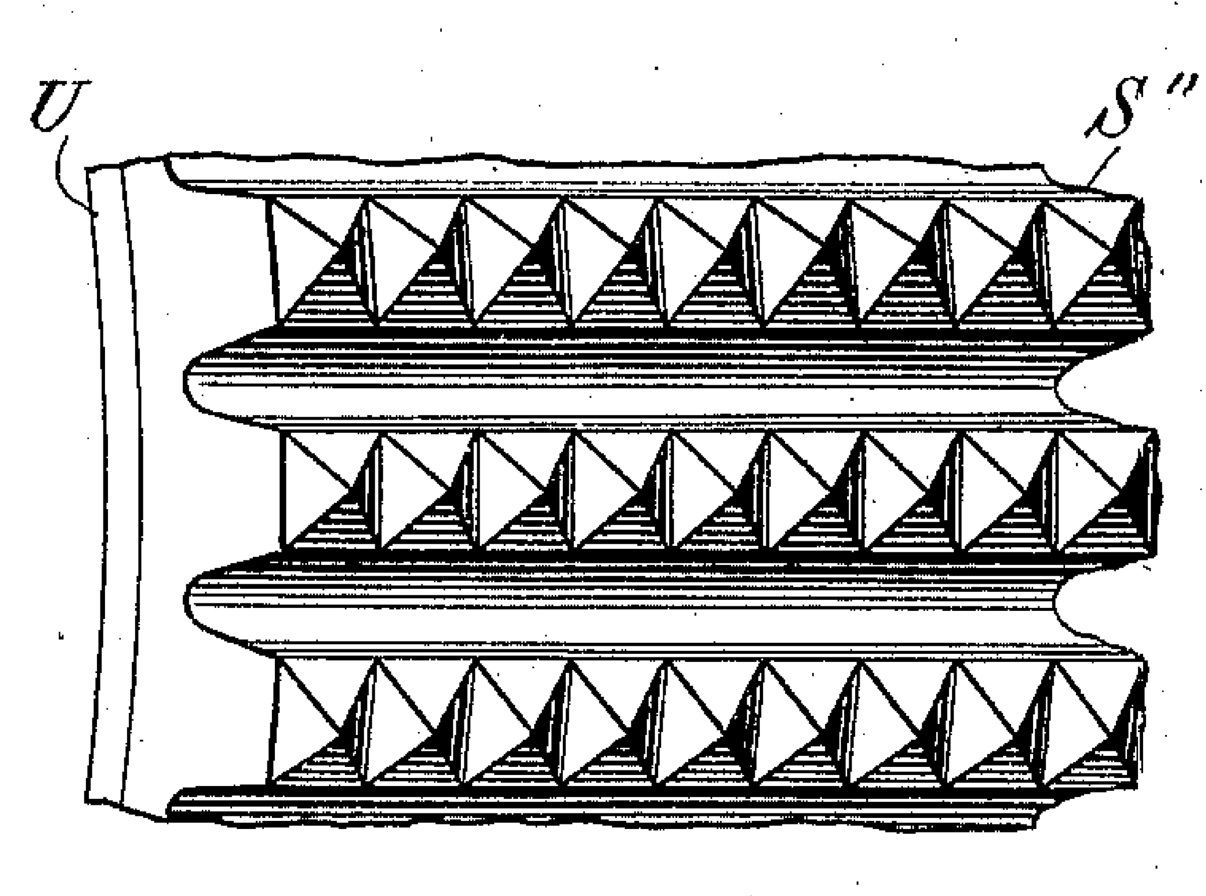


Fig. 4,



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(No Model.) 4 Sheets—Sheet 3.

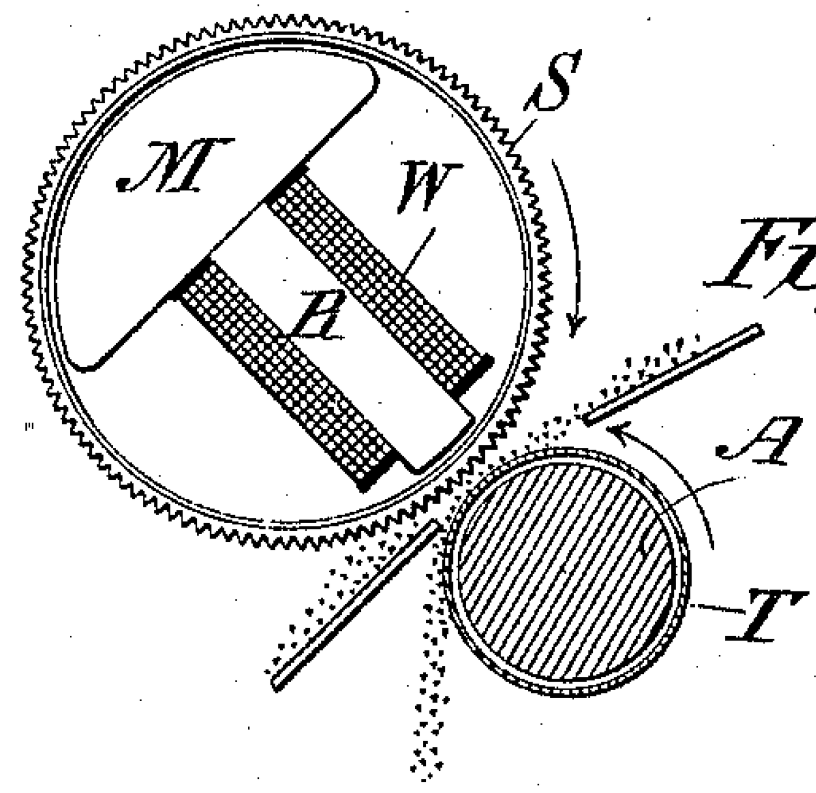


Fig. 5,

Fig. 6,

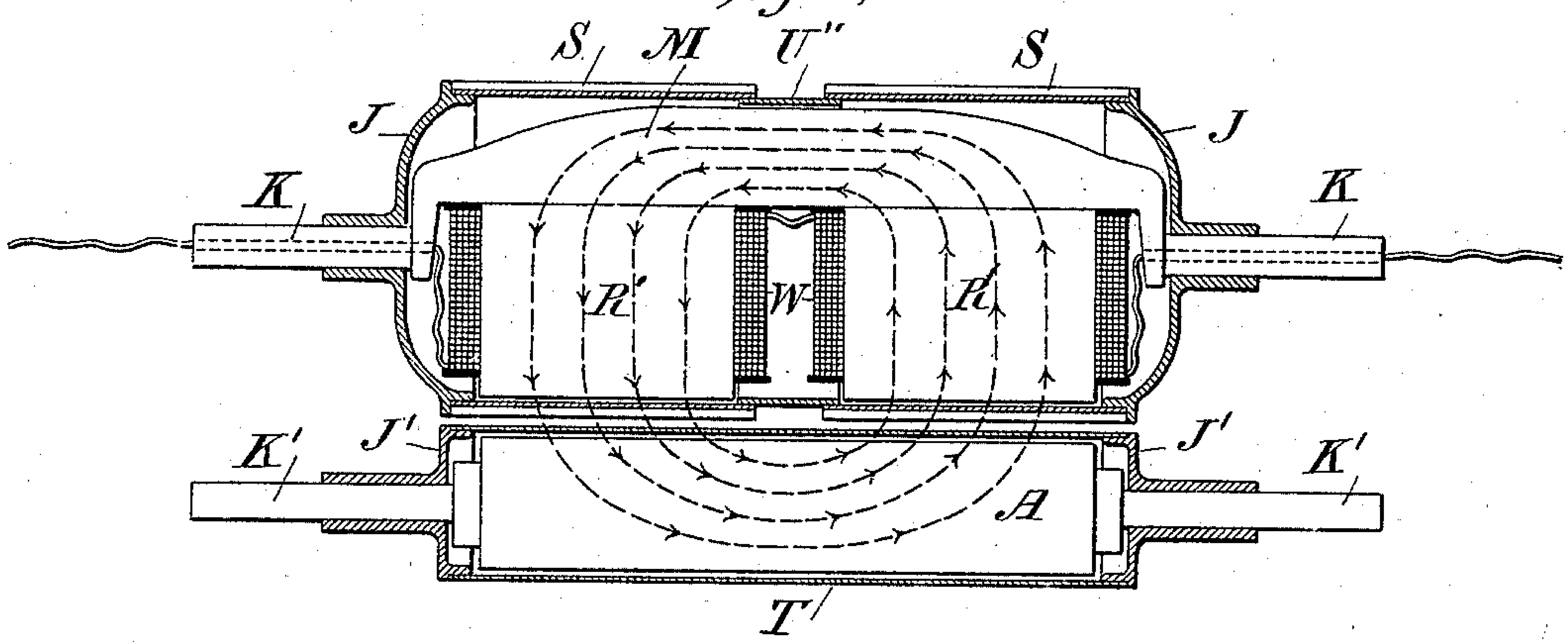
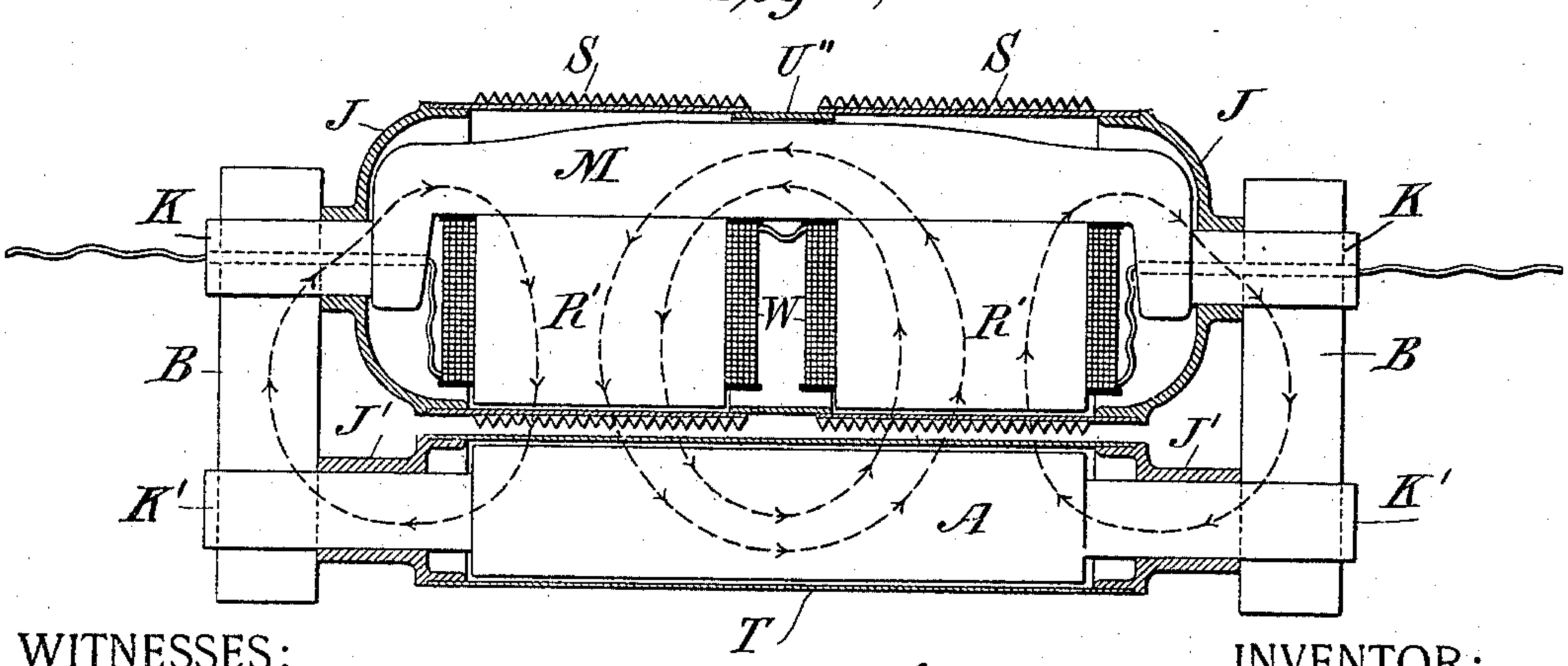


Fig. 7,



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(No Model.) 4 Sheets—Sheet 4.

Fig. 8,

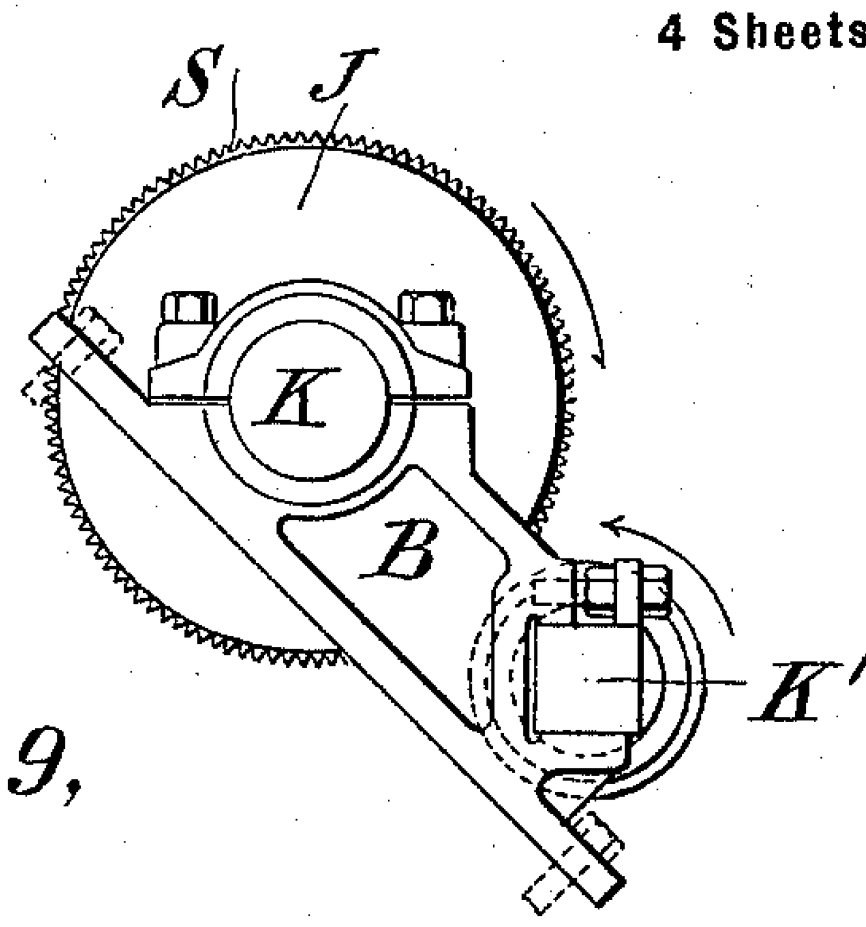
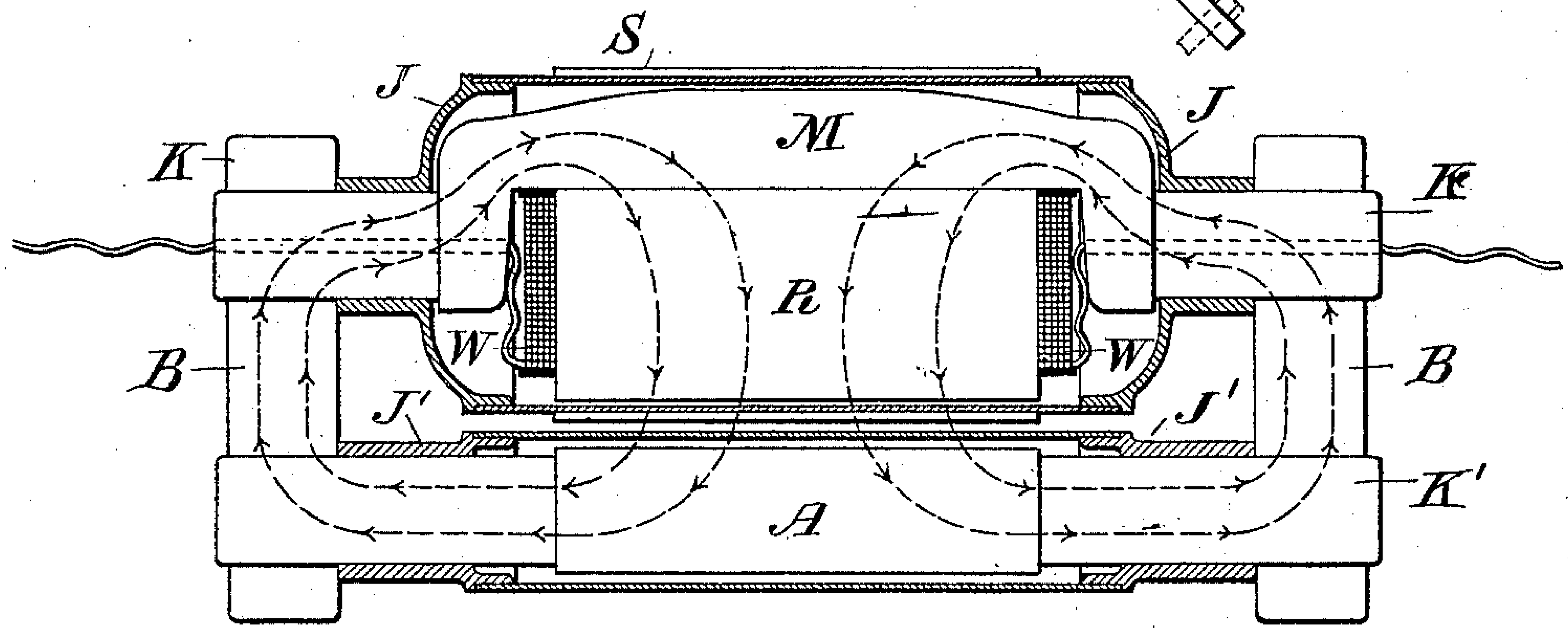


Fig. 9,



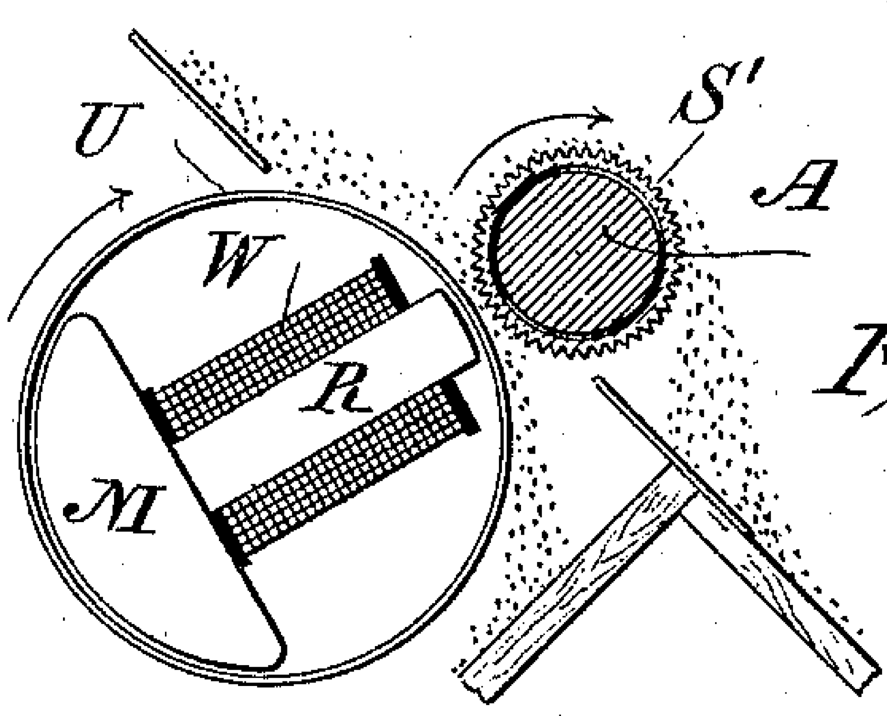
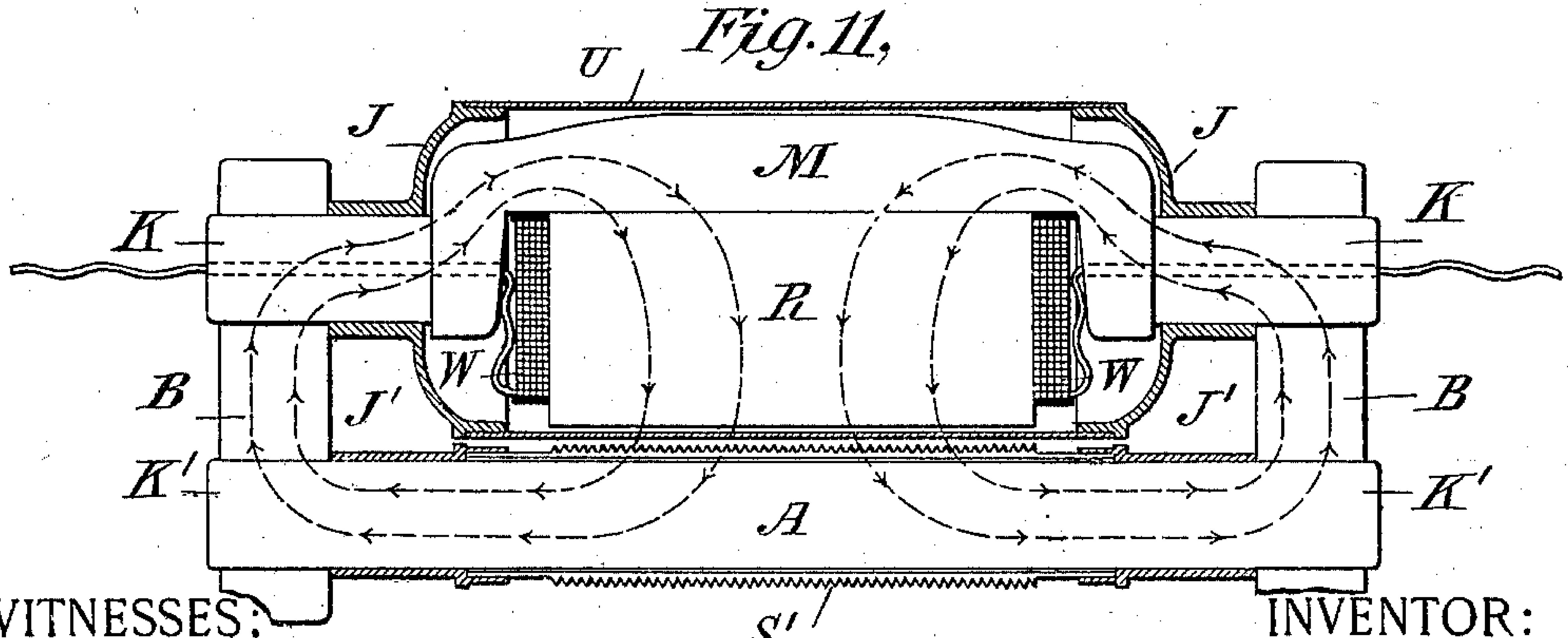


Fig. 10,

Fig. 11,



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UNITED STATES PATENT OFFICE.

CLARENCE Q. PAYNE, OF STAMFORD, CONNECTICUT.

APPARATUS FOR MAGNETICALLY SEPARATING ORES.

SPECIFICATION forming part of Letters Patent No. 641,147, dated January 9, 1900.

Application filed June 26, 1897. Serial No. 642,364. (No model.)

To all whom it may concern:

Be it known that I, CLARENCE Q PAYNE, a citizen of the United States of America, and a resident of Stamford, county of Fairfield, and State of Connecticut, have invented certain new and useful Improvements in Methods of and Apparatus for Magnetically Separating Ores, of which the following is a specification.

My invention relates to improvements in magnetic separators for the concentration of substances of all degrees of magnetic permeability. In a previous application for Letters Patent filed in the United States Patent Office, Serial No. 619,881, I have described an apparatus for magnetically separating ores in which the improvement consists in establishing a more perfect control over the positions of the lines of force in a magnetic field than has heretofore been possible by "line dispersions" of the flux density within the field. A great range of magnetic effect among paramagnetic substances of all degrees of magnetic permeability is thus secured. In said application, Serial No. 619,881, a method of separating these various classes of paramagnetic substances from mixtures containing them by means of undulations of magnetic potential within the field was also described.

In the practical work of separating ores I have found that important advantages are in many cases secured by feeding the ore which is to be separated in a single undivided sheet through the field. The greater simplicity of this operation secures a better control over the material undergoing separation and a more perfect regulation of the field conditions as compared with a division of the ore sheet into two parts, each of which is fed into a separate field, which are both maintained on the same magnetic circuit by a suitable arrangement of a horseshoe-electromagnet and armature.

The present invention consists, therefore, in improvement of means for controlling the circuits of the magnetic flux generated by an electromagnet so as to establish a single magnetic field upon them, within which the improvements of means and method of separation described in the above application may be conveniently employed.

The invention will be best understood by reference to the accompanying four sheets of drawings, in which—

Figure 1 shows in sectional view a complete operating machine. Fig. 2 illustrates by a section through the field the means for controlling the positions of the lines of force within it so as to secure line dispersions of the flux density therein. Figs. 3 and 4 show different constructions of the wedge terminations upon the surface of the separating-carrier. Figs. 5 and 6 illustrate a bipolar electromagnet and its armature. Fig. 7 shows a similar electromagnet and armature joined together by means of yokes. Fig. 8 is a side view of a connecting-yoke. Fig. 9 shows an electromagnet and armature so designed and connected that a single magnetic field is formed between them. Figs. 10 and 11 show a similar arrangement of electromagnet and armature with an alternative position of the separating-carrier.

Similar letters refer to similar parts throughout the several views.

In Figs. 8 and 9 are shown an arrangement of electromagnet and armature which embodies more particularly the present invention. Here an electromagnet M R is shown, with a single core or pole R so designed that it can be supported rigidly within the cylinder S, which revolves about it. The soft-iron armature-bar A is placed opposite the core of the electromagnet, so as to leave a narrow air-gap between the surface of the magnet-pole R and that of the armature. The latter is also supported rigidly within a cylinder T, which revolves about it. Both the electromagnet and armature have cylindrical extensions K K′ at each end, which form shafts or cylindrical bearings for the hubs J J′ of the cylinders or drums S and T to revolve upon. The outer ends of these shaft extensions K K′ on each side are connected together by means of the two iron yokes B B. By maintaining the cross-sectional area of the shaft extensions and yokes at least one-half that of the core area of the electromagnet or of the armature it is evident that the total magnetic flux generated within the core of the electromagnet M R when the coil W is charged with an electric current is enabled to pursue two separate paths in completing their circuits in the manner and direction shown by the broken lines in Fig. 9. These two magnetic circuits, into which the total magnetic flux is thus made to divide, both pass through the air-gap between the electromagnet and armature, and thus jointly form the magnetic field within which the separating action takes place. It is thus possible to feed the ore through the field in a single undivided ore sheet and to exert upon it the separating action, which is illustrated more clearly in Fig. 2 by an enlarged section through the field. Here the separating-carrier U, which surrounds the electromagnet, is composed of a thin brass or non-magnetic cylinder and is provided with an iron ring having a series of wedge-shaped teeth or serrations upon its outer surface. As the separating-cylinder is made to rotate through the field the iron wedges upon its surface are successively magnetized by induction as they pass through it. These iron wedges inductively intercept the lines of force within the field, which normally occupy approximately parallel positions in bridging the air-gap between the electromagnet and armature, and owing to their shape they cause the lines of force to assume rapidly-divergent positions between the edges of the wedge terminations and the armature-surface.

By sharply beveling the iron wedges their edges form approximately lines—that is, they have length without breadth. In this way we obtain what may be called "line dispersions" of the flux density within the magnetic field and establish therein very wide differences of magnetic potential. The positions of the lines of force within the field as controlled by the iron wedges are shown by the broken lines between the electromagnet and armature-surface in Fig. 2.

When the separating-cylinder is made to rotate through the field, the iron wedges produce cyclic variations or undulations of magnetic potential with reference to a fixed point within the field. This enables the ore particles which have been attracted and removed from the non-magnetic particles to be carried out of the field in directions which secure a very complete separating action.

The ore to be separated is introduced into the magnetic field by means of the cylinder T, which surrounds the armature A. This cylinder may be made of brass or other non-magnetic material when used for the separation of strongly-magnetic material—as, for example, magnetite, pyrrhotite, franklinite, &c. It may also be made of iron when used for the separation of feebly-magnetic material, such as hematite, limonite, &c. In the latter case the divergent effect of the flux density upon the ore particles within the field is increased to a maximum by the reduction of the air-gap.

By beveling the iron surface of the separating-carrier along four directions separated pyramidal teeth or projections are also obtained, as shown in Fig. 4. While these projecting points can thus exert a very great magnetic effect, it is accompanied by a decreased attaching-surface for the material undergoing separation.

In Figs. 5 and 6 the relative positions of a bipolar or horseshoe electromagnet and its armature are shown, which secure two magnetic fields upon a single circuit of the magnetic flux generated by the electromagnet. This circuit is indicated by broken lines in Fig. 6. An intermediate design between the bipolar electromagnet shown in Fig. 6 and the unipolar electromagnet of Figs. 9 and 11 is also shown in Figs. 7. Here the use of the two iron yokes B B and a suitable enlargement of the shaft extensions K K', so as to carry a portion of the magnetic flux generated by the electromagnet, causes the total magnetic flux to be divided into three separate circuits, and we have thus two magnetic fields upon three magnetic circuits. Other arrangements and division of the magnetic circuits may also be suggested.

It is also possible to place the iron wedges of the separating-carrier upon either side of the field. In Fig. 10 the separating-carrier is placed upon the armature A. Here the armature itself may be placed somewhat above the horizontal diameter of the magnet-cylinder U, and the latter is then used for the purpose of feeding the material into the field. When so used, the separating and feed cylinders may be rotated in opposite directions or, as indicated by the arrows in Fig. 10, in the same direction, depending upon the character of the material to be treated.

In all of the accompanying illustrations for the sake of simplicity an electromagnet is shown on one side of the air-gap or air-gaps in which the magnetic fields are established and an armature on the other. It is obvious that the same strength of field would be produced in either case if instead of having all the coils of wire upon one side of the air-gap they be divided, so as to have one-half the turns of wire on one side of the field and one-half on the other side. In the latter case we should have an electromagnet on each side of the air-gap. In both cases the same results, as far as the separating action is concerned, can be produced by line dispersions of the flux density within the air-gap, and the field in either case is formed between opposing magnetic surfaces.

The operation of the apparatus is as follows: In the complete machine shown in sectional view in Fig. 1 any one of the electromagnets, with its armature and operating-cylinders, (shown in Figs. 5 to 11, inclusive,) may be employed; but to illustrate more particularly the application of the present invention the form of electromagnet shown in Fig. 9 is here made use of. This electromagnet by means of the two iron yokes B B, which join it with its armature A, has a single magnetic field formed upon two magnetic circuits, and the ore while undergoing separation is thus fed in a single undivided sheet through the field. The coil of wire W which surrounds the core or pole R of the electromagnet is energized by means of an electric current, preferably from a dynamo-electric machine, and the separating-drum S and feed-drum T are caused to revolve. In Fig. 1 they are shown to be rotated in opposite directions by means of pulleys Y Y′, driven by open and crossed belts from the pulleys Y^4 Y^5 on the countershaft upon the side of the frame G of the machine. The material to be separated is fed from the hopper H by means of an adjustable gate L upon the charging-drum F. This charging-drum is mounted upon a shaft and made to revolve, so as to feed a regulated amount of ore upon the guide-plates D D′ D^2, and thence to the feed-cylinder T, which carries it into the field. The distance of the feed-cylinder T from the separating-cylinder S, which depends largely upon the size and nature of the material undergoing separation, is regulated by the adjusting device shown in Fig. 8, which permits the position of the armature to be varied with respect to the electromagnet. When the material to be separated is carried into the field by the rotation of the feed-cylinder T, the ore particles are subjected to a very intense separating force due to the line dispersions of the flux density within the field by the inductively-magnetized wedge terminations upon the separating-cylinder on the other side of the field, as already described, and shown in Fig. 2. This produces very wide differences of magnetic potential within the field, and the magnetic ore particles, even when of very feeble magnetic permeability, are thus attracted to the wedge terminations and removed from the non-magnetic or less-magnetic ore particles upon the surface of the feed-cylinder. By the continued rotation of the latter the attracted particles are then carried out of the field and when beyond the edge of the devision-plate D^3 are discharged into the hopper V^2 by the successive demagnetization of the iron wedges as they pass out of the field. The non-magnetic or non-attracted particles of the material remain upon the feed-cylinder T until carried to a point where they fall by gravity into the hopper V′. The position of the edge of the division-plate D^3 may be varied by sliding or hinging the plate so that in connection with the rotary adjustment of the electromagnet within its cylinder the attracted and non-attracted particles can be deposited on opposite sides of the division-plate D^3 in their respective hoppers V′ and V^2.

What I claim, and desire to secure by Letters Patent, is—

1. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces, and means for producing line dispersions of the flux density within said field, substantially as described.

2. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces, and means for producing wide differences of magnetic potential within said field, arranged to pass through said field, substantially as described.

3. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces; a separating-carrier provided with means for producing line dispersions of the flux density within said field, and means for moving said carrier through said field on one side thereof, substantially as described.

4. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces; a separating-carrier provided with means for producing undulations of magnetic potential within said field, by moving said carrier through said field on one side thereof, substantially as described.

5. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces; a separating-carrier passing through said field on one side thereof provided with inductively-magnetized wedge terminations, and a feed-carrier also passing through said field on the other side thereof, substantially as described.

6. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces; a series of iron wedges passing through said field on one side thereof which are successively magnetized by induction as they pass through said field, and which produce line dispersions of the flux density and wide differences of magnetic potential therein; and means for feeding the material to be separated through said field on the other side thereof, substantially as described.

7. In a magnetic separator, the combination of a suitably-energized electromagnet; an armature; two yokes so connecting the electromagnet with the armature that a single magnetic field may be formed by two magnetic circuits in the air-gap between them; a feed-carrier, and a separating-carrier, each arranged to pass through said field, said separating-carrier being provided with a series of wedge terminations which are successively magnetized by induction as they pass through

said field and produce line dispersions of the flux density therein, substantially as described.

8. In combination, a magnetic separator provided with two opposing magnetic surfaces; a suitably-energized unipolar electromagnet provided with suitable core extensions on each side; a suitable armature placed opposite the core end of the electromagnet; iron yokes joining the ends of the armature to the core extensions of the electromagnet; a rotating feed-cylinder surrounding the armature; a rotating separating-cylinder surrounding the electromagnet, each cylinder arranged to rotate through the magnetic field formed between the electromagnet and armature, said separating-cylinder being provided with a series of iron wedge terminations which are successively magnetized by induction as they pass through said field, and means for rotating said cylinder, substantially as described.

9. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces; a separating-carrier passing through said field on one side thereof provided with wedge terminations which are successively magnetized by induction as they pass through said field; a magnetic feed-carrier also passing through said field on the other side thereof, and means for feeding the ore through said field, substantially as described.

10. In combination, a magnetic separator provided with two opposing magnetic surfaces, connections forming two magnetic circuits whereby a single magnetic field may be formed in the air-gap between the two surfaces; a separating-carrier passing through said field on one side thereof provided with wedge terminations which are successively magnetized by induction as they pass through said field; a feed-carrier also passing through said field on the other side thereof, and means for feeding the ore through said field, substantially as described.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this 22d day of June, 1897.

CLARENCE Q. PAYNE.

Witnesses:
WELLARD PARKER BUTLER,
JOHN FRENCH.