No. 830,924. PATENTED SEPT. 11, 1906.

F. PAWLOWSKI.

CURRENT RECTIFIER.

APPLICATION FILED NOV. 14, 1904.

Fig. 1

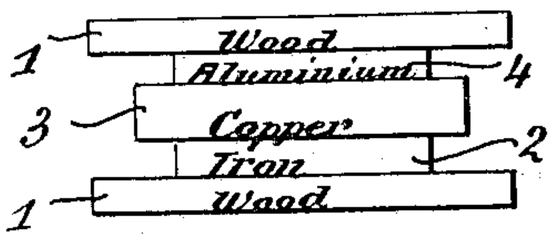


Fig. 2

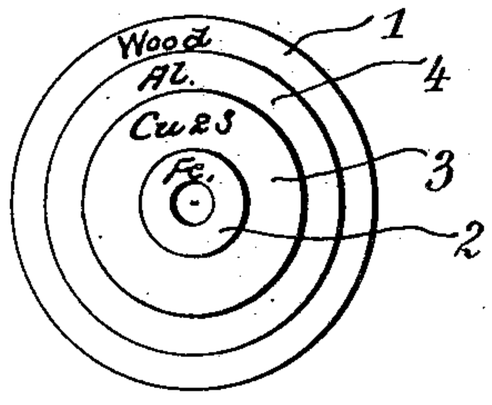
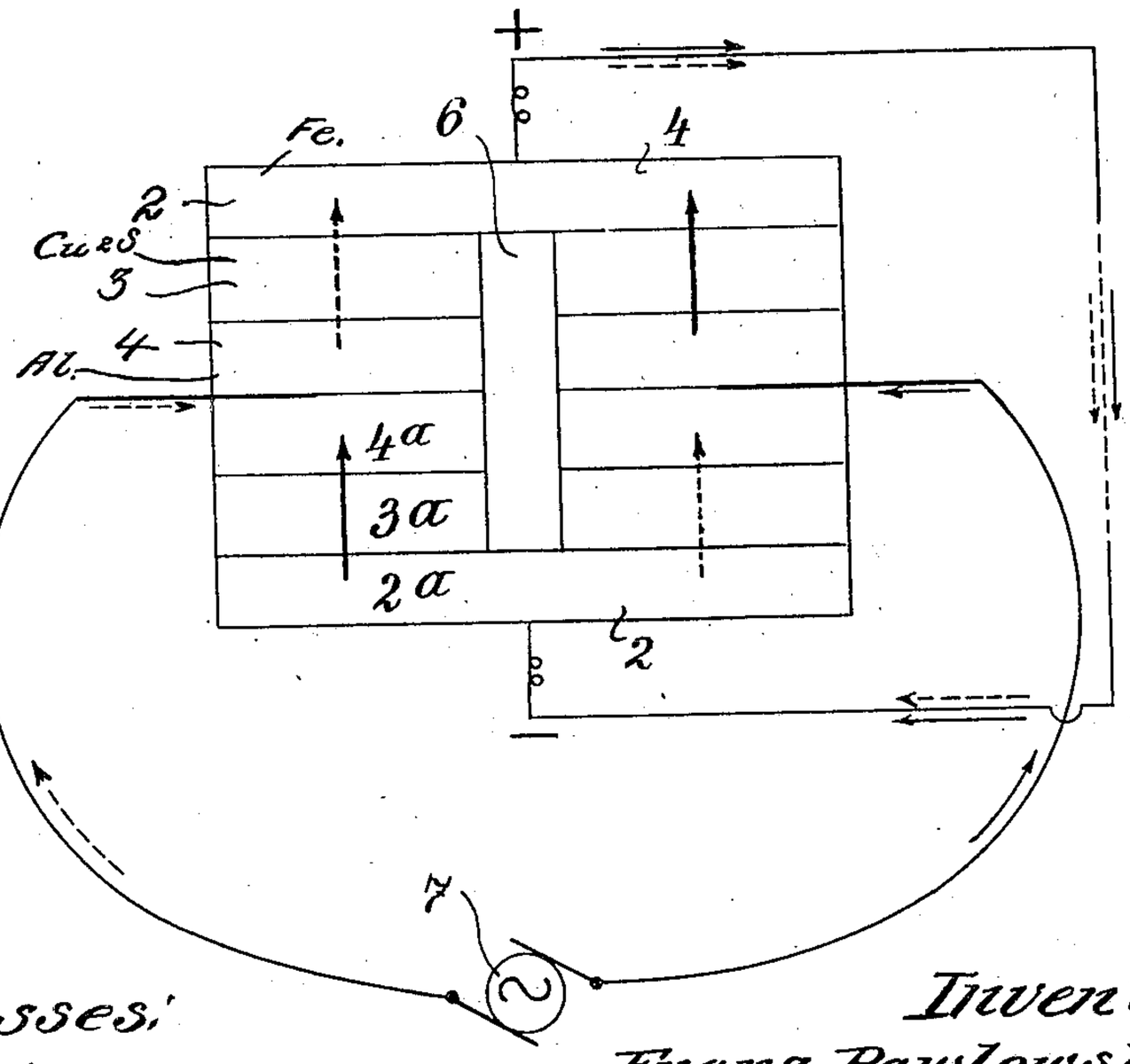


Fig 3



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CURRENT-RECTIFIER.

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Application filed November 14, 1904. Serial No. 232,695.

To all whom it may concern:

Be it known that I, FRANZ PAWLOWSKI, a subject of the Emperor of Austria-Hungary, residing at Vienna, Austria-Hungary, have invented certain new and useful Improvements in Current-Rectifiers, of which the following is a specification.

Among the different rectifier-cells for transforming alternating currents in unidirectional—that is to say, continuous—currents the cells in which one electrode is formed by an aluminium plate are representing a peculiar class. The other electrode is then formed by any other metal, presenting to the current when used as anode less resistance than aluminium, and the intermediate layer is formed by a solution of a salt or by a salt in solid state at ordinary temperature and which must therefore be heated in order to liquify the said salt by melting the same when taking the cell in use. When connecting the aluminium plate of a cell of the aforesaid kind with the positive pole of a generator of continuous current, the passage of the same is meeting a very high resistance, while a much lesser resistance is interposed to the passage of alternating currents.

A characteristic feature of the rectifier-cell forming the object of the present invention consists in that the layer between the two electrodes is formed of hemisulfid of copper, (Cu_2S,) which has been prepared in a peculiar manner. Taking the rectifier-cell in use, the said layer preserves its solid condition, and no supply of heat is required for starting the rectifier. The utility of hemisulfid of copper to the purpose specified was concluded from the fact that it is liable to polarization—viz., an electromotoric counterforce is indicated—when the ends of a bar consisting of hemisulfid of copper are connected with a galvanometer after having passed through the bar an electric current. It has also been found that the resistance of many sulfids is a different one, according to the direction, intensity, and duration of a current passed through them. (See Wiedemann, *Die Lehre von der Elektrizitat*, second edition, Vol. 1, page 548.)

If a system consisting of an aluminium plate, a layer of hemisulfid of copper and a plate of any other metal, preferably iron, should be used as a rectifier-cell, its utility for such purpose mainly depends upon the structure of the hemisulfid of copper, its other physical properties being determined thereby. Hemisulfid of copper prepared by heating sulfid of copper (CuS) to white heat and casting them into molds is not fit for the before-mentioned purpose, because it is a bad conductor at ordinary temperatures. On the contrary, a suitable preparation is obtained by melting together sulfur and copper or preferably by subjecting sheet-copper of a thickness not exceeding two millimeters to the action of sulfurous vapors without admission of air for so long a period as such vapors are absorbed, whereupon the hemisulfid of copper is slowly cooled. In this manner there is obtained a very hard crystalline hemisulfid of copper, resisting to the action of air and water, which melts only at about 1,000° centigrade, and which is a good conductor of electricity. It is to be emphasized that the current is conducted with equal facility at ordinary temperature and in both directions.

The improved rectifier consists of a combination of an aluminium electrode and an iron electrode, separated by an intermediate layer of hemisulfid of copper. In combining the three different substances forming the cell it is of essential importance that the contact is the closest possible. The efficiency of the rectifier-cells depends only upon the extent of the surface.

The accompanying drawings represent the object of the present invention, Figure 1 showing a lamelliform, Fig. 2 a tubiform, arrangement of the parts constituting the cell. Fig. 3 shows a battery, consisting of four rectifier-cells.

As shown in Fig. 1, the cell consists of superposed plates—viz., of an aluminium plate 4, a plate 3 of hemisulfid of copper of somewhat larger surface, and an iron plate 2, all of which arranged between two little boards of wood. The shape in which the several substances are employed is of no account. According to Fig. 2 they are showing, for example, the shape of tubes.

For practical purposes in order to rectify alternating currents in continuous currents any convenient number of cells of the kind specified may be connected in parallel or in series, the efficiency of the battery constituted in this manner being proportional to the sum of the contact-surfaces of all of the plates. Fig. 3 represents a combination of four cells of the kind shown in Fig. 1, the uppermost aluminium plate 4 and the lowermost iron plate 2 consisting in this case each of one piece, while the interposed plates belonging to the cells on the right and on the

left are separated by an intermediate air-space 6.

By means of six or more of the aforesaid cells polyphase currents may be transformed in continuous current. The efficiency of the improved rectifier is much greater than that of any other apparatus of this kind hitherto known on the supposition that the following principles be observed: The extent of the contact-surfaces and the mode of connection must be conformed to the intensity and to the voltage of the alternating current to be rectified or to those of the continuous current to be taken off, respectively—that is to say, when the intensity is a greater one several cells must be connected in parallel, while when the voltage is a greater one several cells must be connected in series. With a suitable arrangement of the apparatus a useful effect of seventy to eighty per cent. is obtained, importunate development of heat is obviated, and no control and attendance are required. Even if the apparatus is in use for several days the plates show no physical or chemical change, and losses of substance or products of electrolytic decomposition do not appear. If, however, the number of cells was not sufficient, considerable flashing of sparks and a large development of heat take place, whereby the loss of voltage is increased. Besides taking care of choosing the suitable number and connection of the cells, the rectifier must be "formed" before starting the same for the first time. For this purpose the apparatus is connected to an alternating-current circuit of high intensity for so long a period as strong sparking takes place, while the poles for supplying continuous current remain open and unloaded during all this time. Even if this arrangement is continued for some days neither loss of alternating current nor short-circuit takes place.

When the rectifier is formed in the aforesaid manner and when sparking has almost ceased, the supply of continuous current may begin, preferably increasing gradually the amount of current delivered. The limit up to which such increase is permitted may be established by the stronger sparking which takes place between the aluminium and the hemisulfid of copper electrodes when the said limit is attained at, whereby the loss in voltage is increased and the durability of the apparatus is diminished.

If a plate of hemisulfid of copper (Cu_2S) has been prepared in the manner hereinbefore set forth and a plate of aluminium of suitable dimensions is disposed on the plate of copper and the circuit of the current is closed, the current will find by far a greater resistance when the aluminium forms the anode than when Cu_2S constitutes the anode. Upon this fundamental experiment or assemblage of the plates set forth is composed the working of the current-rectifier, which forms the subject-matter of the present invention and which, according to the arrangement shown by Fig. 3 of the drawings, is represented as a combination of several rectifier-cells in order to obtain a full and complete rectifying of the current. In view of the fundamental experiments it has been found preferable to employ a connecting metal between the separate cells composed of aluminium and a Cu_2S plate, some other conductor, excepting one composed of aluminium. The working of the cell is an electrolytic process carried out by means of a dry and solid electrolyte. The molecular properties inherent to the aluminium and to Cu_2S play for themselves a part quite independent from the electrolysis, as will be hereinafter more fully set forth. It is of course obvious that in the present instance a layer of aluminium oxid cannot be formed; but, on the contrary, under the influence of electrolysis a layer of aluminium sulfid will be formed which possesses more or less insulating properties. This layer of aluminiun sulfid will, perhaps, consist only of a thin film, but more probably it will consist of an exceedingly thin layer of dust or powder.

If it be supposed that the lowermost left-hand cell of the four cells represented by Fig. 3 for the sake of greater clearness be designated by the reference characters 2^a 3^a 4^a in contradistinction to the other reference characters in this figure, the alternating current which enters at 2 will simultaneously meet the upper cell 4 3 2 and on the other hand the lower cell 2^a 3^a 4^a. At the anode 4^a the current upon meeting a thin layer of AlS will undergo a complete interruption. The current will thereby be deflected in the direction 2 3 4 and pass without any difficulty, because it will meet no insulating layer between 3 and 4. The same process takes place in an exactly analogous manner in the other two cells. In these cells also in consequence of the formation of an insulating layer of AlS the current will be driven into the exterior circuit.

To render the apparatus successful, it is necessary that the working plates have surfaces as smooth as possible, and the expression heretofore noted with respect to the formation of the apparatus is intended to indicate this surface smoothness. By arranging or having the surfaces of the plates smooth and parallel to each other as nearly as possible, and consequently avoiding high pressure, an apparatus will be obtained that will work in a perfect manner.

The working of the current-rectifier takes place only at the place of contact of the aluminium with the Cu_2S, so that the second electrode of the rectifier has, properly speaking, no other function but the simple admission of current to Cu_2S and Al. The products of decomposition which are formed at the first-named place are quite insignificant

and consist of immeasurable small particles of dust of copper, aluminium, and combinations of these elements which will prejudiciously influence the working of the rectifying apparatus in the same measure as the current discharged will be progressing. These particles of dust or powder will enter into chemical combinations of different kinds, and these combinations will increase the permeability of the rectifier for the alternating current.

It is better to explain the phenomena which take place in the rectifying apparatus by the electron theory and that the electrolysis possesses merely a secondary and a rather injurious influence and constitutes not the reason of the passage of the current, but rather a phenomenon accompanying the same.

It is well known that in the tension series aluminium will stand as one of the highest positive conductors, whereas Cu_2S is one of the uttermost negative conductors. With this in view it follows that aluminium will contain mostly positive ions, which will attract the negative charges, whereas Cu_2S contains mostly negative ions, which attract the positive charges. These opposed polar capacities of aluminium and Cu_2S maintain the potential equilibrium as long as no unidirectional current has been discharged, and in this respect they present fully the action of valves. The alternating current remains interrupted, there is no appreciable loss of current, and both continuous-current poles show a considerable tension at the terminals. This potential equilibrium is, however, immediately disturbed as soon as continuous current is being discharged. This manifests itself in the following manner: During the first initial stage aluminium yields to Cu_2S its negative charge very rapidly and without formation of sparks; but in exchange it receives simultaneously reduced copper-dust charged positively, and this dust separated from the Cu_2S deposits firmly on the aluminium. In the second stage when aluminium becomes the anode the copper which has remained deposited on the aluminium is also charged positively and combines easily with S (or also with O of the atmospheric air;) but at the same time it is repelled by the positive charge of the aluminium, since it is also charged positively, and it forms a spark which reëstablishes the original condition. The other and greater part of the positive charge at the aluminium forms with the Cu_2S a very fine layer of aluminium sulfid, which interrupts the dischagre of any further positive charge to the Cu_2S and compels the current to take another way. At the next negative charge of the aluminium the reduced particles of copper positively charged for the exchange meet no longer the pure aluminium, but the extremely fine layer of aluminium sulfid, and they give up to it their charge and are again converted into Cu_2S.

In the above-described manner the operations in the current-rectifier are rapidly repeating themselves with the effect of a corresponding loss of energy. The above exposition concerning the working of the rectifier requires still a very important theoretical addition. The electrolytical phenomena can be considered as being of a secondary nature and as having injurious effects. The efficacious moment which makes the two substances employed, according to the invention aluminium and Cu_2S, particularly suitable for producing in their combination as a cell the rectifying of the alternating current lies in the specific molecular properties of these substances. The aluminium saturated with negative ions effects very easily its exchange with a rigidly-lying positive charge of movable copper atoms if a similar exchange is rendered possible by easily-separable dust particles of a substance like Cu_2S. The positively-charged aluminium has, however, tightly bound the charge to the substance. Its capacity is rather small for the positive ions, and the structure is such that a pulverization is possible only under a very high tension. The giving up of the charge of the positive ions finds, therefore, considerable obstacles, which as a rule are overcome only under formation of sparks. Cu_2S presents quite the opposite properties—a considerable capacity for the positive charge and the facility of the easy dissolution into electrolytical copper atoms which can change their place when the positive charge is lying rigidly.

I claim—

1. A current-rectifier cell having a solid electrolyte composed of hemisulfid of copper.

2. A current-rectifier involving two electrode-plates, one of the latter being composed of aluminium, and a plate of hemisulfid of copper arranged between the two electrode-plates.

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

FRANZ PAWLOWSKI.

Witnesses:

JOSEF RUBARCH,

ALVESTO S. HOGUE.