PACKARD v. LACING STUD CO.

(Circuit Court of Appeals, First Circuit. October 18, 1895.)

No. 135.

1. PATENTS—PRIMA FACIE VALIDITY—OPERATIVE MACHINE.
The fact that no machine has been constructed and put into practical operation under a patent is not, of itself, sufficient to show that the patent is inoperative, or to overcome the prima facie presumption of its validity from the fact of its issuance. If the proofs do not overcome this presumption, and the device is of such a character, or relates to such special and peculiar subject-matters, that it does not come within the range of common experience or judicial knowledge, the prima facie showing must stand.

2. SAME—SUFFICIENCY OF SPECIFICATIONS.
Where it is claimed that a patent, under which no machine has been put into practical use, would be inoperative because of a difficulty pointed out, it is only necessary that the specification should be such that a mechanic of ordinary skill in the art should be able, by the aid thereof, to overcome such difficulty.

3. SAME—ANTICIPATION—UTILITY OF ANTICIPATING MACHINE.
Where a machine is relied on only as an anticipation of the patent in issue, it is not necessarily of importance to inquire whether the same possessed utility or not, or was in all respects patentable.

4. SAME—INVENTION—ANTICIPATION.
A patent for a combination is not necessarily invalid by reason of the fact that all its elements could be brought together by selecting parts from various known machines of the same character, though this may require a strict construction of its claims.

5. SAME—MACHINE FOR SETTING AND FEEDING LACING HOOKS.
The Eppler patent, No. 255,076, for a machine for feeding and setting lacing hooks, *held* void as to claims 1, 6, and 7, and valid as to claim 3, which is also *held* infringed by a machine made in accordance with the Smith patent, No. 309,166. 67 Fed. 115, modified.

Appeal from the Circuit Court of the United States for the District of Massachusetts.

This was a bill in equity by the Lacing Stud Company against Nathaniel R. Packard for alleged infringement of letters patent No. 255,076, issued March 14, 1882, to Andrew Eppler, Jr., for a machine for feeding and setting lacing hooks. The machine used by respondent was made according to letters patent No. 309,166, issued December 9, 1884, to Stephen N. Smith. The first, third, sixth, and seventh claims of the Eppler patent were put in issue in the case, and the circuit court held that each of these claims was valid, and was infringed by respondent's machine. 67 Fed. 115. Respondent appeals.

John L. S. Roberts, for appellant.

Frederick P. Fish and William K. Richardson, for appellee.

Before COLT and PUTNAM, Circuit Judges, and NELSON, District Judge.

PUTNAM, Circuit Judge. This is a suit on a patent for improvements in machines for feeding and setting lacing studs. The defendant below (now appellant) claims that the patented machine of the plaintiff below (now appellee) is inoperative; and, in turn, the plaintiff below claims that the alleged anticipatory machine especially relied on by the defendant was abandoned, as a failure, after a short experimental use. Questions of this character are too often pressed on the court without necessity, diverting its attention from more substantial issues. The rules touching them are well settled. They in no way take on the extreme characteristics insisted on by each side in the case at bar, and the circumstances must be very peculiar to call for their application. The appellant attempts to emphasize his position by urging that there is no evidence in the record that the appellee's machine was ever made, much less put into use. That it was constructed and put into use is alleged in the bill, but this is directly denied by the answer, and there are no proofs touching this issue; so in regard to this the appellant is to be taken as correct. But this, standing alone, falls far short of answering as an equivalent for the appellant's general proposition. If a machine has not been constructed and put into practical use, it may be difficult to determine whether it ever can be; but, notwithstanding this, the grant of the patent makes a prima facie case in this particular, and the court may not be able to find in the record proofs to overcome this presumption. When such is the fact, and when, also, the device is of such a character, or relates to such special and peculiar subject-matters, that it does not come within the range of common experience or judicial knowledge, the prima facie showing must stand. The patent at bar, on the proofs submitted, falls within these conditions. It is claimed that the machine it covers is liable to be clogged at one point so as to become inoperative; but we are referred to no proofs on this proposition, and are asked to determine it by inspection. This we cannot do, to the extent of ascertaining for ourselves that the appellee's device does not represent a completed and useful invention. We are even further from an ability to determine that a mechanic of ordinary skill in the art could not take the patented machine in issue, and, with the aid of the specification, overcome the minor difficulty to which the appellant refers. The law does not require more than this. Persons possessed of the most brilliant conceptions are sometimes the poorest mechanics. Pickering v. McCullough, 104 U. S. 310, 319; The Telephone Cases, 126 U. S. 1, 535, 536, 8 Sup. Ct. 778. Other authorities are sufficiently gathered in Robinson on Patents, at sections 128 and 129, and in the notes thereto. These remarks also apply generally to the Palmer machine. It sometimes happens that a device is abandoned for reasons wholly other than its own inherent qualities. As this machine is relied on by the appellant only as anticipatory, it is not necessarily of importance to inquire whether it possessed utility, or was in all respects patentable, and we agree with the circuit court that it cannot be classed with mere abandoned experiments.

The appellant further says that the patent in issue is what has been termed a "paper patent,"—of no use or benefit to the public, but bought for the purpose of being laid away until such time as it could be brought forth and used on some unlucky rival. We do not find in the record the proofs to sustain this claim, and therefore we need not discuss it. The record does, however, show many machines for placing various articles promiscuously in reservoirs or hoppers, with appropriate devices for selecting and feeding them automatically; and that there have long been such various devices is also a matter of common knowledge. It is also probably true that by selecting from the various known machines of that character, and indeed by selecting only from those devised with reference to lacing hooks, including especially the Palmer machine, all the elements of the patented machine in suit could be brought together. This, however, on well-settled rules, falls far short of demonstrating that appellee's device contains no patentable qualities, though it compels us to regard them as of a limited and restricted character.

Therefore, in view of these anticipations and the state of the art, we think the entire substance of the patent in controversy is in the third claim. The learned judge who tried this cause in the circuit court has fully explained this claim; and, as we agree with his exposition of it, nothing would be gained by enlarging upon it, except to add that we think it represents only an improvement in one particular over Palmer. For the reasons already given, especially in view of the Palmer machine, we think the first claim is too broad. A machine could be constructed embracing all the elements it contains, and yet be substantially the same as Palmer's. The groove is the only new element in the sixth claim. It is now sought to be supported on the proposition that it extends through the entire circle, and serves to steady the arms as they revolve. But neither the claim nor the specification indicates any such purpose, and all their requirements can be met without the groove extending over more than the lower part of the reservoir. Giving them a fair construction, their substance is found in the Palmer device. We think the set screws, which are the only element which is alleged to distinguish the seventh claim, do not create any patentable difference from the third claim, and that, therefore, the seventh is ineffectual and void.

The defendant below appealed against the whole decree. He succeeds in reversing it in some substantial parts, but not in the most important particular. Neither party has wholly prevailed here. Therefore we will follow Mason v. Graham, 23 Wall. 261, 278, where the circumstances, in that the case was in equity, and there was a substantial modification of the decree below, were more akin to the case at bar than those in Railroad Co. v. Harmon, 147 U. S. 571, 590, 13 Sup. Ct. 557. The decree of the circuit court will be modified so as to stand in favor of the plaintiff below on the third claim of the patent in suit, and in favor of the defendant below on the first, sixth, and seventh claims. The case is remanded to that court for further proceedings accordingly, and neither party will recover costs in this court.

THOMSON-HOUSTON ELECTRIC CO. v. WESTERN ELECTRIC CO. et al.[1]

(Circuit Court of Appeals, Seventh Circuit. October 7, 1895.)

No. 232.

PATENTS—ANTICIPATION—DYNAMO-ELECTRICAL MACHINES.

The Thomson and Houston patent, No. 238,315, for improvement in the regulation of currents developed by dynamo-electric machines, and consisting of devices whereby the brushes on the commutator are automatically shifted so as to control variations of the current resulting from variations in the number of lamps depending thereon, is void because of anticipation by patent No. 223,659, to the same parties, for a device for the automatic adjustment of the brushes to prevent sparking and other irregularities.

Appeal from the Circuit Court of the United States for the Northern District of Illinois.

This suit was brought by the appellant, the Thomson-Houston Electric Company, against the appellees, the Western Electric Company and Enos M. Barton, for infringement of letters patent No. 238,315, issued March 1, 1881, to Elihu Thomson and Edwin J. Houston, for a current regulator for dynamo-electric machines. Proof was made of a number of patents both in the prior and later art, but the controversy, as waged here and in the circuit court (65 Fed. 615), turns mainly upon a comparison of the patent in suit with the earlier letters, No. 223,659, granted January 20, 1880, to the same patentees. For this reason, and because they disclose the prior art, as it was known to Thomson and Houston at least, the specifications, claims, and drawings of each of these patents is given in full. They are as follows:

No. 223,659.

"Be it known that we, Elihu Thomson and Edwin J. Houston, both of the city and county of Philadelphia, Pennsylvania, have invented a novel method and device for the automatic adjusting of the collectors or brushes applied to the commutators of dynamo-electric machines, whereby an automatic adaptation to variations of circuit resistance is secured, and the burning and destructive effects of false adjustments obviated.

"It is a fact well known in the art that the greatest freedom from burning and irregular action is secured when the collecting brushes occupy a certain position, dependent in any given case on the speed of motion, and resistance interposed in the outside circuit. A variation of either the speed or the resistance occasions a necessity for readjustment of the commutator collecting strips. After an adjustment has once been made no readjustment would be required, were it practicable to maintain a uniform speed of rotation of the armature, and a constant resistance of the circuit. Attempts have hitherto been made to adjust the commutator-collectors by causing a centrifugal device to move forward said collecting brushes on an increase in the speed of rotation of the armature, and to retract or reverse said motion on a decrease in the speed of running. Such an arrangement fails in its purpose when variations in the circuit resistance are occurring at the same time. By combining the force of centrifugal action, dependent on speed, with magnetic force, dependent on current variation, a more perfectly operating device is secured. Fig. 1 shows one of the ways in which said actions may be combined for securing the automatic adjustment of the commutator collecting brushes. The commutator, K, is mounted on a rotating shaft. C, C, are the collecting brushes, applied to said commutator. A spring, S, tends to move the collectors, C, C, in the opposite direction to that of the revolution of the commutator, K, as shown by the arrow. A flexible cord, t, attached to the supports of the collecting brushes, C, C, passes around a pulley, P, supported by the lever, L. The supports of the collectors, C, C, are free to move around the commutator axis. The lever,

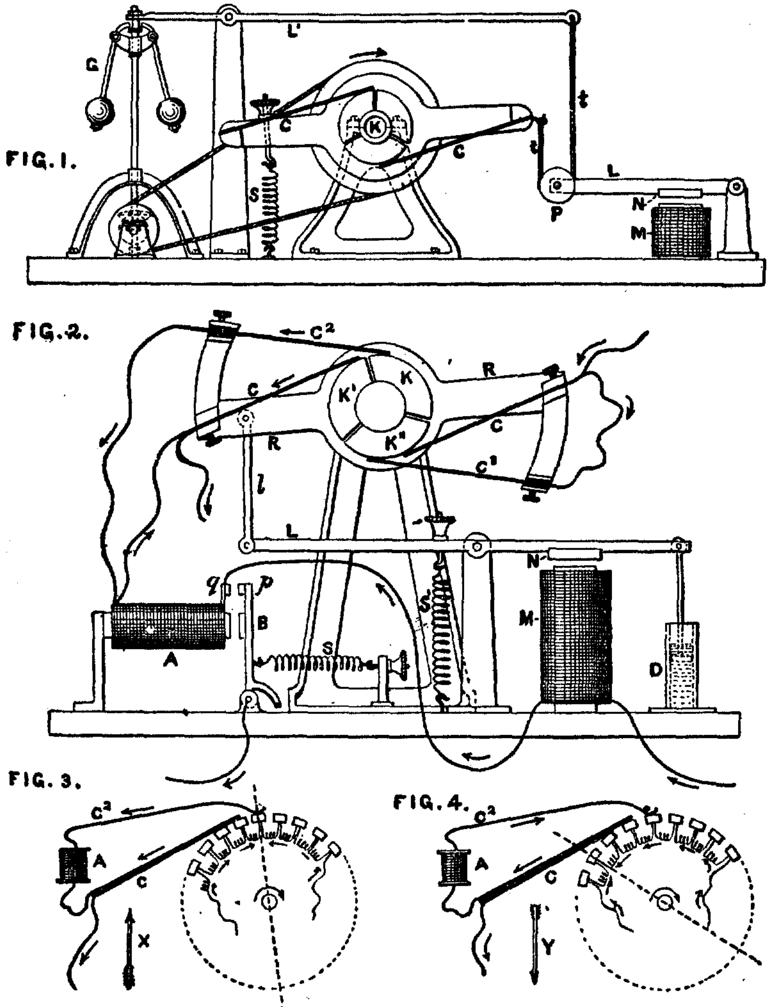
[1] Rehearing pending.

L, and pulley, P, are moved by an electro-magnet, M, whose coils are traversed by the current of the machine, or a shunted portion thereof, attracting its armature, N, as shown. The other end of the cord, t, is attached to a lever, L', the position of which is regulated by the centrifugal action of the governor, G, in a well-known manner. The adjustments are such that an increase in the current strength, or an increase in the speed of rotation, or both together, act to cause the collectors, C, C, to move forward in the direction of rotation, as shown by the arrow, and against the tension of the spring, S, which spring serves to cause an opposite motion of the collectors on a decrease in the current, or a decrease in the speed, or both; but the proper adjustment of the range of motion to be imparted in each case is an operation requiring great nicety, to obviate which we have devised a method of operating by which the amount of motion to be imparted to the collectors is directly dependent upon the action of the collectors themselves in receiving current from the commutator. We are thus enabled to dispense with the centrifugal regulation.

"The principle of our present invention may be briefly stated: We provide, in addition to the ordinary collecting brushes, small accessory brushes (one or more), which serve to receive current from the commutator segments after they have passed out of contact with the main collecting brushes. The current received by the accessory collectors passed through the coils of an electro-magnet serves to throw in or out of action any suitable motor device attached to the collecting brushes for their adjustment. After passing through said electro-magnet, the current from the accessory collector joins that from the main collector. The device for moving the commutator may be adapted to move by the current, or by the motive power, or by suitable clockwork, or other mechanism adapted to be thrown in or out of action by an electro-magnet, and constitutes, therefore, an unessential feature of the invention. In the description which follows, we have assumed that the motor device selected is to be operated by a shunted portion of the current developed by the machine, and this we find, in practice, to be a most convenient disposition for the purpose. In Fig. 2, K, K,' K," represent the segments of a commutator arranged in a suitable manner, and of which any number may be employed. C, C, are the main collectors, as ordinarily used. In addition to these, we apply accessory collectors, C^2, C^3 (one or more), which may be of much smaller width than the main collectors, C, C, and which rest upon the segments, K, K', K", somewhat in advance of the main collectors C, C, as shown. The accessory collector, C^2, which in the figure serves to operate the adjusting device, is electrically connected to the main collector corresponding thereto through the coils of an electro-magnet, A, which, attracting its armature, B, can establish electrical contact between the contact pieces, p, q, as shown. A regulable spring, S, holds the armature, B, away from the magnet, A, when no current is passing. The collectors, C^2, C^3, are mounted upon a swinging bar, R, so as to rock concentrically with the shaft bearing the commutator, K, K', K". A connecting rod, l, joins the rocking supports, R, R, of the collectors, and the lever, L, is moved by the attraction of the electro-magnet, M, upon its armature, N, against the regulable tension of the spring, S'. A dashpot, D, serves to prevent too sudden and violent change of position of the lever, L. The coils of the electro-magnet, M, are placed in a shunt-circuit through the contact points, p, q, around a part of the conducting wire of the machine—as, for example, the field-magnet coils—the object being simply by the contact of the points, p and q, to divert a sufficient portion of the current through the electro-magnet, M, for the movement of the collecting brushes, C, C, as determined by said contacts. As we have before stated, any motor device operated by the magnet, A, or its armature, B, and serving to fulfill the purpose of the magnet, M, and lever, L, may be used, as convenience determines.

"Our invention may be applied to any commutator composed of segments or conducting strips arranged around an axis, the principle of operation remaining the same. When applied to the Paccinotti commutator, in its various forms, we prefer to polarize the armature, B, or the electro-magnet, A, or both, so that on the passage of a current through the magnet, A, in

Drawings of No. 223,659.



one direction, it shall attract its armature, B, but when the current is in the other direction said armature shall be released or repelled.

"The method of operation is as follows, viz.: Assuming the segments, K and K', to be in contact at a certain part of the revolution with the brushes, C^2 and C, respectively, and that said segments are of unequal electrical potential, and in consequence the brushes, C^2 and C, respectively, in contact therewith, are also of unequal electrical potential, a current will flow during said difference of potential through the electro-magnet coils, A, tending to equalize the potentials of C^2 and C. The armature, B, is therefore attracted and the electrical contact made at p and q, thus causing current to circulate through the coils of the electro-magnet, M, which, in turn, attracts its armature, N, the lever, L, being moved thereby, and its motion transmitted to the commutator collectors, C, C, C^2, C^3, through the connecting rod, l, and the rocking supports, R, R, thus effecting such an adjustment of said collectors as will equalize their potentials, at which moment the current through the electro-magnet, A, ceases, the spring, S, breaks the contact at p, q, and the armature, N, in consequence, being released, motion in the opposite direction is begun, to be immediately checked or resumed in the former direction when a difference of potential of the brushes, C^2 and C, again manifests itself. The accessory collector, C^3, may be used, if desired, to assist C^2, or it may be directly connected to the main collector, C, or in certain cases completely dispensed with, as, with a proper adjustment effected on one side of the axis, the opposite collector may be set in a position corresponding thereto. When the brushes, C^2 and C, are thus secured of an equal potential, the operation of the commutator is characterized by the absence of burning or sparks, and other indices of irregularity. Figs. 3 and 4 exemplify the application of the accessory collector, C^2, for the automatic adjustment of the main collector, C, and when the coils of the armature are connected in a closed circuit, as in the Gramme, Siemens, or other similar forms. The dotted lines in Figs. 3 and 4 are supposed to pass through those segments on opposite sides of the commutator possessing the maximum positive and negative potentials, or through those segments at which the two branches of the circuit through the armature coils join. When, in this instance, the accessory collector, C^2, is in contact with the most positive segment, as shown in Fig. 3, the current circulates through it, and through the coils of the contact-making electro-magnet, A, to the main collector, C. In consequence of said current in the magnet, A, contact is effected between points, as in Fig. 2 (p, q), followed by an adjustment of commutator collectors, C^2, C, etc., in the direction as shown by the arrow, X (Fig. 3),—that is, in the direction of revolution of the commutator,—bringing in this manner the main collector, C, over the dotted line, or segments of greatest positive potential. If, now, from any cause, the collectors, C, C^2, are too far forward for effective action, an opposite movement of said collectors is necessary. This condition is shown in Fig. 4, where the dotted line indicating the points at which the two branches of the circuit through the armature coils join is on the other side of collector, C, from that shown in Fig. 3. In this case the current through the electro-magnet, A, is in the opposite direction to that in Fig. 3, in consequence of the accessory collector, C^2, being in contact with a commutator strip or segment less positive than C. The magnet, A, or its armature, B, being permanently polarized, as we have already stated, the current passing, as in Fig. 4, producing the opposite effect from that in Fig. 3, a readjustment of the commutator collectors, C^2 and C, takes place, as shown by the arrow, Y, (Fig. 4) opposite to the direction of revolution of the commutator, thus bringing the main collector, C, again over the segment through which the dotted line passes, viz. the segment of highest positive polarity. The closeness of these adjustments is regulated by the tension given to the spring, S (Fig. 2), which serves to modify the action of the electro-magnet, A, upon its armature in closing the contact, p, q. When the contact, p, q (Fig. 2), is open, the magnet, M, being inactive, the spring, S', moves the collectors in one direction; and when said contact is closed the magnet, M, being active, moves said collectors in the opposite direction. During normal action, however, an intermittent contact at p, q, takes place, in consequence of the constant tendency of the spring, S', to move the collectors. This results in an intermittent action of the magnet, M, just sufficient to counteract said constant tendency of the spring, S', when a slight movement of the collector has been caused by the spring. Thus, a feeble vibratory movement of the collectors is produced, moderated by the dashpot, D. A condition of equilibrium between the force of the spring, S', and the intermittent impulses of the magnet, M, is therefore assumed and maintained. By means of the adjusting device thus described, the injurious effects of closed circuits in armatures, the coils of which are connected in a continuous series, may be greatly lessened, and the construction simplified by the employment of a smaller number of coils upon said armatures. From the foregoing description, it will be readily understood that the accessory collector, C^2, serves, as it were, the purpose of a feeler, the design of which is to test the electrical condition of the segments of the commutator at the moment of leaving the collectors, and to originate from said condition an adjustment of said collectors in whatever direction is needed to secure efficient action.

"We claim:" (1) "The hereinbefore described art of automatically adjusting the collecting-brushes of a dynamo-electric machine, consisting in making said adjustment directly dependent on the electrical condition of the commutator segments on leaving said collecting-brushes." (2) "In combination with a commutator for dynamo-electric machines, an accessory collecting brush (one or more), placed in advance of the main collecting brush, the current taken up by said accessory collector being utilized in the manner substantially as shown, to determine the adjustment of the commutator collecting-brushes, and to hold said collectors in adjustment during operation." (3) "The combination, with a dynamo-electric machine, of a main collecting brush and an accessory collecting brush, connected to one another through the coils of an electro-magnetic device, by the operation of which an automatic adjustment of said collecting-brushes is effected." (4) "In a dynamo-electric machine, for the purpose of controlling the adjustment of the commutator collecting brushes, an electro-magnetic device, polarized or unpolarized, operating as a contact maker by means of the current derived from an accessory collecting brush, substantially as described." (5) "The combination in a dynamo-electric machine, with main and accessory commutator collecting brushes, of an electro-magnetic device operated by a current resulting from a difference of potential of said main and accessory collecting brushes, which electro-magnetic device serves, in turn, to operate a suitable motor for the automatic adjustment of said commutator collecting brushes." (6) "As a motor for effecting the adjustment of the commutator collecting brushes, an electro-magnet, M, traversed by the current, or a portion of the current, of the machine, whose attraction upon its armature, N, moves said commutator collecting brushes in one direction, motion in the other direction being obtained by the action of a spring, substantially as described." (7) "The combination, in a dynamo-electric machine, of a contact maker operated by the current resulting from a difference of potential of the main and accessory collecting brushes with an electro-magnetic motor placed in a shunt or derived circuit around any portion of the field-magnet coils; said shunt or derived circuit to be closed or opened by said contact maker as may be required for the automatic adjustment of the commutator collecting brushes."

No. 238,315.

"Be it known that we, Elihu Thomson and Edwin J. Houston, both of the city and county of Philadelphia, Pennsylvania, have jointly invented certain new and useful improvements in the regulation of electric currents developed by a dynamo-electric machine by a movement of its commutator-brushes, of which the following is such a description as will enable those skilled in art to make and use the same:

"The object of our invention is to provide improved means for controlling automatically the strength of an electric current flowing over a circuit composed of a dynamo-electric machine and one or more electric lamps, or other appliances, through which the current passes, and to obtain said control without the introduction of resistances, as such, and without varying the speed or field of the dynamo-electric machine, and at the same time, if desired, to utilize the reaction principle for the magnetization of said dynamo-electric machine, or, in other words, to cause the current generated to pass through the field-magnet coils. We accomplish these results at the same time that the power expended to drive the dynamo-electric machine varies directly in accordance with the changed resistance of its circuit; being less as the resistance is less, and greater as the resistance is greater. Let us suppose, for the purpose of elucidating the principles of our invention, a dynamo-electric machine running at a constant speed, and having in its circuit twelve lamps of the arc type; the current from the machine passing successively through all the lamps, and through the field magnets of the machine. If the electrical resistance of the circuit remains uniform, the current will remain uniform. Let, now, half of the lamps be removed from the circuit, by switching around them, in the ordinary manner. The resistance of the circuit being thus rendered much less than before, the current produced will be greatly increased; increasing the intensity of the light from the remaining six lamps, throwing a great strain upon the motive power, caused by the increased current, due to the circuit being of small resistance, and giving rise to heating of the wire coils of the machine, and other disadvantages. If all the lamps but one be cut out of the circuit, these disadvantageous effects are enormously intensified, from the machine running on an almost short circuit. Yet, in practice, it is often desirable to reduce the light-giving capacity of a machine so as to either diminish the amount of light given out in each lamp, or to reduce the number of lamps in the circuit. The latter result has heretofore been accomplished by the introduction into the circuit, in place of the unused lamps, of equivalent resistances of iron wire, or the like, or by modifying the speed of the machine, or by changing the field-magnet circuit, or the current traversing it. The first method, or that of resistance substitution, requires that the same power be expended whether all or but few of the lights be used; the second method is impracticable for continuous running; while the third involves special construction of the machine, or the use of apparatus which greatly complicates the working, and requires frequent adjustment of the commutator to be made, to avoid short-circuiting. In the improved system of operation provided by our present invention, we possess the ability to cut out lamp after lamp from circuit, and yet maintain a uniform current strength in the remaining lamps, and economy of motive power proportional to the diminished resistance, while the normal light-giving power of each lamp not cut out is maintained, and an absence of heating, or necessity for any other adjustments than those at the commutator of the machine, obviated. These adjustments are preferably made automatic, for we find that with the commutator used by us, as herein specified, a proper adjustment of the commutator being effected when a certain resistance is in circuit, a similar adjustment will, when the resistance is changed, give the same current. In our system we have employed a dynamo-electric machine in which the commutator is constructed of three insulated segments of a ring connected to three armature coils. The collecting brushes applied to said commutator are supported so as to be movable around the commutator without changing the relative positions of the two collectors. This movement of the collecting brushes is well known in the art.

"Fig. 1 shows a commutator consisting of three insulated segments, K', K", K"', and supposedly attached to the armature coils in accordance with our former inventions. Bearing upon the commutator segments, and parallel and opposite to each other, are two strips of metal, C, C', for conducting off the current from the segments, and called 'commutator collecting brushes.' The slot between or separating two segments, K', K", is made at an oblique angle, as shown. When the two ends of a slot are angularly displaced with respect to each other, twenty to thirty degrees circumferentially around the commutator, a single pair of collecting-brushes is used, the planes of which are tangent to the circumference of the commutator at opposite points, and parallel to each other, as before stated. These collecting brushes are supported on a bar, B, B (Fig. 1), moving concentrically with the center of the commutator, and enabling the collectors, C, C', to be placed in different positions relatively to the commutator segments, while still remaining in the same positions relatively to each other. The ends of the bar, B, B, describe the arcs shown in the dotted lines. The supposed direction of revolution of the commutator is shown by the arrow. The collectors, C, C', are mounted so as to be insulated from each other, and the current discharged into said collectors from the armature coils and segments, K', K", and K"', attached to them, passes from said collectors to the coils of field magnets of the machine (indicated by M, M), and thence also into the circuit of the lamps, six of which are indicated as 1, 2, 3, 4, 5, and 6. At each lamp is placed a switch, S, by which any of them may be shunted round, or cut out of, the circuit. When the six lamps are being used, the collectors, C, C', are adjusted to the proper position, as to absence of spark, and other irregularities, and to carry off the current of the nor-

Drawings of No. 238,315.

FIG. 1.

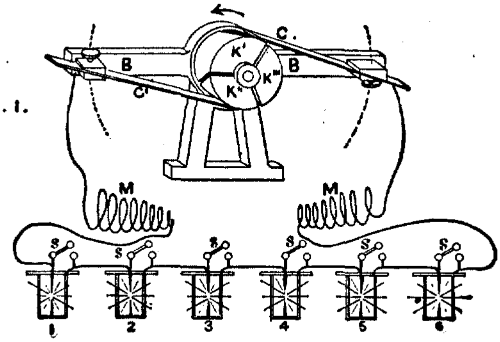


Fig: 2.

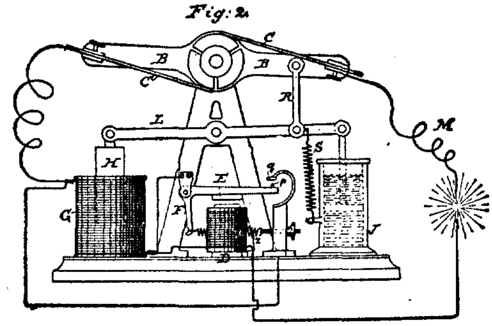


Fig: 3.

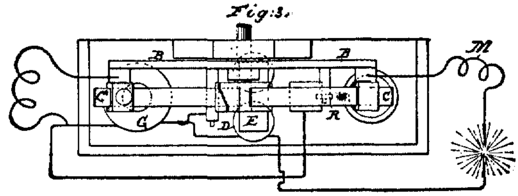
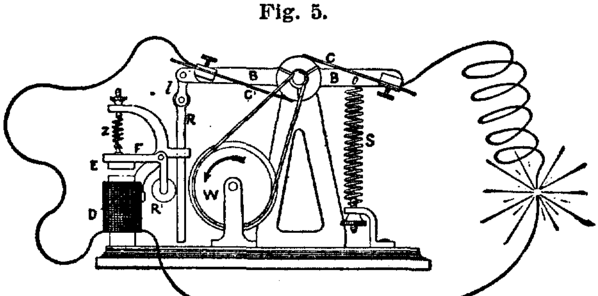


Fig. 5.



mal working strength. Supposing, now, that three of the switches be closed, so as to remove half the number of lamps, a movement of the commutator collectors, C, C', forward in the direction of revolution of the commutator restores the current to its former working strength; and, even though all the lamps but one be switched from the circuit, we find that a similar movement may be given to the collectors, and that they may be set in such position as to discharge into the circuit a current of only the normal working strength. Any number of lamps in circuit may thus be put out of use, and a position of the commutator collectors found which will restore the normal current strength.

"We are aware that in the operation of commutators of the Paccinotti type, such as the Gramme, Siemens, and the like, where the coils on the armature are numerous, and connected in closed circuit, end to end, a movement forward or backward of the commutator collecting brushes around said commutator from the position of maximum effect, or the position when the commutator segments that are simultaneously in contact with a collecting brush are of equal potential, results in decreased current; but the variation of the current so obtained is attended with damaging short-circuiting of the coils of the armature,—a fact well known in the operation of such commutators when the position of equal potential mentioned is not maintained. In our system, short-circuiting of the armature coils is prevented. When the amount of separation of the carbon electrodes or length of arc of the lamps used in our system varies with the current strength, increasing or decreasing therewith, we are enabled, simply by changing the position of the commutator collecting-brushes, to vary the amount of current passing through the lamps, and hence their light-giving power. In practice, therefore, by a single movement of the commutator collectors, C, C', we are enabled to turn up or down the lights in the circuit. A motion in the direction of revolution, or in the direction of the arrow (Fig. 1), diminishes the current-producing power of the machine, while motion in the opposite direction increases it. These results are accomplished with a consumption of power depending on the electro-motive force of the current produced, and without short-circuiting any of the armature coils. We are not aware that these results, unattended by injurious effects, such as waste of power and short-circuiting, have ever before been realized.

"The principle upon which our system is founded is substantially as follows: During revolution the commutator segments have positions one hundred and eighty degrees from each other, of maximum positive and maximum negative polarity, respectively. When the collectors, C, C', are set for the normal current, with the total number of lamps in circuit, the segments, K', K'', K''', will break contact with the collectors, C, C', shortly after passing their positions of maximum electro-motive force. On removing some of the lamps from the circuit, the current is increased, but may be restored to its normal strength by placing the commutator collectors, C, C', in such position that segments are in contact with them when the electro-motive force is below its maximum, this being accomplished by moving the collectors forward in the direction of revolution. The ability to so vary the electro-motive force by a simple motion forward of the commutator collectors in an armature coil system with three branches results from the fact that, for the major part of the revolution, but two armature coils and their corresponding segments, as K' and K'', are in connection with said brushes; the electro-motive force of the current produced in the armature being, when both armature coils—as those attached to K' and K'', respectively—are acting in the same direction to produce current, the sum of their electro-motive forces, and when they are acting oppositely to each other, as when the commutator brushes are placed far forward in the direction of revolution, the difference of their electro-motive forces. In this latter case the segment, as K', may leave the collecting brush, C, even after the armature coil to one terminal of which said segment is attached has passed beyond the neutral point; the current in said coil being prevented from reversing at the neutral point by the superior electro-motive force of the other armature coil, with which, for the time, it is conjointly acting, as that armature coil one terminal of which is attached to K''. The moments when all three segments and their corresponding armature coils are simultaneously in direct contact with the collecting brushes correspond to the times when either of the collecting brushes, C, C', is over a slot between any two segments. At this moment a transfer of the current takes place from the coil and segment, leaving the commutator brush to the succeeding coil and segment coming into contact therewith, which transfer is repeated at every slot in the commutator. This transfer occupies an appreciable time, and the current produced is due to the resultant action between the coils in their maximum position operating in conjunction with coils that have either passed, or have not attained, that position, when in circuit with the collectors, C, C'.

"We have hereinbefore described our method of regulating the strength of the current traversing the circuit by a movement of the commutator collecting brushes, so that whatever be the number of lamps in the circuit, up to the maximum, the normal current strength may be obtained; but as, in practice, the lamps are generally at a distance from the dynamo-electric machine furnishing the current, and as the switching out of circuit of one or more of the lamps would necessitate an adjustment of the commutator-brushes, as before described, we prefer to effect said adjustment automatically, and without the introduction of resistance coils, and maintain, notwithstanding changes in the number of lamps used upon the circuit, a practically uniform current strength without requiring the attendance of the operator. We find in practice, moreover, that we obtain with this automatic regulation of the current strength an independence of speed variations in the machine, it being only necessary to so adjust the speed of running that when the speed is at its lowest the machine shall yet be sufficient in power to maintain the number of lights placed in its circuit. We are therefore able to operate successfully under conditions of motive-power variations that have hitherto been recognized as fatal to steadiness of light obtained.

"In United States patent No. 223,659 (January 20, 1880) before referred to, we have described a means of automatically adjusting the commutator collectors of dynamo-electric machines, which method is adaptable to the present case of current regulation. When a single pair of commutator collectors, C, C', are employed with an inclined or angularly slotted commutator, as hereinbefore mentioned, the current of the machine is caused to traverse an electro-magnet, the variations in the power of which current and magnet either directly or indirectly serve to effect the adjustment of the commutator collectors, with or without centrifugal regulation, in a similar way to that shown and described in patent No. 223,659, before referred to. The regulation of the current strength is readily obtained by causing the main current of the machine, or a shunted portion thereof, to traverse an electro-magnetic controlling device, operating to throw into or out of action an electro-magnet or equivalent motor device, which, in turn, imparts motion to the commutator collecting brushes. As in our former invention, already referred to, the motor device used may be adapted to move by the current, or by the motive power, or by suitable clockwork, or other mechanism adapted to be thrown in or out of action by an electro-magnet, and constitutes, as before, a minor feature of our present system. Our present method of operating, therefore, so far as it relates to automatic regulation, is based upon the same principles of operation as our previous invention; and it consists in an improved construction and mode of use of the apparatus employed in patent No. 223,659.

"In Fig. 2 the direct current of the machine is conveyed through the coils of the electro-magnet, D, placed in the circuit of the machine at any convenient point. Its armature, E, is suitably supported so as to be movable to and from the electro-magnet, as by the lever, F, and held away from the magnet by an adjustable spring, Z. Two contact pieces, p, q, are provided, adapted to be closed or opened by movements of the lever, F, due to variations in the power of the electro-magnet, D, following changes in the current. The contact pieces, p, q, serve as a shunt of small resistance or short circuit around an electro-magnetic coil, G, provided with a movable core, H, suitably supported in the axis of the coil. The core, H, is hung upon a lever, L, connected by a rod, R, with the swinging bar, B, B, of the commutator collecting brushes; a dashpot, J, being provided to prevent too sudden and violent motions of the lever. Variations in the magnetic pull of the coil, G, upon its iron core, H, opposed by the action of spring, S, or equivalent counterbalance weight, imparts motions to said core, which motions are, in turn, imparted by the rod, R, to the supports of the commutator collecting brushes, C, C', thus varying their position with respect to the segments of the commutator.

"The mode of operation is substantially as follows: The cutting out of one or more lamps from the circuit of the machine, or an increase in the speed of rotation of the latter, causes a corresponding increase in the current traversing the circuit of which the coils of the electro-magnet, D, form a part, and a necessity for readjustment of the commutator brushes to prevent a continued increased current and sparks at the commutator. The increased attraction upon the armature, E, opposed by the spring, Z, opens the contacts, p, q, diverting the current of the machine through the coil, G, which, in attracting its core, H, readjusts the collecting brushes, C, C', thus bringing the current strength again to the normal, at which moment the armature E, is released by the magnet, D, and the contacts, p, q, are again closed, and are ready to allow the same action to be repeated on a further increase of current strength. On the decrease in the current strength, due to any cause, the armature, E, not being attracted sufficiently to open the contacts, p, q, the current is diverted through them from the coil, G, which, failing to attract its core, H, a counteracting spring, S, moves the commutator-collectors, C, C', so as to increase the current, or raise it to the normal. A dashpot, J, with oil or glycerine, prevents violent motions of the lever, L; and during normal action a sufficient number of makes and breaks at the contacts, p, q, occur to maintain the current at its proper strength, and the collectors, C, C', in their proper position to maintain that strength, and avoid injurious burning. An automatic readjustment of position is thus made to follow every removal of a lamp from, or introduction into, the circuit.

"Fig. 3 is a plan of the parts shown in Fig. 2, the parts visible in said plan being designated by similar letters to those in Fig. 2, as described.

"In Fig. 2 the various parts are shown as occupying positions separate from one another; but in practice we sometimes combine the motor coil, G, and core, H, with the rod, R, dashpot, J, and spring, S, into a single, compact device. This combined device forms the subject of a separate application for letters patent.

"The magnet, D, and armature, E (Fig. 2), instead of acting to open and close contacts, p, q, may serve to throw in and out of action a mechanical motor device by movements imparted to a friction clutch, or its equivalent. In this case the power which moves the commutator collectors or brushes is obtained either directly from the rotary motion of the machine, or by clockwork, or other suitable mechanism, thrown in or out of action by variations in the strength of the current traversing the magnet, D. As a type of this modified use of the controlling electro-magnet, D, we refer to Fig. 5. The coils of the electro-magnet, D, are, as before, placed in any convenient part of the circuit of the machine. The armature, E, is mounted upon a lever, F, suitably supported, and free to move. The lever, F, bears a roller, R', against which hangs the rod, R, attached to the swinging support, B, B, of the commutators. Held by a spring, Z, away from the magnet, D, the armature, E, is free to respond to variations of its attraction. The rod, R, is suitably guided and attached to B, B, by a double point or link. A wheel or roller, W, rotated in the direction of the arrow by any suitable means, is placed at a small interval from the rod, R, as shown, so that the rod, R, is almost a tangent thereto. A band of rubber preferably surrounds the edge of the wheel, W. The remaining parts, S, B, B, and C, C', are as in Fig. 2, and serve the same functions.

"The operation is essentially as follows: On an abnormal increase of the current strength, the magnet, D, attracts its armature, E, and so moves the lever, F, as to throw the rod, R, against the periphery of the rotating wheel, W. The friction of the wheel, W, upon the rod, R, so produced, results in a movement of the rod, R, and the parts to which it is attached, against the elastic force of the spring, S, resulting in a readjustment of the collectors, C, C', as hereinbefore described. A corresponding decrease of the current strength, and release of the armature, E, the rod, R, being thown out of frictional contact with the wheel, W, by the spring, Z, is followed by a readjustment in the contrary direction by the action of the spring, S. In practice, a position of equilibrium is soon attained between the counteracting influences, such as to maintain the current at a practically normal working strength.

"We claim: (1) In a current regulator for a dynamo-electric machine, the combination of a device responding to changes in the main or generated current, a shifting commutator for said machine, and mechanism controlled by said responsive device to shift the commutator to those positions where the current taken up by said commutator shall be constant. (2) In a current regulator for a dynamo-electric machine, an electro-magnetic device acted upon by variations in the main or generated current, an adjustable or shifting commutator for the machine, and mechanism controlled by said electro-magnetic device to adjust the commutator to those positions where the main or generated current taken up by said commutator shall be constant."

The following summary statement of the prior art is taken from the testimony of Mr. Charles E. Scribner, an expert of conceded intelligence and skill, who was examined in behalf of the appellees: "To recapitulate, there are two ways by which current regulation may be obtained: (1) By varying the circuit resistance, which plan has been employed since 1878, both manually and automatically; such employment, however, not having been so extensive of late years as that of the other method, which is the more economical. This is best shown in Siemen's patent, No. 229,922, of July 13, 1880. (2) By varying the electro-motive force, which method has had a very extended use since 1878, manually, and since 1879, automatically. There are three ways in which the electro-motive force of a dynamo may be thus regulated: (a) Varying the speed of rotation of the armature of the dynamo. (b) Varying the strength of the field of magnetism. (c) By varying the length of the armature wire which is producing the electro-motive force, which is always accomplished by shifting the brushes. The method of automatically regulating by automatically controlling the speed of the armature is shown in patent 205,305, of June 25, 1878, to Sawyer and Man; also, in English patent No. 4,705, of November 19, 1878, to Frederick John Cheesbrough; and in various publications. The method of automatically regulating the current by varying the strength of the field magnetism is shown in patent 224,511, of February 17, 1880, to Charles F. Brush, and in other publications. The method of regulating the current by varying the length of the armature wire which is producing the electro-motive force is shown, as employed manually, in patents 211,311, of January 14, 1879, and 233,823, of October 26, 1880, both to Edward Weston; and, as employed automatically, in patent 223,659, of January 20, 1880, to Thomson and Houston, and patent 228,543, of June 8, 1880, to Hiram S. Maxim; and in other publications. In each instance of automatic regulation of the electro-motive force, and thereby the current, a responsive device connected with the main current of the dynamo has been employed; such device controlling the supply of current to maintain it constant upon any variation of the current taking place, from any cause. Of the three methods of regulating the electro-motive force, and thereby the current of a dynamo machine, the most efficient, in the economy of power, is the method of regulating by varying the strength of the field magnets by cutting into and out of circuit a portion of the field-magnet coils, as shown in the patent to Brush, No. 224,511 (February 17, 1880)."

A general knowledge of electric dynamos, and of their modes of operation, is assumed. They have been elaborately explained, both by the experts and by counsel, with all the clearness possible, probably, for subjects so abstruse; but it is not deemed necessary, and, within reasonable limits, it would be impracticable, to follow, step by step, the excursions which have been made into the tangled fields, from which the judge below was constrained to confess that he came back more bewildered than enlightened. The essence and the intricacy of the case are to be found, and are sufficiently illustrated, in the following questions by Mr. Taylor, and answers from the cross-examination of Mr. Scribner, whom counsel have called the "architect of the defendants' case," and whose accuracy, in most particulars, is conceded:

"C. Q. 31. If I understand your theory of the operation of the apparatus of Fig. 2 of patent 223,659, when applied to a series dynamo running at constant speed under varying load, it is substantially this: (1) A change in the external resistance causes a change in the main current of the machine. (2) The change thus produced in the main current of the machine causes a change in the relative potential of the adjacent commutator segments under the brushes. (3) This change in the relative potential of the adjacent segments causes a change in the current flowing in the accessory circuit and through the magnet, A. (4) By the changes of current thus produced in magnet, A, its contact points, p, q, are opened or closed, as the case may be, and the motor mechanism thus set in operation to move the brushes backward or forward, as the case may require, to bring them to that position on the commutator where there will be the least difference of potential between the adjacent segments under the brushes. Is that substantially correct? A. My theory of the mode of operation of this apparatus, constructed in accordance with the patent, and operated upon such a dynamo, I have arrived at by a study both of the patent, and of the apparatus in operation. Magnet, A, in operation, is at all times in a position of some difference of potential between adjacent segments. This difference of potential is varied by variations of the current strength. It is increased upon an increase of the current strength, and decreased upon a decrease of the current strength. The change of main current, pointed out in paragraph numbered 1 in your question, causes a change in the difference of potential, as pointed out in your second paragraph, and this change causes a change in the current flowing in the magnet, A, as stated in the third paragraph; and the effect of this is to move the brushes backward and forward, as may be required, to bring them to that position on the commutator where such a condition of difference of potential may exist between adjacent segments as will effect an intermittent opening and closing of contact points, p, q, to maintain the brushes in feeble vibration at the point upon the commutator where the commutator segments are substantially of equal potential at the instant such segments pass out of contact with the brush. This results in the maintenance between the brushes, main and accessory, of substantially constant difference of potential for variations of circuit resistance, the amount of difference depending upon the particular machine upon which the apparatus is employed, and upon other conditions.

"C. Q. 32. It was my desire to make the question a fair and exact statement of the whole operation involved in the use of the apparatus of Fig. 2 of patent 223,659, according to your view of it, as expressed in various connections in your preceding testimony. You will see that it is not assumed in the question that there will ever be a condition in which there will be absolutely no difference of potential between the adjacent segments, or absolutely no current in magnet, A. On the contrary, subdivisions two and three assume that such difference of potential and current will always exist, in some degree, subject to variation by the causes stated. I gather from your answer that the fourth subdivision of my question does not express the idea which I intended to convey with absolute exactness, and so I will amend that subdivision to read as follows: '(4) By the changes of current thus produced in magnet, A, its contact points, p, q, are opened or closed, as the case may be, and the motor mechanism thus set in operation to move the brushes backward or forward, as the case may require, to bring them to that position on the commutator where there will be the predetermined minimum difference of potential between the adjacent segments under the brushes at the instant of separation between the main brush and the forward segment.' With the explanation thus given, and the amendment thus made, does my question fairly express your theory of the operation of the apparatus? A. The amendment of the fourth subdivision of your previous question brings the matter under what may be termed instantaneous observation, and while it provides for a condition of things occurring at one instant for every segment in rotation with relation to the accessory brush, it does not provide for the average condition of difference of potential between adjacent segments observed during operation. A dynamo in operation has its adjacent segments at the same potential only at the precise instant of time when a condition of balance is created between the different coils of the armature and the main circuit. If we consider the action as it occurs in the operation of a dynamo, and observe the condition between adjacent segments when they are passing under a two-part commutator brush, we find that when the two segments have, in their rotation, first arrived at the position of contact with the two brushes, there will be a positive difference of potential between the two segments. As the armature advances, and commutation is effected, this difference of potential decreases; and, as the armature further advances, this difference of potential arrives at its practical minimum at the precise instant of time when the forward segment breaks contact from the forward brush during its rotation. This results in an average difference of potential between adjacent segments for the period of this excursion under the brushes, and this average difference of potential may vary as the apparatus of the adjuster is applied to different machines. It may vary with the same machine as the spread of the two brushes, main and accessory, is varied. The fourth subdivision of your former question, failing to take cognizance of this condition of practice, called for the extended answer I gave. Your amended fourth subdivision, assuming a condition which occurs only at one instant of time, and continues only during the time occupied by a point in passing a point, will not permit a categorical answer to the question.

"C. Q. 33. I see the propriety of your criticism, and I will restate subdivision 4 of my question to read as follows: '(4) By the changes of current thus produced in magnet, A, its contact points, p, q, are opened or closed, as the case may be, and the motor mechanism thus set in operation to move the brushes backward or forward, as the case may require, to bring them to that average difference of potential between the adjacent segments under the brushes which will result in securing the minimum of difference of potential at the instant of the separation of the forward segment and the main brush, and so securing a practical minimum of sparking.' Is this a substantially correct statement of that part of the operation covered by subdivision 4 of my question, according to your views? A. It is.

"C. Q. 34. You have, in your testimony in this case, described the operation of a number of devices exhibited as reproductions of the apparatus of Fig. 2 of patent 223,659,—some of them by the complainant, and some by the defendants; and you have stated, I believe, that in every such case the mode of operation of the device, when applied to a series dynamo running under varying load, was, in your opinion, the same as the mode of operation of the apparatus of the patent in suit, as therein set out. Did you, in the expression of that opinion in all these cases, have in mind the mode of operation of the apparatus of Fig. 2 of patent 223,659, set out in my C. Q. 31, as amended in my last preceding question? A. I certainly had in mind the mode of operation of the apparatus as it had been observed, and the mode of operation as pointed out in your last question is substantially that of the apparatus as I witnessed it in operation. This mode of operation, as pointed out in your previous question, subdivision 4, and C. Q. 31, subdivisions 1, 2, 3, of the apparatus 223,659, employed in connection with a series arc-lighting dynamo, is the mode of operation of the apparatus of the patent in suit: (1) A change in the external resistance causes a change in the main current of the machine. (2) The change thus produced in the main current of the machine causes a change in the relative potential of the adjacent commutator segments under the brushes. In the patent in suit there are but two brushes upon a three-part commutator, and these brushes always rest upon adjacent commutator segments. (3) This change in the relative potential of these adjacent segments causes a change in the current flowing through the magnet in the patent in suit which corresponds with magnet, A, of patent 223,659. (4) By the changes of current thus produced in this responsive magnet, its contact points, p, q, are opened or closed, as the case may be, and the motor mechanism thus set in operation to move the brushes backward or forward, as the case may require, to bring them to that position on the commutator where there will be the same difference of potential between the adjacent segments under one of the collecting brushes as will secure the minimum difference of potential at the instant of separation of the forward segments and the main brush, and so secure a practical minimum of sparking. In the patent in suit the difference of potential between the two terminals of the responsive electro-magnet is maintained constant by this mode of operation; it being placed in the main current, and this effect taken advantage of. In patent 223,659 the difference of potential between the terminals of electro-magnet, A, is also maintained constant, and the same advantage is taken of this effect to control the operation of the apparatus. The mode of operation of both depends upon the capacity of the responsive magnets to maintain a constant difference of potential at their terminals by their control of the shifting brushes.

"C. Q. 35. Professor Cross states that in the spark-adjuster apparatus constructed under his direction the resistance in the accessory and main circuits was such, to the point of their junction, relatively, that, when the accessory and main brushes were connected in parallel with the same source of current, no appreciable current flowed in the accessory circuit; and you have stated that in one of the spark adjusters constructed by you the same relation existed. I will ask you whether or not, in your opinion, this is a proper feature of construction to be given to the apparatus of Fig. 4, of patent 223,659, in order to give effect to the mode of operation set forth in that patent? A. If we assume the brush, C, shown in Fig. 2 of patent 223,659, to have an appreciable resistance, then magnet, A, might be varied in resistance through the ordinary range of magnet winding, and no appreciable current would flow through it, under the conditions mentioned in your question. It is only upon the assumption that an appreciable resistance is had in the path through the main brush, C, to the junction of the two circuits, that proportioning of the resistance of magnet, A, to the resistance of the main brush circuit would have any effect. As to the propriety of proportioning these resistances, the patent gives no information upon which to base an opinion. The proportioning of these resistances, one way or the other, would not necessarily affect the mode of operation of the apparatus. I believe Professor Cross has expressed substantially the same opinion in his answer to C. Q. 236, 237, and 338, page 819 of complainant's record.

"C. Q. 36. I take it from your answer that you regard the method of construction pointed out in my last question as a proper, but not, in your opinion, necessary, method of construction, in order to realize the invention of the patent. Am I correct in this? A. I do not think that the patent contemplates any proportioning whatever of these paths. That a proportioning of these paths to secure the result of no current in the accessory circuit might be had, which would be improper, is quite certain. If the resistance of the accessory path were proportioned so high, relatively to the main circuit, as to prevent effective current to flow through the accessory circuit, even when the main and accessory brushes were on different segments, we would have an improper construction of this apparatus. It may be so proportioned with respect to these resistances as to insure proper construction, and the invention of the patent realized. The same adjuster, applied to one machine, and submitted to this storage-battery test under consideration, might be found to be properly proportioned for that machine, but when submitted to the same test with another machine, although fulfilling the requirements of the test as before (that is, having no current through magnet, A, under the conditions named), would now be found to be improperly proportioned, and possibly inoperative upon the new machine.

"C. Q. 37. I think, possibly, you have taken my question in a sense which I did not intend. What is the resistance, or is there any, of appreciable amount, in the main brush itself, including the resistance of its contact with the commutator upon the dynamo, as ordinarily used? A. There is an appreciable resistance in the main brushes, and their contacts with the commutator segments in rotation; the amount of this resistance depending upon the condition of the commutator cylinder, upon the length and cross section and material of the main brushes. I should say this resistance might be as high as one-tenth of an ohm, possibly higher. I think, in the Brush dynamo, it might be found to be higher, and in the old forms of the Thomson and

Houston dynamo as well, although I cannot speak with positiveness upon this point.

"C. Q. 38. In order that the current flowing in magnet, A, shall be due at all times to the difference of potential between two adjacent commutator segments,—one in contact with the main brush, and the other with the accessory brush,—it is necessary, is it not, that the resistance of the accessory circuit shall be sufficient to exclude all appreciable current from it when the two brushes are connected in parallel with the same source of current? A. If I understand your question, the meaning of which is a little uncertain to me, I must say that I do not think that this is necessarily so.

"C. Q. 39. If there is not this relative difference between the resistance of the accessory circuit and the main brush circuit, will not the accessory brush act, in effect, as a mere subdivision of the main brush, and take up more or less current which is not immediately due to the difference of potential between the two adjacent commutator segments under the brushes? A. Even if there is this relative difference between the resistances of the accessory circuit and the main brush circuit, some current will flow in the accessory circuit when the two brushes are on the same segment, as a result of the self-induction of the magnet, A. Your present question, and the one preceding it, call for a consideration of the operation of this adjuster apparatus from instantaneous views of the same at two different moments during the rotation of the commutator; one instantaneous observation being had at a moment when the main and accessory brushes are on different commutator segments, the other instantaneous observation being made when these two brushes are in contact with the same segments. The electro-magnet, A, in operating to open and close contact points, p, q, requires, in order to operate these points, sufficient current to enable its magnetism to overcome the pull of the retractile spring, S, of the armature. When there is a sufficient difference of potential between the main and accessory brushes, by reason of their resting upon adjacent commutator segments, to give sufficient current to magnet, A, to overcome the pull of spring, S, then the contacts, p, q, would be operated, and the brushes adjusted in response. When both brushes are on the same segment, if the resistance of the circuit of the main brush should be so great as to still create a difference of potential between the ends of magnet, A, current would flow through magnet, A, as a result of that difference of potential. If, now, this difference of potential, and the current resulting from it, is of less value than that secured when the brushes are on adjacent segments, then magnet, A, would not be strong enough to overcome the retractile spring, S, and no effect of adjustment of the brushes would be had. Magnet, A, before it can operate to move the brushes through the control it has over the motor mechanism, must have sufficient current flowing through it to overcome this retractile spring, S, thus closing contact points, p, q. Any current flowing through this magnet, of less strength than that required to overcome spring, S, would be of no substantial effect upon the action of the apparatus. It would be, in a measure, like the polarizing of electro-magnet, A, simply creating a condition of magnetic tension in this magnet, the real control and operation of the magnet being dependent upon the current resulting from the larger differences of potential to be found when the brushes are upon adjacent segments. At the moment of either of these two instantaneous observations of the apparatus, the current which flows in magnet, A, results from a difference of potential between the two brushes; in the one case the difference of potential being caused by the brushes resting upon different portions of the commutator at which there is a difference of pressure, and in the other case the difference of potential results from a difference in the resistance of the two paths through which the current of the machine may flow.

"C. Q. 40. I think I understand your answer, and I gather from it that, in your opinion, there might always be found flowing in the accessory circuit some current other than that due wholly to the difference of potential between the adjacent segments; that the effective operation of the apparatus would not depend on that current (which might be more or less without materially changing the result), but upon the variable current produced by the variable difference of potential between adjacent segments. Am I right?

A. In my answer to your last preceding question, I sought to make it clear that a material current might flow in magnet, A, without substantially changing the mode of operation of the apparatus, if this current were of less value than that resulting from the differences of potential between adjacent segments. Of course, the presence of such currents would have an effect upon magnet, A, to magnetize it; but the control of magnet, A, over the movements of the adjuster, would be determined by the changing of its condition through the variations of potential difference of adjacent segments. With this explanation, I answer your question in the affirmative.

"C. Q. 41. Why is it that a change of the strength of the main current changes the relative potential of the adjacent segments of the commutator under the brush? A. I have, I think, answered this question in my consideration of the subject of the actions which take place in a dynamo under changes of circuit resistance, in my first deposition in this case; for example, in answers to interrogatories 4 and 10. I will endeavor to make a brief answer to your question. The current of most dynamo machines is the result of the sum of the differences of potential of several coils upon the armature. In the Thomson-Houston three-coil dynamo, the current is the result of the difference of potential of two coils at any one time. The difference of potential that exists at a given moment between the two ends of any particular coil of the machine is determined by its own electromotive force, which is at that moment generating, modified by the difference of potential of all of the other coils of the machine, together with the condition of circuit resistance that exists at this moment. The difference of potential that exists at any moment is thus controlled. If we consider the actions which take place in a dynamo machine during the period of rotation of the armature when the two brushes of a pair are on adjacent segments, the condition which will prevail at the tips of these two brushes will depend upon the electromotive force of the coil upon whose segments the brushes rest, upon the electromotive force of all of the other coils of the armature, upon the resistance in the main circuit operated by the machine, and upon the resistance of the different coils of the machine. A variation from the prevailing condition at this moment occurs, as a result of a variation of the circuit resistance, or by a variation of the speed of the dynamo, either of which variations produces a different condition of potential strength at the different coils of the machine, including the coils upon whose segments the brushes are supposed to rest. It is thus that a variation of the speed of the machine, or a variation of circuit resistance, by varying the strength of the current of the main circuit and the current flowing in the coils of the armature, causes a change of current in an accessory circuit derived from the armature.

"C. Q. 42. The summary which you have given in your last answer is not intended to modify or change the views expressed by you in your former deposition, to which you have referred, is it? A. I have answered this last preceding question without reference to the correctness or incorrectness of any opinion as expressed by me in giving my former testimony in this case. My answer is based entirely upon my understanding of the matter as arrived at after several years of careful study of this subject. It is even possible that I may have, in the past two years, somewhat modified my opinion on subjects treated of in my earlier deposition. If it is your wish that I should examine that deposition, and make corrections in the testimony, based upon my later investigations, I shall be glad to do so.

"C. Q. 43. I do not know that it is necessary, for the present inquiry, to go over so much ground as was occupied in your former discussion of the subject. All that I care for is to be sure that I understand your views upon some particular points. From your former deposition, I have gathered the impression that the prevention of spark at the commutator depends upon the introduction of the coil, which is at that instant changing its relation from one side of the dynamo to the other, in such a manner that it shall not produce any shock, or offer any resistance to the flow of the current which is being generated upon that side of the dynamo into which the coil is being introduced, and that this requires that the current in the incoming coil, due to its self-induction, shall have been extinguished, and its ohmic resistance overcome, and a current set up in it equal in value to the current which it is to receive from that side of the dynamo into which it is entering by the instant at which the forward tip, or the forward commutator brush, breaks contact with the leaving segment, so that the current of the dynamo shall find at that instant in the newly-introduced coil a path of no resistance. Is that substantially correct? A. I think you have obtained a substantially correct impression of the explanation I have made of the cause of sparking. A coil in that portion of the armature, traveling under the influence of one pole of the field, has current flowing in it resulting from a difference of potential caused by such motion. This same coil, passing out of the influence of the first field, and into the influence of the other field, has current flowing through it in a reverse direction. It is in the transposition of the coil from one field to the other that the changes pointed out in your question are taking place; and the overlap of the brushes, and the adjustment of the brushes upon the commutator with relation to the strength of the current flowing in the other coils and in the main circuit, and the resistance included in the main circuit, determine the instant when the necessary condition pointed out in your question shall be arrived at.

"C. Q. 44. During the time that these changes are taking place, it is necessary, is it not, that the incoming coil shall be short-circuited by contact of the brush with the two adjacent commutator segments into which its terminals are connected? A. Yes; or by some equivalent means.

"C. Q. 45. The length of time necessary to effect these changes in the incoming coil—that is, to extinguish its current due to self-induction, overcome its ohmic resistance, and set up in it a current equal in value to the current of the dynamo—depends, does it not, upon the effective strength of the magnetic field through which it is passing? A. The strength of the field through which the coil is passing is one factor upon which this length of time depends. The other factors upon which this length of time depends are numerous. The amount of overlap of the brushes,—that is to say, the distance the coil rotates while under the brushes, the number of turns of wire upon the coil itself, the amount of iron included within the rotating armature, the strength of the current flowing through the different parts of the apparatus, are all factors in determining the length of time. The reaction of circuit resistance changes in the main circuit upon the field magnet itself, and upon the armature is an important factor in determining this length of time.

"C. Q. 46. I had in mind, in asking my question, that most of the factors which you have named should be regarded as given. For greater clearness, I will put my question in this way: I assume that the dynamo, in all its parts, has been designed and constructed to produce a current of given value; that it is to run at a constant speed, and under a constant load. This fixes, I think, all the conditions which affect the transposition of the incoming coil from one side of the dynamo to the other, except the length of time during which it shall remain short-circuited, which is, I suppose, another way of saying the length of time during which its terminals shall be connected by the commutator brush. Now, assuming all these conditions, is it not true that the length of time during which that short-circuiting is to continue depends upon the effective strength of the magnetic field through which it passes? A. Assuming all of the factors which affect this time as fixed, the length of this time will depend directly upon the effective strength of the magnetic field from which the short-circuited coil obtains its electromotive force. A variation in the strength of field would vary this time, or a variation of any of the factors would vary this length of time.

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"C. Q. 93. The view which you have expressed in regard to the electrical actions which take place in the operation of the spark adjuster and the current regulator, respectively, seem to me to involve, from your standpoint, these distinctions: 1. In the current regulator, the variations of current in the controller magnet upon which its action depends are the identical variations from the standard current which are sought to be corrected. Hence, the variations of current in the controller magnet of the current regulator are not, in any true sense, caused by the variations in the main current, because they are those very variations in their original, unmodified form. 2.

In the spark adjuster the variations of current in the controller magnet which determine its action depend directly upon variations in the relative potential of the adjacent commutator segments under the brushes. This relative potential is affected by: (a) The strength of the main current; (b) the length of time during which the incoming coil is short-circuited by the commutator brush; (c) the effective strength of that portion of the magnetic field through which the incoming coil passes while short-circuited. These are all variables. The current is varied by changes of resistance in the circuit; the length of time during which the incoming coil is short-circuited is varied by change in the collecting area of the brushes; and the effective magnetic strength of the field in which the short-circuiting takes place is varied by changes of the whole field strength, or changes in the place occupied by the coil in the field while short-circuited, if the field is not uniform. In actual operation, one of these elements may vary, while two remain constant, or two may vary and one remain constant, or all three may vary at once. In a constant current series dynamo, so constructed as to possess a uniform field, and provided with brushes of unvarying overlap, the current alone of the three variables named will vary during operation under changes of load. In a constant current series dynamo having a nonuniform field and unvarying overlap, the current and the effective magnetism of that part of the field in which short-circuiting takes place will vary in operation under changes of load. In such a machine having an adjustable spread in its brushes, all three of the elements will vary together. Traced to its source, the effective variation of current in the controller magnet of the current regulator depends directly on one variable, viz. the resistance in the circuit. Traced to its source, the effective variation of current in the controller magnet of the spark adjuster depends directly on the variation of the relative potential of the adjacent commutator segments under the brushes, and that depends on the three variables named. The action of the controller magnet of the current regulator is an immediate and proximate consequence of a change in the current of the machine. The action of the controller magnet of the spark adjuster is a secondary and remote consequence of a change in the current of the machine, such remote consequence resulting directly from an intermediate consequence of such change, viz. a change in the relative potential of the adjacent segments under the brush. I do not ask you to express an opinion whether these differences are material, or not, or whether one of these modes of controlling the controller magnet is the equivalent of the other, or not, but to state simply whether the differences which I have pointed out do or do not exist. For simplicity, I assume throughout my question the presence of a uniform speed in the dynamo. A. The views which I have expressed in regard to the electrical actions which take place in the operation of the spark adjuster and the current regulator do not involve, from my standpoint, the distinction you make in your question. In the current regulator the variations of current in the controller magnet, upon which its action depends, result from variations of potential at the terminals of this magnet, these variations of potential being caused by the variations in the main current. Precisely the same statement is the truth with reference to the controller magnet of the spark adjuster, and the statement in your question, under the second subdivision, with reference to the controller magnet of the spark adjuster, is equally true of the controller magnet of the current regulator, to and including the second division (a). Subdivisions b and c should not be variables, but should be constants, and in the Thomson-Houston three-coil '79 dynamo, and in the Weston dynamo, and other dynamos of that period, they were constants. Where they are not constants they merely modify the effect which changes in the main current produce upon the controller magnet. The action of this controller magnet in no wise depends upon either '(b) the length of time during which the incoming coil is short-circuited by the commutator brush,' nor upon '(c) the effective strength of that portion of the magnetic field through which the incoming coil passes while short-circuited' for its operation. These affecting conditions (b and c) acting simply and solely to shunt a portion of the main current through the controller magnet of the spark adjuster. The current which flows from the main circuit through the controller magnet of the current regulator is precisely the same current as that which flows through the controller magnet of the spark adjuster. Changes in the strength of the main current are changes in the current of the controller magnet of either device. Your question assumes a dependence of the controller magnet upon variable actions, which variables are themselves made variable by changes in the current, and suggests an indirectness of action of the main current upon the controller magnet. This is not correct. The variations of current in the controller magnet of the spark adjuster are the original variations of current as caused by changes of circuit resistance. The variables which are affected simultaneously with the change of the condition of the controller magnet of the spark adjuster are affected by the same change of current which controls the controller magnet. The difference of potential between the main and accessory brushes in the spark-adjuster apparatus is caused by the current flowing in the circuit, just as the difference of potential at the terminals of the controller magnet of the current regulator is caused by the current flowing in the main circuit. As a result of this difference of potential, a part of the main current is shunted through the controller magnet of the spark adjuster, and this current, in its variation, effects the adjustment of the brushes. While I have already endeavored, all through my testimony, to make it clear that the difference of potential between adjacent segments and the amount of such difference of potential depended upon the strength of the magnetic field, the amount of collecting area of the brushes, and the strength of the main current, I have also endeavored to make it clear that these things acted simply to determine a condition, and that the result of this condition thus determined was the flow of a portion of the main current through the controller magnet of the spark adjuster. Magnet, A, of the spark adjuster, is therefore in a position where a difference of potential causes a portion of the main current to flow through its coils, this difference of potential resulting from the pressure of the main current to flow through the short-circuited coil. A variation in the strength of the main current is a variation in the current of the controller magnet. Of course, it is at the same time a variation in the potential difference between adjacent segments, and at the same time a variation in the strength of the field magnet of the dynamo. These collateral effects have no part in determining the variation of the controller magnet. Traced to its source, the effective variation of current in the controller magnet of the current regulator depends directly on one variable, viz. the resistance of the current. Traced to its source, the effective variation of current in the controller magnet of the spark adjuster depends also on one variable, and the same variable upon which depends the effective variation of current in the controller magnet of the current regulator, viz. the resistance in the circuit. Your question states that, 'traced to its source, the effective variation of current in the controller magnet of the spark adjuster depends directly on the variation of the relative potential of the adjacent commutator segments under the brushes, and that depends on the three variables named.' This is entirely incorrect. The action of the controller magnet of both the current regulator and the spark adjuster is the immediate and proximate consequence of a change in the current of the machine, and the action of the controller magnet of the spark adjuster is in no wise a secondary and remote consequence of a change in the current of the machine. You attribute to a result to be corrected for the importance of a controlling condition. The real controlling condition is a change of current which in the spark adjuster acts directly upon the controller magnet, simultaneously producing the new condition of potential difference. By response to the change of current the current is corrected.

"C. Q. 94. A careful reading of your last answer has led me to doubt whether, after all that has been said, I have an entirely correct understanding of your view of the operation of a dynamo during the transposition of a coil from one side of the field to another. I shall recapitulate very briefly the points upon which I want to be entirely clear. I understand, first, that it is necessary, in order to transfer a coil from one side of the field to the other without a shock to the current, that during the period of the transposition it shall lose its current in one direction, and acquire a current in the other direction even [equal] to that flowing in the coils with which it is to take its place in series; and, in order that this reversal shall take place, the incoming coil must be short-circuited through the segments of the commutator, at its terminals, for a long enough time for the change to be effected. This short-circuiting, as I understand it, is accomplished by causing the commutator brush to make simultaneous contact with those two segments, and keep up that contact until the necessary period of short-circuiting has elapsed. Is this a correct statement of the matter, so far, according to your views? A. A comparison of my last answer with my testimony given in response to your interrogatories does not show me any cause for the doubt which you express. I have endeavored to arrive at a perfect understanding of your interrogatories, and have, to this end, freely discussed, off from the record, all questions upon which I was not clear. I have gone so far as to give a full explanation of the actions occurring in dynamos, and, by a discussion of those actions, have sought to facilitate the framing of questions to insure a perfect understanding between us as to the true meaning of such questions. I confess myself surprised at the statement contained in your last preceding interrogatory, to the effect that my expressed views would seem to involve the distinctions pointed out in that interrogatory, as well as the expression of doubt contained in your present interrogatory. Your statement in the present interrogatory of the necessary actions to insure the proper transfer of a coil from one side of the armature (not field) to the other is, I believe, substantially correct.

"C. Q. 95. I did not intend to intimate that there has been any want of fullness and clearness in your answers. If I have not exactly understood them, I am entirely willing to admit that it has been my own fault. Pursuing for a moment further the subject of the last question, I will say that, for the purpose of short-circuiting the incoming coil, it is not material, as I suppose, what precise form of brush is used, so it makes and preserves the short circuit for the necessary length of time. This may be accomplished by a single flat brush and spirally slotted commutator, or a flat, flexible brush, or a compound brush, all operating in substantially the same way, provided they make and maintain the short circuit at the proper time, and for the necessary length of time. I recognize, of course, the necessity of special construction where it is desired to vary the overlap during operation. Is this also correct? A. Properly interpreting your statement with reference to the necessity of a special construction to secure variable overlap, your supposition is correct. This special construction is necessary where the sparkless condition is adjusted for during variations of circuit resistance in the particular types of machines we have considered which possess improperly proportioned pole pieces. Where it is necessary to secure sparkless commutators for variations of circuit resistance by an adjustment of the brushes, a construction of the dynamo which will permit this adjustment without other injurious actions must be employed. In an arc-lighting series dynamo, a variation of circuit resistance varies the current. Decreasing this resistance increases the current. Violent sparking accompanies the action. We have here, then, two abnormal conditions to be adjusted for. An adjustment which corrects for the one, and does not correct for the other, would be of no value, and no one would contemplate its employment. The sparking would destroy the commutator. The excessive current would destroy the coils of the machine, and render the lamps ineffective in their action. Therefore, in adjusting the brushes for the injurious effects resulting from changes of circuit resistance, such a construction of the brushes and commutator must be employed as will admit of rotation of the brushes and a reduction of the total electromotive force of the machine at the same time the sparking is mitigated. To secure this the proper action resulting from overlap must be acquired by the employment of a suitably constructed commutator and brush. If we confine your question to a consideration of sparking alone, and leave out of consideration the question of variations of circuit resistance, then your supposition I believe to be correct.

"C. Q. 96. I will suppose, for my present question, the employment of a compound brush of invariable spread, and that its two divisions are separated so far that they will form contact with the two adjacent segments of the commutator simultaneously. At the instant after contact has been formed between the forward brush and the segment passing under it, one of these brushes resting on one segment, and the other on the one following, the short-circuiting of the incoming coil would be complete through the compound brush. Now, if I understand you rightly, at that instant of time the incoming coil presents a high resistance to the flow of current from that side of the armature in which it is coming; and hence, I take it, the greater part of the main current must flow by way of the forward segment and the forward brush. As the short-circuited coil loses its self-induced current, and acquires current in the other direction, the resistance which it offers to the flow of the main current decreases until at the instant when the forward brush breaks contact with the leaving segment. If the commutation has been perfectly performed, it presents no resistance to the flow of the main current, and hence the main current takes that path without any spark between the commutator segment and the brush. Is that a correct statement of that part of the process? A. It is.

"C. Q. 97. It follows, I take it, therefore, that the amount of current which flows through the forward brush passes through a variation from a maximum to a minimum between the time of its first contact with each segment and its separation from that segment; the maximum including substantially the whole current from the coils on that side of the armature, and minimum, in the case of perfect commutation, a practical zero? A. Yes; this is a correct way to take an instantaneous view of each possible position of the apparatus during the excursion of a segment under a brush. The practical effect of this is to procure an average division of the main current of both halves of the armature through the two members of the brush. Your question would be a more strictly correct statement if, for the phrase, 'the maximum including substantially the whole current from the coils on that side of the armature,' you substitute the phrase, 'the maximum being substantially the whole current of the dynamo.'

"C. Q. 98. In such a case, is the relative distribution of the current between the two brushes affected by the completeness or incompleteness of the commutation; and, if so, how? A. The effect upon this forward brush of incomplete commutation would be to slightly vary the value of the current flowing through the forward brush. Let us take a practical case for consideration. With a dynamo operating a series of arc lamps, and the brushes of the type under consideration operating to collect the current with proper and complete commutation, we have the condition pointed out in your last preceding question and my answer thereto. Now, if we cut out a part of the lamps, and observe the actions at the dynamo and in the main circuit. we will find a largely increased current in the main circuit and in the coils of the dynamo, and we find the condition of incomplete commutation. Before making the change in the number of lamps, the current in each member of the compound brush possessed an average value. This average value for each brush we find increased in proportion to the increase of the current in the circuit, modified slightly by the effect of undercommutation. The current in both brushes increases. That of one brush will increase slightly more than that of the other, because of the effect of undercommutation.

"C. Q. 99. The effect of undercommutation is to increase the resistance of the incoming coils to the flow of current from that side of the armature, is it not, and hence to increase slightly the relative flow of current through the forward brush? A. You do not state it all. The effect of undercommutation is to increase the apparent resistance of the coil to current flowing up from the forward coils of the armatures, and also to decrease the resistance of this coil to the current flowing up from the back coils of the armature. Thus the value of the definite portion of the total main current which shall flow through the forward brush is determined. Once determined, any variation in this current is likewise variation of the current in the forward brush. Indeed, it is upon this fact that my answer to your interrogatory 93 was based, and I have practically demonstrated the correctness of the fact.

"C. Q. 100. If a magnet were placed in circuit with the forward brush in such case, but not with the rear brush, the current in the magnet would experience not only the direct changes of the main current strength of the dynamo under changes of resistance in the circuit, but also a class of minor changes depending upon variations in the completeness of commutations produced by such changes in the main current. Is that correct? A. Taking an instantaneous view of the condition of this magnet, it would theoretically experience minor changes resulting from the effect of improper commutation. These minor changes would not determine in any degree the variations in the magnet, but would possibly modify the effect of such changes to a limited extent. Practically speaking, the result of such a construction, which, of course, is that employed in the adjuster apparatus of patent 223,659, is to produce in this magnet an average current which is a fixed and definite portion of the main current, the changes in which control the actions of this magnet. In practice, the modifying effect of improper commutation is of no importance, and is the effect of a collateral condition brought about simultaneously with the change in current strength. To take a practical case, if such a structure were employed upon a dynamo carrying a given load, with proper commutation had at the brushes, a definite portion of the current of both halves of the armature would be directed through the forward brush and through the electro-magnet connected to that brush, as suggested in your question. Now, upon cutting out a portion of the lamps, the strength of the current of the machine would be substantially increased, and, of course, the strength of the current in this electro-magnet would be increased. Another result of the increase in the strength of the current would be undercommutation, which will have the effect to again slightly increase the current flowing through the magnet. It does not produce a current in the magnet, but simply acts to increase very slightly the proportion of the main current which at that instant flows through this magnet. Upon an adjustment of the brushes to reduce the main current, the current of the forward brush is likewise reduced and at the same time the result of proper commutation is secured.

"C. Q. 101. Are these variations the variations to which you have referred in your previous testimony as determining the action of the controller magnet in the adjusting apparatus of Fig. 2 of patent 223,659? A. Yes; they are. This controller magnet is in circuit with the forward brush, and a definite portion of the main current is shunted through its coils by virtue of these actions which I have described. It is in response to the variations of this current that the controller magnet of the adjuster apparatus shifts the brushes to the point upon the commutator where proper commutation is effected, and where this definite portion of the main current flowing through the controller magnet is maintained constant, and consequently where the main current in the exterior lamp circuit is maintained constant. That this action of the apparatus of the automatic adjuster was contemplated by the inventors is apparent by a consideration of the drawing, Fig. 2, and the specification. The statement on page 2, lines 89 and 95, inclusive, as follows: 'The accessory collector, C^3, may be directly connected with the main collector, C, or in certain cases completely dispensed with, as, with a proper adjustment effected on one side of the axis, the opposite collector may be set to a position corresponding thereto,'—means that brush, C^3, connected directly to brush, C, forming a direct compound brush, is the equivalent of, and produces precisely the actions of, brush, C^2, connected through magnet, A, to brush, C. It is apparent that these acts of commutation that I have described are to take place alike in both the upper and lower compound brushes. It is also evident that the resistance of magnet, A, must be low enough to offer no substantial interference to proper commutation. It was upon a consideration of this portion of the specification, and the knowledge I possessed of the actions in commutation, that I employed a low resistance in magnet, A, of the apparatus I constructed, which apparatus has been introduced in evidence by the defendants in this case. The magnets employed by the complainants in their exhibits of the same adjuster apparatus, while of higher resistance than that employed by me, were still of low enough resistance to permit the proper operation of the apparatus as an adjuster, but were, from my standpoint, of too high resistance to permit proper commutation after the manner pointed out in the patent. In all of the apparatus employed by the complainants to represent the adjuster of patent 223,659, proper commutation was secured by means of an overlap or collecting area of the brushes, independent of that secured by the accessory brush. The magnet to represent magnet, A, in complainant's apparatus was purposely made high to preclude the possibility of the accessory brush and its circuit through magnet, A, acting to produce commutation. That the patent did not contemplate such a construction is certain, and the evidence of this fact may be found in the portion of the specification quoted, when taken in connection with the drawing and the rest of the specification.

"C. Q. 102. I perceive now clearly where it is that I have been proceeding under a misunderstanding of your views throughout this entire cross-examination. I have assumed throughout that, in the construction of the spark-adjuster apparatus, there was provided, first, a main collecting brush sufficient for the purpose of commutation without spark, provided it was set at the right place on the commutator, and that the accessory brush was something additional to that. Being now advised that you have, all along, held a different view, viz. that the accessory brush of the spark adjuster of patent 223,659 is simply the forward half of a compound brush, your whole testimony assumes a new meaning; and I was therefore entirely wrong in propounding question 93 in the supposition that I was looking at the matter from your standpoint. I take it, from what you now say, that in the apparatus made by you, and in all the testimony given by you in respect to the operation of the apparatus of patent 223,659, we are to understand that what is called the 'accessory brush' is simply the forward member of a compound brush. Am I right in that? A. In your present question, you appear to have discovered a distinction between a main brush and an accessory brush, employed together upon a commutator, and a structure known as a 'compound brush.' No distinction can be made between these two structures. They are one and the same, mechanically considered; and the operation of the apparatus is the same, whether either structure is employed. Upon the addition of an accessory brush to an existing structure, such accessory brush or feeler becomes at once a part of the compound brush, and at once enters into, and partakes of the functions and duties of, such compound brush. If this were not true, the apparatus would be incapable of operation. There is no real basis for a misunderstanding between us on this point. I think this will be evident to you if I suggest a question you might have put to me, and its answer, viz.: 'Q. If a magnet were placed in circuit with the forward brush in such a case, but not in circuit with the rear brush, what would be the effect of the resistance of the magnet upon the current which ordinarily finds passage through such forward brush?' This question, if asked after C. Q. 99, would be answered as follows: 'A. The presence of the resistance of an electro-magnet in circuit with the forward brush acts to vary its capacity to effect commutation to an extent dependent upon the amount of such resistance. The forward brush, in this event, becomes an accessory brush, and performs a smaller portion of the commutation, the rear brush performing a larger proportion of the commutation. In case of the employment of such a magnet, the proportion of the main current which shall flow through the accessory brush and magnet and the rear brush will depend upon the resistance of the magnet.' (End of answer.) Your assumption in your present interrogatory that throughout there was provided, first, a main collecting brush sufficient for the purposes of commutation without spark, provided it was set at the right place on the commutator, and that the accessory brush was something additional to that, is quite correct, if you assume, as it seems to me you must assume, that the added accessory brush, when added, becomes a part of the system of commutation. Sparking always takes place at the tip of the brush last in contact with the moving segment. This, in the adjuster apparatus, is the tip of the accessory brush. The distinction drawn is a distinction of words only. The real misunderstanding, if indeed there be a substantial misunderstanding between us, is found in your supposition made in C. Q. 93,—that the magnet in the accessory brush circuit responded to differences of potential between adjacent segments in a secondary manner; that is to say, a change in the main current caused a new condition, as to potential difference, to exist between the segments, and in response to this new condition a new current was set up in the magnet. The fact is, this new condition of potential difference at the segments, while being a result to be corrected for, is but a collateral condition, and in no wise a determining condition. Even assuming the correctness of the distinction you seek to make in your present question, I fail to find a basis for the statements contained in your interrogatory 93 of the operation of the adjuster apparatus in the supposition of your understanding of my standpoint, as stated in your present question. I have made a thorough and a practical demonstration of my views, and am satisfied as to the correctness of these views. I have employed dynamos in which a main brush upon a spirally slotted commutator performs the commutation in conjunction with an accessory brush placed in advance of that main brush. Such accessory brush became at once an operative part of the main brush precisely in the manner contemplated in patent 223,659. This construction was realized in the employment of the Weston five-light dynamo of '79, and in the Thomson-Houston '79 three-coil dynamo. I have also employed a compound brush with a straight-slotted commutator, which is the precise arrangement of the patent with the electro-magnet, A, of the adjuster apparatus connected in circuit with the forward member of the compound brush, this forward member becoming an accessory brush by reason of the connecting into its circuit of a magnet. This construction was realized in my operation of the apparatus of patent 223,659 upon the Sperry dynamo, and upon the Western Electric dynamo, as well as upon the Weston five-light dynamo, in which latter case, in one of my demonstrations, I removed the spirally-slotted commutator, and substituted therefor the straight-slotted commutator and the precise brush arrangement shown in patent 223,659. I have, also, in these demonstrations, employed various resistances in the winding of the controller magnet representing magnet, A, of patent 223,659. These practical demonstrations showed conclusively that in every employment of this apparatus there was but one mode of operation, and that the variations which did occur were variations in degree, and not in kind. A variation in the resistance of the magnet varied the amount of current flowing through that magnet, but not the effect of that current. A variation in the first adjustment of the amount of overlap varied again the amount of current in magnet, A, but in no wise did it vary the effect of the current upon the apparatus to adjust the brushes in response to changes in circuit resistance. Variations of the distribution of the overlap between the main and accessory brushes, which is the point directly under consideration, affected the amount of current in magnet, A, but not the effect of that current upon the magnet.

"C. Q. 103. Your answer is altogether pertinent to the general subject-matter of discussion, but does not quite meet the precise point of my inquiry; that is, whether we are to regard your testimony throughout the case as predicated upon the assumption that it is a proper construction of the apparatus of Fig. 2, of patent 223,659 to use what is there called the 'accessory brush' as the forward division of a compound brush, and thus cause the entire process of commutation to take place between the contacts of what is there called the 'main brush' and the accessory brush. A. I sought, in my last preceding answer, to make it perfectly clear that in any possible construction of this apparatus the accessory brush at once entered into, and became a portion of, the main brush, in the process of commutation. A brush could not be placed upon a commutator in advance of a main brush, and be connected to that main brush, without becoming a forward division of a compound brush; and in the employment of any possible construction of this apparatus, if a sparkless condition is maintained at the brushes, this accessory brush must, in some degree, take part in the entire process of commutation.

"C. Q. 104. You still have not answered my question. I don't ask you whether any assumption that you have heretofore made is right or wrong, or to justify it. I simply ask whether we are to regard your testimony throughout the case as predicated upon the assumption that it is a proper construction of the apparatus of Fig. 2 of patent 223,659 to use what is there called the 'accessory brush' as the forward division of a compound brush, and so cause the entire process of commutation to take place between the contacts of what are there called the 'main and accessory brushes.' A. I have stated that an accessory brush, having a magnet included in its circuit, and applied to a commutator in addition to the already existing main brush, formed a compound brush. The accessory brush would be the forward division of this compound brush. My testimony in this case is based upon the assumption that it is a proper construction, and, indeed, the only possible construction, of the apparatus of Fig. 2 of patent 223,659 to employ this structure, and to thus cause the entire process of commutation to take place between the different members of this compound brush, consisting of a main and accessory brush.

"C. Q. 105. It is a necessary result of the construction of the apparatus mentioned in your last answer, is it not, that, in order to secure a proper working of the dynamo, a large fraction of the main current—approaching to half of it—shall flow through the accessory brush? A. No, indeed; it is not. If the accessory brush is connected direct to the main brush, then this would be true; but if connected through a resistance, as of magnet A, this is not true. In Fig. 2 of patent 223,659, accessory brush, C^3, is shown connected direct to the main brush, C, and substantially half of the current of the machine will flow through this accessory brush, C^3; that is to say, there will be conducted through accessory brush, C^3, an average current substantially equal to half of the main current. Likewise, through the main brush, C, to which accessory brush, C^3, is directly connected, there will flow an average current equal to half the current of the machine; but with accessory brush, C^2, which is connected through magnet, A, to main brush, C, the presence of the resistance of magnet, A, in its circuit, creates a condition in commutation pointed out in my previous answers, the result of which is to cause a smaller proportion of the entire main current to flow through this accessory brush, C^2, and magnet, A. If the magnet is of low resistance, as I believe the patent contemplates, a larger proportion will flow through accessory brush, C^2, than would flow through this brush with a high resistance of magnet, A.

"C. Q. 106. In the apparatus constructed by you as a reproduction of the spark-adjuster apparatus the proportion of the current flowing in the accessory circuit was, in a number of cases, substantially half of the entire current, was it not? I refer to the apparatus described by you in your original deposition in this case. A. The current varied in these original automatic adjusters. In some of them an average current, substantially half of the main current, was found to flow through the forward brush and magnet, A. In some cases this average current was equal to less than half of the main current, and in some cases even more than half. The resistance of magnet, A, in these early devices, was very low, which, indeed, is the proper construction of magnet, A, as indicated by the patent. In the later structures, based upon patent 223,659, a much higher resistance was given magnet, A, and the average current through this magnet was, with this construction, much smaller.

"C. Q. 107. In the apparatus put in evidence by the complainant as reproductions of Fig. 2 of patent 223,659, and which you saw in operation at Lynn, there was, as I remember, a complete provision for commutation by the main brush independently of the accessory. This was accomplished in the case of spark adjuster No. 1, which was applied to the 1879 T.-H. dynamo by a flat brush and a spirally-slotted commutator. In the one applied to the Brush machine, this was accomplished by the alternating distribution of the commutator segments. In the one applied to the Fuller-Wood machine, it was accomplished by a compound brush. In each of these cases the machine was supplied with a brush suitable for the process of commutation, provided it was set in the right place independently of the accessory brush. Is not this your recollection of the construction of those devices? A. Each dynamo was certainly provided with a commutator and brushes providing overlap, as suggested in your question; but, when put in operation, each dynamo was provided also with accessory brushes, and the accessory brushes were connected to the main brushes. In the process of commutation the accessory brushes performed the distinct functions of the main brushes in combination with them. In the Thomson-Houston three-coil '79 dynamo, a spirally-slotted commutator was provided. Two main brushes, one above and one below, bore upon this commutator. An accessory brush in advance of the upper main brush also bore upon the commutator, and was connected through magnet, A, of the apparatus, and thence to the main brush. Another accessory brush was placed in advance of the lower main brush, the second accessory brush also bearing upon the commutator, and being connected directly with the main brush. The complete act of commutation took place through the medium of the compound brushes thus formed. A removal of either of the accessory brushes, without an adjustment of the brushes in a rotary direction, produced violent sparking, showing conclusively that the overlap provided in the main brush was not alone sufficient to produce perfect and proper commutation, under the existing conditions of use. Indeed, I was informed by Mr. Harthan that the lower accessory brush was necessary to balance the upper accessory brush to secure sparkless commutation. The same or equivalent arrangements were found in the other dynamos shown me at Lynn. In the American dynamo shown me at Lynn, the upper brush was composed of two separate brushes connected directly together, and an additional accessory brush which was connected through magnet, A, of the adjuster apparatus, and thence to this double upper brush; the whole structure forming a compound brush, of three leaves. I have criticised this structure as being something of a departure from the construction pointed out in the patent, in which but two brushes are shown, viz. a main and an accessory brush, in either of the compound brushes of the apparatus.

"C. Q. 108. During the operation of those several devices, measurements were made of the currents flowing in the accessory circuits, and they were found to be relatively small, were they not? A. They were, and this was due to the amount of resistance in the magnet, together with the distance the accessory brush was placed in advance of the main brush, and also to the amount of overlap given to the main brush. In Fig. 2 of patent 223,659, no overlap is provided in the main brush, the entire overlap of the apparatus being equally divided between the main and accessory brushes. This variation from the construction indicated in the patent produces the effect noted, viz. that a small proportion of the main current found its way through the accessory brush and magnet, A.

"C. Q. 109. If we suppose the dynamo represented in Fig. 2 of patent 223,659 to be provided with a spirally-slotted commutator, and the main brush to be a broad one, would not the construction there indicated result in an overlap of the main brush? A. Yes, it would; and in such a case the proper place to connect magnet, A, would be directly in the main circuit. In fact, the inventors, when applying this same automatic adjuster to precisely such a modified construction, did so connect this magnet. An examination of the file wrapper and contents of the patent in suit, No. 238,315, reveals the following statement: 'When the two ends of a slot are angularly displaced with respect to each other, 20° to 30° circumferentially around the commutator, *the accessory collecting brushes of patent No.* 223,659, *above referred to, may be dispensed with, and a single pair only be employed, as C, C'*, the planes of which are tangent to the circumference of the commutator at opposite points, and parallel to each other, as before stated.' The italicized portion of the language here quoted was stricken out by an official action before the patent issued. Your present interrogatory is fully answered by the inventors themselves, in this language. My statements that the main and accessory brushes together performed the commutation of the dynamo in the construction of the apparatus of patent 223,659 are entirely in harmony with this language quoted from the file wrapper and contents of the patent in suit. Quoting again from the file wrapper and contents of the patent in suit, No. 238,315: 'Our present method of operating, therefore, so far as it relates to automatic regulation, is based upon the same principles of operation as our previous invention, and consists in an improved construction and mode of use of the apparatus employed in Pat. 223,659. *Fig.* 2 *of the present invention corresponds to Fig.* 2 *of Pat. No.* 223,659, *but since only a single pair of collecting brushes, C, C,* *Fig.* 2 *(of our present invention), replaces, when used in connection with an obliquely-slotted commutator, the double pair, Fig.* 2 *(of our former invention), we use the contact-making electro-magnet, A, of our former invention, by placing it in the main circuit of the machine, so as to act in a substantially similar manner to the electro-magnet, M, Fig.* 1 *(Pat.* 223,659); *that is, by variations of the main current itself.'* The italicized portion of which quotation being matter stricken out before the patent issued, we find matter which also bears directly on the point in question. The inventors here state that the operation of commutation being secured with a single pair of collecting brushes used in connection with an obliquely-slotted commutator, instead of with the double pair in Fig. 2 of patent 223,659, magnet, A, of the former invention is placed in the main circuit. It becomes an easy matter to interpret the specification of patent 223,659, and to determine the intention of the inventor, when we read the language as quoted above.

"C. Q. 110. You speak of these quotations as having been stricken out by official action. They were stricken out by the applicants themselves, were they not, by their own amendment of their application? A. Of course, the applicants themselves, by amendment to their application, caused the matter in question to be stricken out. The official action of the examiner in this case, dated December 7, 1880, suggests to the inventors the striking out of these portions relating to the prior patent, and by an amendment of January 1, 1881, the inventors, complying with the suggestion of the examiner, order these portions referred to stricken from the specification."

The argument for the appellant has been summarized in ten propositions, which are said to be undisputed, and nearly every one of them either stated in the examination, or admitted on cross-examination in the testimony of Mr. Scribner. They are the following: (1) The running of a dynamo without spark at the commutator depends upon the proper adjustment to one another of three factors which enter into the operation. The volume of the current affects one of them directly, but there are two others equally important. (2) The variation of any one of these factors produces sparking, and requires a readjustment among them in order to restore the nonsparking condition, which it may or may not be possible to effect by mere movement of the brushes, depending on the type of dynamo to which the apparatus is applied. (3) When the adjustment is restored by the movement of the brushes, that movement may or may not restore the former strength of current, depending, as before, on the type of the dynamo. (4) The types of dynamo here referred to are distinguished as dynamos having a uniform field, and dynamos having a nonuniform field. Both of these types are in common and successful use, and each has advantages peculiar to itself, in respects that do not have any place in this discussion. As a general proposition, it cannot be said that either type is better than the other. Both are good. (5) The defendants selected for their experiments with the spark adjuster dynamos having uniform fields. Upon such dynamos, when sparking is caused by a variation in the volume of current, the movement of the brushes necessary to restore the adjustment upon which nonsparking depends operates also to restore the former current. Hence, on such dynamos the spark adjuster (subject to the fatal defects in its practical operation already pointed out, resulting from the feebleness of the accessory current, and the instability of its adjustment) will operate as spark adjuster and current regulator both; performing both functions at the same time, and by the same movement of the brushes. (6) For the same reason the current regulator applied to the same kind of dynamo will operate as current regulator and spark adjuster both; performing the same functions at the same time, and by the same movements of the brushes. In such a case, when sparking results from a change of current, and the current regulator restores the former current, it at the same time, and by that process, restores the adjustment of the three factors on the equilibrium among which nonsparking operation depends. (7) But these results do not follow when either of these devices is applied to a dynamo having a nonuniform field. In that case, when a change of current produces sparking, and the spark adjuster moves the brushes to the nonsparking point, it does not restore the former current. And so, also, when a current regulator is applied to such a dynamo, and, upon a change of current, moves the brushes to the point where the former current is restored, it does not, by that movement, restore the nonsparking adjustment. (8) These differences of action are a consequence and proof of the fundamental and essential differences of principles on which the two inventions operate. The spark adjuster looks for the point on the commutator at which is found the equilibrium of forces upon which nonsparking depends. Except as affecting that adjustment, it is entirely oblivious to changes in the current. It will follow the law of its organization, and put the brushes at the nonsparking point, and hold them there until the current burns up the machine. On the other hand, the current regulator cares nothing about sparking, or the maladjustment of forces by which sparking is produced. Upon a change of current, it will move the brushes to the point on the commutator where the former current will be restored, without the least regard to sparking. If that happens to be the point where the adjustment for nonsparking is restored, well and good. If not, the sparks may melt the commutator before it will stir. (9) To state the distinction in its broadest form: The current regulator depends for its operation on the variation of a single factor in the dynamo,—the volume of its current. The spark adjuster depends upon the intervariation or variation of adjustment among themselves of three factors in the dynamo, of which the current is one, or, to be exact, of which the current controls one. (10) Since the invention of the current regulator, another invention has been made, which supplements the motion of the brushes produced by that apparatus for the regulation of the current by another action, which preserves the adjustment necessary for nonsparking. So that, as the current regulator is now most commonly used, it operates, in full accordance with the law of its organization, to shift the brushes to the points of constant current, entirely regardless of the effect as to sparking. That is controlled by a distinct and supplementary device.

Frederick P. Fish, Robert S. Taylor, Charles K. Offield, Henry S. Towle, Charles C. Linthicum, and Geo. R. Blodgett, for appellant.

George P. Barton and Charles A. Brown, for appellees.

Before WOODS, JENKINS, and SHOWALTER, Circuit Judges.

WOODS, Circuit Judge, after making the foregoing statement, delivered the opinion of the court.

We are unable to find in the current regulator of the patent in suit anything more than an adaptation of the brush adjuster of the earlier patent. The two are essentially the same in mechanism, adjustment, motive power, and law of operation; and, in so far as the purposes intended or accomplished are not the same, they are distinctly analogous. The second patent purports to be only an improvement upon the first, "the method" of which is declared to be "adaptable to the present case of current regulation." As first drawn, the specification declared the correspondence of Fig. 2 of the present invention with Fig. 2 of No. 223,659, with the explanation that, since a single pair of collecting brushes, when placed upon an obliquely-slotted commutator, replaces the double pair of the earlier design, the contact-making magnet, A, of that invention, is placed in the main circuit of the machine, so as to act substantially in the same manner as the magnet, M, in Fig. 1, of that patent; "that is, by variations of the main current." By the specification, as it stands, the patentees say:

"As in our former invention, already referred to, the motor device used may be adapted to move by the current, or by the motive power, or by suitable clockwork, or by other mechanism adapted to be thrown in or out of action by an electro-magnet, and constitutes, as before, a minor feature of our present system. Our present method of operating, so far as it relates to automatic regulation, is based upon the same principles of operation as our previous invention, and it consists in an improved construction and mode of use of the apparatus employed in patent No. 223,659."

But, as the present method relates entirely to automatic regulation, it follows that, if the patent shows invention, it must be solely "in an improved construction and mode of use" of a known apparatus, which, notwithstanding the improvement, is to operate upon the same principles as before. In just what feature of the construction, or of the mode of use, the novelty and utility entitled to be called invention were supposed by the patentees to be found, is not specified and can only be inferred. According to the brief for appellant, "the improvement consists in discarding the accessory collector, with its intermittent, uncertain, feeble current, and unstable adjustment, and substituting the simple, practicable, and effective combination of the controller magnet, and main current." "In both inventions," it is said on another page, "the brushes are mounted on a rocking yoke, so that the positions of their points of contact with the commutator can be shifted. In both of them the result sought is obtained by so shifting the brushes. In both of them this is accomplished by a motor mechanism which is automatically set into operation in one direction or the other, as the case may require, by a controller mechanism which acts in response to the abnormal conditions which are to be corrected. Here the similarity between them ends, and the dissimilarity, both in mechanical construction and mode of operation, begins. The taking away of the accessory collector changes the structure and introduces a new mode of operation, * * * for the reason that the current which actuates the controller magnet of the spark adjuster is not the main current, or any part of it, but a different current, derived from a different source." In its last analysis, the argument for the appellant ends in this assertion, that magnet, A, of the earlier patent, is not excited by the main current of the machine, or a shunted portion thereof, but only by a different current, derived from a different source, "flowing intermittently, and sometimes in one direction and sometimes in the other." The truth of this proposition is disputed, and, though it is supported by the statement in the specification that "the accessory collector, C^2, serves, as it were, the purpose of a feeler, the design of which is to test the electrical condition of the segments of the commutator at the moment of leaving the collectors, and to originate from that condition an adjustment of said collectors in whatever is necessary to secure efficient action," it does not seem to follow, necessarily, that no current was intended to flow, or does flow, through the controller magnet, A, except that which results from the difference of potential between successive segments at the moment when the forward one passes from under the accessory brush. That is not declared to be an essential feature of the invention, and instruction is not given in the patent for so constructing the different parts of the combination, or for so proportioning the resistance in the main and accessory circuits, as to produce that result. On the contrary, the current through the accessory brush, it seems to be agreed (C. Q. 97, and answer, supra), "passes through a variation from a maximum to a minimum between the time of its first contact with each segment and its separation from that segment," and, besides, it is shown to be a delicate, and, except with the experienced and skillful, a difficult work, to make an adjuster through whose controller magnet no portion of the main current shall flow, and which shall be operative under the supposed intermittent or pulsatory current which is intended to be taken up by the accessory brush. Indeed, the objection urged against the experimental spark adjusters constructed by the defendants in professed conformity with Fig. 2 of patent No. 223,659 is that the resistance of the accessory circuits was made so low as to permit the constant passage of a distinct part of the main current; and on that ground the experts and counsel of the appellant are agreed in asserting that the exhibits were really current regulators, embodying the invention of the patent in suit, and not the invention of the other patent. The uncontroverted testimony of Prof. Cross, examined in behalf of the appellant, is to the effect that it can be determined whether a brush regulator constructed in apparent conformity with Fig. 2, of patent No. 223,659, is in fact a spark adjuster under that patent, or a current regulator under the patent in suit, only by the experimental employment upon each apparatus of tests adapted to show whether or not an appreciable and effective portion of the main current passes through the accessory circuit. This alone ought to be conclusive of the dispute. When such tests are necessary to distinguish one such device from another, it is manifestly an impracticable, not to say dangerous, proposition that the making or using of either under a given patent may be declared to be an infringement of a different patent upon the other. It being admitted that, if the construction of a brush adjuster under No. 223,659 be such that a distinct portion of the main current will pass through the controller magnet, the device becomes a current regulator, it follows that, in respect to the question of invention, the omission of the accessory brush is of no significance. Its presence or absence does not affect essentially the mode of operation, nor determine the character of the device.

But, waiving other considerations, we will assume that the 10 propositions of counsel for appellant are true; that the appellant's theory of the process of short-circuiting is correct; that the accessory brush of No. 223,659 is not a member of a compound brush, designed to assist in the process of commutation, but a mere feeler, which finds and takes up the residual current or difference of potential which remains after imperfect work by commutator brushes proper. Does it follow that the current regulator of No. 238,315 is an essentially different device, working upon a different principle? We think not. The specification, as we have seen, says that the principles of operation are the same. In physical structure they are alike, and, both practically and theoretically, they operate in like ways to effect like purposes. The proof shows, and it was understood to be admitted at the hearing, that upon all dynamos which existed when the patents were issued the two devices were interchangeable, so that, when the brushes were moved so as to prevent spark, they established and maintained constant current, and vice versa. For all possible purposes then known, each device might have been called, with equal propriety, a spark adjuster (though that name is of later invention) or a current regulator. In dynamos of later construction, however, the points at which the brushes prevent spark and establish constant current are not coincident, as they were in the earlier machines; and, that being so, the brushes of a spark adjuster, it is conceded, will move to the place of no spark, regardless of current, while in the current regulator, responding to the current to be regulated, they will seek the point of constancy regardless of spark; and hence, it is insisted, the two devices are essentially different in their modes of operation and in the purposes to be accomplished. The force of this reasoning is very much weakened by the further fact, which seems to be undisputed, that neither the adjuster nor regulator, when constructed according to the patent covering it, can be successfully used upon dynamos of irregular or nonuniform fields, in which the points of least spark and constant current are not quite nearly coincident. In order to avoid this difficulty, commutator brushes, applicable alike, as we conclude, to the brush adjuster of No. 223,659 and to the current regulator of No. 238,315, were devised, and so adjusted as to have a variable spread, corresponding momentarily with the strength of that portion of the field within which the process of commutation should be going on. Both devices being capable of adaptation by the same means to dynamos of nonuniform field, and when so adapted effecting, as they did upon uniform dynamos, the same results, the inference is strengthened that in their law of operation, as well as in mechanism, they are essentially identical. The discussion of the question has been varied and exhaustive, but, along whatever lines pursued, the argument has come back to the difference between the currents which are supposed to flow through the respective controller magnets. That difference we concede, but do not deem it controlling. One current is constant, the other is intermittent or pulsatory; but the pulsations are so frequent that the current seems to be constant, and its effect in energizing the magnet is the same as if it were. It differs practically from the main current only in strength. In order to be effective, it must be strong enough to cause the magnet to overcome the counteracting spring, or, conversely, that spring must be so weak as, at the proper time, to be overcome by the strength of the magnet. If, instead of being in the accessory current, the magnet be transferred to the main current or a shunted portion thereof, exactly the same kinds of operation, effected in the same way and by like adjustments, must go on. In both constructions, the levers, springs, coils, armatures, magnets, brushes, and dynamos are, or may be, the same; the electrical currents, whether coming from one part of the machine or another, *are alike;* and, acting by one and the same law, they differ only in volume or energy. The magnetic current, it may be said here, as in Western Electric Co. v. Sperry Electric Co., 7 C. C. A. 164, 18 U. S. App. 177, and 58 Fed. 186, is not itself a part of the device or invention, any more than a current of water is an element of a water wheel. The invention is in the mechanism, not in the power which moves it; and, once a device has been patented, it is protected for all uses or functions of which it is found to be capable, whether anticipated by the patentee or not.

It is not difficult to suggest the employment of appliances for the control of water power in a way to illustrate not inaptly our view of the present question. The water of a stream is accumulated by means of a dam, and, through head gates, is turned into a race or flume, whereby it reaches and turns a wheel to which is geared the machinery of a mill or factory. That wheel, for the purpose of illustration, is the magnet, M, of the patents; the head gates are the commutator brushes; and the water flowing through the flume or race is the main current. First, we will suppose that it is desired to maintain in the reservoir, by automatic means, a constant level or head, without waste or overflow at the dam. How shall it be done? With patent No. 223,659 before us, the answer is plain. It may be accomplished by such a construction of the dam that whenever there shall be an overflow the surplus will, by means of another flume and a head gate or valve, corresponding to the accessory brush, be turned into and made to move a second wheel, representing magnet A, connected with suitable mechanism adjusted to lift or lower the head gates in the main current so as to effect the purpose of restoring the normal level in the reservoir. Theoretically, at least, head gates or valves in water flumes might be adjusted and controlled in that way. Next, we will suppose it to have been found desirable to establish constancy of current in the main flume or head race. How shall that be done? If constancy of level in the reservoir could be maintained, it is evident that the desired constancy of current would follow as effect follows cause. They are coincident facts, and, if the coincidence could be permanent, no additional or different mechanism would be necessary. But the overflow current is intermittent, and sometimes feeble and inefficient. When the stream is swollen it is strong and lifts the gates too high; and if the stream runs so low that it becomes necessary for a time to draw down the reservoir, in order to obtain the desired current in the flume, the overflow disappears and does not act at all. Does it require invention to devise a remedy? Clearly not. One familiar with the existing device could not fail to see that, in order to effect the new purpose, it was only necessary to make the controller wheel constantly and efficiently responsive to changes in the current to be regulated, just as Thomson and Houston, once they had found constant electrical current desirable, immediately proposed, as Prof. Thomson himself has testified, "to accomplish the necessary shifting or movement of the commutator brushes by automatic means in something the way that we had before used in adjustment through a limited range, only that we saw clearly that we must make whatever small variations the current in the main circuit underwent, during the cutting out or on of lamps, act to control the position of the brushes through a considerable angle around the commutator; and this could be done by a sensitive magnet in the main circuit setting in motion, through contacts, a device which should do the main work of shifting the brushes." In other words, it was only necessary to put magnet, A, in the main current, or a shunted portion of that current; and that, it was evident, could be done without any change of structure, except such as was necessary to cause a diminution of resistance in the accessory circuit, or an increase of the resistance in the main circuit, either of which could be accomplished in a number of ways explained by the witnesses. It was a plain case of mere adaptation of known means to a modified but analogous use. In the illustration supposed, the water wheel, in connection with mechanism employed to move the head gates in order to maintain constancy of level and to prevent overflow, may well have been patentable as an original combination; but it is not an additional invention to turn into that wheel a different or additional current, by force of and in response to which it will, by the same mechanism, move the gates or valves over a wider range, if need be, to keep in the flume a constant current, instead of a constant level in the reservoir. No new law or new mode of operation is brought into play, and, at most, only improved and enlarged action is effected.

But the current regulator of the patent in suit, it is said, has gone into extensive use, and we are met with the usual inquiry, why, if there is no invention in it, did not somebody else make the same or like improvement upon the earlier construction? It would be enough to answer that if done by anybody else than Thomson and Houston, or their assignee, it would have been an infringement of the first patent. However, it was done by Maxim, in whose patent, No. 228,543, the controller magnet is placed in the main circuit, and though the collector brushes moved thereby are not upon the commutator of the dynamo from which the current of that circuit is derived, but upon a second dynamo, employed for the purpose of exciting the field of the first, the effect of the adjustment being to maintain a constant field and thereby to establish the desired constancy of current, the employment of the second dynamo does not disguise the fact of automatic regulation of the commutator brushes in the manner and by the means of the Thomson-Houston patents. If the patent now in suit should be upheld, it would be, in our opinion, an unwarrantable prolongation of the just monopoly conferred by the first patent, which, notwithstanding the strenuous efforts made to minimize it, we deem to have been of great merit, and entitled to liberal construction. The decree below is affirmed.

TAWS et al. v. LAUGHLINS & Co., Limited.

(Circuit Court, W. D. Pennsylvania. August 19, 1895.)

1. PATENTS—ANTICIPATION—ANALOGOUS USES.

A flexible pipe joint for conveying air for air brakes, or steam or hot water for heating purposes, between railway cars, or a flexible pipe connection in a steam and smoke conveyer for railway cars, cannot be considered as an anticipation of an oscillating joint upon a water-cooled tuyere used in connection with a blast furnace; for the divergence between the uses is so extreme and the conditions so radically different that it would require inventive faculty to perceive the adaptation of the one to the requirements of the other.

2. SAME—FURNACE TUYERES.

The Hartman patent, No. 205,744, for an improvement in furnace tuyeres, consisting in a flexible joint which adapts itself to the contraction and expansion of the parts, *held* to disclose patentable invention in respect to claims 7 and 8; and *held*, further, that these claims were not anticipated by anything in the prior art, and were infringed by one of defendant's structures, but not by the other.

This was a bill in equity for the alleged infringement of a patent relating to furnace tuyeres.

Joseph C. Fraley, for complainants.

John D. McKennan, J. Snowden Bell, and George H. Christy, for defendant.

BUFFINGTON, District Judge. This is a bill in equity brought by the firm of Taws & Hartman, assignees of John M. Hartman, against Laughlins & Co., Limited, for infringement of claims 7 and 8 of letters patent No. 205,744, issued to him July 9, 1878. The patent is for an improvement in furnace tuyeres, and a brief account of furnace working will aid in a proper understanding of the case.

Around the stack of a furnace, some distance above its base, is a circular steel pipe, called the "bustle pipe," about four feet in diameter, and lined with firebrick. To this pipe a hot-air main leads from the blowing engine by way of a blast-heating apparatus, and from its several conduits lead to the tuyeres, through which latter the blast for smelting passes into the stack. These tuyeres are tapering tubes from four to seven inches in diameter, usually made of bronze, and the shell hollow, so that through them water for cooling purposes may circulate. The connecting conduit between the bustle pipe and the tuyere is called the "tuyere stock." It consists of two or more lengths of pipe joined end to end, one portion of which depends downwardly from the bustle pipe, either in a straight line or shaped like the letter S, to the level of the tuyere, but terminating several feet away from it. The other portion is horizontal and straight, connecting the lower end of this downwardly depending pipe just mentioned with the tuyere itself. This straight horizontal pipe is usually called the "tuyere pipe," sometimes the "belly pipe." To reduce the interior area of the tuyere and intensify the jet-like force of a blast, a hollow "nozzle" is sometimes placed within the opening of the tuyere, fitting closely against its inner face. These tuyeres and nozzles require frequent changes, being often burned away by the intense heat of the furnace or clogged by the adhesion of cinder, which sometimes backs not only into the tuyeres, but runs into the tuyere pipe also.

Prior to the patent in suit the usual method of connecting the tuyere and tuyere pipe was as follows: The front end of the tuyere pipe was made of smaller diameter than the interior of the butt end of the tuyere, and extended some distance into the latter, a bead or projecting rim being formed on the extremity of the tuyere pipe. The interspace between the outside surface of the tuyere pipe and the interior of the tuyere was then closed by ramming wet clay and fragments of pounded fire brick therein. The bead or rim upon the front end of the tuyere pipe served as a sort of dam against which to ram the packing, and, when no bead was used, it was necessary to prop up the tuyere pipe within the tuyere with little pieces of brick, so as to get an even or uniform space, around and within which the packing should be inserted. Under the heat of the furnace the clay baked into a hard mass, and a rigid immovable joint formed. The objection to this method was obvious. The temperature of a furnace changes frequently, or, as one of the witnesses says:

"Every stop of more than a few minutes means a cooling down of all the exposed surfaces, and a contraction of the same. When the blast is put on again, as it warms up the surfaces, we find more or less leakage taking place where there are packed joints. The blast is always taken off when the iron is run, and that takes place from three to six times per twenty-four hours, according to the capacity of the furnace, each time involving from ten to thirty or more minutes, according as any difficulties may arise. There are also many stoppages arising through the loss of the tuyeres, or the bad working of the furnace causing stoppages in the pipes which introduce the blast through the tuyeres. These stoppages may be from ten minutes to a half a day or more."

It will be seen that, as one of the witnesses expressed it, there was a constant creeping or moving of the tuyere, the tuyere pipe, and the bustle pipes from the contraction and expansion. As no provision was made for these changed conditions, leakages frequently occurred.

The labor of changing tuyeres under the old system is thus described by Hartman, the patentee:

"Taking the case of the old-style wrought-iron tuyere having sprung a leak, the blast is taken off the furnace, which stops it. Two men with steel bars about eight feet long, and two other men with sledges, cut away the brickwork and packing around this tuyere, leaving a space of about three inches between the tuyere and the wall. On the end of the tuyere in the furnace the iron has accumulated in the form of a ring, which requires a large hole to pull the tuyere through. After the tuyere is out, the fuel in the furnace falls into the cavity made by the tuyere. This fuel has to be raked out cautiously, and a sheathing of clay packed up against the upper part of the cavity to hold the fuel in check. The new tuyere is then inserted and got into an alignment in a rough sort of a way, as quickly as possible, and the clay-packing was rammed in tight between the clay and the wall. After this was done, the tuyere pipe was placed in the tuyere, the ball joint bolted together at the end of the tuyere pipe, and the clay joint was rammed up between the tuyere pipe and the tuyere. The blast was then turned on the furnace. This work required six men, and about three quarters of an hour stoppage. If the end of the tuyere had got 'ironed up' badly, it took a longer time. After the blast was turned on, the tuyere pipe heated up, and the clay joint had begun to shrink, the workmen took their rammers and drove up the joint tighter