

J. SAHULKA.
ELECTROPNEUMATIC SYSTEM OF DRIVING.

APPLICATION FILED APR. 18, 1903.

NO MODEL.

5 SHEETS—SHEET 1.

Fig. 1

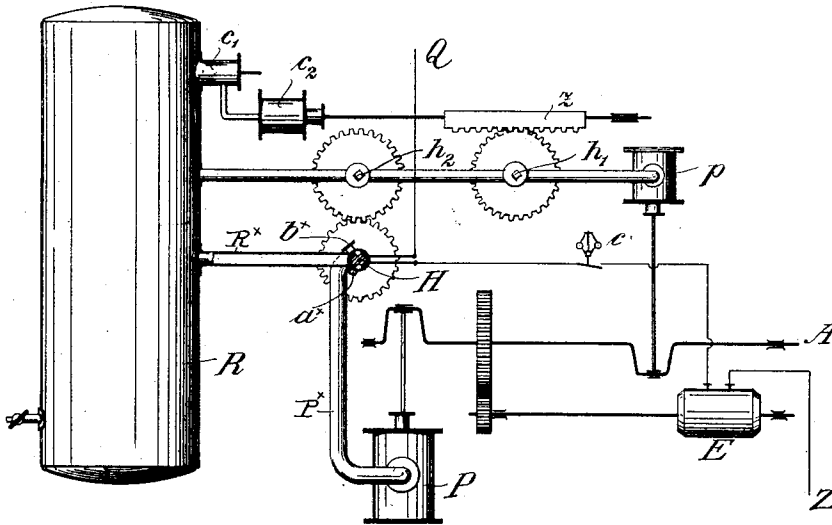
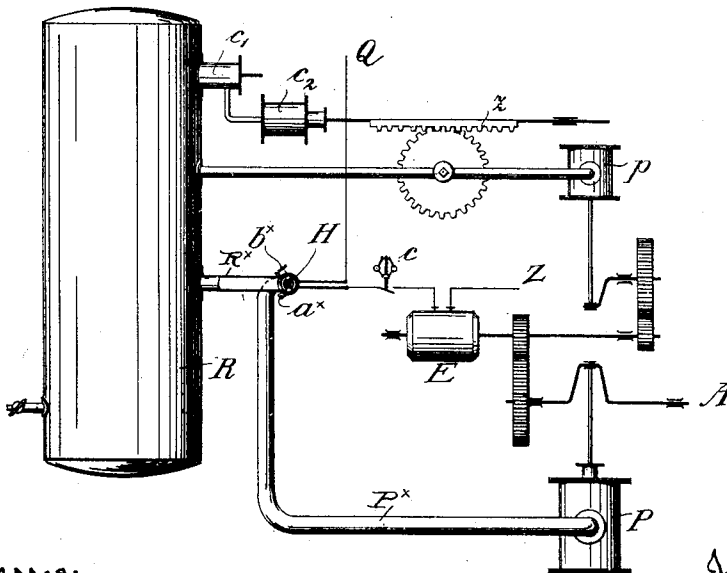


Fig. 2



Witnesses:

L. M. L. L. L.
Anna L. L.

Inventor:

Johann Sahulka
by his attorney,
James Hamilton

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5 SHEETS—SHEET 2.

Fig. 3

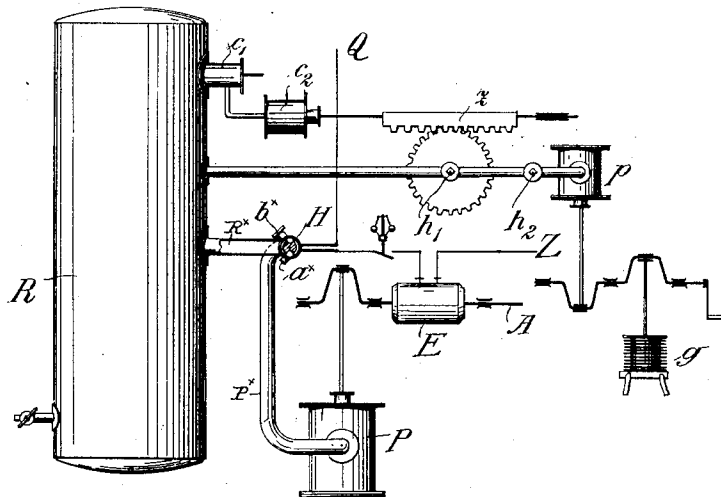
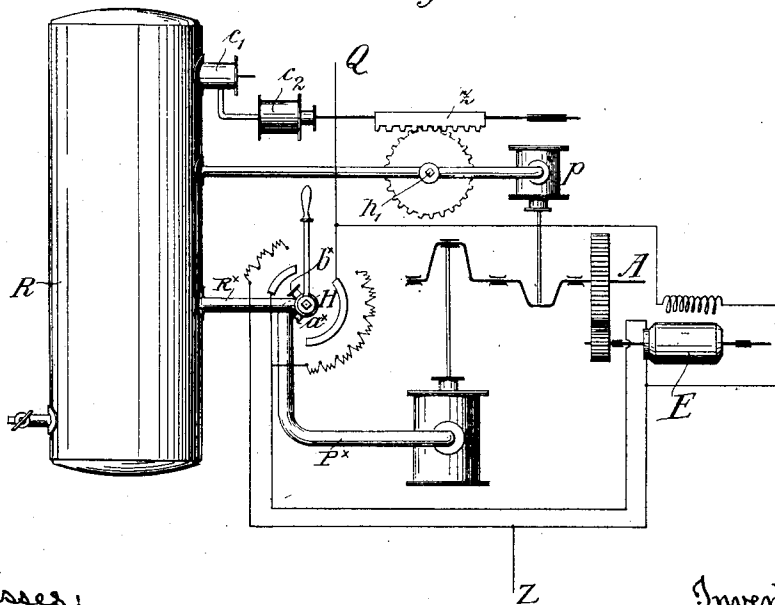


Fig. 4



Witnesses:

Laura Livingston
Anna Livingston

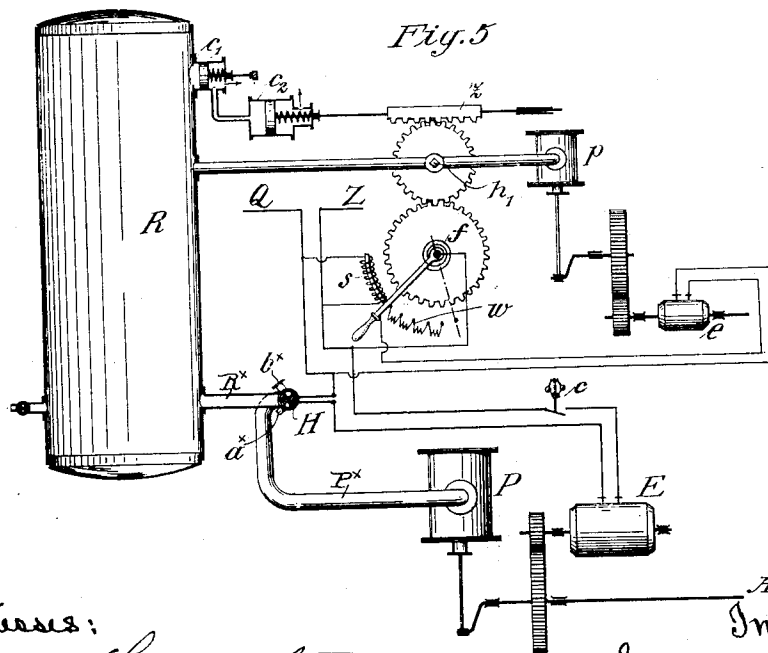
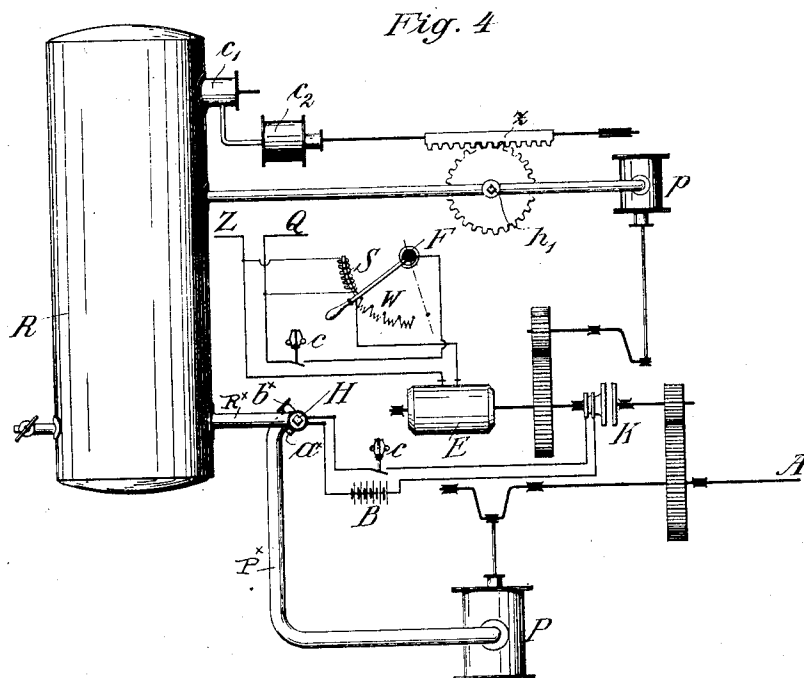
Inventor:

Johann Sahulka
by his attorney
James Hamilton

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5 SHEETS—SHEET 3.



Witnesses:

Laura Livingston
Anna. Loring.

Inventor:

John Sahulka
by his attorney,
James Hamilton

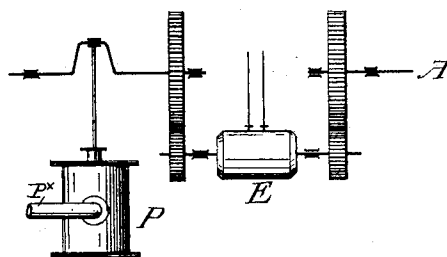
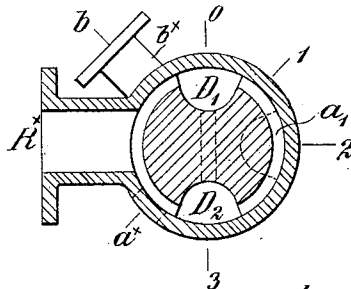
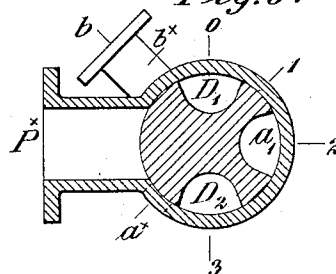
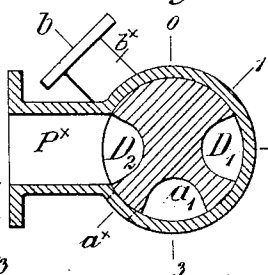
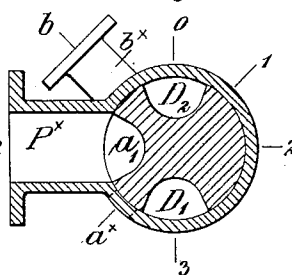
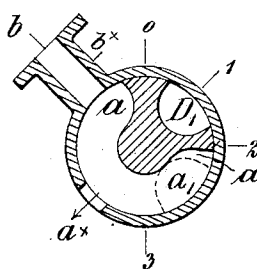
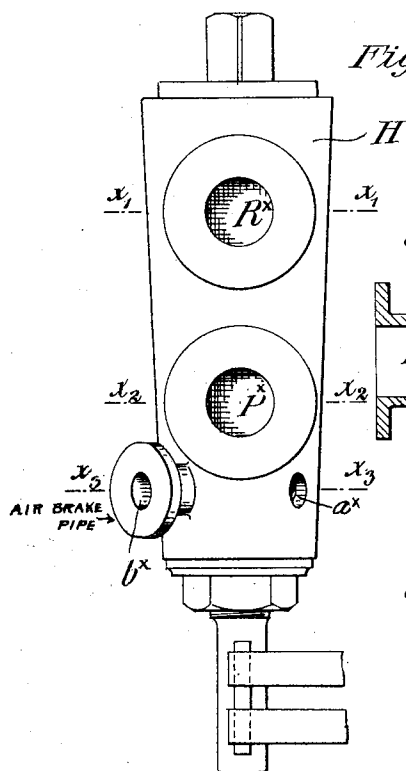
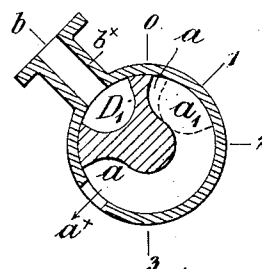
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5 SHEETS—SHEET 4.

Fig. 6

Fig. 8^aFig. 8^bFig. 8^cFig. 8^dFig. 8^eFig. 8^f

Witnesses:
Lama Linington
Anna Linnery

Inventor:
Johann Sahulka
by his attorney
James Deamilton

J. SAHULKA.

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NO MODEL.

5 SHEETS—SHEET 5.

Fig. 10

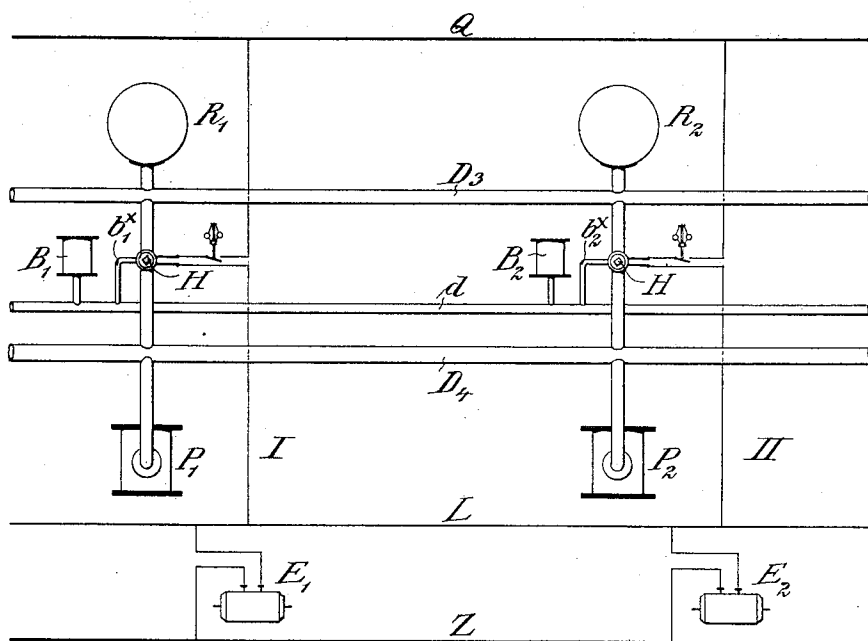


Fig. 11

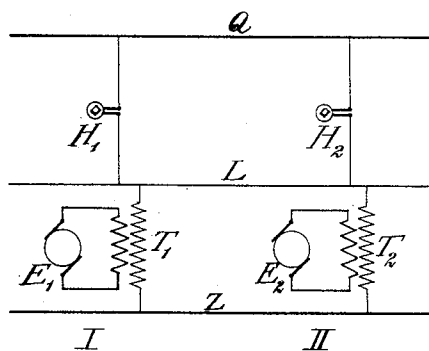
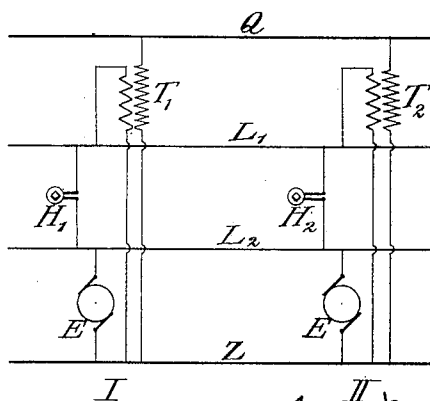


Fig. 12



Witnesses:
Laura L. Linington
Anna L. Linington

Inventor:
Johann Sahulka
 by his attorney,
James Hamilton

UNITED STATES PATENT OFFICE.

JOHANN SAHULKA, OF VIENNA, AUSTRIA-HUNGARY.

ELECTROPNEUMATIC SYSTEM OF DRIVING.

SPECIFICATION forming part of Letters Patent No. 755,173, dated March 22, 1904.

Application filed April 18, 1903. Serial No. 153,298. (No model.)

To all whom it may concern:

Be it known that I, JOHANN SAHULKA, doctor of philosophy, residing at Vienna, Austria-Hungary, have invented certain new and useful Improvements in an Electropneumatic System of Driving, of which the following is a specification.

This invention relates to a system of driving hereinafter described, the object of which is to render possible the use on stationary electric power plants and electric railways of motors which exert little if any tractive force at starting, though any kind of motors may be employed. Moreover, when applied to railways the system presents the advantage of dispensing with the necessity for providing line conductors or third rails within the precincts of the stations.

The invention is applicable to locomotives as well as to motor-carriages.

The principle of this system, which, like the known Arnold system, makes use of a pneumatic accumulator, consists in providing the driving-shaft of the power plant or the electrically-driven carriage with two separate motors connected with each other only by means of the driving-axle, with or without intermediate gear or coupling, an electromotor, and a compressed-air motor, both acting upon the driving-shaft. The compressed-air motor, however, only comes into action at starting and at such parts of a railway-track where no line conductors are provided, eventually, also, on short sections of track where increased power is required, whereas the electromotor is working all the time or at any rate during the time that full speed is maintained. Now as during the greatest portion of the working time full speed will be maintained the compressed-air motor as a rule will merely act as a starting-motor, the electric motor constituting the main working motor. In place of a single electromotor and single compressed-air motor groups of motors may be used, and compressed air may be replaced by any other form of power. The electromotor may be either a continuous-current motor or a mono or poly phase motor of any system. The pneumatic and the electric motors can be controlled

by separate controlling mechanisms or by a common controller.

The present system has in common with that of Arnold (see British Patents Nos. 20,088 and 20,101 of 1901) the arrangement of a pneumatic accumulator mounted upon the vehicle. The principal difference between the present system and Arnold's is that in the latter the constantly-running electromotor is, so to speak, the sole "working" motor, the compressed-air device being regarded merely as a coupling device between the electromotor and the car-axle, the said coupling permitting a variation of the transmission of speed between the working motor and the axle, whereas in the present system the compressed-air motor and the electric motor act as entirely independent driving-motors actuating the carriage-axles, these motors being in connection with each other only by means of the driving-axle. The present system may therefore be characterized as a "mixed electrical and pneumatic system of driving," wherein, however, the electric motor acts as the main working motor. In the employment of the present system for stationary power plants and railways numerous advantages are secured in comparison with the Arnold system, chief among them being the extremely great simplification in the construction of driving and regulating devices and the dispensing with line conductors or third rails within the limits of railway-stations. There is no tendency on the part of the vehicle to continue moving when stopped, as is the case in Arnold's system, wherein a part of the motor is actuating a compressor during the stoppages, while the other part of the motor is braked, but at the same time endeavors to turn with the same force as that of the part still running. In the Arnold system both parts of the electromotor, armature, and field-magnet are rotating, and each of the two parts of the motor is coupled with its own compressed-air engine, working at one time as a motor and at another as a pump. Hence two compressed-air engines are necessary, whereas in accordance with the present system only a single compressed-air engine is required, which needs to work as a motor ex-

clusively. Another great simplification in comparison with other systems accomplished by the present system is that in nearly all modifications of same the electromotor may be connected with the circuit at only periods of full speed, thus dispensing with all starting-rheostats. Moreover, all line conductors or the like can be abolished in stations. On account of the specially simple character of the controller devices the system may also be readily used for trains operated according to the multiple-units system. Finally, in sections of the track where there are no line conductors for the supply of current the system presents the advantage that no special trouble need be taken in looking out for the spot at which the line conductor's recommence. The system when applied to mountain railways permits of recovering energy in the form of electrical energy and compressed air during the downhill trip, the speed being then controlled automatically. To recover compressed-air energy, an arrangement can be used similar to that described in the United States Patent No. 673,975, the compressed-air engine P being put to work as a compressor in descending. In all the various modifications of the system only a single controller-crank is required, and in all cases the electromotor alone supplies power to the axles during the greater part of the trip, so that this motor must be regarded as the principal motor, the compressed-air motor merely as a supplementary starting-motor.

The accompanying drawings represent various modifications of the system applied to railways.

In Figures 1, 2, 3, 4, 5 compressed-air motor P alone drives the carriage-axle during the starting period, the work then being taken over by the electric motor E. Fig. 6 represents a modification of this arrangement. Fig. 7 illustrates a case wherein the compressed-air motor works only at starting, whereas the electric motor E transmits power to the carriage-axle throughout the entire trip, except on places where there are no line conductors which supply current. The Figs. 8^a, 8^b, 8^c, 8^d, 8^e, 8^f show various sections through the controller, a side view of the latter being given in Fig. 9. Figs. 10, 11, 12 illustrate the application of the system in the event of the so-called "multiple-units" system being used in the train.

The same parts are indicated by the same characters in each of the figures.

For the sake of simplicity only a single line conductor Q is assumed to be supplying current, the rails Z forming the return-circuit; but in the same way polyphase currents can be employed.

In all the modifications illustrated in the drawings the controller-valve may be arranged as shown in Figs. 8^a, 8^b, 8^c, and 9, as explained hereinafter, whereby it may be set in five prin-

cipal positions—viz., *b o 1 2 3*. In position *b*—i. e., that for applying the brakes—e. g., the Westinghouse brake—compressed air is delivered from the compressed-air accumulator R into a brake-pipe. Position *o* is that of repose, all the pipes being closed and the electrical circuit broken. In position 1 the brakes are set off, but the motors P and E not yet started. At position 2, the starting position, compressed air is admitted from the accumulator R to the motor P, which thereupon transmits power to the car-axle A. In general the current for the motor E is not yet closed at this stage, except in the case of the modification shown in Figs. 4 and 7, where the motor is already receiving current. In the position 3 the circuit for the motor E is closed; but, on the other hand, communication is cut off between the motor P and the accumulator R. Hence the motor E alone transmits power to the car-axle A.

In all the figures, *c* indicates a switch which is controlled by the centrifugal governor and shuts off the admission of current to the motor E as soon as the speed of the car decreases below a certain rate.

The letter *p* in all cases indicates a compressor of relatively small capacity in comparison with that of the compressed-air motor P. All that this compressor *p* has to do is to replace the compressed air consumed in starting and in putting on the brakes; but it may continue running all through the trip and even during the stoppages.

The letters *c'* *c''* indicate a device, (represented in greater detail in Fig. 5,) the object of which device is to suddenly push forward a rack *z* in the event of the air-pressure in the accumulator R attaining the permissible maximum. In this manner a tap *h'* is turned in such a position that the compressor *p* runs empty, the delivery-pipe being placed in communication with the outer air by the tap *h'*. When the pressure in the accumulator R decreases, the rack *z* is suddenly forced back, thus setting the tap *h'* so as to reestablish communication between the compressor *p* and the accumulator R. Devices of this kind, though of different construction, are already known. The arrangement of that shown in Fig. 5 is as follows: Within the small cylinder *c'*, which is always in communication with the outer air, is placed a piston which is acted on by a spring. From the cylinder *c'* a pipe leads into a second cylinder *c''*, which also contains a spring-controlled piston and is likewise in communication with the outer air. The spring in the cylinder *c'* exerts a strong pressure on its piston, so that the latter does not move until the pressure in the accumulator R has reached the maximum. When this happens, compressed air is admitted to the cylinder *c''*, and owing to the comparatively feeble power of the spring in this second cylinder the piston and attached rack *z* are

driven forward, thus effecting the turning of the tap h' . When the pressure in the accumulator decreases, the piston in cylinder c returns to its normal position. This enables the compressed air to escape from the cylinder c^2 . The piston in c^2 is forced back by its spring, and the tap h' is readjusted to the working position. In order to enable the compressor to be run empty even when the tap h' is in the working position, a second tap h^2 , similar to h' , may be mounted in the pipe leading from the compressor to the accumulator, as is shown in Fig. 1. This device, however, is not required in most modifications of the system. When the tap h^2 is set in such a position that communication is established between the delivery-pipe from the compressor and the open air, the compressor runs empty, even though the tap h' be still in the working position.

The modifications of the new system illustrated in the various drawings are as follows:

In Fig. 1 the motors E and P transmit power independently of each other to the car-axle A . From this latter is driven the small compressor p . In starting, the motor P alone comes into action, and it is only when a certain rate of speed has been attained that the controller H completes the circuit for the motor E and throws P out of action. The motor E has no starting-rheostat and works alone until the next stoppage has to be made. In order to avoid the necessity of the starting-motor P having to drive the car-axle A and compressor p simultaneously, the tap h^2 may be connected with the controller H , the result then being that the compressor p does not begin to work until P has been disconnected and E is running. The special construction of the tap h^2 and also the arrangement that the compressor p runs empty while the starting-motor P is set running form no part of the present invention. The tap h^2 may be dispensed with, the capacity of the compressor p being small in comparison with that of P . Besides, the accumulator R will generally be already charged from the previous trip, so that the tap h' will already be set to make the compressor run empty. When the car is started for the first time, the accumulator R must be fully charged, which is done from an outside source. During the trip R is always kept charged, and even after being at rest for several hours there will always be enough pressure in R to insure the starting of the car. There is no difficulty in recharging R after work has been suspended for some time, since the accumulator R may be comparatively small, as its sole task consists in supplying the compressed air required for starting. Should R be quite empty, it could be recharged by attaching the car to another and drawing it along some distance. In this case the controller H of the drawn car must be set in the cut-off position and h^2 would have to be omitted, as above mentioned.

The modification shown in Fig. 2 differs from that in Fig. 1 merely in so far that the tap h^2 is omitted and the compressor p is driven from the shaft of the motor.

In Fig. 3 it is assumed that the motor E is mounted directly on the car-axle, which is more feasible in this system than in others in view of the fact that the motor is not connected with the circuit until full speed has been attained. Furthermore, it is assumed in this case that the compressor p is driven by a small explosion-motor g , (benzene or petroleum motor or any suitable gas-engine.) This arrangement offers a very great advantage for electric railway plant designed in accordance with the present system. Thus no charging places either for current or compressed air are required within the precincts of the stations or in the engine-houses, the engines receiving high-tension current only after having passed the precincts of the station. Should from any cause the accumulator become empty during a journey, restarting becomes possible at any point, even when monophasic alternating current is used, since the explosion-motor is able to recharge the accumulator quickly. The driving mechanism for the compressor p may also be arranged in such a way that the compressor can be driven either by the car-axle or by the small explosion-motor. For this purpose it is only necessary to provide the necessary changeable couplings, (of any known type.)

In Fig. 4 it is assumed that the motor E continues running even when the car has stopped and that a coupling K connects the motor with the car-axle. In starting, the motor P alone drives the axle. When a certain rate of speed has been attained by the car, the coupling K is actuated by moving the controller-lever to position 3. In the example illustrated the coupling is assumed to be an electrical one. The device for closing the circuit for the coupling is exactly the same as in the previous figures. The coupling is actuated when the two parts to be coupled have attained equal speed, or nearly so. The electrical coupling may be replaced by one actuated mechanically or by compressed air. In either case the coupling may be actuated by means of the controller H —*e. g.*, compressed air being admitted to a pneumatic tube instead of the battery B , circuit being closed. The motor E is fitted with a starting-rheostat. The switch-lever is influenced on the one hand by a spring F or weight and on the other by a solenoid S , controlled by the pressure of the current. The spring tends to throw the motor out of circuit, while the solenoid has the contrary effect by attracting the iron core attached to the switch-lever. When the solenoid is supplied with current, its force overcomes that of the spring. The switch-lever should be fitted with a brake attachment—*e. g.*, an oil-brake or dash-pot—in order to

prevent too-rapid movement. In sections of the track unsupplied with current the motor is thrown out of circuit automatically and, conversely, is connected with the circuit again when the supply is resumed. In this case the motor *E* must be a self-starting one, at least when not under load. The motor *E* also drives the small compressor *p*, and the arrangement described is intended to effect the result that the compressor *p* continues to be driven by *E* even while the car is at a standstill. In view of the complication resulting from the necessity for a starting-rheostat for *E* a coupling *K* and the provision of line conductors within the precincts of the station and also seeing that the compressor *p* is comparatively small the previously-described modifications would appear to afford a much simpler solution of the problem.

In the modification according to Fig. 5 it is assumed that the compressor *p* is driven by a small electromotor *e*. In other respects the arrangement is the same as that in Fig. 1. The arrangement of an electromotor for the production of compressed air is already known in connection with electric railways, and hence this device does not form part of the present invention. The electromotor *e* is fitted with a starting device similar to that shown in Fig. 4, but acting in a special manner in conjunction with the tap *h'*. In shunt derivation from the main conductor supplying the motor *E* are inserted on one hand the solenoid *s*, influencing the switch-lever, and on the other hand the motor *e*. The spring *f* tends to throw the motor out of circuit, the solenoid to close the circuit. The spring *f* should overcome the force of the spring in the cylinder *c*². When the car is not in work, the pressure in the accumulator *R* is too low, and consequently the cylinder *c*² is in communication with the outer air on both sides of the piston. The spring forces the switch-lever into the cut-off position, (indicated by the dotted line,) and in this position the tap *h'* closes the air-pipe. On current being supplied to the car the solenoid *s* draws the switch-lever gradually into the starting position, and the first effect of this on the tap *h'* is to turn it from the original position until it reaches one in which *p* is put in communication with the external air. At this instant the circuit for the motor *e* is completed.

The switch-lever is moved still farther, whereby the rheostat *w* is gradually cut out and *h'* is brought into the working position. Hence the motor *e* starts when *p* runs empty. When full pressure has gradually been attained in *R*, the pressure of the air entering the cylinder *c*² causes the tap *h'* to be turned, and consequently the switch-lever is returned to the cut-off position under the influence of a force far superior to that of the solenoid *s*. The motor *e* now remains at rest until the pressure in *R* falls, and if full pressure prevails in *R* at the moment of restarting the car

the motor *e* remains out of circuit. The switch-lever is provided with a liquid-brake. (Not shown in the figure.) The foregoing arrangement enables the compressor *p* to be left to itself without any need for troubling whether the entire length of track is fitted with line conductors or not or as to whereabouts these conductors are resumed. It may even happen that the conductors are suddenly deprived of current and that the supply is only resumed after an interval; but in this case the motor *e*, like the motor *E* in previous figures, is not endangered. When the supply of current in the conductor ceases, the motor *e* is at once thrown out of circuit by the action of the spring *f*, even though *h'* be still in the working position, and the said motor is not started again until the conductor supplies current once more. The motor *E* in Fig. 4 is disconnected from the line conductor in the same way on the cessation of current. Using the arrangement shown in Figs. 1, 2, 3, the decrease in speed causes the centrifugal governor *c* to act upon the attached switch, thus disconnecting the motor *E* from the line conductor on the cessation of current-supply. In the arrangement according to Fig. 5 also no electric conductors are required within the precincts of the railway-stations. It will be sufficient in this case to provide charging-contacts in the engine-houses or at such parts of the station as are usually occupied by the water-supply tanks, so that the compressor *p* may be kept working while the cars are at a standstill.

Fig. 6 illustrates merely a modified arrangement of driving the car-axle *A*. As before, the motors *E* and *P* work independently; but in this case the motor *P* drives the axle *A* through the intermediary of *E* instead of directly. In the same manner *P* might be the intermediary instead of *E*, whereas up to the present it has been assumed that the motors *E* and *P* do not act upon the axle *A* simultaneously. Fig. 7 shows a modification wherein the motors both act on the axle *A* during the starting period, and when a given speed has been attained *E* alone remains in action. In Fig. 7 the motor *E* is supposed to be of the continuous-current shunt-wound type. The valve of the controller *H* may be attached to the handle of the starting-rheostat for *E* either directly or by intermediate gear. The positions of the controller-valve are the same as already described. In the braking position pneumatic and electric braking takes place in accordance with Fig. 7, the armature of the motor being short-circuited and compressed air being admitted into the brake-pipe, as explained hereinafter. When the car is running downhill, electric energy can be restored to the line conductors, and in addition *R* can be recharged when not fully charged at the time, using an arrangement similar to that described in United States Patent No. 673,975, setting the compressed-air engine to

work as a compressor during the downhill trip. The compressor p is driven from A, as in Fig. 7. Should R be empty when the car is to be set in work and E alone be insufficient to start the car, the latter may be slightly lifted in the engine-house and R charged by means of E. As a rule, however, this device will rarely or never have to be employed. In the disposition according to Fig. 7 it is a matter of indifference during what portion of the starting period E and P act simultaneously on the car-axle A, the important point being that they are in connection with each other by means of only the driving-axle and that the compressed-air motor by itself be able to effect the starting.

Figs. 8^a, 8^b, 8^c, 8^d, 8^e, 8^f represent various sections through the controller H, while Fig. 9 gives a side view of the latter. In the known system of traction with compressed air the cars are already fitted with controllers which can be set in the aforesaid positions 0 1 2. In the present instance there is an additional position 3 for disconnecting the compressed-air motor P from the receiver R and closing the circuit of the motor. The valve of the controller H is fitted with corresponding contact-pieces in order to effect the necessary makes and breaks of current. As a rule the controller-valve acts only as a switch to close and interrupt the circuit of the motor E. Therefore only one contact is necessary in case a continuous current or a single-phase current be applied to the motor E. The contact is shown in Fig. 9. In Figs. 8 and 9 it is assumed that the compressed air is admitted to the valve of the controller through the pipe R^x, Fig. 9, while it is admitted to the compressed-air motor through the pipe P^x below. Underneath the pipe P^x is fitted on one side the lateral brake-pipe b^x, and on the other side is an outlet a^{*}. Other passages may be drilled in the valve of the controller—*e. g.*, when compressed air is required for pneumatic couplings. Fig. 8^a represents a section through the plane X' X' in Fig. 9. Figs. 8^b, 8^c, 8^d represent sections through X² X²; Figs. 8^e, 8^f sections through X³ X³. At the compressed-air inlet, Fig. 8^a, an annular recess is provided in the body of the controller, from which recess two borings D' D² proceed downward through the body in a direction parallel to the axis. These borings are of equal length; but while D' extends somewhat farther downward, as far as a^{*} b^{*}, (X³ X³), D² extends a little above the annular recess beyond the plane X' X'. By this arrangement the controller can be turned easily. The borings D' D² may be connected by cross-passages, as indicated in Fig. 8^a by broken lines. As may be seen from Figs. 8^e, 8^f, the body of the valve is provided in the plane X³ X³ with a recess a , which remains in communication with the outer air throughout the turning of the controller-valve. From this recess a bor-

ing a' extends upward through the valve-body in a direction parallel to the axis, but not so far as to reach the plane X' X'. The positions indicated by 0 1 2 3 at the commencement of the description relate to the position of the boring D' when turning the tap of the controller. The function of the controller when turning the tap in the different positions can be understood from the drawings. Figs. 8^b, 8^c, 8^d relate to the admission of compressed air to the motor P. In the position 0, Fig. 8^b, the motor is shut off from the accumulator R. In position 2, Fig. 8^c, the motor P is at work, and in position 3, Fig. 8^d, it is again shut off from R. Figs. 8^e, 8^f relate to the braking arrangements. Fig. 8^e indicates the position 1, in which the brakes are off; but the motor P has not yet begun to work, the brake-pipe being still in connection with the outlet and the boring D² having not yet come into communication with the pipe P^x. In position 2, in accordance with Fig. 8^f, the brakes are on, the brake-pipe being in connection with the pipe P^x. It is not necessary to mention that using the system shown in Figs. 1 to 9 two controllers, one on each platform, can be arranged instead of a single one. The details of the controller remain quite the same. One controller has to be placed in the cut-off (zero) position, while the other controller is turned in the different positions. The system permits also of driving forward and backward, as the starting pneumatic motor and the electric motor can be reversed in a manner well known. In case the electric motor is a single-phase motor no commutator is necessary to reverse the motor, as it continues to turn in the direction in which the starting pneumatic motor is turning. It is also possible to drive forward and backward.

In view of the fact that the controlling mechanism acts automatically in the manner already described this system is suitable to application to trains containing several motor-carriages, (multiple-units system.) In this case no modification is required to control the motors of all carriages by the controller H of the leading car except that corresponding through-pipes for the compressed air and through-conductors for the current must be provided. As can be seen in Fig. 10, the accumulators R' R² are connected with a compressed-air pipe D³ and the motors P' P² with the compressed-air pipe D⁴, these pipes being connected in each carriage with a pipe communicating with the controller H' H². The brake-pipes b^x b^{x2} issuing from the same are also connected with a through-pipe d . By means of the trolleys the current is led from the line conductor Q to H, and from thence a conductor leads to the through-wire L, the motors E being coupled in circuit between this latter and the return-conductor, (in this case represented by the rails Z.) The con-

pressors p are not shown in the figure, but they act automatically independently of H' . In all the cars except the leading one the controllers are set in the position 0, the supply of compressed air and current to all the motors E' E^2 and P' P^2 being solely controlled by the controller in the leading car. In this arrangement the trolley of the leading car also conveys the current for all the motor-carriages. If it be desired to avoid this, it will then be necessary to provide in addition a through-conductor connected up with all the trolleys. Thus it be evident that when a monophasic alternating current or a continuous current is employed two through-pipes for compressed air and two through-conductors for current will be sufficient; but one of these conductors may consist of the rails. When polyphase currents are employed, the number of the through-conductors is increased by one. The compressed-air pipe D^3 may eventually be omitted.

Fig. 11 represents a modification for cars supplied with high-tension current, which is transformed by transformers T' T^2 , arranged on the cars. The number of conductors in this case remains the same as in Fig. 10. Fig. 12 refers to the same case; but here none but low-tension conductors lead to the controllers H' H^2 . In this case the number of through-conductors is increased by one.

In all modifications of the described system the motor P invariably runs empty all the time the normal car speed is maintained. It may be disconnected from the car-axle by means of disconnectible couplings—for instance, by the coupling described in United States Patent No. 673,975. Finally, it is also possible with the described system to provide each car with a separate switch, enabling the motor E to receive current when the circuit has been interrupted by the controller H or the centrifugal governor e . Should a short length of steep gradient have to be ascended, the said switch will enable the car to be driven by electricity and compressed air conjointly. Eventually the controller H could also be arranged to effect the same end (simultaneous driving by both kinds of motor) when set in a special position, whereby also during the starting period a higher acceleration is obtainable than with other systems.

In the same way as electric railways the described system is also applicable to all kinds of stationary electrical power plant.

Having now particularly described and ascertained the nature of my invention and in what manner the same is to be performed, I declare that what I claim is—

1. A system of driving for electrical power plants, electrical railways in particular (locomotives, motor-carriages,) consisting in the combination of the driving-axle with a pneumatic motor, or with a group of such motors, for starting; and an electric motor, or a group

of such motors, for the ordinary driving; both motors being in connection with each other by means of only the driving-axle, and a controlling device common to all said motors.

2. A system of driving for electrical power plants, electrical railways in particular, consisting in the combination of the driving-axle with a pneumatic motor, or with a group of such motors, for starting; an electric motor, or a group of such motors, for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means to drive the axle in starting and when turning at moderate speeds by solely the pneumatic motor; means to drive the axle at periods of full speed by solely the electric motor; and a controlling device common to all said motors for throwing them into and out of action at the proper time.

3. A system of driving for electrical power plants, electrical railways in particular, consisting in the combination of the driving-axle with a pneumatic motor, or with a group of such motors, for starting; an electric motor, or group of such motors, for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means to drive the axle in starting and when rotating at moderate speed by the pneumatic motor; means to drive the axle during the whole working time by the electric motor; and a controlling device common to all said motors.

4. A system of driving for electrical power plants, electrical railways in particular, consisting in the combination of the driving-axle with a pneumatic motor, or group of such motors, for starting; an electric motor, or group of such motors, for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means to couple the motors or groups of motors with the axle; and a controlling device common to all said motors.

5. A system of driving for electrical power plants, electrical railways in particular, consisting in the combination of the driving-axle with a pneumatic motor, or group of such motors, for starting; an electric motor, or group of such motors, for the ordinary driving, and a brake-operating and motor-controlling apparatus.

6. A system for driving electrical power plants, electrical railways in particular, consisting of the combination of the driving-axle with a pneumatic motor, or group of such motors, for starting; an electric motor, or group of such motors, for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; and a controlling mechanism common to all the motors.

7. A system of driving for electrical power plants, electrical railways in particular, consisting of the combination of the driving-axle with a pneumatic motor, or group of such motors,

for the starting; an electric motor, or group of such motors, for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means for

controlling the motors; and a centrifugal regulator which interrupts automatically the circuit of the electric motors when the speed of rotation of the axles falls below a certain rate.

8. A system of driving for electrical power plants, electrical railways in particular, consisting of the combination of the driving-axle; a pneumatic motor for the starting; an electric motor for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means to control the motors; a pneumatic accumulator; a small compressor for feeding the accumulator; and an automatic device for throwing said compressor out of operation.

9. A system of driving for electrical power plants, electrical railways in particular, consisting in the combination with the driving-axle of a pneumatic motor for the starting; an electric motor for the ordinary driving, both motors being in connection by means of only the driving-axle; means for controlling the motors; a pneumatic accumulator; a small compressor for feeding the accumulator; and means for driving the compressor from the axle to be driven.

10. A system of driving for electric power plants, electrical railways in particular, consisting in the combination of the driving-axle with a pneumatic motor for starting; an electric motor for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means for controlling the motors; a pneumatic accumulator; a small compressor feeding the accumulator; a small electric motor for driving the compressor; a starting device which tends to throw the small electric motor out of circuit; a solenoid which tends to insert the small electric motor into the circuit; and a device which throws the motor out of the circuit when the pressure in the accumulator attains a maximum.

11. A system of driving for electrical power plants, electric railways in particular, consisting in the combination of the driving-axle with a pneumatic motor for starting; an electric motor for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; means for controlling the motors; a pneumatic accumulator; a small compressor for feeding the accumulator; a small motor for driving the compressor; means for driving the compressor from the axle; and means for coupling the compressor either with the small motor or with the driving mechanism actuated by the axle.

12. A system of driving electric railways in which the multiple-units system is used, consisting in the combination in every motor-car of the driving-axles with a pneumatic motor

for starting; an electric motor for the ordinary driving, both motors being in connection with each other by means of only the driving-axle; a controller common to the motors; a pneumatic accumulator; a small compressor for feeding the accumulator; electrical conductors extending from end to end of the car equal in number to that of the isolated line conductors; and a pipe for compressed air extending from end to end of the car, said pipe forming a connection among the pipes between the pneumatic motors and the controllers.

13. A system of driving electrical railways in which the multiple-units system is used, consisting in the combination in every motor-car of the driving-axles with a pneumatic motor for starting and with an electric motor, both motors being in connection with each other by means of only the driving-axles; a controller common to the motors; a pneumatic accumulator; a small compressor for feeding the accumulator; electrical conductors extending from end to end of the car and equal in number to that of the isolated line conductors; a pipe for compressed air extending from end to end of the car, said pipe forming a connection among the pipes between the pneumatic motors and the controllers; and a second pipe for compressed air extending from end to end of the car and forming a connection among the pipes between the pneumatic accumulator and the controller.

14. In an electropneumatic system of driving, the combination of a shaft; a pneumatic motor for driving said shaft; an electric motor for driving said shaft; and a device by which to load the pneumatic motor at starting and simultaneously run the electric motor idle and to load the electric motor after speed is gained and simultaneously run the pneumatic motor idle.

15. In an electropneumatic system of driving, the combination of a shaft; a pneumatic motor for driving said shaft; an electric motor for driving said shaft; said motors being connected with each other through only said shaft; and a controller device by which the pneumatic motor is permitted to work only at starting and the electric motor to work only after speed has been gained.

16. In an electropneumatic system of driving, the combination of a shaft; a pneumatic motor for driving said shaft; an electric motor for driving said shaft, said motors being suitably arranged to transmit power to said shaft; and a controller device by which the pneumatic motor is thrown out of action and the electric motor is thrown into action.

In witness whereof I have hereunto signed my name, this 6th day of April, 1903, in the presence of two subscribing witnesses.

JOHANN SAHULKA.

Witnesses:

JOHANN LUXT,
ALVESTO S. HOGUE.