E. F. GALLAUDET.

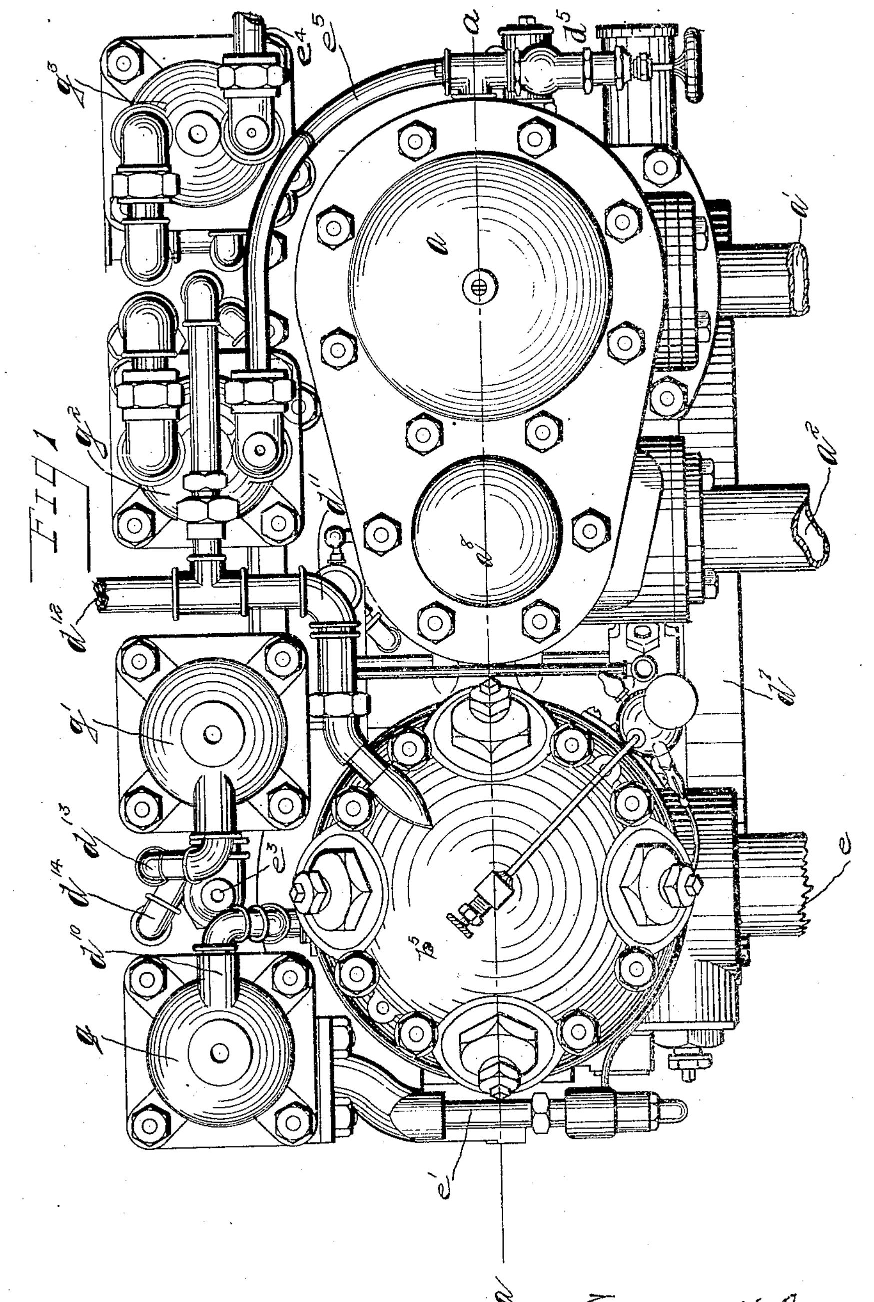
AIR COMPRESSOR.

APPLICATION FILED MAR. 8, 1909.

952,798.

Patented Mar. 22, 1910.

8 SHEETS—SHEET 1.



Witnesses

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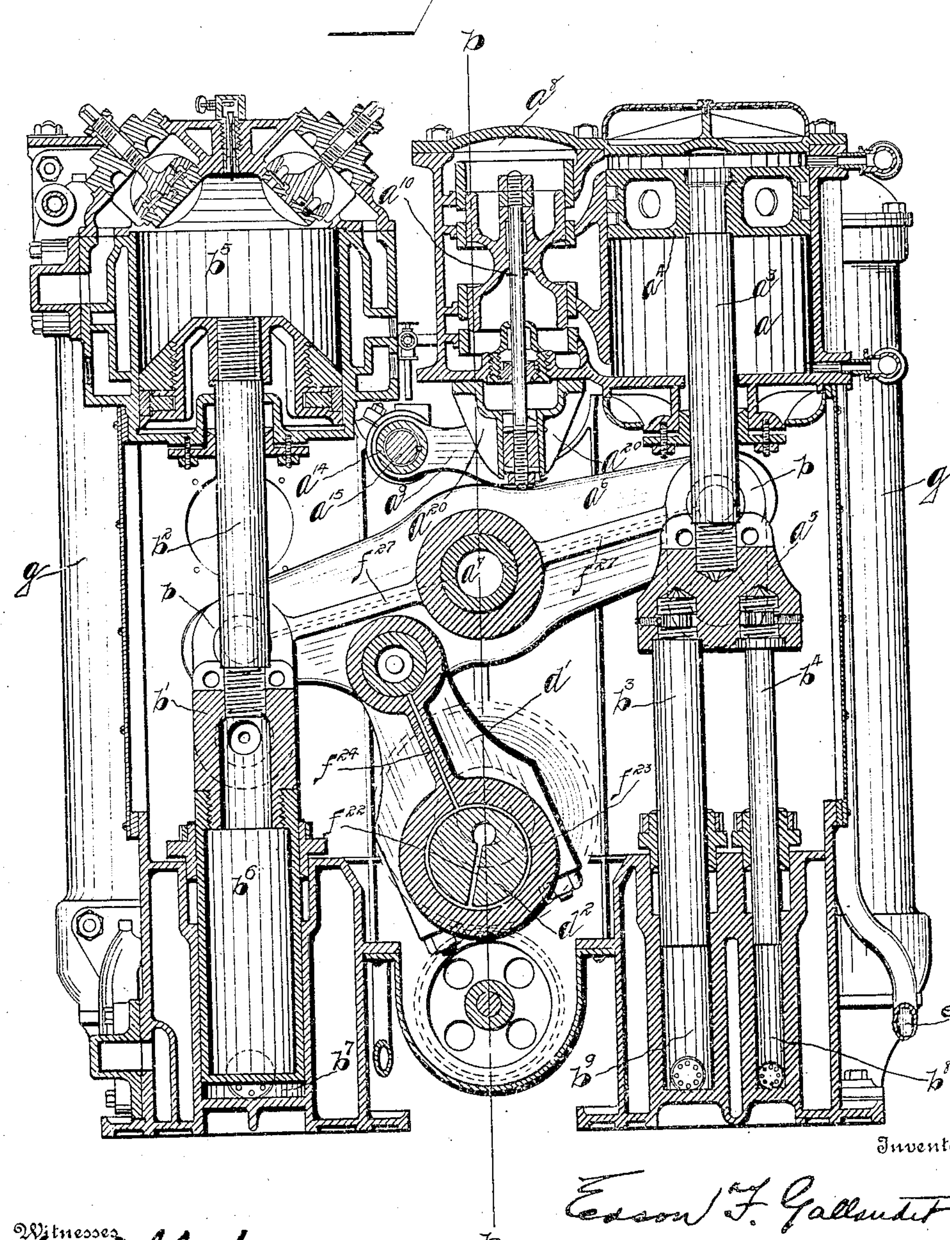
8 SHEETS—SHEET 2.

FIG. 2.



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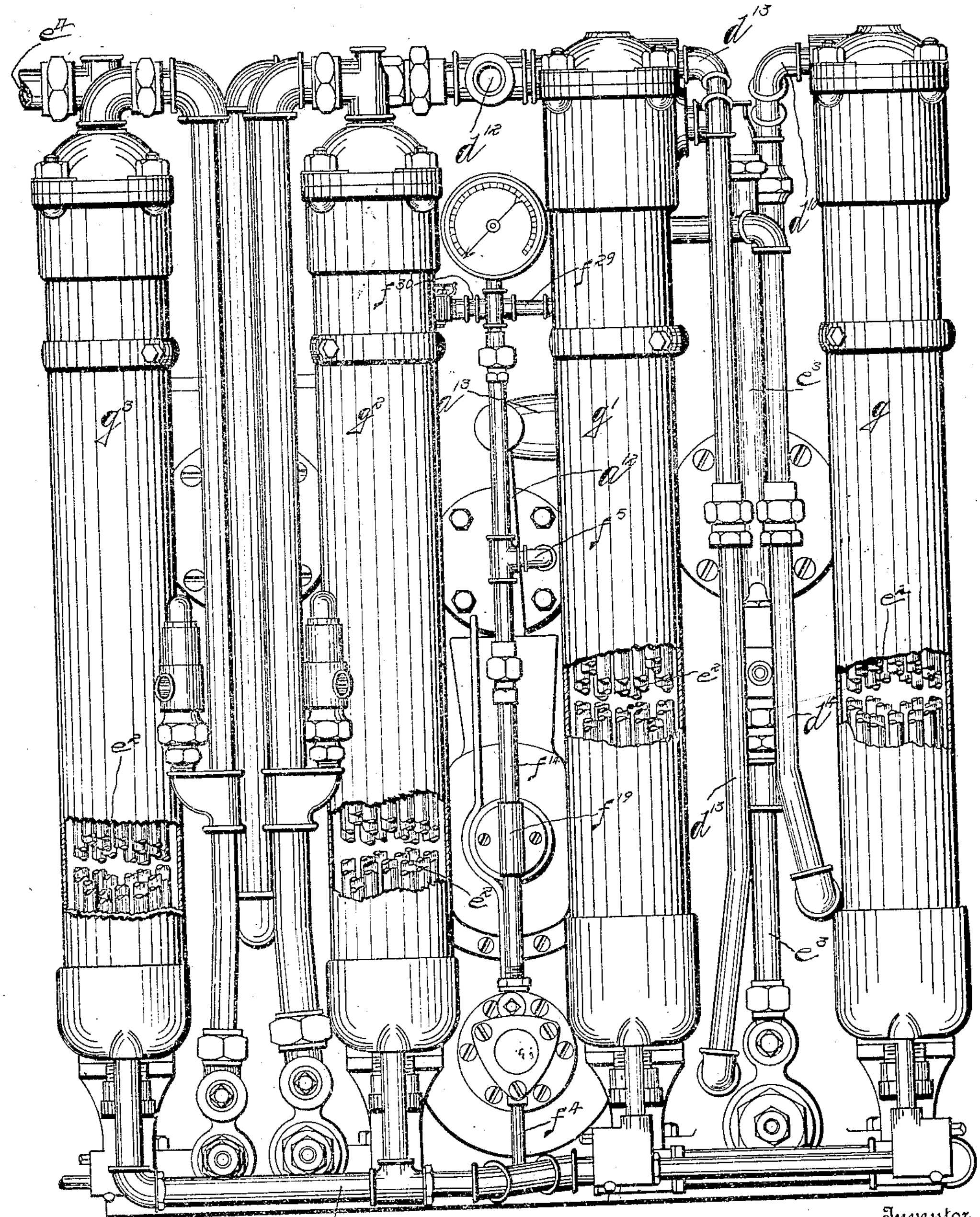

FIG 3

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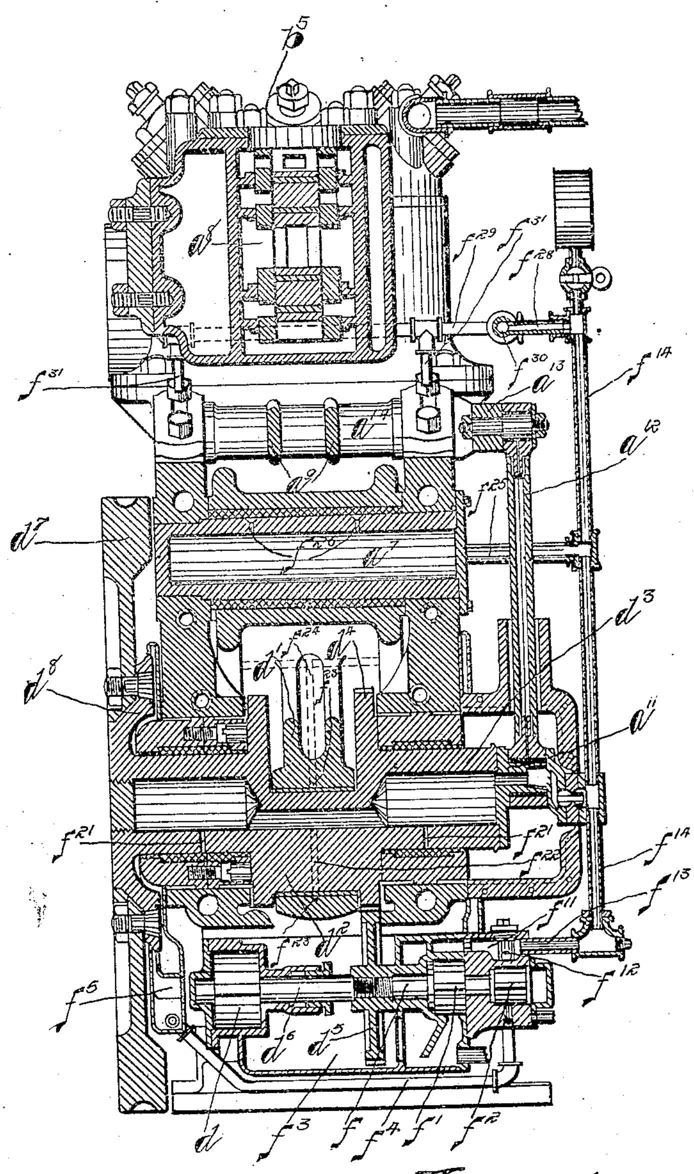
8 SHEETS—SHEET 4.

Fig 4



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8 SHEETS—SHEET 5.

FIG 6

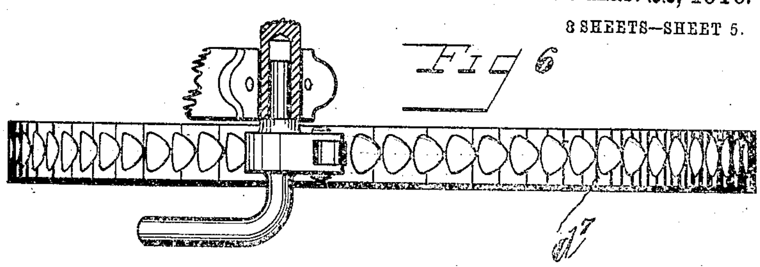
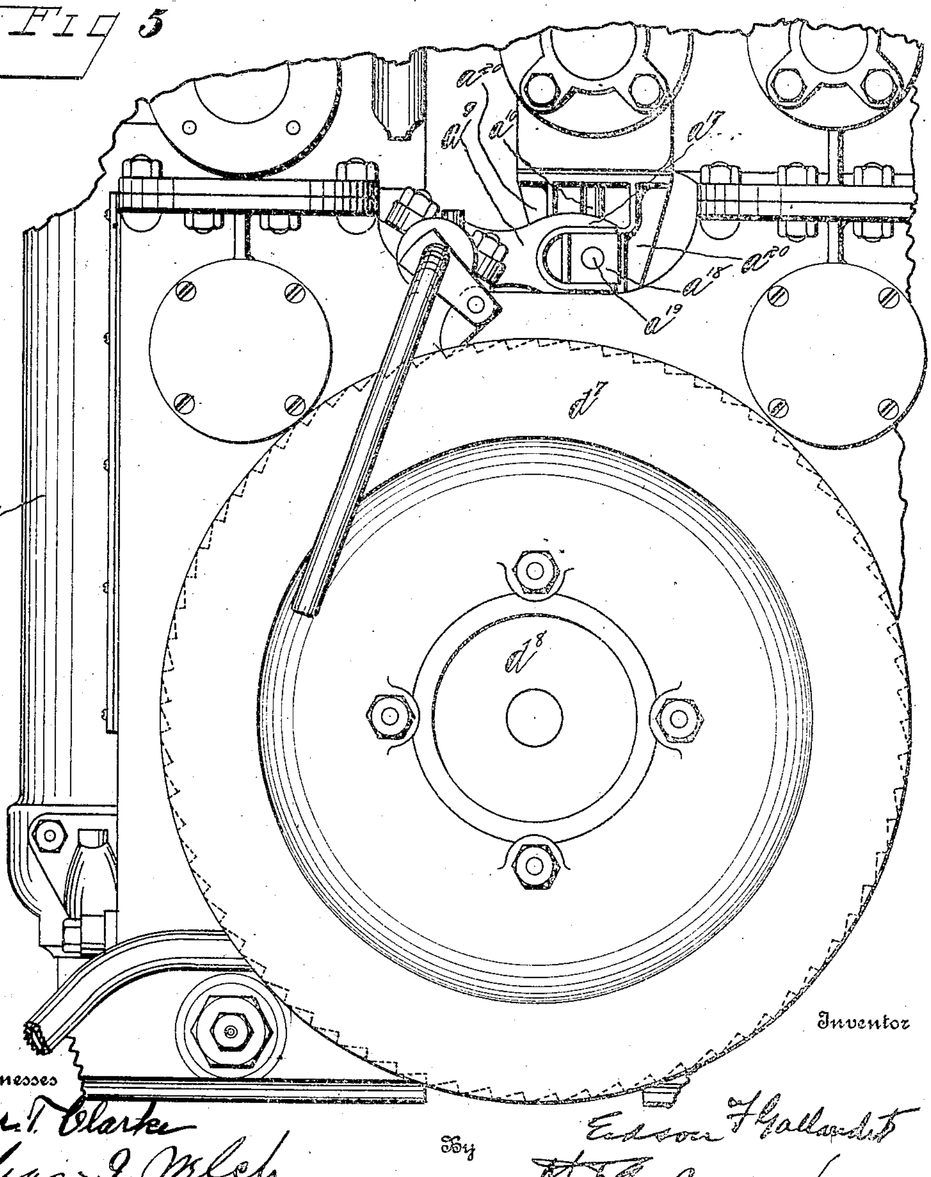


FIG 5



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8 SHEETS—SHEET 6.

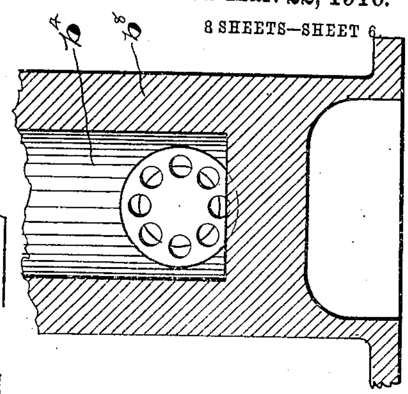

Fig. 8

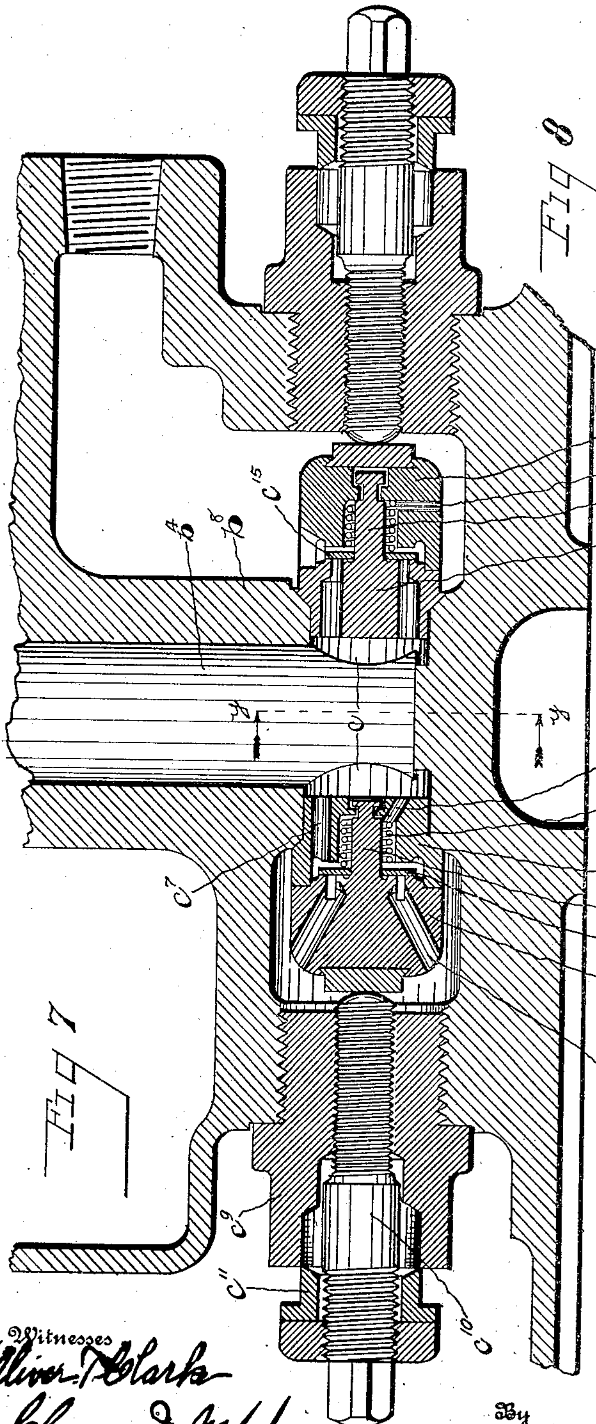

Fig. 7

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8 SHEETS—SHEET 7.

Fig 9

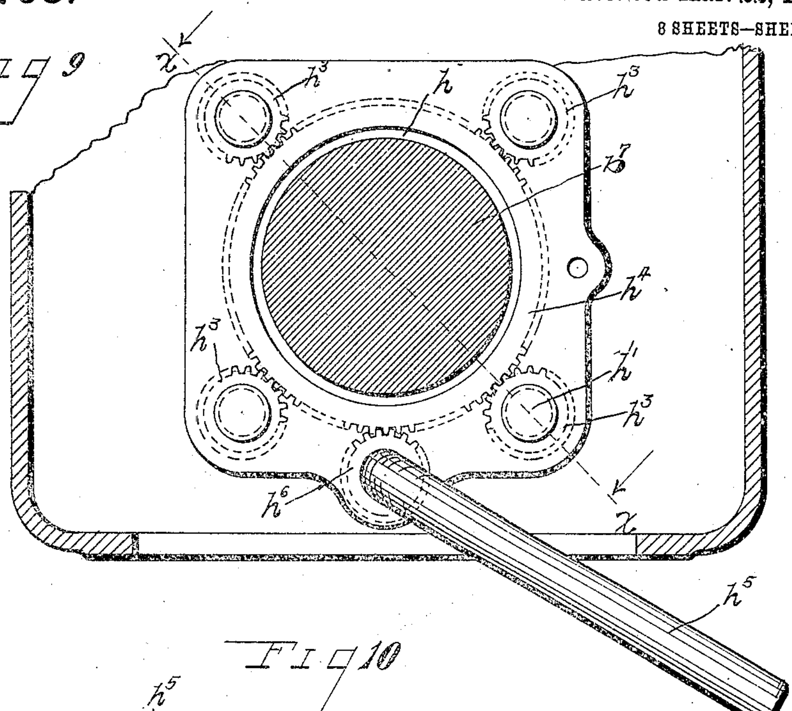
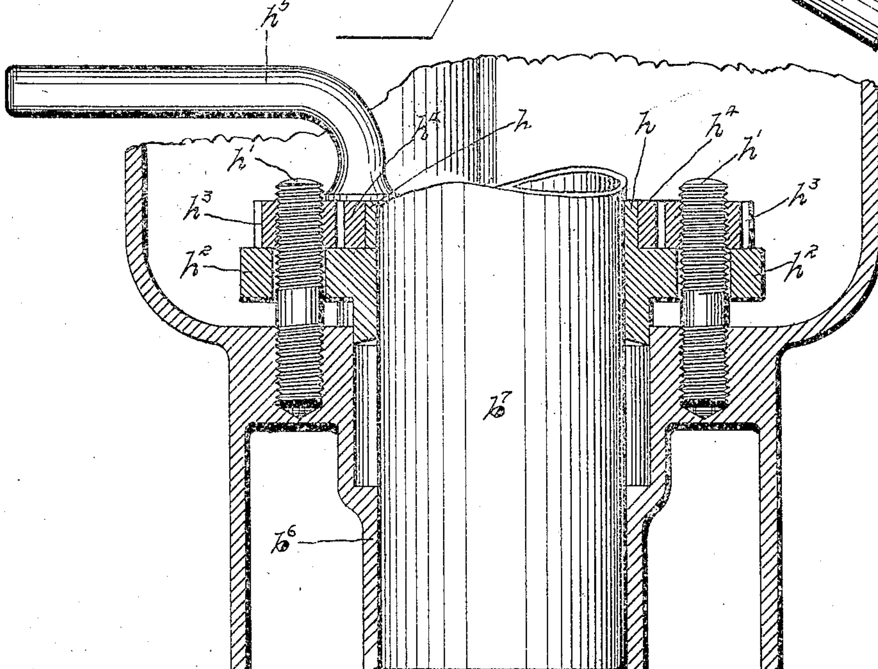


Fig 10



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8 SHEETS—SHEET 8.

Fig 11

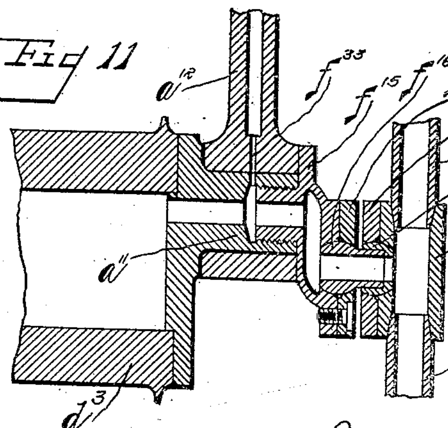


Fig 14

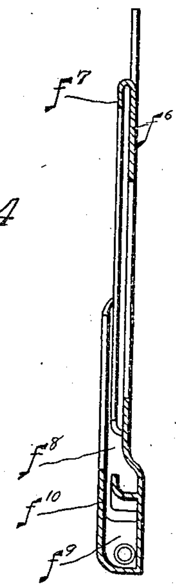


Fig 12

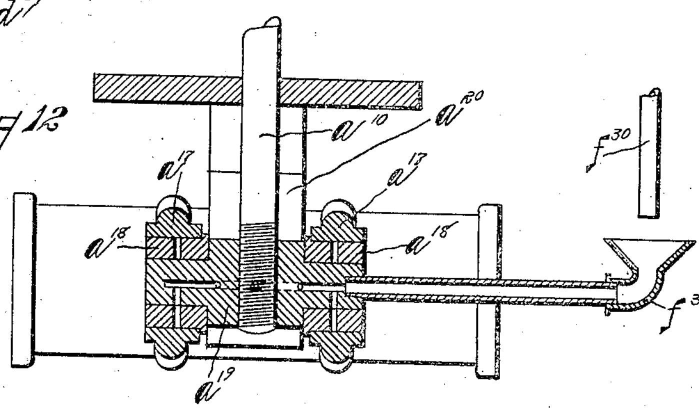
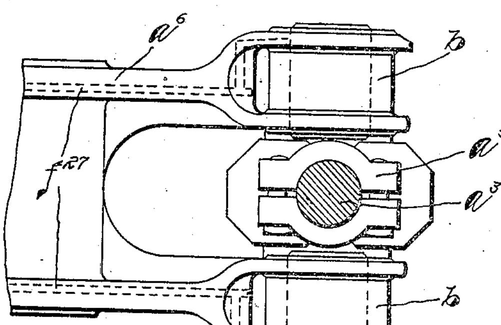


Fig 13



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Attorneys

UNITED STATES PATENT OFFICE.

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AIR-COMPRESSOR.

952,798. Specification of Letters Patent. Patented Mar. 22, 1910.

Application filed March 8, 1909. Serial No. 482,113.

To all whom it may concern:

Be it known that I, EDSON F. GALLAUDET, a citizen of the United States, residing at Norwich, in the county of New London and State of Connecticut, have invented certain new and useful Improvements in Air-Compressors, of which the following is a specification.

My invention relates to improvements in air compressors and particularly adapted to a steam air compressor for torpedoes where the air is compressed to a very high degree.

My compressor is a multiple stage cylinder compressor with an arrangement of multiple stage coolers and my improvement, in a broad sense, consists in improving the efficiency and the compactness of the device.

General arrangement.—The general arrangement of the machine is such that the steam cylinder and multiple stage compression cylinders are arranged at the top and bottom of the compressor, while the intermediate connecting device for the steam cylinder and the multiple stage compressing cylinders is located between the cylinders and the pump devices for the cooling medium of the multiple stage coolers as well as the pump device for the oil are located near the bottom of the machine in a substantially central location.

Referring to the drawings, Figure 1 is a top plan view. Fig. 2 is a sectional view taken on the line *a a* of Fig. 1. Fig. 3 is a rear elevation. Fig. 4 is a sectional view on the line *b b* of Fig. 2. Figs. 5 and 6 are detail views of the flywheel and starting mechanism. Figs. 7 and 8 are detail views of one of the multiple stage compression cylinders. Figs. 9 and 10 are detail views of one of the compression cylinders showing the stuffing gland. Fig. 11 is a detail in section of the universal connection between the main oil supply pipe and crank-shaft. Fig. 12 is a detail in section of connection between the steam-valve rod and rocker-arm. Fig. 13 is a top plan of one end of the rocking beam and connections. Fig. 14 is a vertical section of the oil catcher.

Like parts are represented by similar characters of reference in the several views.

As will be apparent from an examination of Fig. 2, the arrangement of parts is such that the steam cylinder can be located at the top of the machine near one side thereof while the multiple stage compression cylinders can be grouped so that the low-stage compression cylinder will also be located at the top of the machine and to one side of the steam cylinder, while the second-stage compression cylinder will be located immediately below the low-stage cylinder, and the third and high-stage cylinders are also located in the lower or bottom part of the machine and immediately below the steam cylinder. The general arrangement of the cooling system is such that the pump for the cooling medium may be located near the bottom of the machine and between the second and third stage cylinders and the cooling medium will be pumped upwardly from the bottom of the machine through the different coolers and the cooling medium circulation will thereafter be downward to the various compressors. In a general way the cooling medium circulation follows that illustrated and fully described in the application of A. J. Pocock and R. E. Allgire, Ser. No. 275,819, filed August 25, 1905. As explained fully in that application, the cooling medium is pumped direct to each of the multiple stage coolers and from the coolers it circulates through the jacket of the associated air compression cylinders and thereafter is discharged. The air circulation is from the low-stage compression cylinder to its associated cooler and thereafter to the second-stage compression cylinder and from that cylinder to the next higher cooler and thereafter to the succeeding compression cylinder and its associated cooler always circulating through the various coolers and the after-cooler in a direction opposite from that of the cooling medium. Likewise, the circuit for the oiling medium is in a direction from the bottom of the machine upwardly and the same is circulated under pressure by means of the pumping mechanism located near the bottom of the machine.

Steam cylinder and connections.—Referring to Figs. 1 and 2, the steam cylinder is indicated by *a* and steam inlet by a^1, while the steam exhaust is indicated by a^2. The piston rod, a^3, of the piston, a^4, is connected to the two-part cross-head a^5. The cross-head a^5 is pivotally connected to one end of the rocking-beam, a^6, by links, *b*, (see Fig. 13 for detail) which rocking-beam is pivotally mounted on the hollow shaft a^7. This rocking-beam, a^6, constitutes the main connecting device between the steam cylinder and the low-stage compression cylinder and the second-stage compression cylinder and also comprises the connection between the steam cylinder and the various pumping devices and parts other than the third-stage and high-stage compressors, which latter are operated direct from the cross-head a^5, as clearly shown in Fig. 2. The valve-chest for the steam cylinder is indicated by a^8 and the valve mechanism is operated by means of the bifurcated rocker-arm, a^9, which is in turn operated by connections with the rocking-beam, a^6, as will be more fully explained hereinafter.

Multiple stage compressors.—As heretofore explained, one end of the rocking-beam, a^6, is connected to the plungers or pistons of the low and second stage compressors, which are indicated by b^5 b^6. This end of the beam is pivotally connected to a cross-head, b^1, through the medium of links, b, and the plunger, b^6, of the second-stage compressor is securely fastened to said cross-head and the piston-rod, b^2, of the piston for the low-stage compressor is likewise secured to said cross-head b^1. The plunger, b^3, for the third-stage compressor, b^9, is secured in the ordinary manner to cross-head a^5 and the plunger, b^4, for the high-stage compressor is likewise secured to said cross-head. Links, b, pivotally connect this cross-head to the rocking-beam, a^6.

Inlet and outlet valves to compression cylinders.—In Figs. 7 and 8 is shown an improved form of inlet and outlet valve mechanism for the compression cylinders. In these figures the valve mechanism of the high or fourth stage compression cylinder, b^8, has been illustrated. The cylinder wall is preferably cut away at points opposite the respective inlet and outlet openings, as shown at c c. Located in the inlet opening in the lower end of the cylinder is a two-part cage containing the valve mechanism, the respective parts of which are represented by c^1 c^2. The part c^1 has a series of air inlets, c^3, and also an extending stem, c^4, which projects into the central chambered portion of the part, c^2, and has an interlocking connection therewith by projecting into a groove-way in the end of the stem projections on the part, c^2; these projections only extending part way around the stem so that by inserting the same and giving it a quarter turn the projections will be caused to engage in the groove. A spring, c^5, is placed about the stem and bears against the valve proper, which is in the form of a disk c^6, perforated to receive the stem, and which bears against the part, c^1, which is faced off to receive the same, so as to normally close the opening in said part c^1; the adjacent end of the part, c^2, having an enlarged chamber or recess to receive this disk. The part c^2 has a series of openings, c^7, leading from the enlarged chamber or recess into the cylinder. Also located in the part c^2 and leading from the cylinder into the small spring chamber is a series of openings c^8, so that after a charge of air has been drawn into the cylinder and the plunger descends to compress the same, a certain amount of the air will be forced through said openings c^8 to assist the spring in forcing the disk c^6 tightly against its seat so as to securely close the inlet openings in the part c^1. The inlet is provided with an opening in which is screwed a plug, c^9, having a stuffing box in the outer end. Located in the plug, preferably screw-threaded therein, is an adjustable thrust-screw, c^{10}, the end of which bears against the part, c, of the valve cage, to hold the same in position; the part c^2 of this cage having a peripheral beveled shoulder adapted to bear against a similar shoulder in the inlet opening so as to form a tight joint. The plug c^9 also has a shoulder which fits tightly against the outer end of the inlet opening, as shown. The stem c^{10} carries a gland, c^{11}, which fits the stuffing box of the plug. This cage for the valve mechanism of the outlet opening is also in two parts, c^{12} c^{13}, fitted to the inlet opening and to each other in the same manner as described in connection with the valve mechanism for the inlet opening; the projecting stem, c^{14}, however, being located on the opposite part to that of the other valve mechanism, with the spring receiving chamber in the other part so that the spring will force the valve disk, c^{15}, against the part c^{12}. The part c^{13} has one or more openings, c^{17}, communicating with the air outlet from the cylinder so that the compressed air will assist in holding the valve disk to its seat.

Cooling medium circuit.—As shown in Fig. 4, the pump for the cooling medium is a rotary pump of substantially the same construction as that shown and fully described in the pending application referred to, indicated by the reference letter, d. The actuating mechanism for the rotary pump and the shaft supporting the same is through the devices connected to said rocking-beam, a^6. Intermediate the hollow shaft, a^7, and the end of the rocking-beam there is pivotally connected therewith, as clearly shown in Fig. 2, a connecting rod, d^1, and this connecting rod, d^1, at its free end is pivotally connected to the crank-pin, d^2, of the crank-shaft, d^3, journaled in suitable bearings in the main frame. On one side of the crank pin is an integral gear, d^4, meshing with a gear d^5 on the pump shaft d^6, to which shaft is connected both the rotary pistons of the oil and water pumps. The fly-wheel d^7 is connected to one end of the crank-shaft preferably by bolting to a peripheral flange, d^8, on the end of the shaft.

The inlet for the cooling medium is indicated at d^{15} (Fig. 1) and this cooling medium is pumped by the rotary pump, d, direct to the coolers and after-cooler by the pipe connection d^9 (Fig. 3). Examining Fig. 1 it will be seen that the various compressors and coolers are so arranged in series that the low-stage compressor and the second-stage compressor are in close proximity to the first and second coolers, g and g^1 and the third and high stage compressors are located in close proximity to the third and after-coolers, g^2 and g^3. In this way, after the cooling medium has circulated through the cooler it passes to the jacket of its associated compressor. It will only be necessary to explain the circulation of the cooling medium through one of the coolers and jacket of its associated compressor, since the arrangements are duplicated through the machine. Referring to the first cooler, the cooling medium passes out of the top of that cooler to the jacket of the first-stage compressor through the pipe d^{10} (Fig. 1) and from that compressor the water passes through the pipe, d^{11}, to the discharge opening indicated by d^{12}. The cooling medium passes from the second-stage cooler to the jacket of the second-stage compressor through the pipe, d^{13}, in a downward direction, as appears clearly in Fig. 3, and thence to the common discharge opening, d^{12}, through the pipe, d^{14}, (Fig. 3).

Air circulation.—The air inlet is indicated by the reference letter, e, (Fig. 1) and it passes from the low-stage compression cylinder, b^5, to the first-stage cooler through the pipe e^1, and as heretofore explained in the co-pending application of Pocock and Allgire, the air passes through the low-stage and the second-stage cooler around the conduits or tubes, e^2 (Fig. 3) and the cooling medium circulates through said tubes, while in the third-stage coolers and the after-cooler, the cooling medium passing around the tubes, e^2, while the air circulates through said tubes. The air passes from the first-stage cooler and from the bottom thereof to the cylinder of the second-stage through a pipe connection arranged similar to that shown in Figs. 1 and 2 connecting the third-stage cooler and the fourth-stage compressor marked e^4, and from the cylinder of the second-stage compressor the air passes upwardly through the pipe e^3 (Fig. 3) to a point near the top of the second stage cooler and from the cooler it passes into the third-stage compressor and then to the third-stage cooler and from the cooler to the high-stage compressor and then to the after-cooler and from the after-cooler to the air outlet, e^4 (Figs. 1 and 3).

As indicated in Fig. 1, the third-stage cooler and the after-cooler are so arranged that the air passes downward at one side of the cooler and upward on the other side, the air both entering and discharging at the upper end of these particular coolers.

Steam valve operating mechanism.—As before stated, the valve mechanism of the steam cylinder is operated from the rocker-arm, a^9, which is connected to the crank-pin, a^{11}, secured to the end of the crank-shaft, through the medium of the rod, a^{12}, which rod is pivotally connected to the end of the crank-arm, a^{13}, on the hub, a^{14}, of the rocker-arm, which hub is pivoted on the rod, a^{15}, supported in suitable brackets from the main frame. The rocker-arm has two bifurcated extensions, a^{17}, at its forward end, (see Fig. 12 for detail) in each of which is mounted a block, a^{18}, the bifurcated end being capable of a movement independent of said block. Pivotally mounted in the blocks, a^{18}, is a head, a^{19}, to which the valve rod, a^{10}, is connected. Arranged on each side of this head are guide-ways, a^{20}, between which the head slides when the rocker-arm is rocked in either direction.

Oil circuit.—Coupled to the driving gear, d^5, is a shaft, f, upon which is secured the pistons of a main oil pump, f^1, and an auxiliary oil pump, f^2, the main pump being located in the chamber or casing, f^3, in which the oil from most of the bearings of the machine is caught. The auxiliary oil pump is located without this casing and is connected by a pipe, f^4, with an oil catcher, f^5, which lies closely adjacent to the flywheel and surrounds the fly wheel bearing. This oil catcher is shown in detail in Fig. 14. f^6 represents one side or wall which completely surrounds the bearing for the flywheel. The wall, f^7, completely surrounds the flange, d^8, to which the flywheel is bolted, with the exception of an opening, f^8, therein which communicates with the lower chamber, f^9, of the catcher which is formed by the wall, f^6, and the wall, f^{10}, which wall f^{10} overlaps the wall f^7 and extends partly about the flange d^8.

Both oil pumps communicate with a chamber, f^{11}, a check-valve, f^{12} being located between the chamber and the auxiliary pump. This chamber communicates with the vertical pipe, f^{14}, through the medium of a short pipe f^{13}. Oil is delivered under pressure from this pipe to the hollow crank shaft, d^2, through a universal connection. This universal connection is shown in detail in Fig. 11. Screwed into the end of the valve crank pin, a^{11}, is a socket plate, f^{15}, which receives a ball sleeve, f^{16}, held in place by the plate, f^{17}, which is secured to the socket plate f^{15}. The ball, f^{18}, is screwed onto the end of the ball sleeve, f^{16}, which fits in a socket in the connecting piece, f^{19}, forming a part of the supply pipe f^{14}. The plate f^{20}, secured to the connecting piece f^{19}, holds the ball, f^{18}, in position in the socket.

From the hollow crank-shaft the oil passes through the channels f^{21} (Fig. 4) to the crank-shaft bearings, and through the channel, f^{22}, (Figs. 2 and 4) to the bearings or journals of the crank and connecting rod, d^1. A channel, f^{23}, extends about the connecting-rod bearing and is connected by the passage-way, f^{24}, extending up through the connecting-rod, with the connecting-rod wrist-pin. Through the connection, f^{25}, the oil is forced into the hollow shaft, a^7, on which the rocking-beam is journaled; thence through channels, f^{26}, to the bearings; thence through channels, f^{27}, to the pivots for the links, b. One branch, f^{28}, of the connection, f^{28}, supplies oil for the bearings for the rocker-arm, a^9, through the medium of the drips, f^{31}. Another branch, f^{30}, extends over a funnel or cup, f^{32}, connected to one of the trunnions of the head a^{19}, (Fig. 12) to which the steam valve rod is connected so as to supply oil to a series of channels in said head and the blocks a^{18}. The connecting rod, a^{13}, which operates the rocker-arm is hollow and communicates with the hollow crank-pin, a^{11}, through the medium of a channel f^{33} so that oil may be supplied to the connection between said rod and the crank a^{13}.

Stuffing gland for compressor cylinders.—In Figs. 9 and 10 is illustrated the manner of securing the stuffing gland of one of the compressors in position. The cylinder which is illustrated is that of the second-stage compressor, b^6; b^7 representing the piston or plunger. h is the gland. Secured in the cylinder is a series of screw-threaded studs, h^1, preferably four in number, which extend loosely through perforations in the flange h^2 of the gland. Screwed onto these studs above the flange are pinions. Meshing with the respective pinions is a large gear, h^4, located on the flange of the gland between the pinions and the gland proper. Pivoted at a suitable point on the gland flange is a lever, h^5, carrying a pinion h^6 meshing with the gear h^4. By operating the lever all of the pinions, h^3, may be turned down against the flange and force the gland down uniformly into the stuffing box.

Having thus described my invention, I claim:—

1. In an air compressor, the combination of a steam cylinder and a plurality of multiple stage air compressors, three of said compressors being located at the lower part of the machine and one located at the side of said steam cylinder and in the upper part of the machine, a plurality of coolers one adjacent to each air compressor, a pump for the cooling medium in the bottom part of the machine, connections extending upwardly direct to each cooler, and a common discharge pipe for said coolers, substantially as specified.

3. In an air compressor, the combination of a steam cylinder and a plurality of multiple stage air compressors, the high stage compressors being located directly below the steam cylinder and the two low stage compressors at the side of said high stage compressors, a plurality of coolers, and connections for carrying the cooling medium from each cooler direct to its associated compression cylinder jacket and thereafter to the common discharge pipe, substantially as specified.

4. In an air compressor, the combination of a steam cylinder and a plurality of multiple stage air compressors, the high stage compressors being located directly below the steam cylinder and the two low stage compressors at the side of said high stage compressors, a plurality of coolers, and connections for carrying the cooling medium from each cooler direct to its associated compression cylinder jacket and thereafter to the common discharge pipe, a pump for the cooling medium at the bottom of the machine, an oil pump also located at the bottom of the machine, and independent connections extending upwardly from each pump, substantially as specified.

5. In an air compressor, the combination of a main operating device and a plurality of compressors and plungers therefor coupled together and located directly opposite the main operating device, additional compressors, an intermediate connecting device between said operating device and said additional compressors, said last-mentioned compressors being located one above the other, a plurality of coolers so arranged that one cooler is adjacent to each compressor, and a rotary pump for the cooling medium located between the compressors and at the lower part of the machine, substantially as specified.

6. In an air compressor, the combination

pump for the cooling medium located between the compressors and at the lower part of the machine, for the purpose specified.

7. In an air compressor, an operating device, and a plurality of compressors directly opposite said device and additional compressors in proximity thereto, a rocking beam intermediate said operating device and said additional compressors, coolers, and a cooling medium pump operated by said operating device, connections extending upwardly from said pump to said coolers, and connections extending downwardly from said coolers to the compression jacket, an air conduit from each compressor to its associated cooler carrying the compressed air in a direction reverse to that of the cooling medium.

8. In an air compressor, an operating device, and a plurality of compressors directly opposite said device and additional compressors in proximity thereto, each of said compressors having a cooling medium jacket, a rocking-beam intermediate said operating device and additional compressors, coolers, and a cooling medium pump operated by said operating device: connections from said pump extending upwardly to the bottom of each cooler, and connections extending downwardly from said coolers to the compressor jackets, and air conduits extending from each compressor to the top of the associated cooler carrying the compressed air in a direction reverse to that of the cooling medium, substantially as specified.

9. In an air compressor, the main operating device and a plurality of compressor plungers coupled together directly opposite said operating device, a plurality of compression pistons on the side opposite the first mentioned compressor plungers, a rocking-beam connecting said pistons with the operating device, coolers at the side of each of the compressors, a pump and connections extending direct to each cooler, and a common discharge pipe for all of said coolers, substantially as described.

10. In an air compressor, the main operating device and a plurality of compressor plungers coupled together directly opposite said operating device, a plurality of compression pistons on the side opposite the first mentioned compressor plungers, a rocking beam connecting said pistons with the operating device, coolers at the side of each of the compressors, a pump and connections extending direct to each cooler, and a common discharge pipe for all of said coolers, an oil pump, and connections extending upwardly to the bearings for said rocking beam, substantially as specified.

11. In an air compressor, a rocking beam, a steam-cylinder located on one side of one end of said beam having a piston pivotally connected with said beam, an air compressor also located at the same end of said beam in line with said steam cylinder but on the opposite side of the beam therefrom, the piston or plunger of said compressor having a connection with said steam-cylinder piston, and an air compressor located on each side of the opposite end of said beam, the pistons or plungers of said air compressors having a pivotal connection with said beam, substantially as specified.

12. In an air compressor, a rocking beam, a steam cylinder located on one side of said beam at the end thereof having its piston pivotally connected with said beam, a high and third stage compressor located side by side on the opposite side of said beam from said steam cylinder and in line therewith, the pistons or plungers of said compressors having a connection with said steam cylinder piston, and a low-stage and second-stage compressor located on opposite sides of the opposite end of said beam, the pistons or plungers of said compressors having a pivotal connection with said beam, substantially as specified.

13. In an air compressor, a rocking beam, a steam cylinder located on one side of said beam at the end thereof, a head to which the piston of said steam cylinder is connected, said head being pivotally connected with said beam, an air compressor located on the opposite side of said beam from said cylinder and in line therewith, the piston or plunger of said air compressor having a connection with said head, an air compressor located on each side of the opposite end of said beam in line with each other, a head to which the pistons or plungers of said air compressors are connected, and a pivotal connection between said beam and last-named head, substantially as specified.

In testimony whereof, I have hereunto set my hand this 13th day of February 1909.

EDSON F. GALLAUDET.

Witnesses:
E. M. GALLAUDET,
JOSEPH T. FANNING.