C. TELLIER.

COMPRESSED AIR REFRIGERATING APPARATUS.

APPLICATION FILED MAY 25, 1905.

923,604.

Patented June 1, 1909.

3 SHEETS—SHEET 1.

Fig. 1.

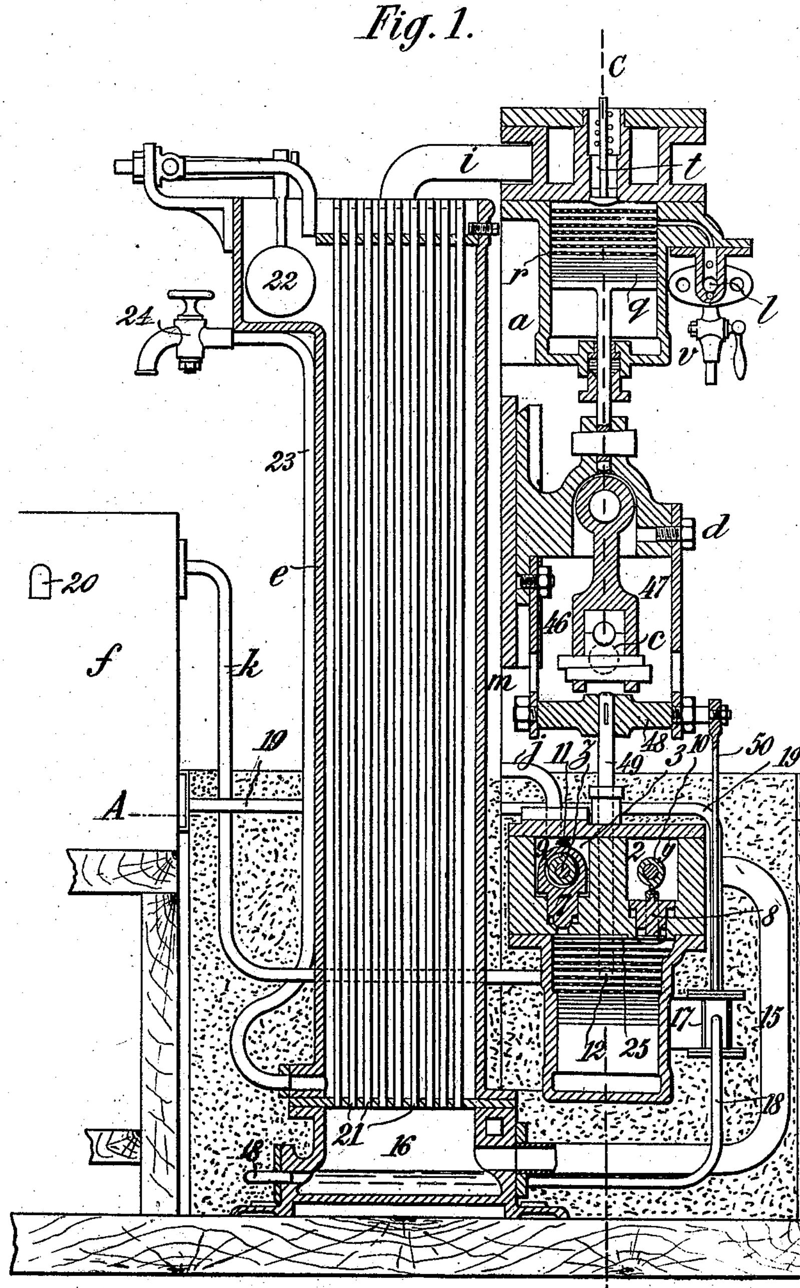
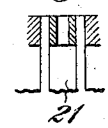


Fig. 1a



WITNESSES:

Fred White

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By his Attorneys

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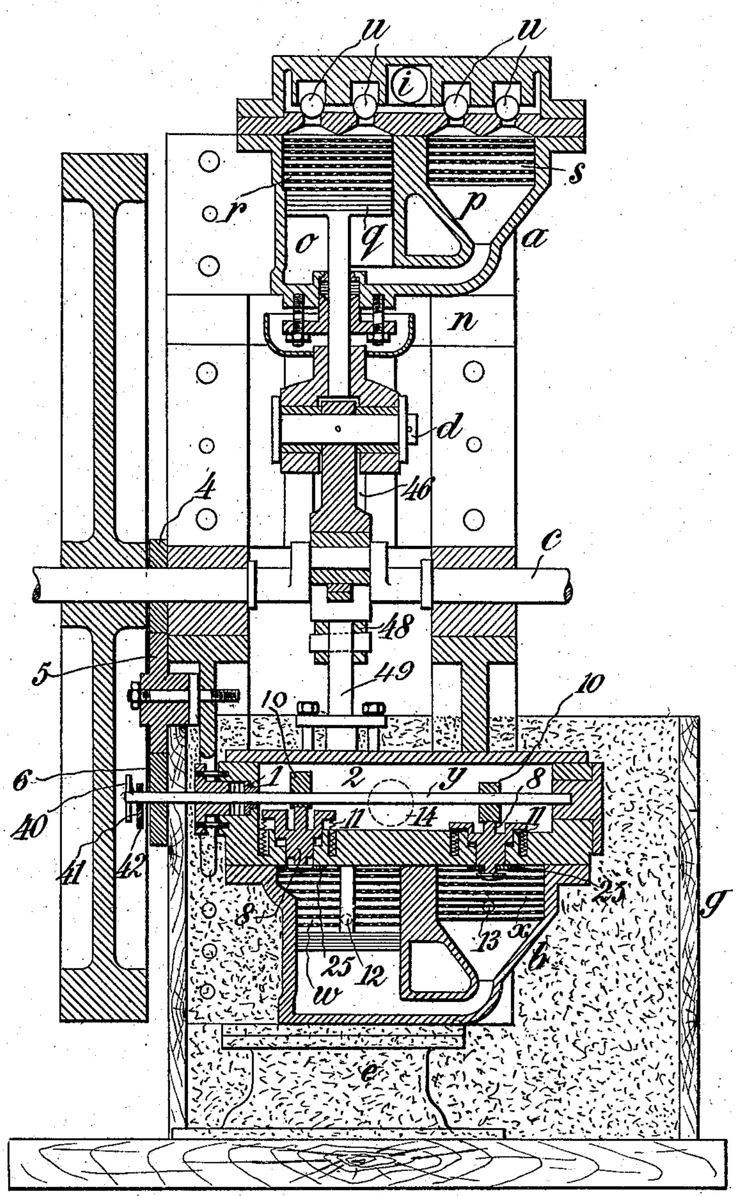
3 SHEETS—SHEET 2.

Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 3.

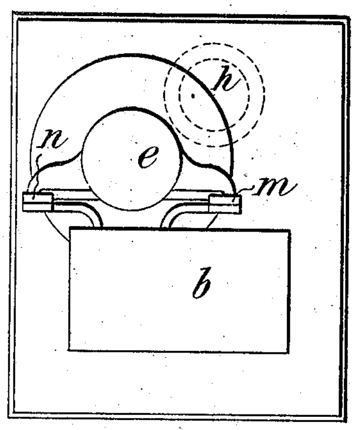


Fig. 4.

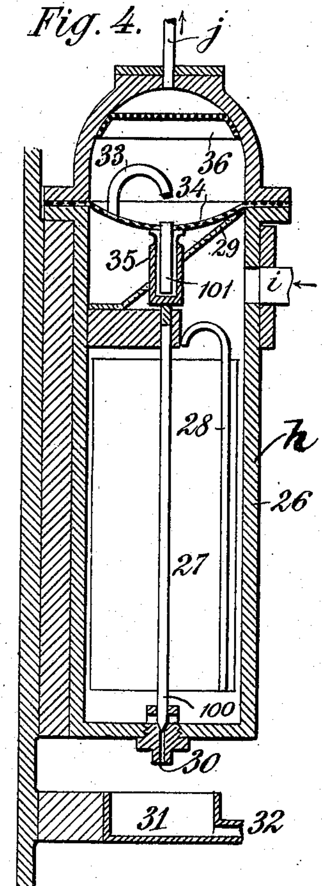


Fig. 6

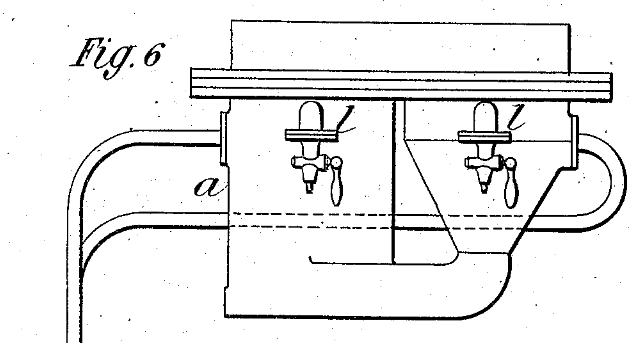


Fig. 5.

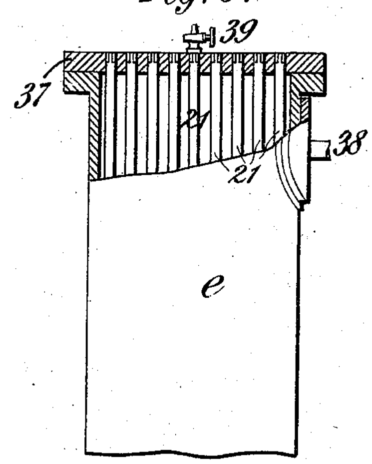
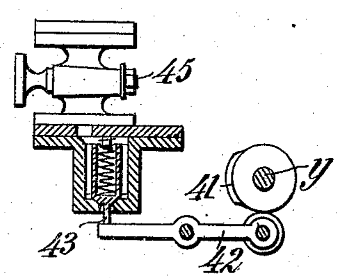


Fig. 7.



WITNESSES:

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UNITED STATES PATENT OFFICE.

CHARLES TELLIER, OF PARIS, FRANCE.

COMPRESSED-AIR REFRIGERATING APPARATUS.

No. 923,604. Specification of Letters Patent. Patented June 1, 1909.

Application filed May 25, 1905. Serial No. 262,291.

To all whom it may concern:

Be it known that I, Charles Tellier, a citizen of the Republic of France, residing at Paris, France, have invented certain new and useful Improvements in Refrigerating Apparatus Operating by the Expansion of Compressed Air, of which the following is a specification.

The invention aims to obtain low temperatures for various purposes, such as freezing, preserving, industrial applications, etc., by means of air isothermically compressed and isothermically expanded.

The apparatus may be actuated by any mechanical or animal power, or by a motor combined with either of these.

An apparatus embodying the invention is illustrated in the accompanying drawings, in which,—

Figure 1 is a vertical transverse section of the apparatus. Fig. 1[a] is a detail of Fig. 1. Fig. 2 is a vertical longitudinal section through the axes of the compressor and the expander, on the line C—D of Fig. 1. Fig. 3 is a diagrammatic sectional plan on line A—B of Fig. 1, on a smaller scale. Fig. 4 is a vertical section of the water-separating apparatus. Fig. 5 is a part sectional view of a modified construction of the temperature interchanging apparatus. Fig. 6 is a detached view of the discharge valves for the water used in the compressor *a*. Fig. 7 shows an enlarged sectional view of one of the said valves.

The apparatus consists mainly of an air compressing pump *a*, an expansion cylinder *b*, a motor shaft *c*, a slide *d*, a temperature interchanger *e*, a freezing apparatus *f*, an isolating casing *g*, and an automatic water separator *h*, the latter being shown in dotted lines in Fig. 3, and in vertical section in Fig. 4. The action of the apparatus is as follows:

The air is compressed isothermically by the pump *a* to the required degree of compression, and (being mixed with moisture) is led by the pipe *i* (Fig. 1) into the automatic water separator *h*, which in Fig. 1 is hidden by the heat exchanger *e*, but is shown in section in Fig. 4. It is there separated from the water with which it was mixed in the compression pump and issues through a pipe *j* which leads it to the expansion cylinder *b*.

By the expansion of the air in the cylinder *b* heat is absorbed, and the resulting cooling effect is transmitted to a current of incongealable liquid circulating through the said cylinder. This current of liquid is taken from the freezing apparatus *f* by the tube *k* which is connected by a check valve to each chamber of the expansion cylinder *b*, a similar check valve being shown at *l* (Fig. 1) connected to the compression pump *a*. The current of liquid thus refrigerated passes either to the freezing apparatus *f* or to any other refrigerating apparatus for producing the required cooling action.

Having thus generally stated the arrangement of the apparatus, I will now proceed to describe the same in detail.

In the type of apparatus shown in Figs. 1 and 2, the principal parts are mounted upon two upright supports *m n* cast in one with the interchanging apparatus *e*. The compression pump *a* is composed of a bored cylinder *o*, Fig. 2, communicating with a chamber *p* (Fig. 2); the cylinder *o* being provided with a piston *q*; above the cylinder *o* at the height of the top stroke of the piston *q* is a rectangular space *r* at the same level as a space *s* above the funnel-shaped chamber *p* (Fig. 2) which communicates with the lower end of the cylinder *o*.

The spaces *r* and *s* contain thin perforated plates arranged one above the other at a certain distance apart, such as from 4 to 6 mm., this distance being maintained by means of the heads of rivets in the plates. The spaces *r* and *s* have at top one or more suction and discharge valves, one of the suction valves being shown at *t* (Fig. 1) while the discharge valves are shown at *u* (Fig. 2). Their number may be varied, and any form of valves or slides may be employed. By the action of the piston *q* air is drawn in through valves *t*, and after compression is forced out through the valves *u*. At each suction stroke of the piston a small quantity of water is drawn in, which at each expelling stroke of the piston completely fills the chamber *r* or *s* whichever is in operation. The water is introduced through the check-valve *l* (Fig. 1), the quantity being regulated by means of a cock *v* on the supply pipe, so as to regulate the degree of cooling of the air during the compression.

The result of the above arrangement is as follows:—(1) The compression of the air is effected under the withdrawal of an optional amount of heat, which may vary between the temperature of the water employed and that of the compressed air discharged from cylinder *a*. (2) No leakage of air can take place past the piston, as it is covered on each side with water. (3) The valves are also protected against leakage by the water. (4) There are no dead spaces, as during the compression the excess of water which is driven off fills all the empty spaces. (5) In consequence of the above facts, high compression pressures can be employed, which greatly reduces the bulk of the apparatus. These various conditions enable the compression pump to work with a maximum output. The slide *d*, the connecting rod of the cranked driving shaft *c*, and the bearings of the latter, are of any suitable known construction.

The motor shaft *c* carries a fly-wheel at one end as shown in Fig. 2, while on the other end may be mounted driving pulleys or toothed gear, or it may be directly connected to a motor, unless it be preferred to arrange a motor cylinder in tandem with the pump *a* and expansion cylinder *b*.

The expansion cylinder *b* is arranged similarly to the compression pump *a*, being constructed with chambers *w* and *x* similar to *r* and *s*, but in place of circulating water through the same an incongealable liquid is employed which is supplied from the freezing apparatus *f* through a pipe *k*.

The distribution of the compressed air is effected by means of valves actuated by two shafts *y* and *z* which pass through stuffing boxes into the supply and discharge chambers 3 and 2. These shafts *y* and *z* are driven from the motor shaft *c* by means of a toothed wheel 4 gearing with an intermediate wheel 5 which gears with pinions 6 on the shafts *y* and *z*.

As shown in Fig. 1, shaft *z* works the supply valves 7 and *y*, the discharge valves 8, the shafts carrying disks with studs or rollers, which are shown at 9 and 10, Fig. 1, and at 10, 10, Fig. 2. Springs 11, 11 act upon the valves for effecting their rapid closure. They can be arranged as equilibrium valves, in particular for large machines.

At each stroke of the piston a charge of compressed air is admitted to the cylinder through the valves 7 and expanded, and is then discharged through the valves 8. A current of incongealable liquid is introduced by the pipe *k* through a regulating cock not shown, and through openings 12 and 13 into the chambers *w* and *x*, a pump being employed if necessary to force it in. This liquid in coming in contact with the expanding air takes up the cold therefrom, and is thereby reduced to —10 degrees C. more or less, according to circumstances. The cooled liquid together with the expanded air are discharged through the valves 8 into chamber 2, whence it issues through opening 14, Fig. 2, and passes through pipe 15, Fig. 1, into the space 16 in the base of the machine. A pump 17 draws the liquid from 16 through pipes 18 and forces it through pipe 19 into the lower part of the freezing chamber *f*, the action of which is thus rendered continuous.

As the liquid absorbs the water carried along by the compressed air, an overflow opening 20 is provided in the freezing chamber *f*, and the diluted liquid thus discharged is collected, and after being concentrated again it is passed back into the circulation. The air separated from the liquid in chamber 16 being still very cold, this cold is utilized in order to increase the economy of the apparatus by passing the air through the tubes 21, 21 of the cold interchanging apparatus *e*, the openings at the upper ends of which tubes are very restricted in order to insure the better distribution of the air through all the tubes. Water supplied through the cock controlled by a float 22 passes into the space of the interchanger surrounding the tubes 21, and consequently takes up the cold from the air passing through. This water is withdrawn at will through the pipes 23 with cock 24 for filling the molds of the ice machine with cooled water. Thus any material loss of cold is prevented.

If no production of ice is required, the cold of the air passing through the tubes 21 may be taken up either by the cooling fluids coming back from cooling chambers or by the compressed air on its way to the expansion cylinder, as shown by Fig. 5.

In cylinders in which liquid is propelled by the piston, it happens that at the end of the stroke a portion of the liquid is confined during the time intervening between the closing of the discharge valve and the opening of the inlet valve, whence concussions arise which are transmitted to the rest of the apparatus, and which should therefore be avoided. In order to avoid these concussions in the present apparatus I provide an enlargement of the rectangular chambers of the cylinder beyond the surface 25, against which the valves 8 close as shown at Figs. 1 and 2, which enlargement constitutes a chamber into which the excess of liquid can pass and which will also contain a small quantity of air acting as a buffer to prevent the said concussions. This body of liquid and air under compression will also facilitate the starting of the piston on the suction stroke. In apparatus of large dimensions the said enlargement may be made of sufficient size to contain a loose piston, having a cushion of air behind it. The apparatus for separating the compressed air and water, coming from the compressing cylinder, is shown in vertical section at *h* (Fig. 4). It consists of a casing 26 containing a float 27, the interior of which communicates with the chamber h by means of a tube 28 open at its two ends, and to which casing is fixed a discharge valve 30. The mixture of compressed air and water enters through the pipe i (see Fig. 1) and is projected against a screen 29, whence the water falls back into the chamber h so as to raise the float 27, thereby lifting the stopper 100 of the valve 30 and allowing the water to escape into the tank 31, whence it flows off through a pipe 32. The compressed air passing through the screen 29 issues through a bent pipe 33 into the space above a dished partition 34, which catches any water carried along by the air, such water being discharged through a pipe 101 into a surrounding tube 35 having overflow openings at top through which the water flows off into the chamber h. The compressed air flows off through a finely perforated plate 36, and is conducted by the pipe j to the expansion cylinder.

Fig. 5 shows a modified construction of the cold interchanger e, this being closed by a cover 37 at top, instead of being open, and the water being supplied thereto by a pipe 38, any air collecting in the upper part of the casing being discharged through a cock 39, so that the casing is thus always maintained full of water surrounding the tubes 21, which are traversed by the air coming from the expander. This cooled water is then drawn off at need for the filling of the freezing molds or for other purposes.

The water arriving in the separator (Fig. 4) is under considerable pressure, and in large machines it might be used for driving a small hydraulic motor connected with the apparatus. In smaller machines, however, it is preferable to withdraw the greater portion of the water during the period of the suction stroke of the air compressing cylinder when there is only a slight pressure. The apparatus shown in Figs. 6 and 7 serves for this purpose. The shafts y and z that work the valves of the expansion cylinder are provided with cams 40 and 41 (Fig. 2), of which 41 on shaft y is shown on an enlarged scale in Fig. 7; this cam in revolving with the shaft acts on the lever 42, which, during the suction stroke of the compression pump, lifts a valve 43 in a box communicating by a pipe 44 with the chamber of the compression pump, as shown in Fig. 6, and thus allows a certain amount of water to be discharged from this chamber during the suction strokes. A cock 45 enables the quantity of water to be regulated. It is to be understood that there is a separate discharge valve 43 and pipe 44 for each of the pump chambers. l l, Fig. 6, are the before described water inlet valves to the pump chambers. Referring again to Figs. 1 and 2, it will be seen that the slide d which is actuated by the crank of the motor shaft c is connected by rods 46 and 47 and a crosshead 48 to the piston rod 49 of the expansion cylinder b, as also to the rod 50 of the pump 17.

The details of the apparatus being clear, the complete operation is as follows: Atmospheric air is drawn into the compressor a by the movement of the piston q. The air is compressed on the perforated plates contained in the chambers r and s, Figs. 1, 2 and 3, which plates are constantly cooled by a current of water. Consequently the heat of compression is absorbed by these plates as it is produced, and the compression is effected isothermically; the same heat being taken up by the current of water.

The air and water pass out of the compressor by the valves u and pipe i, Figs. 1 and 2, to the separator, Fig. 4. The water escapes by the orifice 30, while the air escapes by the tube j and passes over to the expander b. This expander is a true motor cylinder with this difference from the ordinary motor cylinders, that it carries two chambers w and x filled with perforated metallic plates similar to those in the chambers r and s. These plates are wet by a current of incongealable liquid which conveys the cooling action either to the cooler f or to any other desired cooling apparatus. The plates are maintained at a cooling temperature determined by the quantity of incongealable liquid in circulation. Consequently the expansion takes place at the temperature of these plates, and cannot be of any substantially lower temperature. This is a great advantage, since the motive power of the air which is operated on and which is opposed to the resistance of the compressor is thus utilized in great proportion and thus diminishes the force which is required to operate the apparatus.

The expanded air passes through the temperature exchanger e containing the water which is to serve for the freezing operation. This water being submitted to the cooling effect of the circulating air is the more easily manufactured into ice. If, instead of manufacturing ice, the machine is used for other cooling purposes, the air would still be passed through the interior of the tubes of the interchanger e. But on the outside of these tubes within the vessel e there would be passed either the incongealable liquid employed in the machine, or air which is to be cooled, or other medium.

What I claim is:

1. An apparatus for producing cold by the expansion of compressed air, including in combination a compressor, an expansion cylinder, and a temperature interchanger, the air compression cylinder and the air expansion cylinder being provided with two chambers r and s and w x, superposed perforated

metal plates in said chambers, and means for causing a current of water to flow through said plates to take up heat from the compressed air.

2. An apparatus for producing cold by the expansion of compressed air, including in combination a compressor, an expansion cylinder, and a temperature interchanger, the air compression cylinder and the air expansion cylinder being provided with two chambers *r* and *s* and *w x*, superposed perforated metal plates in said chambers, and means for causing a current of water to flow through said plates to take up heat from the compressed air, and means for causing the liquid to fill the cylinders so that there are no dead spaces, and thereby to prevent leakage of air through the stuffing boxes, pistons and valves, and to enable high compression pressures to be obtained, substantially as described.

3. An apparatus for producing cold by the expansion of compressed air, including in combination a compressor, an expansion cylinder, and a temperature interchanger, the air compression cylinder and the air expansion cylinder being provided with two chambers *r* and *s* and *w x*, superposed perforated metal plates in said chambers, and means for causing a current of water to flow through said plates to take up heat from the compressed air, and an air chamber for preventing concussion of the liquid at the end of the compression stroke, substantially as described.

4. An apparatus for producing cold by the expansion of compressed air, including in combination a compressor, an expansion cylinder, and a temperature interchanger, the air compression cylinder and the air expansion cylinder being provided with two chambers *r* and *s* and *w x*, superposed perforated metal plates in said chambers, and means for causing a current of water to flow through said plates to take up heat from the compressed air, and means for preventing concussion of the liquid at the end of the compression stroke, substantially as described.

5. An apparatus for producing cold by the expansion of compressed air, including in combination a compression cylinder, an expansion cylinder, pistons and piston rods working in said cylinders, and a temperature interchanger, the air compression cylinder and the air expansion cylinder being provided with two chambers *r* and *s* and *w x*, superposed perforated metal plates in said chambers, and means for causing in the one a current of water to flow through said plates to take up heat from the compressed air, and in the other case incongealable liquid to take up cold from the expanded air, the piston rods of the compression and expansion cylinders being connected tandem-wise, substantially as described.

In witness whereof I have hereunto signed my name this 11th day of May 1905, in the presence of two subscribing witnesses.

CHARLES TELLIER.

Witnesses:

JULES ARMENGAUD, Jeune,
HANSON C. COXE.