THE LATEST LIQUID AIR PLANT.

BY PROF. W. C. PECKHAM.

A very considerable addition to the appliances for liquefying air and other refractory gases has been made in the plant of the General Liquid Air and Refrigerating Company, which has just been completed and put into operation in New York city. A brief notice of its first production of liquid air appeared in our issue of June third.

We have known the plans for this machine for some time, and have felt certain of its success when it should be started. We have, however, deferred giving our readers any information concerning it till that information could be given upon the basis of an actual result.

We are now able to present a full description of this very interesting plant, with actual tests made in the presence of the writer. The data for this description have been furnished and the copy has been read by the inventors of this system of liquefaction, so that our readers may rely upon it as correct. The inventors are Messrs. Ostergren and Berger, of New York city. Mr. Oscar P. Ostergren is a graduate of the Royal Institution, Stockholm, Sweden, and has followed the profession of naval designer. Mr. Moriz Berger, the associate of Mr. Ostergren, was graduated at the Royal Polytechnic School of Munich. Mr. Ostergren states that he began to work out his design for a liquid air plant in 1896, several years before public attention was called to the subject.

We pass over the details of the filtering, purifying, cooling, drying, and separating apparatus, as simply auxiliary, and liable to be changed at any time, when experience shall suggest improvements. All of these parts, however, show great ingenuity in design. At every point throughout the works regulating and safety valves are provided, and pressure gages enable the engineer to see at a glance the exact working condition of the machinery.

We present quite fully the liquefying apparatus, since it is in this that the chief novelty is found. This part of the apparatus is protected by patents, both in the United States and in the principal foreign countries. It is claimed that these are the only patents which have been granted in the United States up to the present time upon apparatus for liquefying air or other gases.

The compressors for this plant were built by the Ingersoll-Sergeant Company, the larger one from special designs, made for the purpose. The quadruple compression system is employed, divided between two independent compressors, No. 1 and No. 2, Fig. 2. Compressor No. 1, shown in this figure, has air cylinders 18¼ inches and 12 inches in diameter respectively. The initial air pressure in the first compressing cylinder varies from zero to 10 pounds per square inch absolute, as may be required, at which pressure the air enters partially from the air compressor and partially from the atmosphere at such a reduced pressure. The second compressing cylinder brings the pressure up to 80 pounds per square inch, with a piston speed of 300 feet. The power required for this compressor aggregates about 60 horse power.

Compressor No. 2, shown in figure 2, has air cylinders 7¾ and 7 inches in diameter respectively. The initial pressure in the 7¾-inch cylinder is 80 pounds per square inch, and this is raised to 300 pounds terminal pressure, which is the initial pressure of the fourth and last cylinder. This fourth cylinder receives all the air from the third cylinder, the rest of the displacement being supplied by the return current from the liquefier, as will be shown later. In this cylinder the charge is compressed to 1,250 pounds per square inch, which is the pressure usually employed in the machine. The indicated horse power of compressor No. 2 is about 100 horse power. The total horse power used by the two compressors is thus about 160 horse power. This exceeds any plant hitherto reported by about 50 per cent. This is by far the largest liquid air plant in the world.

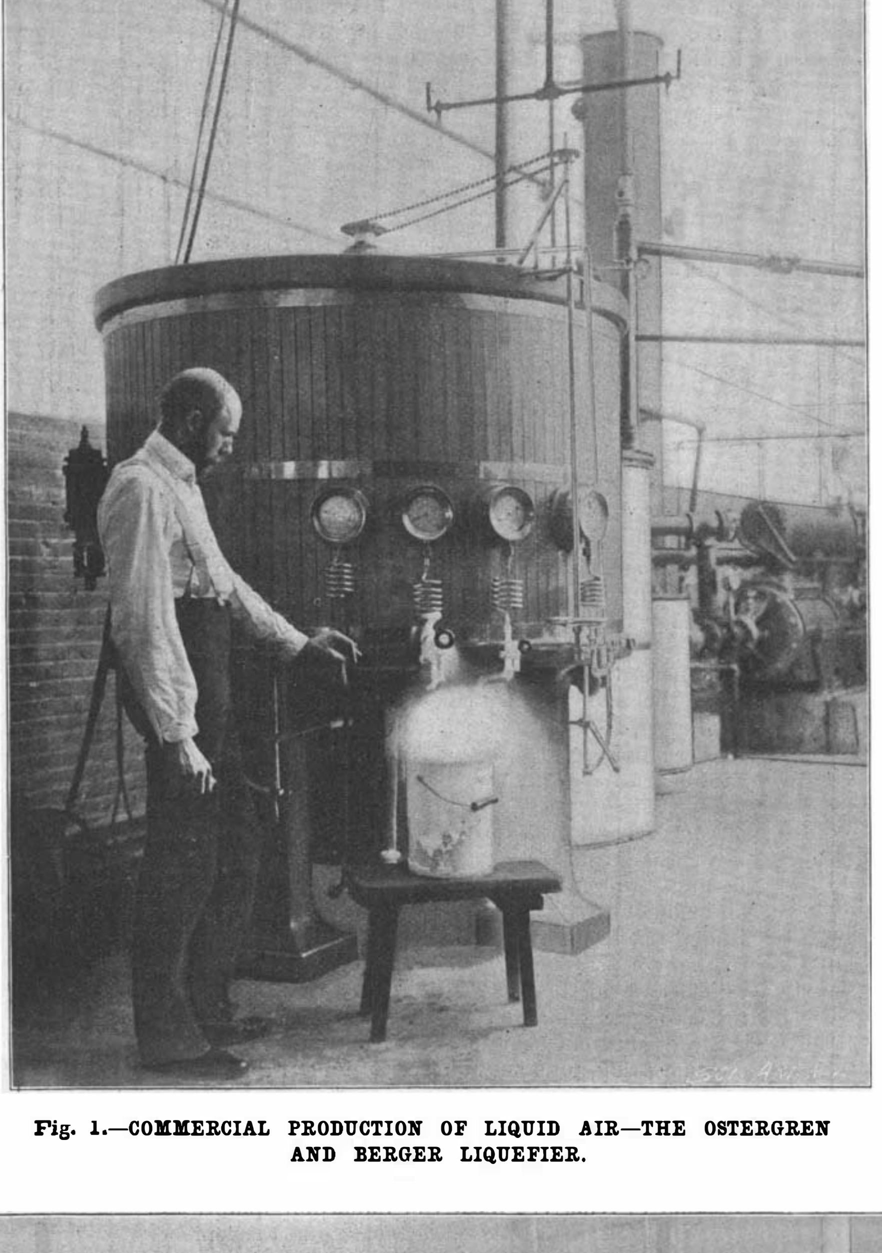


Fig. 1.—COMMERCIAL PRODUCTION OF LIQUID AIR—THE OSTERGREN AND BERGER LIQUEFIER.

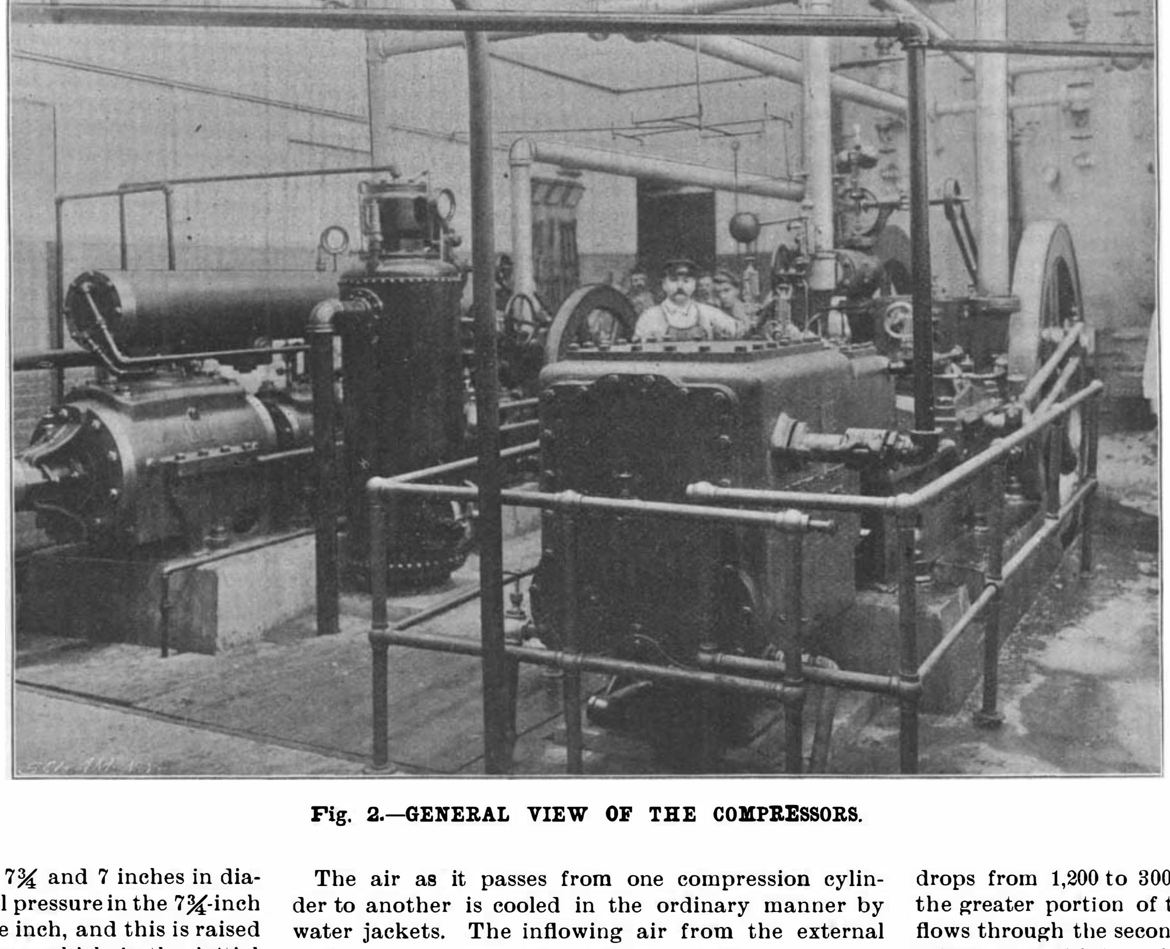


Fig. 2.—GENERAL VIEW OF THE COMPRESSORS.

The air as it passes from one compression cylinder to another is cooled in the ordinary manner by water jackets. The inflowing air from the external atmosphere is passed through an air filter, shown in our sectional view of the apparatus, Fig. 5, to remove its mechanical and other impurities, before entering the compressors.

After leaving the compressors the air passes to the brine or equalizing tank, Fig. 5, where the coil through which it flows is in close contact with the coil which carries the expanded air from the liquefier back to the fourth compression pump. In the brine tank the temperature of the air under high pressure is reduced nearly or quite to that of the expanded air in the return coil.

From the brine tank the air enters a tall separator, Fig. 5, in which the moisture, oil, and any other impurities are removed from it. Here it bubbles up through a tank of water and passes a system of baffle plates, which have satisfactorily performed the work for which they were designed. From the separator the air enters the condenser, or liquefier, at the temperature of cool water, and under a pressure not to exceed 1,250 pounds per square inch.

In the air condenser, or liquefier, there is a complete departure from former models. The system employed is that of "self-intensification of cold," as it has been termed, which appears to have been first employed by Cailletet in 1877 for liquefying oxygen, and which is fundamental in all the machines which have produced liquid air in considerable quantities. A portion of the air under high pressure is allowed to escape from a valve as in Linde's machine, and is expanded, while its pressure drops from 1,250 pounds to 300 pounds per square inch. There is thus produced a large and continuous fall of temperature which ultimately causes that portion of the air remaining in the high pressure system of pipes to liquefy. While this method of cooling a gas below its point of liquefaction is not new, the design of the apparatus and the attention to the details of economical working are novel, and differentiate it completely from its predecessors. A detail drawing, both in plan and elevation, is presented in Figs. 4 and 5, showing its completed form. It is about 7 feet high and its upper part is 6 feet in diameter.

The object had in view by the inventors was the most complete insulation from the heat of the external atmosphere during the process of liquefaction, and also the under-cooling of the air to such an extent that it would not at once return to the gaseous condition again upon being drawn out of the liquefier. In all previous machines the air has been brought only to its boiling point, or at best a very little below it, in the liquefier, and when drawn out into the open air, it boils with great violence and a considerable proportion returns to the gaseous condition, nor has any one hitherto succeeded in preventing this waste to any great extent.

In our sectional elevation of the liquefier, Fig. 4, the cooling of the air to the point of liquefaction occurs in the upper or larger, and the under-cooling takes place in the lower or smaller portion. The current of air under a pressure of 1,250 pounds to the square inch enters the liquefier through the standpipe on the right, from which 36 copper tubes of ⅝ inch diameter and 200 feet long lead in flat spirals toward the center of liquefier, as shown in the plan, Fig. 4. Here they connect with a casting containing two concentric chambers, with a regulating valve between the two chambers. This valve is controlled by the wheel shown at the top of the liquefier, Fig. 5. Passing this valve, the pressure drops from 1,200 to 300 pounds per square inch, and the greater portion of the air at this reduced pressure flows through the second chamber of this casting as a return current into a similar set of 36 tubes to the exit pipe, and so goes back to cylinder No. 4 of the compressor to be raised to 1,200 pounds and sent on its round again. The two sets of spiral tubes are soldered firmly together thus forming a vertical wall of 72 tubes, and inclosing a spiral space leading from circumference to center of the liquefier. An important use is made of this space, as will be seen later.

The heat of the inflowing current of air under high pressure is absorbed by the returning low pressure current which has been cooled by its passage through the regulating valve and its expansion on its return path. This action is so complete that the inflowing and outflowing current have practically the same temperature in the pipes just outside of the liquefier, as has been mentioned above. From the chamber just below the regulating valve a part of the air, which is under a pressure of 300 pounds and either liquefied or just on the point of becoming liquid, is allowed to expand a second time to a pressure of 10 pounds absolute in the under-cooler, which is seen below the liquefier in the sectional drawing, Fig. 4. The portion of the air which is expanded the second time is drawn out of the under-cooler as return current No. 2 by the suction of compressor No. 1, passing through the channel formed by the spiral turns of the wall of 72 tubes described in the liquefier, thus keeping the space around and between these tubes at a very low temperature. This expanded air enters again upon its round of compression and coolings, and in its turn contributes to the liquid product of the machine. The total cooling surface inside the liquefier is 2,200 square feet.

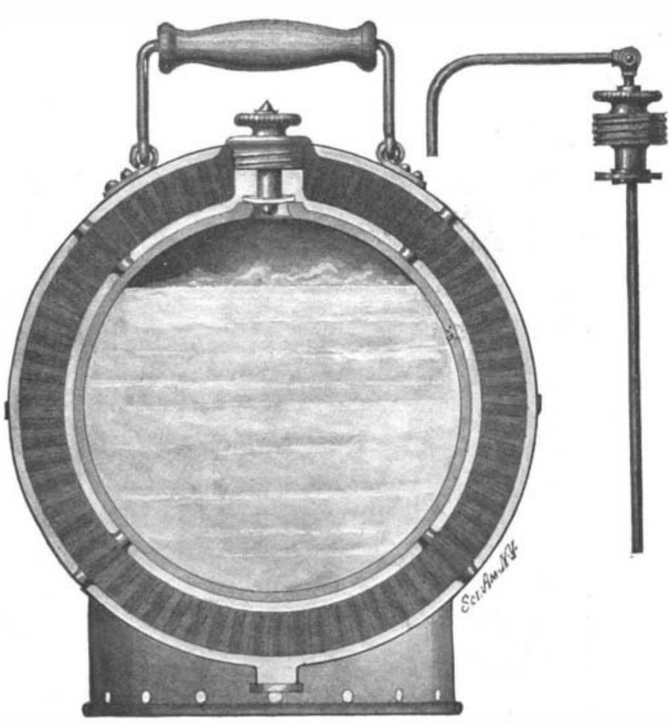


Fig. 3.—PORTABLE VESSEL FOR TRANSPORTING LIQUID AIR.

It will be seen that there is no waste of air which has once been compressed and partially expanded and that the only loss of air in the machine is the quantity of air which is liquefied. This is supplied from the atmosphere in the manner described above. It will be noticed also that the portions of the apparatus in which the liquefaction and under-cooling take place are most completely protected from the accession of external heat by means of the return current from the under-cooler of very cold air, expanded to a pressure less than normal by the suction of compression pump No. 1, which produces a vacuum from zero to 15 pounds as may be desired. It is thought that the liquid air could even be frozen in the lower portion of the under-cooler, by evaporating liquid air in the vacuum produced by pump No. 1.

The importance of the spiral space between the coils of pipes in both the liquefier and under-cooler will now be seen. It is traversed continually from center to periphery by a current of cold and rarefied air, which thus surrounds the working parts of the machine and insulates them from external heat, so that no especial packing is required, as is necessary in all other liqu.d air machines. But the production of liquid air is a matter of small moment unless some means for preserving it can be devised. This has been provided by Messrs. Ostergren and Berger in their receptacle for liquid air, Fig. 3, upon which the claim has been allowed in the United States Patent Offic. Numerous forms and sizes of these receptacles have been designed for special uses. The largest one built up to this time has a capacity of 40 gallons. Our illustration shows one which will hold 3 gallons. The central vessel is a sphere of copper. This is surrounded by an air space in the form of a spherical shell. Outside of this is an insulating layer which may be composed of any desired material.

This in turn is surrounded by another air space between the insulating layer and the external vessel. A poppet valve closes the opening into the inner vessel, which may be adjusted to any desired pressure. The expanding vapor from the inner vessel lifts the valve and passes into the space surrounding the vessel of liquid air. In order to reach the external atmosphere this vapor of air must pass through the insulating layer and then fill the external spherical air space. To emerge from this it must open a valve shown in the bottom of the receptacle, which is adjusted to work at any desired pressure. Thus the air expanding from its liquid form is made to cool the entire external space surrounding the liquid in the interior of the receptacle, and in order that heat from the atmosphere may enter the receptacle, it must pass in the opposite direction to the air which is escaping from the receptacle. To the receptacles pressure gages may be attached. For the purpose of removing the air, a tube extending to the bottom of the receptacle is provided, which operates upon the same principle as the so-called siphons of mineral waters.

Much curiosity has been felt to see the actual operation of machinery so carefully designed and constructed. The test of a full run has however been delayed from time to time by slight changes and repairs, such as are always unavoidable in new machinery. On Thursday, June 22, a trial was made, steam was turned on, and the compressors started. In about two hours after, liquid air was produced in such a quantity that it flowed from the outlet in almost a continuous stream. This was kept up for nearly five hours. No actual measurement of quantity could be made, since receptacles were not at hand for retaining it ; but certainly the output was very large.

An interesting experiment was made by opening the valve at the top of the liquefier, which showed that even in that part of the machine the temperature of the air was so low that it could be liquefied by allowing it to expand. The jet of escaping air liquefied, as could be plainly seen. There was distinct stratification, the alternate layers presenting a milky and transparent appearance. There was apparently a set of waves produced by vibrations set up in the outrushing current at the edge of the nozzle.

From the indications of the gages it would seem that the under-cooler could be increased considerably in capacity, and the total output be made correspondingly larger.

As a result of the successful operation of this plant, the company owning it has already an order for a plant to be set up in Los Angeles, California, with a capacity of 1,500 gallons of liquid air a day. This is to be used for refrigeration in the shipment of fruit from Los Angeles to Chicago. In this plant new features intended still further to increase its efficiency will be introduced. The result of this first projected application of liquid air to practical refrigeration, on a scale sufficiently extensive to furnish results definite and valuable as data for future operations, will be watched with much interest.

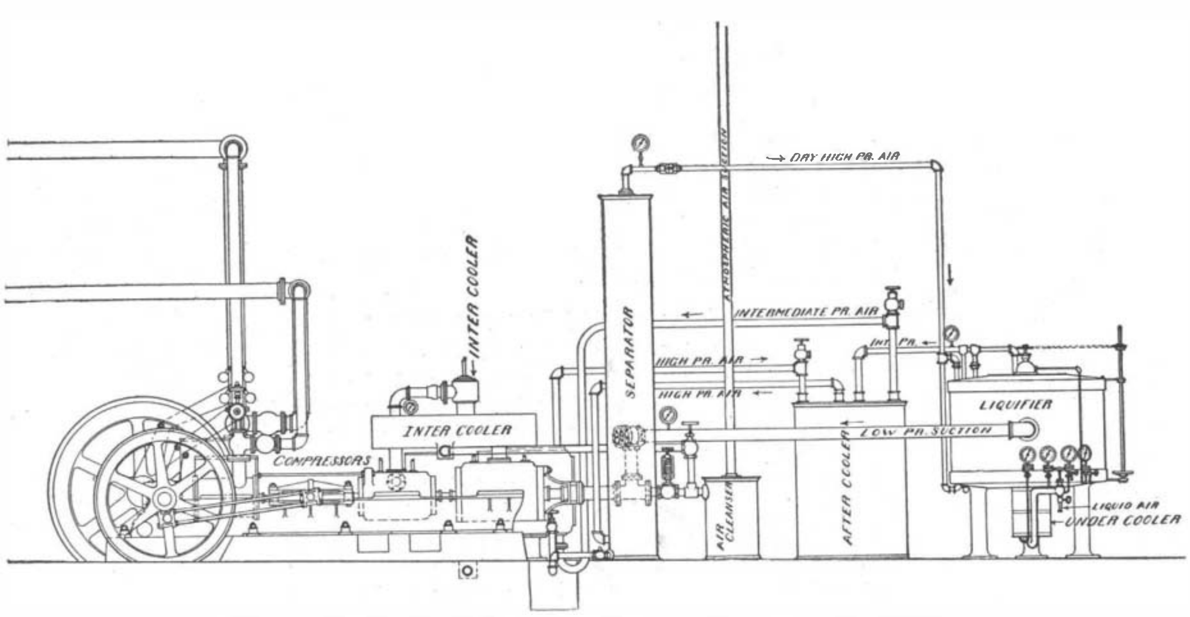


Fig. 5.—DIAGRAM SHOWING GENERAL VIEW OF THE PLANT.

Our illustrations were made by our own photographer during and after the close of the trial run. Messrs. Ostergren and Berger are to be congratulated for putting up a complicated plant, which has been operated successfully with so short a period for adjustment, especially since they had neither of them any previous experience in making or operating liquid air machinery.

Nocturnal Flight of Birds.

A new use for the telescope has been discovered in a new field of scientific observation, that of nocturnal bird flight, and the results are told by Mr. O. G. Libby, in The Auk.

A six-inch glass at the Washburn Observatory, overlooking the largest lake near Madison, Wis., was the instrument used. It was turned upon the moon, and the birds were counted as they crossed its surface. Observations were made on three successive nights in September, each being divided into fifteen-minute periods, and the record for each being kept distinct.

The total number of birds counted in the three nights was 583 ; of these, 358 were seen in one night. The number varied very much for different hours; the highest, three a minute, was reached at half-past ten, and it diminished to about one a minute at midnight. From that hour the number still declined, though varying at intervals. The prevailing direction up to ten o'clock was almost due south. Between twelve and two in the morning, while two-thirds of the whole number was still moving southward, others were flying toward the eight chief points of the compass.

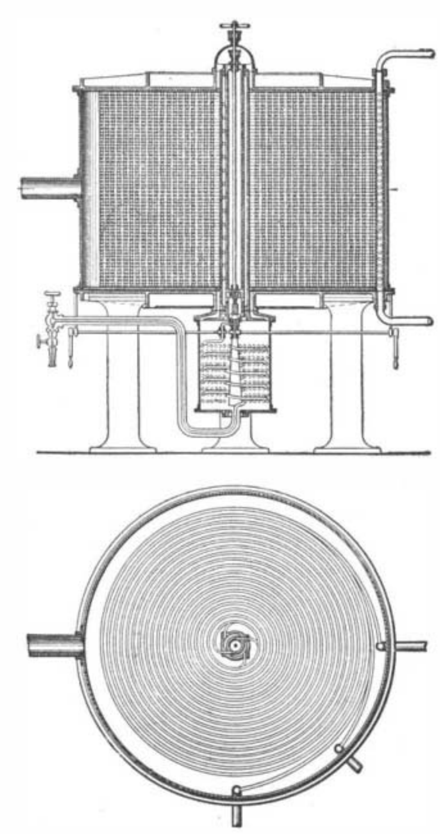


Fig. 4.—INTERNAL CONSTRUCTION OF LIQUEFIER.

Toward daylight the numerous calls heard indicated that flocks had been scattered during the hours when fewer were seen.

Taking into account the small size of the moon's surface, compared to the length of its path from east to west, within range of vision, it is reckoned that about 9,000 birds per hour passed during the period of observation. When we compare this path with the entire breadth of country over which the birds migrate, we arrive at astonishing figures, which should go into a bird census.

It was somewhat difficult to identify the birds, for they moved across the field in from one-tenth to one-half a second. Swamp blackbirds and meadow larks were distinguished in greatest number, but sparrows, yellow-hammers and ducks were also seen.

It is interesting to query how the birds are guided ; it is suggested that it may be by the stars, or by the contour of the country, lakes, forests, etc. It is certain that they lose their way on cloudy and foggy nights, and not infrequently a strange bird is seen flying with a flock of totally different species.

This field of night study, so full of novelty and interest, need not be confined to owners of telescopes, for good field glasses will show all but the smallest birds.

MILDEW is one of the danger signals that nature hangs out. Whenever and wherever it is visible, be on your guard. It means calamity to all organic life. The only remedy is unlimited fresh air and sunshine.

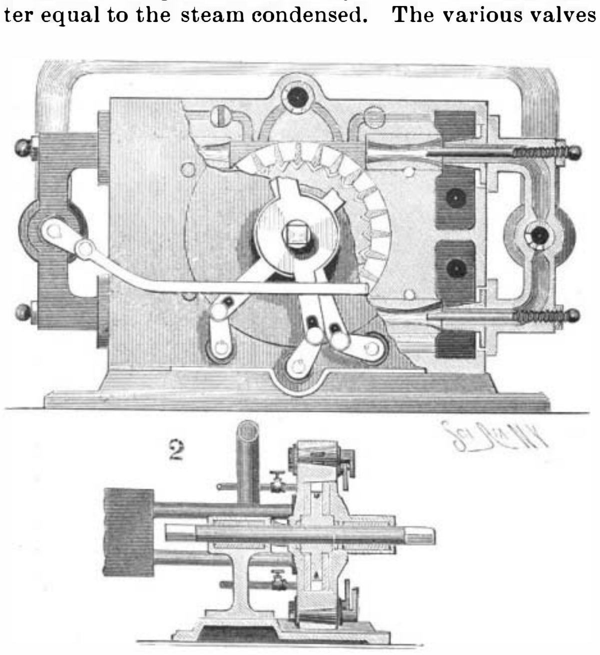
Preservation of Photographic Materials in a Vacuum.

Mr. Steffans has suggested the preservation of sensitized paper and plates in vacuo as a practical means of preservation in the case of articles sent out commercially; an excellent suggestion and one which merely amounts to extending to commercial use that which has long been done in the experimental laboratory. Several sheets of paper may be rolled up and sealed in an exhausted orange-colored glass tube, and even the soldering up of an exhausted tin case is a very easy matter, a method of doing this, which we have frequently practiced, being as follows: The tin casing must be so supported inside as not to collapse, and all being closed by soldering, except a minute countersunk pinhole for exhaustion, the countersink is tallowed, and a small bead of very fusible solder is laid in. A suitable solder is Wood's fusible metal, cadmium 1, tin 2, lead 4, bismuth 7; this melting between 60° and 70° Centigrade. To exhaust the air and at the same time fuse the bead of solder is a very easy matter. A small glass bell jar, rimmed with India rubber and connected with the air pump, is pressed down on a flat surface, and at the right moment a pointed copper soldering bit, which passes through a stuffing box, is brought down on the bead of solder. The whole question merits the attention of those who pack photographic goods, especially for export. In practice, the soldering bit would be heated electrically or by steam, and it must be remembered that a temperature below the boiling point of water is sufficient if the above mentioned solder is used.—Amateur Photographer.

A NEW TYPE OF ROTARY ENGINE.

In the engraving annexed we present two views of a novel rotary engine, driven by the action of a volume of water impelled against the piston by steam jets. Fig. 1 is a partial vertical cross section of the engine. Fig. 2 is a vertical longitudinal section, certain parts being omitted.

The casing of the engine has a central chamber in which the piston turns, and two water chambers on each side of the central chamber. The four water chambers communicate with the central chamber by means of throat tubes, and with a condenser by means of pipes, the same quantity of water being, therefore, constantly circulated through the casing. The water chambers communicate with valved relief passages extending parallel with the throat tubes, and serving to prevent back pressure against the piston. Above and below the piston two by-passes are located, each controlled by a two-way valve. These by-passes serve to regulate the action of the piston. Steam nozzles extend into the throat tubes and communicate with the arms of a main steam-feed pipe having two branches, each of which feeds two of the four arms. Each pair of arms is connected by a two-way valve by means of which the steam may be thrown into any one of the arms or cut off entirely. The two valves are connected to move in unison by means of a connecting rod. Through the steam nozzles and throat tubes valved exhaust tubes pass, which carry off an amount of water equal to the steam condensed. The various valves



SCOTT'S ROTARY ENGINE.

of the relief passages, by-passes, and pipe-arms are controlled by an arrangement of crank arms and levers, as shown in Fig. 1.

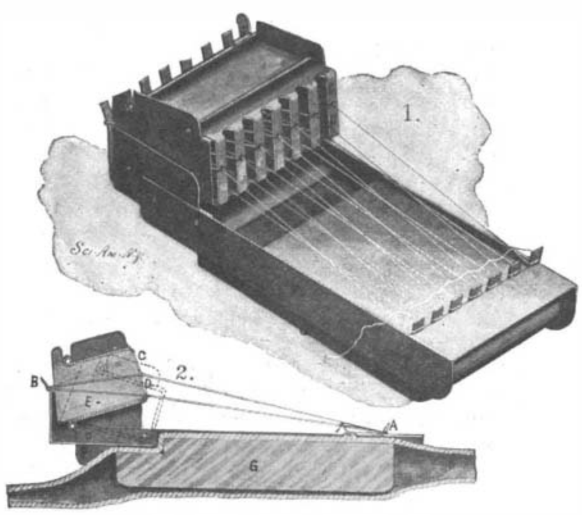
Assuming the valves to be adjusted, as shown in Fig. 1, then the active steam nozzles and water chambers will be those at the upper left hand and lower right hand corners. The steam passing through the nozzles mentioned will draw the water from the corresponding water chambers and impel it against the piston in opposite directions. The back-pressure produced by the action of the steam on the water causes a quantity of water to be forced into the exhaust tubes—a quantity equal to the amount of condensed steam. The four nozzles and water chambers, it will be observed, work in diagonally opposite pairs. The engine is reversed by means of the valves in the steam-pipe arms and the relief passages. The inventor of this engine is Mr. James Scott, 73 Motomachi, Hadokate, Japan.

AN APPARATUS FOR DARNING STOCKINGS.

A machine for darning stockings and other fabrics has been invented by Mrs. Hannah C. Hamann, of 3535 Half Howard Street, Omaha, Neb., which machine is so constructed that the work done is the equivalent of a weave, the darned or mended portion being equally smooth on both sides.

Fig. 1 is a perspective view of the device, and Fig. 2 is a longitudinal section.

The apparatus consists of a main frame, *F*, and a



A DARNING MACHINE.

frame, *E*, pivoted to an auxiliary frame riveted to the main frame. At its front end the main frame, *F*, is provided with a cross-bar having a series of upwardly projecting teeth, coinciding in position and number with teeth formed on a back piece of the auxiliary frame. Notched fingers, *D*, project vertically up from the bottom of the pivoted frame, *E*. From the hinged cover plate of the frame, *E*, notched fingers, *C*, extend downwardly, corresponding in number and location with the fingers, *D*. In connection with the main frame, *F*, a block, *G*, is employed.

In using the device, a square opening is made in the portion of the stocking to be darned; the block, *G*, is passed into the stocking so that the upper face will be beneath the opening in the stocking, and is forced upward into frictional engagement with the main frame, *F*. A warp-thread is then threaded on the teeth of the main frame and of the auxiliary frame, in the manner shown in the illustrations. The loose end of the warp-thread is passed through the eye of a needle, and the needle is passed through the perfect portion of the fabric adjacent to the opening, and under two strands from the inside to the outside of the fabric. The thread is then carried back over one strand and returned again under two strands, the operation being repeated until the end of the opening to be closed is reached. The pivoted frame, *E*, is now alternately raised and lowered so as to produce a changing shed in the arrangement of the warp-threads. The needle is passed between the upper and lower threads of the shed, alternately from one side to the other as the position of the warp-threads is changed, the thread attached to the needle and forming the cross or weft-threads being carried forward. Each time the needle passes back and forth between the separated warp-threads it also passes through the edges of the opening. The thread is drawn properly in place to close the opening and present a surface perfectly smooth on both sides.

An American Blue Grotto.

Many of the beautiful phenomena seen at the celebrated Blue Grotto of the island of Capri are reproduced on a small scale in a cavern at Lake Minnewaska, New York. This lake is situated on the Shawangunk range of mountains at an elevation of about 1,700 feet.

The cavern is formed by several huge rocks of white quartzite overhanging the water so as to form a comparatively dark hole, and the space between the under side of the sloping rocks and the water varies from about two feet to not more than two inches.

The cavern faces the southwest; it is very irregular in shape, and at one point the roof and walls reverberate in response to a deep bass note. The water just at the entrance to the cavern is 33 feet deep, and two or three feet away, 40 feet; it is very transparent at considerable depths. As the rocks overhang so close to the water, the optical effects can only be seen by a swimmer, and it was while swimming along the shore that H. Carrington Bolton discovered the American Blue Grotto three years ago, and described the same in Science. As one approaches the mouth of the cavern the bluish color of the water is noticeable, but the beautiful effects are best seen by entering the opening and looking outward toward the light.

The water varies in color from Nile green through turquoise blue and sky blue to deep indigo blue, and in all these shades exhibits the silvery appearance, when agitated, characteristic of the grotto at Capri. A body immersed in the water has a beautiful silvery sheen, similar to the reflection of moonlight. The water has these colors at all hours, but they are strongest when the sun is in the zenith; late in the afternoon the slanting rays of the sun enter the opening and light up the cavern, greatly diminishing the optical effects.

Another pleasing phenomenon must be mentioned. Just below the water line, where the rocky sides are lapped by the waves, the white quartzite exhibits a brilliant siskin-green hue; this bright color is limited to a space about three or four inches below the level of the lake and to certain walls of the cavern. The bare arm immersed in the water partakes of the green color when the light is reflected at one angle, and of the silvery blue color at another angle.—Science.

AN IMPROVED SASH-BALANCE.

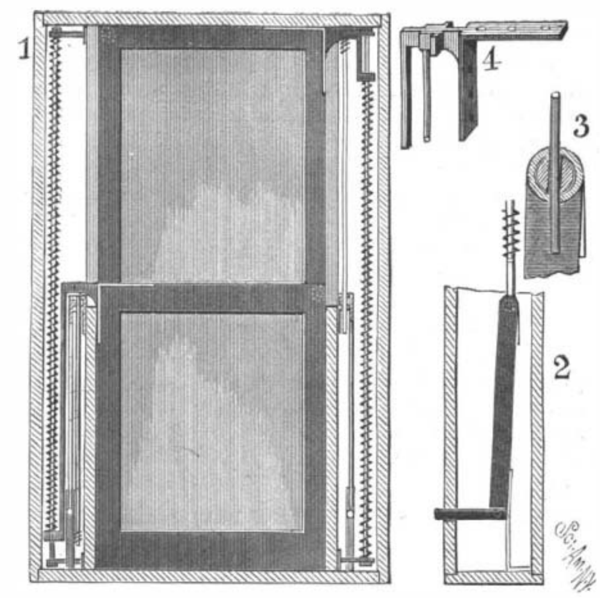
A patent has been granted to Joseph A. Manahan, of 23 East 129th Street, Manhattan, New York city, for an ingenious mechanism by which a window can be automatically operated.

Of the accompanying illustrations, Fig. 1 is a front elevation of a window with the mechanism applied, parts being in section; Fig. 2 is a section showing a detail; Fig. 3 is a section of a locking device employed; Fig. 4 is an enlarged view of the bracket for the lower sash.

To diagonally opposite corners of the two sashes brackets are secured, each provided with a vertical locking-rod and a projecting guide-arm moving on a guide-rod. Coiled around each guide-rod is a spring which acts against the corresponding guide-arm. Each locking-bar slides longitudinally through a lock or clutch (Fig. 3) which consists of a sleeve having a longitudinal bore and a transverse cut. In the transverse cut a pivot is placed which has a perforation corresponding with the vertical bore of the lock, so that the locking-bar passes through both lock and pivot. The locking-bars are normally locked because the pivot is slightly turned or jammed in the lock by the action of the spring-pressed lever (Fig. 2). When the lever is thus held at an angle, the vertical bore of the lock is out of alinement with the perforation in the pivot, for which reason the locking-bar cannot move up or down, but is jammed in fixed position.

In Fig. 1 the sashes are shown in closed position. When it is desired to open either sash, the proper button is pressed against its spring so as to turn the pivot in the lock and release the locking-bar. The coiled spring will then open the sash. When the proper elevation has been reached, the lever is allowed to spring back to hold the locking-bar. A slit is cut along the window-casing for the passage of the brackets and their guide-arms and rods. The closing of the sashes is effected by hand.

The bracket shown in Fig. 4 differs from the upper



MANAHAN'S SASH-BALANCE.

sash bracket, only in having a depending shank, a construction due to the position of the bracket. A mechanism of the character described is particularly applicable to car windows.

UTOPIA is now known to be located at Orsa, in Sweden. The community has, in course of a generation, sold $4,600,000 worth of trees, and by means of judicious replanting has provided for a similar income every thirty or forty years. In consequence of this commercial wealth there are no taxes. Railways, telephones, etc., are free, and so are school-houses, teaching, and many other things.