[Engineering and Mining Journal.]

ON THE COMPRESSION OF GASES.*

By CHARLES F. BRUSH, M.E., of Cleveland, O.

THE compression of gases to a very high degree, for purposes of scientific research, has long presented serious difficulties to the physicist.

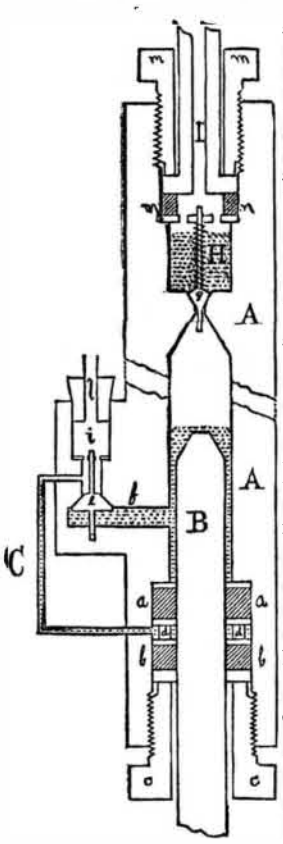
Great advances have been made of late years in the construction of ordinary air or exhaust pumps, while very little has been done towards the improvement of compression-pumps. The principal difficulties encountered in the construction of such apparatus are the existence of the so-called "dead space" in the pump-barrels, leakage of the piston-packings under high pressure, and the trouble arising from the unequal expansion of parts caused by the development of the latent heat of the gas during compression. Of these obstacles to success, the "dead space" is far the most serious, as it fixes a limit to the performance of the pump beyond which it is impossible to carry the compression.

The writer having occasion, some time since, to make a series of investigations on gases very highly compressed, and finding no apparatus, or description of apparatus, adequate to produce the required pressure, devised the following, which appears to entirely eliminate all the difficulties above mentioned.

The accompanying diagram represents a longitudinal section of the pump through its axis. The barrel A, which may be made of any convenient length, is of cast-iron, and is made rather heavy, both for the purpose of resisting great pressure and to absorb and dissipate, to some extent, the heat evolved during action. B is a steel plunger of less diameter than the interior of the pump, so that an annular space is formed between A and B. The plunger passes through two stuffing-boxes, *a* and *b*, whose packings are supported by movable iron rings; thus both are compressed to the requisite degree by means of the screw *c*.

The stuffing-boxes are separated by a ring *d*, thus leaving a small space between them as shown. This space is connected by a small tube C, with the chamber *i*, which latter communicates with the reservoir of gas to be compressed, by means of the cork and tube *l*. The inlet-valve *e* is of steel, conical in form, and carefully ground to its seat. It opens into the passage *f*, thus communicating with the interior of the pump. The exit-valve *g* is also of steel, but smaller than *e*, and is ground to its seat with much care. It opens into the chamber H, and is held firmly in position by a spiral spring of steel. This valve is prolonged at its lower extremity to such an extent that it comes in contact with, and is raised a short distance by, the plunger B, at the completion of its upward stroke. I is a strong tube for the conveyance or storage of the compressed gas. It is firmly secured to the body of the pump by means of a flange on its lower end, and the screw *m*, which forces the flange against the rubber-washer *n*. Such a washer will make a tight and permanent joint under any degree of pressure, provided the flange of the tube I fits the bore of the chamber with tolerable accuracy.

The plunger B may be actuated either by a crank and fly-wheel, or by a lever so arranged that its short arm shall lie in a straight line with the axis of the plunger at the completion of its upward stroke. This arrangement is absolutely necessary when very high pressures are to be produced, as the resistance at and near the completion of the stroke is very great, and could scarcely be overcome without thus taking advantage of the "knee-lever" principle.



The body of the pump is finally partially filled with mercury, as shown by the dotted spaces, to such an extent that at the completion of the upward stroke of the plunger, the annular space around it, together with the passage *f*, are entirely filled, and the chamber H nearly so.

The operation of the apparatus is then as follows: At the downward stroke of the plunger, the valve E is opened, both by its own weight (the mercury having receded from under it at the completion of the stroke) and by the pressure of gas above it. Gas, from the chamber *i*, then rushes through the valve and fills the vacuum above the plunger. At the beginning of the upward stroke, mercury flows into the passage *f*, and closes the valve *e*, by *floating* it into position. As the plunger proceeds upward, the compressed gas may force open the valve *g*, and escape into the chamber H, rising through the mercury there contained; or, if the compression has already advanced to a considerable extent in the chamber, the valve may not open until raised by the end of the plunger; but, at the end of the stroke, the space above the plunger will be entirely filled with mercury, leaving no dead space whatever, and *all* of the barrelful of gas will have passed up into the chamber. The valve *g*, being still held open by the plunger, will allow a small quantity of mercury to pass from the chamber back into the pump when the plunger recedes, thus insuring sufficient mercury in the barrel to completely fill it at the end of the next stroke, after allowing for leakage through the stuffing-box *a*. The object of *two* stuffing-boxes, *a* and *b*, will now be apparent; the small quantity of mercury which must certainly be forced through the box *a* at each stroke, by the great pressure in the pump, and which, if allowed to escape, would very soon exhaust the supply inside, is conveyed by the tube C to the chamber *i*, and is drawn into the pump again at the next stroke.

No leakage occurs through the box *b*, as the pressure sustained by it is only that due to the height of the short column of mercury in the vertical part of the tube C.

It will be noticed that the upper portion of the interior of the pump-barrel contracts gradually toward the valve-passage; this is to prevent small bubbles of compressed gas sticking to the walls, and allowing the advancing mercury to flow past them, as might happen if the contraction was abrupt.

* A paper read before the American Institute of Mining Engineers, at the Cleveland Meeting, October, 1875.

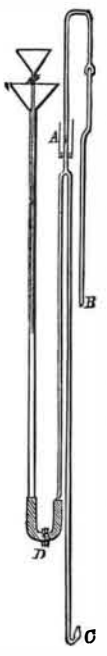
[Chemical News.]

USE OF THE SPRENGEL VACUUM-PUMP.

By ERNEST FRANCIS.

THE difficulty of filling tubes with mercury so that air may be excluded is well known, and instruments in which this condition is attained are highly prized. The ordinary process of filling barometers by boiling is tedious and unsatisfactory, more especially to those unused to the operation.

It has been found that the improved form of the Sprengel pump affords an admirable means of accomplishing the operation, and adds another to the numerous good qualities for which the instrument is famed. The process is easy and would enable barometers to be filled in the laboratory with perfect accuracy. It has the additional advantage of being applicable to tubes of any calibre.



The operation is performed by connecting and exhausting the barometer-tube; the outflow-orifice of the pump being then stopped, mercury passes in and fills the exhausted tube.

Further details may be gathered from the accompanying diagram, but the arrangement would vary slightly with the shape of the tube to be filled. The diagram shows a Bunsen syphon barometer, connected to the pump at A by vulcanized tubing, with the joint surrounded by a tube filled with mercury. After exhaustion, the end of the pump C is closed either with the finger or by a specially furnished clamp or stop-cock. The mercury which is kept flowing from the reservoir then ascends and completely fills the barometer. The mercury falls over the bend to the point B, but without sufficient force to break the tube. The inflow of mercury is regulated by the clamp D. When full the barometer can be safely disconnected with a little care, and the excess of mercury poured out. For filling straight tubes the part A can be bent and connected to the barometer inclined downwards. It is almost needless to add that the barometer during the filling must be supported by a clip or otherwise.

A barometer filled in this manner answered every test most satisfactorily. The tube became completely filled with clear, bright mercury, no trace of air being visible at any part. Tested by repeated gentle tiltings it gave no dull sound, and finally the vacuous part being surrounded by hot water, produced no alteration in the height of the mercurial column.

In conclusion I would suggest that the same process might prove satisfactory for filling *thermometer* and other tubes with mercury. GOVERNMENT LABORATORY, TRINIDAD, B.W.I.

THE GELATINO-BROMIDE EMULSION.

By REV. H. G. PALMER, M.A.*

I PROPOSE to notice, first, the main causes of failure with gelatine, and these, I think, may be resolved into three:

1. The character of the light in the working-room.
2. Want of patience in preparing the emulsion.
3. The length of time allowed for the plate to dry spontaneously.

As to No. 1 of these causes, I may remark that it is a mistake to imagine, as some do, that gelatine emulsion and plates can only be prepared in the gloomiest of lights, and therefore in the greatest discomfort. It is not the quantity of light in the laboratory which is so often the cause of fog so much as its character. The first thing, then, is to ascertain the amount and quality of light by which this process can be worked without risk. I have made many experiments with different kinds of ruby and professedly non-actinic glass, and find in practice that Forrest's non-actinic orange, plus one thickness of orange tissue-paper, gives absolute freedom from fog, even with bright sunlight passing through it. Accordingly, in my work-room I have a wooden lantern standing in the centre of the top of my drying-cupboard, by the light of which I work with the greatest ease and safety. The accompanying drawing of it will explain itself (No. 1). The lamp burns paraffine and gives a very bright light, and I wrap around the glass one thickness orange tissue. In the grooves A A A are three sheets of Forrest's non-actinic orange glass (each pane being 18 inches by 12 inches), and at the top and bottom of the back there are apertures to give ingress and egress to the air.

Fig. 1.

The next cause of failure on my list arises mainly from overhaste in passing the emulsion through the fine linen filter. The gelatine receives a preliminary soaking of half an hour; it is then placed in a hot bath, frequent shaking being administered to effect the solution of the pellicle; it is next passed through fine linen to remove bubbles, etc. But very often the last operation is performed too soon, and, on examination, the linen is found to contain a portion of the pellicle undissolved. The result of this will naturally be a batch of plates which will afford the thinnest of negatives, and which will obstinately decline intensification of any sort or kind. To avoid this, the emulsion should be mixed, and solution of the pellicle obtained by frequent stirrings with a glass rod (the bottle containing the gelatine being in a hot bath the while); and on no account should the emulsion be passed through the filter so long as any soft substance can be detected with the rod at the bottom of the bottle. The result of too long protraction of the process of drying is not evidenced until the time comes to develop a picture, and then it will make itself manifest in blisters in the centre and in frillings at the margin of the plate. In damp weather it is sometimes well-nigh impossible to get the plates to dry spontaneously; and it is no easy matter to raise the temperature of the room to just the proper height to secure speedy drying. The small apparatus (for the idea of which I am indebted to Mr. Kennett depicted in plate 2 answers admirably for this purpose. A is an iron cone, firmly fastened to a circular base of the same metal; B is the inlet for air, with movable cover; C, to regulate the supply; D is the outlet, and this is fixed in an aperture at the bottom of the drying-cupboard; the lamp underneath is called the Rechaud spirit-lamp. Drawing No. 3 will explain the cupboard and its appliances; mine contains four shelves accurately levelled, and sufficiently capacious to hold eight dozen quarter plates, or two dozen 9 by 7. The top is my operating-table, and in front are light-tight doors, with lock and key to baffle inquisitive visitors to the dark-room. After coating a batch of plates, they are placed in succession upon the shelves, the doors are closed, the lamp lighted, the supply of hot air regulated at pleasure, and in a few hours the whole batch will be ready for use. Without doubt, the simplest and safest plan is to prepare the emulsion with Kennett's pellicle. This is done as follows: Two ounces of distilled water are poured upon eighty grains of pellicle in a four-ounce wide-mouthed bottle; in about half an hour the bottle is placed in a vessel of hot water, and then roughly stirred until the gelatine is entirely dissolved. If, however, it is desired to make the emulsion *ab initio*, the following formula will be found to answer well:

Nelson's gelatine	40 grains.
Distilled water	14 drachms.
Alcohol	2 "
Bromide of potassium	25 grains.
Nitrate of silver	40 "
20-grain per oz. solution of bromide of ammonium	2 drops.

Let the gelatine be soaked for five or six hours in water, and be then drained. The bromide is next dissolved in seven drachms of water, and poured upon the gelatine. The latter is now treated to a hot bath, and stirred with a glass rod until complete solution has taken place. The silver is then dissolved in seven drachms of water, and is poured little by little into the gelatine, the whole being frequently shaken. After this, two drachms of alcohol and two drops of bromide of ammonia are added; emulsion is poured into a flat dish until it has set; it is then cut into strips with a slip of glass, placed in a sieve with fine linen stretched over the bottom, suspended under a tap to which a rose has been fastened, and thoroughly washed for six hours at least. After draining, it is treated to a hot-water bath until completely liquefied, and then distilled water is added to bring up the amount to two ounces.

I will now give the details of the preparation of gelatine

Fig. 3.

dry plates in proper sequence. On the top of the drying-cupboard are the following articles: The wooden lantern is in the centre, and to the right of it a flat hot-water tin, covered with a sheet or two of blotting paper. This is used to give warmth to plates, if I am coating those of large size. Small plates do not require to be warmed. On the right side also I have an infant's food-warmer with the burner alight, a little hot water in the tin boiler, and the porcelain cup clean, empty, and ready to receive the emulsion. I need hardly say that the light emitted by the burner must be carefully screened off with brown paper. On the left are the clean plates, a brush for sweeping each plate before coating, a pneumatic plate-holder, and a glass rod in a vessel of warm water (for large plates only). It is unnecessary to urge the importance of clean plates, but I may notice here an advantage of this process over every other with which I am acquainted—namely, that old gelatine plates need to be merely placed under a tap of hot water until the film is dissolved, then thoroughly rinsed and polished with cloth and leather without further trouble. The emulsion must be filtered through fine linen into the porcelain cup of the food-warmer, and the filter-bag should rest against the side of the vessel to prevent bubbles in the filtered emulsion. If the plates are of small size, it will be found that the gelatine flows after a little practice as easily as collodion without the assistance of a glass rod. Large plates, however, must be warmed (or the gelatine will chill and thicken), and can then be coated with the greatest ease as follows: A pool is poured from the lip of the cup along the right-hand margin of the plate from corner to corner. The emulsion is then swept before the glass rod to the other end, without endeavoring in the least to secure evenness of film. This is effected by now flowing over a fresh supply of emulsion, and the surplus is disposed of by allowing a corner of the plate to touch the side of the cup. The two things to be avoided in the process of coating are bubbles on the film or in the emulsion, and over-draining of the plate and consequent thinness and weakness of the negative.

The whole process, whether with small or large plates, is done with the greatest ease and rapidity, the chief desideratum for comfortable working being a pneumatic holder, which may be relied upon to cling fast to its plate. As soon as the coating is effected, the plates are put one by one upon the level shelf below, until all are finished; the doors of the drying-cupboard are closed; the lamp below is lighted; and a stream of hot air is sent over the film until they are dry.

As regards exposure, it should be borne in mind that Kennett's rapid pellicle and plates are, with good light, really instantaneous. Nothing can surpass the cloud, wave, and street views taken with this preparation; and for baby portraits it is simply perfection itself. The ordinary pellicle is much slower, and admits of considerable latitude of exposure. On a bright January day I exposed six plates experimentally upon a well-lighted subject, giving (1) 10, (2) 20, (3) 30, (4) 40, (5) 60, and (6) 120 seconds respectively. I developed with a three-grain solution of pyro, using at first one drop of a one-in-sixteen solution of strong ammonia to two

* Read before the Edinburgh Photographic Society.

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