

ON A CENTRIFUGAL SEPARATOR FOR LIQUIDS OF DIFFERENT SPECIFIC GRAVITIES.

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This machine, the invention of Mr. De Laval, of Sweden, is constructed for the purpose of dividing or separating from each other any two fluids of different specific gravity. Hitherto the machine has been specially constructed for the separation of cream from milk, so as to do away with the slow and often troublesome process of setting the milk. From a mechanical point of view the arrangement offers some interest; and the writer will therefore describe the machine as it is now made, after considerable improvements in the construction have been carried out.

The apparatus, Fig. 1, Plate 92, consists of a globular or cheese-shaped vessel A, opening above into a cylindrical neck, and mounted upon an axis on which it is rotated by means of a small pulley K. On the inner side of the cylindrical part of the vessel is fixed a small open tube B, which is bent round inside the globular part, so as to terminate where the diameter of the globe is greatest. A small orifice C, about $\frac{1}{8}$ in. diameter, leads out of this tube, and can be partially opened or closed by a small set-screw, Fig. 2. In the rim of the cylindrical part of the vessel is another orifice D, cut down from the top, about $\frac{1}{8}$ in. deep and about $\frac{1}{16}$ in. wide, Fig. 3. A cup E, to which a thin wing is fixed, is made to hang down into the cylindrical neck. The object of the wing, which is on the opposite side to the tube B, is to give the milk always the same velocity as the vessel.

The globular vessel is 12 in. in its greatest diameter, and the speed necessary to secure a perfect separation is between 6,000 and 7,000 revolutions per minute.

The milk is fed into the machine through the cup E, from which it enters the globular part A through a small tube F. On account of the high velocity of rotation, the interior surface of the rotating liquid takes very nearly the form of a vertical cylinder, and the cream is almost immediately separated, and forms a thin layer on the inside of this cylinder.

In the same proportion as the vessel is filled with milk, the inner surface of the liquid cylinder contracts in diameter; but no liquid will flow out until the diameter of the interior space becomes just equal to the diameter of the upper or cylindrical part of the vessel. It will then begin to rise by centrifugal force, and flow out of the two orifices D and C; that which flows through the orifice D being the innermost layer of cream, while that through the orifice C is the milk, which has passed up the tube B. The proportion of the areas of the two orifices will regulate the respective flow through each. If the orifice C is partly closed up by the set-screw, so as not to allow all the skimmed milk to flow out there, the cream will then be greatly mixed with milk, and flow out very thin; but if this orifice is left entirely open, the skimmed milk will flow quickly away through it, leaving the cream to flow out at D without the least mixture of milk. The two streams of milk and cream are caught in two tin covers, whence they flow out through tubes attached. The cast-iron arm G is used to keep the feeding spout central, and also, by the india-rubber washer at H, to deaden any vibration of the covers. The process can thus be continued as long as is desired.

The rotating vessel is constructed of the best Bessemer steel, made from Swedish iron. It is forged into the desired shape from one single sheet of steel; the spindle is then attached, being screwed into it at S, and bolted through the flange; and the whole is most carefully turned inside and outside. It is tested up to 250 atmospheres pressure before being put in the machine. To prevent vibration, the weights of the wing and of the tube B opposite are so proportioned as to preserve the balance.

By specially constructed friction gear the speed can be got up gradually. This gear consists of a wooden disc fast on the driving shaft, and a cast-iron disc loose on the same shaft. The latter can be

pressed against the former by means of a spring, and then gradually assumes the same speed: the rate at which it gets up speed being varied by screwing up the spring more or less. From the cast-iron disc a round leather strap $\frac{3}{8}$ in. diameter is led to the small pulley K, Fig. 1, Plate 92. On the top of the spindle J of this pulley is a step L, into which is rammed a lining of boxwood, Fig. 4, shaped so that the end of the spindle of the rotating vessel fits well into it. The upper bearing N is surrounded with an india-rubber ring, which arrangement prevents any injurious effects from vibration. The lower end of the spindle J is convex in shape, and rests upon the pivot on the upper surface of the block P, which is also convex. All the bushes are made of grey cast-iron. By this double arrangement of friction gearing it is possible to bring the speed up very gradually and steadily, even if the motive power should be unsteady. If the pulley K should be started too fast to allow the heavy upper spindle at once to attain the same speed, the only result will be that the spindle will slip in the wooden lining at L, until the same velocity is attained. As the cylinder rotates on the principle of a top, it will vibrate somewhat at starting; but when it has once attained its proper speed, not the slightest vibration can be observed.

The arrangements for lubricating the bearings are very simple. From the oil-cup O, on the side of the cast-iron frame, a tube leads into the groove on the top of the bearing N. From this groove the oil runs into the bearing, from the lower rim of which, by the rotation of the spindle, it is thrown outwards into the circular cup R, surrounding that part of the bearing. Thence through the tube Q it is carried down to the lower bearing T, from which the waste oil is again carried down to the pivot P, by the same arrangement as above described.

After having thus described the separator, it may be of interest to mention some of the machines previously constructed for the separation of cream from milk by centrifugal force.

The first attempt in this direction was made about twenty years ago in Germany. A disc about 4 ft. diam. was made to rotate horizontally at a high speed. Round the rim of this disc were fixed

strong iron hooks, on which buckets filled with milk were hung. After, say, twenty minutes' rotation, the heavier portion of the milk (or the skim milk) was forced to the bottom of the buckets, leaving the cream on the top. The disc was then stopped very gradually, so as not to disturb the cream which was floating on the milk. When the disc was brought to a standstill, the cream was skimmed off with a spoon in the ordinary way.

The next machine constructed was a great improvement on the first. This was a vertical cylinder, the top of which was partially covered, leaving only a hole in the centre. After the milk had been passed into the cylinder, the latter was made to rotate at a high speed; the milk was thus thrown to the sides, leaving a cylinder of cream in the centre. When the separation was considered complete, the machine was again stopped very carefully, and the cream which was left floating on the milk was skimmed off. It will be seen from this description that the separation of cream from milk could easily be effected; but no arrangement for drawing off the cream mechanically was used until some six years ago. A cylinder very nearly of the same construction as the last described was then employed, having on the top a rim extending inwards 4 or 5 inches. By the rotation of the cylinder the separation was produced as before. When the cream was formed, *skimmed* milk was fed into the machine, which, taking its place behind the cream, pressed the latter up and over the rim of the cylinder, where it was collected in a cylindrical receptacle round the machine. When the cream was all drawn off, the feed was stopped, and the cylinder emptied by means of a cock in the bottom.

Subsequently Mr. De Laval brought out his invention of a tube fixed inside the neck of the cylinder, and leading to the largest internal diameter, so as to draw off the skim milk, as shown in the drawing, Plate 92.

It will readily be understood that this machine, with some slight alterations, can be made to separate a great variety of fluids, as for instance in the purifying of oils, &c. An experiment was made some time ago at the Birmingham Gas Works with coal tar. The tar was taken direct from the scrubbers, strained, so as to take away the

grains of coke left in it, and was then passed through a machine constructed only for separating milk. In an instant the clear ammonia liquor was flowing out of the one spout, and the purest tar out of the other spout. Again, in one factory in Norway the machine is already in practical use for the purifying of fish oil.

Abstract of Discussion on Centrifugal Separator.

Mr. BERGH showed the working of the machine by means of a small model, which was run by hand at 8000 revolutions per min., one turn of the hand-wheel producing 300 revolutions of the separator. A good separation of milk and cream was produced, though not so good as could be effected by a full-size machine. One of the latter was also exhibited, kindly lent for the occasion by Messrs. Mather and Platt.

With regard to the experiments made at Birmingham with coal tar, he observed that the machine there used was not exactly like the one now exhibited. It was of the old type, constructed only for milk, so that they could not have expected such good results as they really got. It worked for half an hour without stopping; but there was a quantity of fine coke dust in the tar, which accumulated in the cylinder, and consequently in the course of time it got choked up. That of course was a difficulty which might possibly be overcome. A larger machine had been worked in Sweden, with a cylinder 24 in. diam.: it was worked six hours without stopping, and passed through six barrels of what was considered pure tar, from which it extracted nearly one barrel of ammoniacal liquor. There however the cylinder was also choked up after working the six hours.

Mr. JOHN WEST said the beautiful model which had just been exhibited proved the utility of the process on a small scale; but the

question with him was whether it would be a practical advantage to the profession to which he belonged, that of the gas engineer. The separation of tar and ammoniacal liquor was not a very difficult thing to accomplish, as the tar soon settled down into the tar well; and he doubted whether it would be worth while to separate it by expensive mechanical means. The machine might however be used with advantage for separating the thicker from the lighter hydro-carbons in the tar, but that would be a question more for the distillers than the gas-makers. He should like to know what quantity would pass through a machine of given size per hour, so as to have some idea of the capacity of the apparatus that would be required if the process were adopted for the separation of ammoniacal liquor from tar. In Manchester, during the winter season, they would require to operate on about 52,000 gallons of tar and ammoniacal liquor per day; and that he thought would require a very large apparatus indeed.

But it had struck him, on looking at the construction of this machine, whether it could not be utilised for handling gas. The process now used to condense the particles of tar and ammoniacal liquor out of crude gas consisted in passing the gas through a series of pipes; but the whole of the tar could not be got out in that way; some of it would go forward with the gas, and unless some mechanical means were adopted to arrest it in its passage, it went on to the purifiers, and there gave trouble. He thought that if the gas were passed into the cylinder of a De Laval machine the tarry matter would fly to the outside and be taken out; so that there would be no necessity to resort to other mechanical means, to which some engineers thought there were certain objections. The method commonly employed was to pass the gas through a series of sieves covered with ammoniacal liquor, so as to wash it. The chief objection raised against this plan was the pressure required to force the gas through the sieves.

Mr. WILLIAM ANDERSON said that the Royal Agricultural Society of England had thought the mechanical separation of cream and milk so important that last year they offered a gold medal for the best machine. This was competed for in July at the Annual Show

at Reading, and it had been his duty as their engineer to conduct the experiments. Unfortunately, from various circumstances, only two competitors appeared in the field—the De Laval, and another machine on the same principle, but in which the axis was horizontal. The De Laval machine obtained the gold medal; and it might be interesting to give a few of the facts upon which the judges founded their opinion.* The machine separated 53 gallons of milk per hour, and took $\frac{1}{2}$ H.P. to drive it, when running at full speed, or 6000 to 7000 revs. per min. It had a $\frac{3}{8}$ in. round leather band to drive it, and this band was only joined by a staple of wire—a proof of the extremely small amount of power which the machine required. The Society had set a limit to the quality of the separation, namely that no machine should leave so much as 0.4 per cent. of butter-fat in the skim milk; and the De Laval machine left 0.24, or rather less than $\frac{1}{4}$ per cent. It took three minutes on the average for the separation to begin, and it took thirteen minutes to clean the vessel out after the working was ended, *i.e.* at the end of the day's work; and then the milk left in the machine, which would have to be separated afterwards, was only $12\frac{1}{4}$ lbs.

He might add that nothing could be better than the way in which the machine worked, its perfect smoothness in running, and the total absence of any need of attention while it was in operation. He was very glad to be able to bear such testimony to what he believed to be a very valuable invention.

Mr. HENRY DAVEY considered that this machine opened up a new field; and it was probable there might be many other applications of it besides those that presented themselves at first sight. One such application had suggested itself to him, namely the separation of metallic particles from flowing water. In mining operations a large amount of muddy water was usually produced by the stamping machines which pulverised the mineral, and much of the mineral was often so fine that it was capable of being held in suspension and carried away in the water. Cases had come under his notice in

* See Royal Agricultural Society's Journal, 1882, p. 623.

Cornwall where water from mines had been stored in ponds for the purpose of working water-wheels, and the sediment formed in the pond had been cleared out at certain intervals, and left there to accumulate for years on the bank; and where it had been found profitable to separate the mineral from that mud by passing it over what were termed "round buddles." * That was a very slow process, and consisted in passing the water through a revolving machine which distributed a film of it over a very large surface, and reduced the velocity of the stream to such an extent that the metallic particles were able to settle. It was necessary in lead and tin mines to pass the muddy water or slimes through three or four buddles in succession, before any considerable quantity of ore was got out. It appeared to him that, if passed through a machine like this centrifugal separator, the lead and tin particles would be immediately separated from the water. It would be necessary however to stop the machine periodically, to take out the deposit, the heavier portions of which, including the mineral, would be found nearest the sides of the vessel, because the heaviest particles would have the greatest centrifugal force. He would not say off-hand that it would be, commercially speaking, more profitable to treat slimes by that machine than by the round buddle; but he thought the subject was worth consideration.

Mr. BERGH, in reply, said he could not offer any definite opinion whether it would be profitable to separate coal tar in the way suggested; but it certainly struck him that if double the quantity of ammoniacal liquor, or liquor of double the strength, could be obtained by the process, there must decidedly be a gain; and the tar, he believed, was also very much purer. As to the purifying of gas, he had no experience himself; but no doubt the principle would be applicable to that case. As to the separation of particles from dirty water, that was perfectly easy, and had been already tried. Of course as the machine worked, the water would come out clear, while the solid residue would settle in the machine;

* See Proceedings, 1881, p. 622.

and the machine would have to be stopped as soon as it got foul. Even in the separation of milk, the milk was to some extent purified, because there was always in milk some solid matter which it was impossible to strain out even with the finest strainers. Hence, when the machine had been working three or four hours, or even less, there would be found inside the cylinder a thin layer of greasy dirty stuff that did not properly belong to the milk at all, but was composed of fine hairs, skin from the animals and from the fingers of the milkers, &c. These foreign particles were taken out by the separator, and the milk was thereby purified. For that reason the butter or cheese made from milk so treated kept much longer than any other, because those impurities tended of course to hasten the putrefying of the product.

Mr. JOHN RAMSBOTTOM, in proposing a vote of thanks to Mr. Bergh, said that the paper had brought before them an interesting contrivance, which, he had no doubt, had presented itself to the minds of many as being capable of considerable extension and of wide application. So far as he was concerned, he did not see why it should not be applied to effect a more perfect separation of tar from gas.

Fig. 1.
Vertical Section.
Scale 1 to 6.

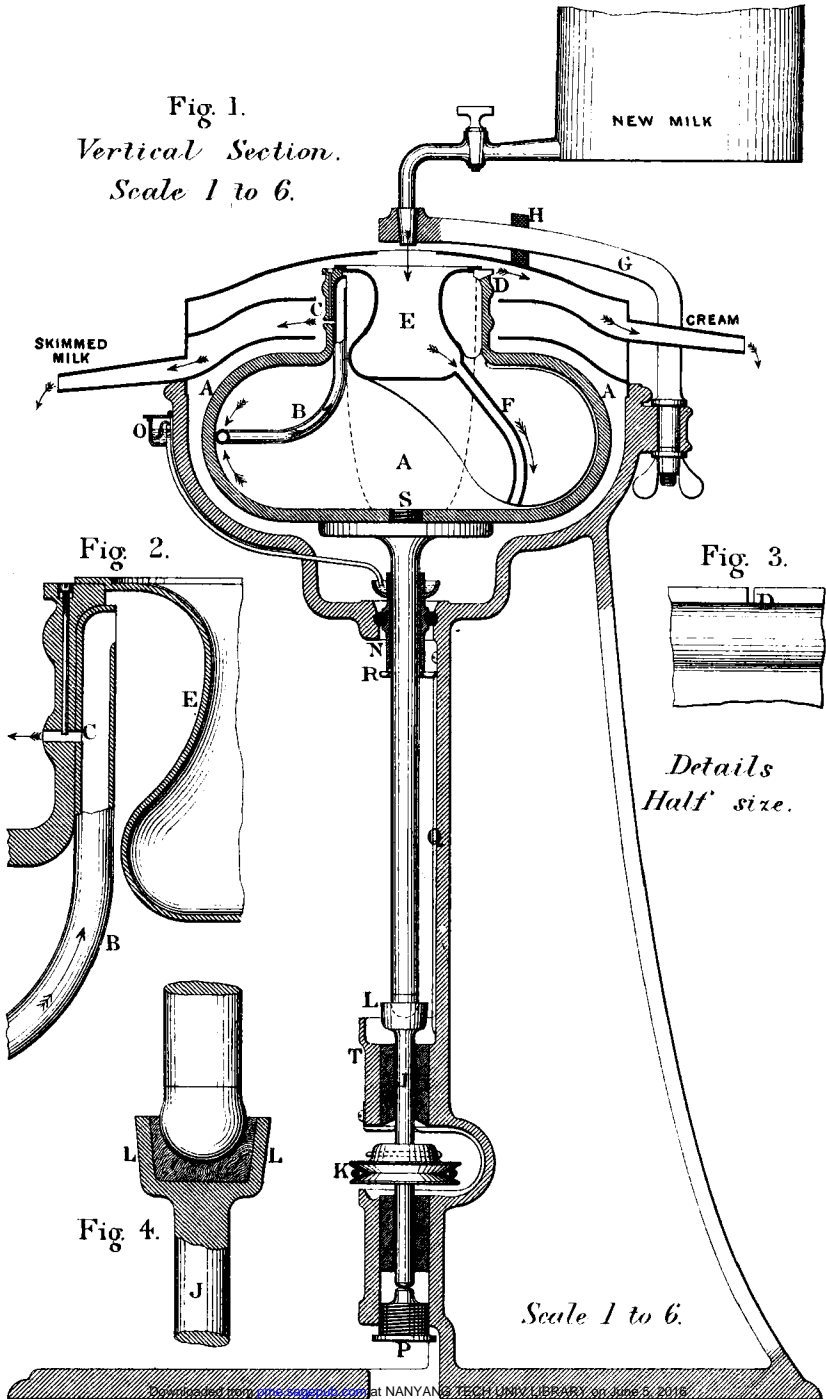


Fig. 2.

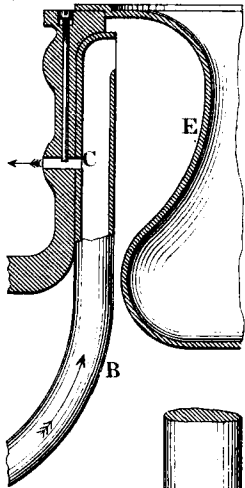
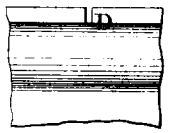
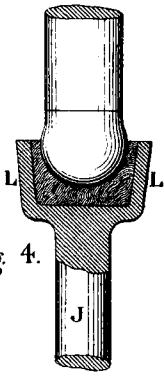


Fig. 3.



Details
Half size.

Fig. 4.



Scale 1 to 6.