contact with concentrated sulphuric acid to absorb the steam. The HCl gas was then absorbed in water, and estimated by titration. The increase of weight of the sulphuric acid, after deducting from it the HCl absorbed by the sulphuric acid, gave the water carried over.

The results of the analysis were:—

		By Formula.
Air	82.76	80.05
HCl	10.67	10.82
H ₂ O	6.52	8.23

2.—A similar experiment, made with acid of 25° Tw., 0.333 grm. HCl to 1 grm. of water at 83° C. and 751 mm. barometric pressure, gave—

		By Formula.
Air	60.07	57.40
HCl	11.42	11.23
Steam	27.61	31.30

It would be seen that the greatest error lay in the steam, not in the hydrochloric acid; a slight error in temperature would seriously affect the amount of steam.

The calculated results were obtained from the formula—

$$P = \sqrt{\frac{0.15}{0.3040 - 0.0016 t} \cdot \frac{C}{t}}$$

putting for C 0.419, and for t, the temperature, 55, they calculated the partial pressure of the hydrochloric acid to be 82.8 mm. and from Table II. the tension of steam was found to be 63 mm. The barometer being 765 mm., the partial pressures are—

		Per Cent.
Air	605.2	or 80.05
HCl	82.8	or 10.82
Steam	63	or 8.23

And a similar calculation would give the results as shown for the second experiment.

He wished, in conclusion, to remind them that whatever merit there might be in adapting Roscoe and Dittmar's results to the wants of the manufacturer, the great credit belonged to those investigators for supplying the accurate facts needed for the adaptation.

Meeting held on Wednesday February 5th, 1890.

DR. F. HURTER IN THE CHAIR.

A NEW FORM OF SPRENGEL PUMP, AND APPARATUS IN CONNEXION THEREWITH.

BY SIDNEY G. RAWSON, D.Sc., F.I.C.

Demonstrator of Chemistry, University College, Liverpool.

ANYONE who has used an ordinary Sprengel pump will know that the gas from the vessel which is to be exhausted is removed by small pistons of mercury. These rapidly succeed one another in the barometric fall tubes, and portions of the gas are trapped, and carried away between each two of these pistons. When the exhaustion is approaching completion, the volumes of gas so removed become exceedingly small, and the last portion of the process is then one of increasing slowness. The newer forms of pumps work on another principle. The mercury in them is caused to issue in the form of a fine jet or spray, and the molecules of the gas are, as it were, driven forward and caught by the mercurial bombardment to which they are subjected. They are then trapped by the pistons of mercury which form in the ordinary way lower down in the fall tubes.

This form of pump is divisible into two main kinds, viz., the one in which the jets of mercury issue in a horizontal plane as figured in Gillingham's paper (this Journal, III., 83), and the other in which the mercury flows from the commencement in a vertical direction, as in Fig. 1.

Fig. 1.

Of these two modifications, I prefer the latter, and for these reasons:—If the mercury issues horizontally, it is somewhat difficult to so place the jets that the streams of mercury shall exactly impinge on the mouths of the tubes. Unless the pump is well made, they will either strike too high or too low, and further, unless there is a considerable pressure of mercury, the jets may not carry even so far as the bounding walls of the exhaust chamber, then the lowest tube receives an excess of mercury, and becomes choked.

In the second form of pump, if the fall tube is slightly opened at its origin, the mercury can only run down that fall tube opposite to its own supply jet. This latter form is also more readily made, and especially is this the case as the number of fall tubes increases. The peculiar mercury distributor of this pump we owe to Nicol, though it had been used by myself some time before the publication of his paper in the British Association Reports for 1887.

My own form of this pump differs somewhat from Nicol's in the following respects. I seal the fall tubes to the pump

Fig. 2.

head, and use no india-rubber as a connexion (see Fig. 1, A), thus doing away with all chance of leakage. The mercurial supply tube, within the exhaust chamber in his pump, ends freely, and in the same horizontal plane with it is the exhaust tube. This, to my mind, would impose rather a strain on the tube from the leverage of the mercury, and I have therefore always sealed the tube to the wall (Fig. 2, A), and so placed my exhaust tube B that it opens in from above. The fall tubes are also sufficiently long to enable me to collect the gases which are exhausted. All these are, however, minor differences.

It will be found that if a pump has been working for some time the fall tubes always become coated inside with a thin

film, possibly of oxides of foreign metals. The mercury which I use I have had distilled two or three times, and one would feel inclined, therefore, to say that it was quite pure. But even with this pure mercury the deposit, though it formed very slowly, always made its appearance in the end. Small air bells or bubbles cling most obstinately to this film, and hence it becomes a matter of some importance to be able to remove it easily, and without stopping the pump. For this purpose the small funnel C, is attached to the pump. Usually this is kept filled with mercury, but when necessary, a little sulphuric acid is poured on the mercury, and the plug D, which is ground in, is gently raised, and the mercury, together with a portion of the acid, is allowed to run into the distributor, and thence into the fall tubes. The plug is replaced, and a little more mercury poured in. I have found sulphuric acid very good for this purpose. Professor Ramsay recommends the use of the vapour of glacial acetic acid as a cleansing agent.

This pump is a very excellent one and of great power. If only three fall tubes are required their free ends can be easily bent up so that they shall all deliver their gas together; this becomes more difficult as the number increases, but if mere exhaustion be required other tubes can be added with ease.

While experimenting with this pump I devised the very simple form which is shown in Fig. 3. A piece of ordinary pump-tubing some 50 ins. in length is taken, and about

Fig. 3.

10 ins. from the one end a small bulb is blown. There is then sealed into this and projecting into the cavity a small glass jet, about a quarter of an inch in length and of exceedingly fine bore, with the nozzle pointing inwards. It will be noticed that whilst in the other forms the feed-jets of mercury are detached from the fall tubes, here each fall tube carries its own jet, the arrangement being very compact.

The rate at which the feeding-jet will supply mercury entirely depends on the depth of the mercury in the exhaust chamber, and therefore on the length of the tube lying above the bulb. By regulating this depth the pump can be caused to work more or less rapidly as may be required, and this without any contrivances in the shape of taps, &c. There is further a very thorough division of the mercury in the little trapping bulb, for the fine jet of mercury, which is under considerable pressure, impinges strongly on the opposite wall, and is there broken up, filling the bulb with a shower of mercury drops. Possibly this effect might be increased if two feed-jets were sealed into the bulb. I have found it more advantageous to replace the piece of pump-tubing above the bulb by some of considerably wider bore and thinner walls; the difficulties of exhaustion are increased if the molecules of gas have to travel along capillary tubes.

Though two or three fall-tubes of this description can be sealed into a glass exhaust chamber, it is a somewhat difficult task. Unless an extreme amount of accuracy in the volume of gas to be collected is required, it is quite sufficient to take a piece of wide glass tubing which is strangled at either end so as to firmly hold the rubber corks with which it is to be closed. Through the lower cork passes the pump and fall tube combined, and through the upper the mercury feed-supply and the exhaust tube. From some experiments which I have made I agree with Gillingham (loc. cit.) that the diameter of bore of the fall tubes should be about 1.6 mm., and the length about 1 metre, reckoning from the level of the mercury in the lower reservoir to the mercury feeding-jet. In longer tubes than this the mercury falls with much force, and the incessant hammering which goes on is apt to cause the tubes to crack: several have been thus rendered useless in my hands.

In working with exhaust pumps there is usually some difficulty in making an air-tight joint between the pump and the apparatus which is to be exhausted. Of course the most effectual and certain way is to unite the two ends by an actual glass seal, but in many cases this is by no means easy, and when made successfully it has the disadvantage of converting all the different portions into one solid rigid whole. Professor Crookes uses very thin spiral glass tubes to unite the various pieces, and these from their elasticity do allow of there being a certain amount of play, but the glass seal, and with it considerable experimental skill, is still required.

India-rubber tubing is of very little or no use. All sorts of cements have been tried for this purpose. Thus Professor S. Thompson* mentions a mixture of Burgundy pitch, 96 parts, with 4 parts of gutta-percha or 1 part of vaseline with 3 parts of paraffin wax. Others are equal parts of beeswax and resin, india-rubber, and many more. I have myself used beeswax and resin containing a little vaseline, but I cannot recommend it highly, though it is as good as any of the others. Paraffin wax, pure and simple, I have also tried and found to work well, but it contracts on solidification, and attaches itself more especially to the glass walls, leaving a fissure between when these are close together, and hence there is always the chance that air may get in. No organic compound can be said to be good, as at high vacua they all evolve vapour. As suggested by Professor Thompson in his paper, some experiments were made by me on fused chloride of lead. This only melts, however, at a high temperature, somewhat below a red heat, and at the same time emits fumes. On cooling it contracts considerably and cracks in all directions.

After trying many materials, the following is the cement I now employ, and which is of very easy application. It is nothing but fusible metal containing a considerable amount of mercury. Its percentage composition is as follows:—

	Per Cent.
Bi	40
Pb	25
Sn	10
Cd	10
Hg	15

* "The Development of the Mercurial Air Pump." Journal of the Society of Arts, 1888. From this paper Fig. 1 is copied.

If ordinary fusible metal be taken it will crack the glass, from the large amount of expansion which it undergoes on solidifying. The addition of a little mercury reduces its expansibility and at the same time lowers the melting point. As it still, however, expands considerably on cooling, it forces itself into every minute crevice, acting as a most efficient cement. It should be applied in a molten condition, and the glass should also be hot, and, before exhausting, the joint should stand for an hour to allow the alloy to become thoroughly set. Tubes cemented to the pump by this compound I have had exhausted for weeks without any sign of leakage. I wish here to express my thanks to Mr. H. S. Marsh for the trouble which he has taken in experimenting with me on these alloys.

I also employ a special form of joint. It is shown in Fig. 4 as in use between two U-tubes which have been

Fig. 4.

taken for drying the gases which are to be collected. Each limb bears a small glass cup A carried on a cork B, through which passes one end of the U-tube. A curved tube C, bell-mouthed at either end, fits in each case outside the free end of the tube but within the glass cup. The molten alloy is poured in almost to the level of the mouth of the U-tube, and on cooling grips the whole firmly together. Until the alloy is poured in there is any amount of play, as can easily be seen, between the different parts of the apparatus, for the bell tubes need not be placed in position until everything else has been finally adjusted.

Moreover, instead of there being a long stretch of U-tubes or other apparatus, these can be ranged in rows of twos or threes, &c., one behind the other, by placing the proper bell-tubes at right angles to the others in that row, and thus making connexion with those coming both before and after.

The apparatus can be readily disconnected by placing round each of the glass cups in turn a brass cup riveted to a rod of the same metal. When the rod is warmed

Fig. 5.

the brass cup rapidly becomes heated and the alloy, as it melts at such a low temperature, is easily liquefied, and the bell-tube can then be lifted out. It will be found more

convenient to have the brass cup in two halves attached to two brass rods as in Fig. 5; it is then more easy to remove it, otherwise, as it must fit close to the glass cup, it will be necessary to wait until the brass cup is cool before it can be bent open.

In some experiments on which I am engaged I have found it necessary to use a particularly formed flask for the preparation of certain gases. A short description of this may prove interesting.

Fig. 6.

It holds about 200 cc. and fitting to the neck and ground to it with the *greatest care* is a glass hollow stopper A perforated in two places. For cement I use a mixture of beeswax, resin, and a little vaseline. Through one perforation B in the stopper passes an inlet tube for acid, terminating within the flask in a tube bent up slightly on itself. Outside the flask it bears a glass bulb into which acid can be poured; the bulb is choked by a ground glass rod, cut into which is a slot, corresponding to one in the bulb. When the slots coincide the acid passes down, but by turning the glass rod through 180° the connexion is cut off. A little acid should always be left in the bulb. Through the other perforation C passes the exit tube, terminating in a bell mouth.

The whole apparatus, from pump to generating flask, it will be observed, is without a single tap of any kind, is air-tight, and yet is readily put together and disconnected, and requires, except in the case of the glass flask, no special skill in its manufacture.

DISCUSSION.

Dr. C. A. Koux said he had worked with Dr. Rawson's pump, and could testify to the value of the alloy, which gave very satisfactory results. He would like to ask Dr. Rawson what the efficiency of his simpler form of pump was, as compared with the ordinary forms of Sprengel pump.

Dr. HURREN said that in many of his own investigations he had had many of the difficulties to contend with which Dr. Rawson had so ingeniously overcome. The nuisance of corks and taps in researches where every trace of a gas had to be kept together was very great indeed. He recollected that a few years ago, when he was busy with the investigations of an ammonia-soda process, he had to avoid loss of every trace of ammonia which was evolved at a red heat. He could only do this by sealing the whole apparatus together into one piece, and when he had very nearly finished the apparatus he broke it and had to start again. Fusible metal he had also tried, and to his great grief it broke every

glass he put it into, and he was glad to learn that the addition of a little mercury would correct that property of expansion on cooling just sufficient to make a joint without breaking the glass.

Dr. Rawson said, in reply to Dr. Kohn, that as regarded the working of his new pump, he had tried it under various conditions, and had found that the exhaustion to be obtained with it was quite as good as that with any other pump with which he was acquainted. Fusible metal and glass tubes, though remaining intact for a time, were invariably broken sooner or later.

HOME-GROWN SUGAR FOR GREAT BRITAIN AND IRELAND.

BY G. SCHACK-SOMMER, PH.D.

THE agricultural question is undoubtedly one of the most pressing and vital importance both in England and Ireland. In which of these two countries it is of most immediate moment it is not necessary for my present purpose to inquire; and to go into the causes that have led to this state of things is equally beyond my province or intention. I would merely mention, in passing, that the British Government have thought it advisable to establish a Board of Agriculture, and to appoint Mr. Chaplin as its first president; sufficient proof, if any was needed, that the agricultural interests of the United Kingdom are of importance enough, even in their condition of decadence, to require the attention of a special department. To that special department and to you, members of the Society of Chemical Industry, I have something to say, which I think is worthy of the serious consideration of both.

I ask you why cannot we grow beetroot, and manufacture sugar from it, as successfully as they do in France, Germany, Austria, Russia, Holland, Belgium, and many other countries?

With the fiscal difficulties in the way of doing this I am not at present concerned. My attention has been concentrated principally upon what are supposed to be the natural difficulties of growing sugar beetroot in Ireland or England for the purpose of manufacture, and in this way creating a new industry for both countries. The popular impression has hitherto been that the climate of these islands is too cold and damp for the successful cultivation of sugar beetroot, but I have no hesitation in saying that practical experience has proved the popular impression in question to be entirely wrong and mistaken.

In 1879 a Select Committee of the House of Commons was appointed to inquire into the effect produced upon the home and colonial sugar industries of this country by what may be called, for the sake of brevity, the bounty system in those foreign countries which manufacture sugar for exportation. In the course of his evidence before the Committee, Mr. James Duncan was asked if he could give any explanation of the fact that the growth of beetroot was practically confined to the Continent; and if no part of this country was adapted to the growth of beetroot. Mr. Duncan's reply was that it was adapted, but that the disadvantage of growing was owing to the bounty system, foreign sugar having a bounty which acted as a preventative to the growth of sugar in England, and which might be taken to be in the average 2*l.* a ton. In answer to further questions, Mr. Duncan stated that the bounty rendered it practically impossible to grow any beetroot in this country, though it could be done in the east of England of quite as good quality, if not better, than in France; but that, in face of the bounty, it was impossible.

Mr. George Martineau, giving evidence before the same Committee, said that he had given a very considerable amount of attention to the subject of the growth of beetroot in this country. One of the questions asked Mr. Martineau was as to the relative richness of roots grown in England as compared with foreign countries. In answer to this it was stated that Dr. Voelcker, the chemist to the

Royal Agricultural Society, found 12 per cent. of sugar in roots from Suffolk; 12½ and 13 per cent. in roots from Berkshire; 11½ per cent. in roots from Surrey; 10½ to 13½ per cent. in roots from Yorkshire; and 10, 12, and 13, up to 15 per cent. in roots from Kilkenny. That was in 1870. Since then Mr. Martineau himself had taken a considerable amount of trouble in the matter, and had roots grown both in Lincolnshire and the Isle of Thanet; and as far as the latter were concerned had in his own laboratory extracted 15 per cent. of sugar; an amount of richness in which England, in his opinion, could certainly compete with France, where the average was not more than 10½ per cent.

My object, however, in reading this paper is not to repeat evidence given 10 years ago before a Select Parliamentary Committee, but to bring before you the results of my own experiments made last year on the farms of Mr. John Ennis, Springwood, Ballymitty, county Wexford, Ireland, and Mr. John Gibbons, Dunbabin farm, Wavertree, near Liverpool. For the purpose of these experiments four different kinds of beetroot seed were sent to me by Dr. C. Scheibler, the eminent sugar chemist of Berlin, and to all three gentlemen I herewith tender my best thanks for their kind co-operation. Before proceeding to give the results of my experiments I may mention that in Germany and Austria the roots have been grown for years under an artificial system which causes them to be produced of an excessive richness.

YIELD PER CENT. OF WEIGHT OF BEETS.

	Per Cent.
1850-51	6'60
1860-61	8'62
1870-71	8'61
1871-72	8'28
1872-73	8'25
1873-74	8'25
1874-75	9'30
1875-76	8'60
1876-77	8'15
1877-78	9'24
1878-79	9'21
1879-80	8'52
1880-81	8'79
1881-82	9'56
1882-83	9'51
1883-84	10'54
1884-85	10'79
1885-86	11'43
1886-87	11'87
1887-88	13'08
1888-89	11'96

In this respect Germany surpasses other countries, but from the smallness of the size of the roots there are not so many tons produced to the acre. The seeds I obtained from Dr. Scheibler were:—

1. Dippe's Zuckerreichste Elitezüchtung.
2. Gebrüder Dippe's Zuckerreiche Imperial Elitezüchtung.
3. Gebrüder Dippe's verbesserte Zuckerreiche rothköpfige Elitezüchtung.
4. Gebrüder Dippe's verbesserte Zuckerreiche Kl. Wanzelholmen Elitezüchtung.

Of course you must not forget that, though I obtained the best seed procurable, both with reference to choice of soil and manure, I had to leave the necessary care of the plant to quite inexperienced hands. Possibly it may be the intention of some members of this Society to make experiments as I have done—experiments which I have already been asked to repeat by several Irish farmers. In such a case a hint or two about soil and manure may not be unacceptable. As to the first point, viz., the soil, it must be noted that very wet or swampy ground is quite unsuited for beet growing. What this requires is a loose clay containing lime, with a well-drained bottom. As to the second point, a very good artificial manure for beetroot is one containing one part of nitrogen to two parts of phosphoric acid as superphosphate. They spend as much as 5*l.* to 6*l.* per acre for artificial manure in Germany. The proportion wanted is about 200