Department of Science and Art of the Committee of Council on Education.

CATALOGUE

OF THE

SCIENCE COLLECTIONS FOR TEACHING AND RESEARCH

IN THE

SOUTH KENSINGTON MUSEUM.

PART III.

CHEMISTRY.

LONDON: Science Museum.
PRINTED BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1891.

Price Fourpence.

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PART III.

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1. Apparatus and Specimens illustrating the Application of Chemistry to Research.

2. Apparatus and Specimens illustrating the Application of Chemistry to the Arts and Manufactures.

⁂ *Circulating Collections appear under Nos.* 107 *to* 126 *and* 130.

U 64346. 1500 & 6.—2/91. Wt. 3565.

1. APPARATUS AND SPECIMENS ILLUSTRATING THE APPLICATION OF CHEMISTRY TO RESEARCH.

A.—APPARATUS INTENDED TO BE USED IN LABORATORIES AND LECTURE ROOMS.

1. Series of ½-inch cardboard cubes, with different colour for each chemical element on which its symbol, atomic value, and combining weight are marked, illustrating the laws of chemical combination and the binary theory of Salts.

1876. *Lent by Rev. Nicholas Brady, M.A.*

Only a comparatively small number are sent, as they will sufficiently show their method of use; thus represents the molecule of water, the dyad oxygen requiring two monads to satisfy it, the molecular weight of the compound being $1+1+16=18$.

H	H	O
1	1	1

2. Case containing five stands and a collection of spheres made to demonstrate the structure of chemical combinations according to the theories of A. W. Hofmann.

E. 271.—1877. *Made by Manuel Gonzalez, Madrid.*

3. Large copper gas holder, of bright metal.

Made by Warmbrunn, Quilitz, & Co., Berlin.

E. 139.—1877.

The apparatus consists of a cylindrical reservoir of copper, fitted with an entrance tube for water, an exit tube for the gas with a long tapering nozzle, and a glass water gauge. There is no top-water reservoir.

4. Large copper gas holder, bronzed, with top-water reservoir.

Made by Warmbrunn, Quilitz, & Co., Berlin.

E. 140.—1877.

Similar to the above, but fitted with a top-water reservoir.

5. Gasometer, consisting of tub with iron vessel to be raised and lowered within it by means of pulleys.

From the Pedagogical Museum, St. Petersburg.

E. 744.—1877.

6. Glass gasometer.
Made by W. J. Rohrbeck, J. F. Luhme & Co., Berlin.
E. 270.—1877. *(Dr. H. Rohrbeck).*

The apparatus consists of a glass gas reservoir, communicating by two brass pipes fitted with stopcocks, with a glass water reservoir above. One pipe leading to the bottom of the gas reservoir is for admitting water to drive out the gas, the other is finished off level with the top of the gas reservoir. The exit pipe for the gas is fitted with a tapering nozzle. The gas reservoir is furnished with a large tube at the bottom, closed with a screw cap, by which to empty it when full of water.

7. Set of beakers, without lip, 16 in the set, up to 280 mm.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 143.—1877.

8. Set of beakers, not lipped, No. $\frac{1\text{–}16}{1}$, $\frac{1\text{–}12}{1}$, $\frac{1\text{–}8}{1}$, $\frac{1\text{–}5}{1}$ set.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 144.—1877.

9. Sets of beakers, lipped, No. $\frac{1\text{–}12}{1}$, $\frac{1\text{–}8}{1}$, $\frac{1\text{–}5}{1}$ set.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 145.—1877.

10. Series of funnels, 10 pieces from 30 to 130 mm. diameter.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 146 to 155.—1877.

11. Bottle with etched label and cut stopper.—*Price* 2*s*. 9*d*. Bottle with sand-blasted label and cut stopper.—*Price* 3*s*.
1886. *Exhibited by Townson & Mercer.*

12. Cabinet with 26 bottles for re-agents. *Price* 2*l*. 17*s*. 6*d*.
1876. *Exhibited by J. Orme & Co.*

13. Glass jar for mercury, provided with glass stopcock.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 171.—1877.

14. Stopcocks (2) of rock crystal.
E. 29 and 30.—1877. *Made by H. Stern, Oberstein.*

15. Agate mortars and pestles (8).
E. 21 to 28.—1877. *Made by H. Stern, Oberstein.*

16. Plattner's diamond mortar, in steel. No. 1, with brass capsule. No. 2, without capsule.
E. 134 and 135.—1877. *Made by A. Herbst, Berlin.*

17. Percolator with stopper.—*Price* 3*s*. Aspirator with stopcock and stopper.—*Price* 8*s*. 6*d*.
1886. *Exhibited by J. Orme & Co.*

18. Separators (3), 6 oz., 10 oz., and 20 oz. sizes. All fitted with stoppers and glass stopcocks.—*Prices* 2*s*. 6*d*., 3*s*., and 5*s*. 6*d*. Fresenius tube.—*Price* 2*s*. 6*d*. **U**-tubes (2), with glass stoppers, with outlets through stopper on one limb, and with side tube introduced below solid stopper on the other limb.—*Prices* 2*s*. *and* 3*s*. 6*d*. Specimen jars (5) of different shapes and sizes, for exhibiting specimens.—*Prices* 1*s*. *to* 6*s*.
1886. *Exhibited by Townson & Mercer.*

19. Mercury trough. Gas bags (2).
1890. *Exhibited by J. Preston* (late Cubley & Preston).

20. Support, stoneware, with six holes for holding test tubes in position in a bath of water, &c.—*Price* 6*d*. Wood blocks of mahogany (6), circular, and of different thicknesses for raising objects.—*Price* 3*s*. 6*d*. *the set*. Raising table, 6 in. diameter.—*Price* 3*s*.
1886. *Exhibited by Townson & Mercer.*

21. Woulff's bottle.
From the Pedagogical Museum, St. Petersburg.
E. 742.—1877.

22. Woulff's bottle, 48 oz., three-necked, glass stoppered, with tubes through two of the stoppers.—*Price* 5*s*. Wash bottles (2), an ordinary 40 oz. wash bottle provided with removable handle for lifting when hot, and Allihn's, with glass stopper in place of cork.—*Prices, Allihn's* 4*s*., *the* 40 *oz*., 2*s*. Gas wash bottles, 20 oz., with stoppered tube; Hahman's 12 oz.; and Habermann's bottle.—*Prices* 5*s*., 2*s*. 6*d*., *and* 1*s*. 9*d*.
1886. *Exhibited by Townson & Mercer.*

23. Series of lettered (etched) wash bottles, for water, alcohol, and ether.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 156, 157 and 158.—1877.

24. Graduated tube on foot, 1,000 cc.'s.—*Price 5s. 6d.* Graduated tube on foot, 1,000 cc.'s, stoppered.—*Price 7s.*
1886. *Exhibited by Townson & Mercer.*

25. Graduated cylinders, of 1,000, 500, 250, and 100 cc.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 159 to 162.—1877.

26. Graduated flasks, of ¼, ½, and one litre.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 163, 164 and 165.—1877.

27. Flasks to contain 1,000 c.c.'s, stoppered and unstoppered.—*Prices 1s. 6d. and 2s. 3d.* Flask for preparing gases, glass stopper, thistle-headed funnel, and delivery tube all in one piece.—*Price 3s.*
1886. *Exhibited by Townson & Mercer.*

28. Glass-stoppered burettes, four, on stand.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 166 to 169.—1877.

29. Burettes :—
Mohr's, with stopcock, 1,000 c.c.
Binks', on wood stand, graduated in c.c.
Geissler's, with stopcock and stopper, graduated in c.c.
Mohr's, with clip, 1,000 grains in 200 divisions.
1876. *Exhibited by J. Orme & Co.*

30. Burettes (2), with clip and jet, graduated to 50 c.c. —*Prices 4s. and 3s. 9d.* Burettes (2), with glass taps, graduated to 55 c.c. and 60 c.c. respectively.—*Prices 5s. 6d. and 6s.*
1886. *Exhibited by Townson & Mercer.*

31. Burettes (2), Geissler's graduated to 50 c.c. and 100 c.c. respectively. *Prices 7s. 6d. and 10s. 6d.*
1886. *Exhibited by Townson & Mercer.*

These are stoppered above to keep out the dust, and yet arranged that in a certain position, when a passage through the stopper coincides with one through the burette tube, air is admitted into the burette, and allows the liquid to run out through a glass stopcock in a side-arm near the bottom of the graduated tube.

32. Stand for six burettes on round porcelain foot with polished brass rod and gun-metal mounts. *Price* 2*l.* 2*s.*
1886. *Exhibited by Townson & Mercer.*

33. Burette stands:—
Stand for eight burettes.—*Price* 15*s.* 6*d.* Dr. Percy's form.—*Price* 7*s.* 6*d.*
1876 and 1886. *Exhibited by J. Orme & Co.*

34. Hempel's explosion pipette. *Price* 13*s.*
1886. *Exhibited by Townson & Mercer.*

The bulbs on the right limb are of 100 c.c. and 50 c.c. capacity respectively, and the bulb on the left limb is of about 160 c.c. capacity. About 160 c.c.'s of a 5 per cent. solution of pure potash is introduced into the pipette. Then with both pinch-cocks open the liquid is blown from the left limb up to a mark on the right limb between the bulbs, and the cocks are then closed so that there has been a known volume of air at atmospheric pressure introduced, which is necessary for explosion by burning. Then connect top of pipette to a burette containing gas to analyse and introduce a known quantity. The explosive gas necessary for the analysis is produced directly by the electrolysis of the potash, and the liquid is depressed into the left limb. Agitate the apparatus so as to mix the gas before explosion. All the potash is then sucked to top of the left bulb, and the cocks closed, and the spark passed. The gas is agitated with the potash and re-measured.

35. Hempel's gas pipette, two bulbs. *Price* 9*s.* 6*d.*
1886. *Exhibited by Townson & Mercer.*

The lower bulb of the pipette is filled with the absorbing liquid, and the capillary tube is connected with a gas burette, which contains usually about 100 c.c.'s of gas, which is forced from the burette into the lower bulb, thus displacing most of the absorbing liquid into the higher bulb. After a few minutes the gas is sucked back into the burette, and its volume measured, and the amount which has been absorbed thus determined.

36. Enamelled iron-digester, with five holes in cover to receive evaporating basins, test-tubes, &c.—*Price* 6*s.* 6*d.* Porcelain rings; a set of 7 rings interfitting for covering evaporating baths, &c.—*Price* 3*s.* 6*d. the set.*
1886. *Exhibited by Townson & Mercer.*

37. Crucibles and covers, nickel; set of 3. *Prices* 2*s*., 2*s*. 6*d*., *and* 3*s*.
1886. *Exhibited by J. Orme & Co.*

Nickel goods are used to some extent to replace platinum, as they do not oxidise at red-heat, and they are only slightly acted upon by acids.

38. Nickel crucible and cover. *Price* 4*s*.
1886. *Exhibited by Townson & Mercer.*

39. Evaporating basins, nickel; set of 4. *Prices* 1*s*. 6*d*., 2*s*., 2*s*. 6*d*., 3*s*.
1886. *Exhibited by J. Orme & Co.*

40. Nickel evaporating basin, 4 in. diam. *Price* 4*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

41. Cork borer sharpener, arranged so that the brass cone which is slotted to receive the thick knife blade, may be introduced inside the cork borer, and the knife blade pressed against the outside, so that on turning the cork borer will become sharpened.—*Price* 2*s*. Retort stands (4).—*Prices* 3*s*. *to* 8*s*. 6*d*. Clamps (6).—*Prices* 1*s*. 6*d*. *to* 3*s*. Large clamp of bell metal.—*Price* 7*s*. 6*d*. Spatula, nickel plated.—*Price* 1*s*. 9*d*. Bunsen burner, nickel plated, $\frac{3}{8}$ in. diam.—*Price* 4*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

42. Bunsen burners (2), of simple construction.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 141 and 142.—1877.

43. Bunsen burner, brass.
From the Pedagogical Museum, St. Petersburg.
E. 745.—1877.

44. Argand Bunsen's burners (2), $\frac{1}{2}$ in. size with gas consumption of $3\frac{1}{2}$ feet per hour. *Price, with tripod stand,* 2*s*.; *without*, 1*s*. 6*d*.
1884. *Exhibited by Thomas Fletcher.*

45. Bunsen burner, improved form, with air jet to increase the temperature of the flame to any required extent without re-adjustment of height or position.
1876. *Exhibited by Thomas Fletcher.*

In the above, the blow-pipe flame obtained with the blast tube, when confined by the loose cap, is compact and very powerful, owing to the partial mixture of air before the blast begins to act.

46. Low temperature gas burner, to dispense with drying closets, sand and water baths, and adapted for drying, evaporating, boiling, &c.
1876. *Exhibited by Thomas Fletcher.*

This burner gives a range of temperature from a gentle current of warm air without visible flame to clear red heat, and is so perfectly under control that a common glass bottle may be placed on a tripod, and heated to the required temperature, without risk of fracture.

For very low temperatures, the ring must be lighted through the lowest opening. This gives a steady current of heated air through the gauze above. For boiling, &c. a light must be applied on the surface of the gauze, thereby providing a large body of blue flame, which can be urged by the blast-pipe until it gives a clear red heat.

47. Gas burner with stopcock and small wood platform round tube, which has a flat opening, and gives flame suitable for use with mouth blowpipe.—*Price* 4*s*. Bunsen gas burner to give a flame 6 in. broad, and suitable for heating tubes.—*Price* 8*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

48. Hot blast blowpipe, for temperatures up to the fusion of platinum.
1876. *Exhibited by Thomas Fletcher.*

The air jet in the above is coiled round the gas pipe in a spiral form, and both are heated by three Bunsen burners underneath, which are controlled by a separate tap. By this arrangement the power is double that of the ordinary blowpipe. When the jet is turned down to a small point of flame, it will readily fuse moderately thick platinum wire.

49. Automaton blowpipe on stand for jets not exceeding $\frac{1}{8}$ in. bore. *Price* 10*s*.
1884. *Exhibited by Thomas Fletcher.*

50. Foot blowpipe, ordinary type, with universal motion. *Price* 15*s*.
1886. *Exhibited by Townson & Mercer.*

51. Apparatus for drying in vacuo.
Presented by Prof. Markownikoff, Moscow.
E. 488.—1877.

52. Desiccators of different patterns:—
Bohemian glass, with zinc support. *Price* 3*s*.
Bell glass, ground glass plate, and sulphuric acid dish. *Price* 5*s*. 6*d*.
Thorpe's with dome cover. *Price* 4*s*. 6*d*.
Form with flat cover. *Price* 3*s*. 6*d*.
Form with bell glass and zinc plate, on stand. *Price* 8*s*. 6*d*.
1876 and 1886. *Exhibited by J. Orme & Co.*

53. Desiccator, 4 in. diam., according to Dr. Schiff, with stopcock and glass hook, arranged so as to be readily evacuated. *Price* 7*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

54. Drying closet for precipitates, with mica plates.
E. 138.—1877. *Made by Max Raphael, Breslau.*

55. Water oven and condenser. *Price* 3*l*. 15*s*.
1886. *Exhibited by Townson & Mercer.*

56. Water bath, Bunsen's, with regulator. *Price* 2*l*. 10*s*.
1876. *Exhibited by J. Orme & Co.*

57. Gas regulators, two forms, Tollens' and Lothar Meyer's. *Prices* 1*s*. 6*d*. *and* 6*s*.
1886. *Exhibited by Townson & Mercer.*

These are used for regulating the supply of gas to burners. In Tollens' form there is a quantity of air shut in one bulb by mercury. This air expands and contracts by variations of temperature, and thereby forces more mercury into or withdraws it from the other bulb. Into this latter bulb the gas enters by a tube, which is regulated so that the mercury will just touch the lower end when the bath to be heated has obtained the desired temperature, and a diminution in the gas supply will thus be brought about which will effectually prevent the bath from attaining too high a temperature. Lothar Meyer's form and many others are based upon the same principle.

58. Gas regulator.
1881. *Exhibited by J. Garbutt.*

59. Gas regulators (2), Jago's. *Price* 3*s*. 6*d*. each.
1886. *Exhibited by J. Orme & Co.*

60. Furnace, Bunsen's, with 24 burners and combustion tube. *Price* 4*l*.
1876. *Exhibited by J. Orme & Co.*

61. Potash bulbs :—Liebig's, *price* 2*s.* ; Geissler's, *price* 1*s.* 3*d.* ; Geissler's, with drying tube, *price* 3*s.* Chloride of calcium tube.—*Price* 10*d.* Nitrogen bulb, Will and Varrentrapp's.—*Price* 8*d.*
1876 and 1886. *Exhibited by J. Orme & Co.*

62. Absorption tubes, five forms. *Prices, Todd's,* 1*s.* 3*d.*; *Babo's,* 3*s.*; *Stromeyer's,* 3*s.*; *Emmerling's,* 4*s.*; *Winkler's,* 5*s.*
1886. *Exhibited by Townson & Mercer.*

Babo's and Emmerling's are filled with glass beads which are wetted with the absorbing liquid; the gas passing through the tube is thus brought well in contact with the liquid. Stromeyer's is a form chiefly used for absorbing carbonic acid by potash; the gas being caused to frequently bubble up through the potash, by which means all the carbonic acid is removed and may be weighed. Todd's is a form wherein the gas is exposed for a time to a large surface of absorbing liquid without bubbling through it.

In Winkler's arrangement the gas enters the bottom of the spiral tube containing the absorbing liquid and passes up the spiral through the liquid.

63. Filter pump tubes (4) of various shapes, in glass (Finkener's, Geissler's, &c.). *Prices* 1*s.* 6*d. to* 3*s*
1886. *Exhibited by Townson & Mercer.*

Water passing through these tubes takes air along with it and produces a diminished pressure in the filtering flask thereby accelerating the filtration.

64. Bunsen's filter pump. *Price* 1*l.* 10*s.*
1886. *Exhibited by J. Orme & Co.*

65. Hofmann's steam generator, for the lecture-room table.
E. 269.—1877. *Made by E. A. Lentz, Berlin.*

The apparatus consists of two copper hemispheres bolted together so as to be perfectly steam tight, fitted with a glass water-gauge, a steam pressure gauge, a safety-valve and two steam pipes, each fitted with a screw stopcock.

66. Condensers (2), Allihn's and Liebig's. All glass without any corks. The inner tube in Allihn's has bulbs upon it; otherwise it is like the Liebig's form. *Prices* 3*s.* 6*d. and* 2*s.* 6*d.*
1886. *Exhibited by Townson & Mercer.*

67. Glass condenser, consisting of three equal-sized bell-glasses connected by ground necks, holding about 2,000 c.c.

Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 170.—1877.

68. Fractional distillation tubes, two forms, one with five and the other with six bulbs. *Prices* 5*s.* *and* 8*s.*
1886. *Exhibited by Townson & Mercer.*

These tubes are used in separating a liquid of a low boiling point from a liquid of a higher boiling point. The tube is inserted through a cork in the neck of the flask in which the liquids are boiling. A thermometer is inserted in the other end of the tube. The temperature should be kept intermediate between the boiling points of the two liquids, the vapour of the liquid of lowest boiling point passes off through the side tube at the top and may be condensed and will be found nearly pure, because in the upper bulbs there will be found to be only a very small amount of the liquid of highest B.P., and consequently this liquid on evaporating from the bulb will give a purer vapour than if it had largely been contaminated with the liquid of higher B.P. The series of bulbs give every opportunity for the vapour of the liquid of higher B.P. to condense, when it runs back to the flask, either through the side tube or from bulb to bulb.

69. Specific gravity bottle, 10 grammes, stoppered by a funnel-shaped stopper. *Price* 1*s.*
1886. *Exhibited by Townson & Mercer.*

70. Specific gravity bottles:—1,000 grns., globular form, *price* 2*s.*; 1,000 grns., Regnault's, *price* 2*s.* 6*d.*; 100 grammes with thermometer, *price* 5*s.*
1876 and 1886. *Exhibited by J. Orme & Co.*

71. Sprengel's specific gravity tube. Used as an ordinary specific gravity bottle, but being more easily filled by aspirating the liquid into it and completely filling each time. This tube is also used as a stoppered U-tube for gas absorption. *Price* 1*s.* 6*d.*
1886. *Exhibited by Townson & Mercer.*

72. Weighing bottles (2). *Prices* 7*d.* *and* 1*s.*
1876. *Exhibited by J. Orme & Co.*

73. Hofmann's apparatus showing that in the synthesis of water two volumes of hydrogen unite with one volume of oxygen to form two volumes of water-gas or steam.

E. 257.—1877. *Made by J. Schober, Berlin.*

This apparatus consists of a long narrow tube closed at the upper end, and fitted with two platinum wires. The tube is filled with mercury; and a mixture of two volumes of hydrogen and one of oxygen is admitted into it. This mixture is most readily obtained from the electrolysis of water. The gas-filled part of the tube is entirely surrounded by a glass jacket through which the vapour of amylic alcohol is driven, the lower end dips in the glass trough containing mercury. The length of the column of mixed gases when fully expanded is marked. A spark is now passed between the platinum wires and the gases combine with an explosion, at the high temperature (132°) produced by the amylic alcohol vapour, the water formed remains as a gas. If the mercury in the tube be now adjusted to its former level with respect to the mercury in the trough, it will be found that the original measure of the gases is diminished by one-third, the remaining two-thirds being steam, which condenses if the tube is allowed to cool.

74. Apparatus for showing the simultaneous decomposition of water, hydrochloric acid, and ammonic chloride.

Made by J. Schober, Berlin.

E. 259, 260, and 261.—1877.

These three instruments are of similar form, consisting of a U-tube, closed at both ends by stopcocks, and connected below with a tube having a reservoir at the upper end above the level of the U-tube. Two of the instruments are provided with carbon poles, passing through corks in the prolongations of the straight limbs of the tubes, and wrapped round with wire for connecting with the terminals of a battery. The third is provided with poles of platinum foil. The instruments with the carbon poles are used in the decomposition of hydrochloric acid and ammonic chloride. If platinum were used, it would be at once attacked by the chlorine given off and dissolved.

The two gases collect separately in the two tubes, and may be allowed to flow out through the stopcocks, being driven out by the pressure of the liquid in the large reservoir. The chlorine will not collect until the liquid is saturated with the gas, it being very soluble in water.

75. Hofmann's lecture-room eudiometer.

E. 266.—1877. *Made by J. Schober, Berlin.*

This apparatus consists of a U-tube, one limb closed at the upper end by a stopcock, and provided with platinum wires fused in the glass; the other open, and having a tap near the bend. The closed limb in this instrument is graduated, so that the volume of the enclosed gas may be at once read off. A horizontal pointer is also provided for getting the mercury accurately level in both tubes.

76. Hofmann's apparatus for showing the synthesis of water.

Made by J. Schober, Berlin.

E. 263, 264, and 265.—1877.

These instruments consist of **U**-tubes, with one closed and one open limb; two of the instruments having the former provided with a stopcock. All have platinum terminals.

They are used in exactly the same way as the above, but unless the closed limb is surrounded by a jacket the steam will condense, any excess of either gas (oxygen or hydrogen) above the combining proportions being left.

77. Hofmann's apparatus for decomposing phosphuretted hydrogen.

E. 258.—1877. *Made by J. Schober, Berlin.*

This apparatus consists of a **U**-tube, one limb being sealed and provided with two carbon points to be connected with a battery. The open limb is provided with a stopcock at the lower end.

The apparatus is used in the same way as the one for decomposing ammonia, two vols. of phosphuretted hydrogen liberating three vols. of hydrogen, the phosphorus being deposited as a brown powder on the sides of the tube. Carbon points are used, as the liberated phosphorus is apt to combine with the hot platinum to form a fusible compound.

78. Hofmann's apparatus for decomposing ammonia gas.

E. 256.—1877. *Made by Julius Schober, Berlin.*

This apparatus consists of a **U**-tube, with one limb terminating in a narrower tube, and closed with a stopcock, the other limb being open and fitted with a tap near the bend of the limb. The closed limb is fitted with two platinum wires fused into the glass near the top, and nearly meeting inside. These are to be connected by the outside loops with the terminals of a battery.

The sealed limb is filled to about one-third of its height with dry ammonia, and the volume of the gas measured by bringing the levels of the mercury in the two limbs into coincidence. A series of electric sparks is now passed between the wires. The volume of the gas immediately increases, and in about 10 or 15 minutes, after adjusting the level of the mercury, the volume will have become doubled. By allowing a little gas to escape the odour of the ammonia will no longer be perceptible, and the hydrogen will inflame. This experiment shows that if we could make three vols. of hydrogen combine with one vol. of nitrogen we should obtain two vols. of ammonia.

79. Hofmann's tube, U-form, with five stopcocks and four steam jackets, for showing the influence of temperature and pressure on compound gases. *Price* 1*l*. 15*s*.
1876. *Exhibited by J. Orme & Co.*

80. Hofmann's electrolytic apparatus for the decomposition of hydrochloric acid.
E. 255.—1877. *Made by Julius Schober, Berlin.*

This apparatus consists of a V-shaped glass tube, with one closed and one open limb, the former being provided with a platinum wire, fused into the glass and terminating near the bend in a piece of platinum foil. Hydrochloric acid, coloured with indigo, is introduced so as to fill the closed limb and half the open one. If we connect the negative pole of the battery with the closed limb, at the same time connecting the positive pole with the platinum foil in the other, we observe that gas is almost exclusively evolved at the negative pole in the closed limb, the gas at the other only being noticeable by its suffocating odour and its bleaching action on the indigo coloured solution. The gas in the sealed limb is transferred to the open limb, previously filled with water and closed by the thumb, and tested. It will be found to be inflammable and may be recognised as hydrogen.

If the poles are now reversed hydrogen escapes at the open limb, and after some time we are able to collect a greenish-yellow gas in the sealed limb, which may be proved to be chlorine.

This apparatus may also be used in a similar manner for the decomposition of water into hydrogen and oxygen.

81. Hofmann's tube, with bulb and two stopcocks for showing that chlorine and hydrogen combine to form HCl without alteration of volume. *Price* 5*s*. 6*d*.
1876. *Exhibited by J. Orme & Co.*

82. Hofmann's apparatus for demonstrating that the volumes of oxygen which enter into the composition of carbon and sulphur dioxide are equal to the respective gas volumes of these compound gases.
E. 267.—1877. *Made by Julius Schober, Berlin.*

This apparatus consists of a U-tube with a bulb blown on the end of one limb, capable of being closed with a stopper, through which are passed copper wires, one sustaining a deflagrating spoon to contain carbon or sulphur, the other nearly touching it, the ignition being effected by a fine platinum wire connecting the two through which the electric current passes. The bulb being filled with dry oxygen, and the level of the mercury in the limbs being marked, the current is passed and the carbon or sulphur ignited; on cooling it will be observed that no change of volume has occurred on conversion of oxygen into carbon or sulphur dioxide.

The two bulbs on the limbs act as reservoirs for mercury, otherwise it might be driven out of the tube owing to the expansion caused by the combustion.

83. Hofmann's apparatus for showing the constancy of the proportions in which hydrogen and chlorine combine to form hydrochloric acid gas.

E. 262.—1877. *Made by J. Schober, Berlin.*

This apparatus consists of a straight tube provided with end stoppers and a stopcock at one-third its length.

84. Hofmann's apparatus for illustrating the phenomena of combustion.

E. 268.—1877. *Made by J. Schober, Berlin.*

This apparatus consists of a wide glass tube terminating at the bottom in a narrow tube bent at right angles, and closed above by a cork through which two tubes pass, one passing just through the cork, the other, a narrow one, is provided with a stopcock outside and ends inside in a platinum nozzle. The gas which it is required to ignite is brought in through the latter tube, the former being for the gas in which it is to burn. By this apparatus oxygen may be caused to burn in hydrogen.

85. Carbonic acid apparatus; Geissler's, two forms. *Prices* 4*s. and* 4*s.* 6*d.*

1886. *Exhibited by Townson & Mercer.*

These are used for determining the amount of CO_2 in carbonates, by displacing it with an acid, such as hydrochloric or dilute sulphuric. A weighed quantity of the carbonate is placed in the small flask, the tube to run acid upon it is filled with dilute acid, the bulb through which the displaced CO_2 passes is filled with strong sulphuric acid, and the whole is weighed. The dilute acid is then run upon the carbonate and the apparatus warmed, so that all CO_2 is displaced but no water as that becomes absorbed by the strong sulphuric, so that the decrease in weight is entirely due to CO_2 liberated from the known weight of carbonate introduced.

86. Carbonic acid apparatus. Fresenius and Wills', Kipp's, Orme's, Rose's, Schrötter's, Geissler's (two forms).

1876 and 1887. *Exhibited by J. Orme & Co.*

87. Sulphuretted hydrogen apparatus, Kipp's. *Price* 7*s.* 6*d.*

1876. *Exhibited by J. Orme & Co.*

88. Gas apparatus, Winkler's. On stand. *Price* 2*l.* 10*s.*
1876. *Exhibited by J. Orme & Co.*

89. Apparatus for experimenting with liquid sulphurous acid.
Made by Warmbrunn, Quilitz, & Co., Berlin.
E. 176.—1877.

90. Graduated Nessler tube with tap in side arm near bottom.—*Price* 5*s.* Nessler tubes (three), two plain, the other marked at 50 c.c.'s.—*Prices* 10*d. and* 1*s.* Stand, black wood, for use in Nessler's test.—*Price* 3*s.* 6*d.*
1886. *Exhibited by Townson & Mercer.*

Nessler's test is a very delicate method of detecting or estimating very small quantities of ammonia. Nessler's solution is made as follows:—35 grams KI are dissolved in 120 c.c. of water, 5 c.c. of it transferred to a beaker and the remainder added to a concentrated solution of mercuric chloride until the precipitate which forms ceases to be redissolved, some of the 5 c.c. of potassium iodide removed is added until the precipitate just redissolves, then an aqueous solution of 100 grams of caustic potash in 200 c.c. of water is added and the mixture is diluted to 500 c.c. This solution when added to water containing traces of ammonia or ammoniacal salts gives a yellow or brown colouration. The tint produced by adding 1 c.c. of Nessler's solution to 50 c.c. of the water containing traces of ammonia is compared with the tint produced from water containing a known quantity of ammonium chloride, and when after trial these tints have been obtained of the same intensity the amount of ammonia to be estimated is known.

91. Apparatus for simultaneous production of hydrogen, carbonic acid, and sulphuretted hydrogen.
Presented by P. Waage, Professor of Chemistry and Director of the Chemical Laboratory at the Royal University of Christiania, Norway.
E. 487.—1877.

The apparatus consists of a reservoir for hydrochloric acid of 10–15 per cent. strength. At the bottom of this reservoir are three apertures through which it is connected in the usual manner by glass tubes and stopcocks with three cylindrical jars, one filled with zinc, the second with marble, and the third with sulphide of iron. Beneath each of these, and communicating with the sewers, is another reservoir into which the solutions of chlorides are gathered. The three gases generated are conducted through wash bottles furnished with stopcocks of glass; when these are turned off the several gases and the solutions of chlorides will pass through the lower reservoirs into the sewers.

The apparatus once fitted up is always ready for use, and all superfluous gas is completely led away without producing any smell in the room where the apparatus is fixed.

92. Cailletet's apparatus for the liquefaction of oxygen.

Lent by the Chemical Laboratory, Royal College of Science.
1887.

The oxygen is contained in a vessel of the same pattern as that exhibited on the floor of the case.

The body of this vessel is enclosed in a strong steel cylinder, and is surrounded by mercury; the capillary tube forming the upper portion of the oxygen receiver passes through a packing in this outer cylinder and is then bent at 120°, and again, in the same sense, at 60°.

When in position the end of this tube points downwards; it is in this portion of the tube that the oxygen is liquefied. A narrow-bore copper tube connects the interior of the steel cylinder with a hydraulic pump by means of which very high pressures may be obtained.

The end portion of the capillary tube is immersed in liquid ethylene contained in a test-tube, which is surrounded by another glass vessel; the air between the two vessels is dried by strong sulphuric acid, by this means the deposition of hoar frost upon the outer surface of the ethylene bath is prevented.

The liquid ethylene may be rapidly evaporated by the passage through it of a current of air previously cooled by transmission through the outer copper worm of a methyl chloride bath, placed immediately above the ethylene bath; by this means the contents of the capillary tube may be cooled to $-123°$ C., *i.e.*, below the critical temperature for oxygen.

Under the combined effect of the high pressure and low temperature, dry oxygen gas is readily condensed to the liquid state, and shows, at the surface of separation between the gas and liquid in the capillary tube, a well-defined meniscus.

The liquid ethylene is delivered from an inverted steel tube through the inner copper worm in the methyl chloride bath into the test-tube previously mentioned.

The methyl chloride is rapidly evaporated by a current of dry air; both the liquid ethylene and the dry air for its evaporation are thus cooled to about $-70°$ C. before passing into the lower bath.

93. Gay-Lussac's apparatus for determining vapour densities.

1876. *Exhibited by J. Orme & Co.*

This method consists in determining the volume of a given weight of the vapour.

The graduated and calibrated glass tube is filled with mercury, and placed in the iron vessel containing this metal. The substance is contained in a thin bulb of known weight; this is then filled with liquid, again weighed, and then passed up to the top of the divided tube. Surrounding this is a wide glass cylinder open at both ends, and filled with water. The iron vessel is now heated. The expansion due to the heat bursts the bulb, and liberates the liquid, which is converted into vapour. The water is agitated by a stirrer to keep the temperature equally distributed. As soon as the temperature at which the determination is to be made is reached the volume of the vapour, the temperature of the water, and height of the barometer are read off, the temperature of the air, and the difference in height of the mercury inside and outside the tube, being ascertained at the same time.

From these data the vapour density may be calculated.

94. Dumas' apparatus for determining vapour densities.

Price 1*l.* 10*s.*

1876. *Exhibited by J. Orme & Co.*

The method used with this apparatus consists in the determination of the weight of a given volume of vapour.

The bulb is first filled with dry air, and weighed, the temperature of the balance case being taken. A quantity of the liquid, sufficient to produce enough vapour to expel the air, is then introduced. The bulb is then heated in the iron vessel, filled with water, oil, or paraffin according to the volatility of the substance, the temperature being raised to a point at least 30° to 50° above the boiling point of the liquid. The capillary tube is sealed when no more vapour issues from it, and the temperature noted. The globe is then removed, cleaned, and weighed when cold. To determine the volume of the globe the point is broken off under mercury, which rushes up and fills the globe; the contained mercury is weighed or poured into a graduated vessel to obtain its volume.

Having these data the vapour density may be calculated.

95. Bunsen's apparatus for determining the specific gravity of gases by effusion.

E. 18.—1888. *Made by C. Desaga, Heidelberg.*

The glass tube to contain the gas under examination is open at the bottom, and furnished with a stopcock above. The upper end of the tube is closed by a metal cap, which can be screwed on and off. The lower end of this cap is closed by a small piece of platinum foil sealed on to the cap, and pierced with a small aperture. This small aperture is the only exit for the gas from the tube. The tube dips into a narrow mercury reservoir, and is held in its place by a clamp sliding on a vertical rod.

In order that the gases should issue from the tube under similar conditions of pressure, a float made as light as possible is placed in the tube. This float carries at the top a black disc, and lower down two black rings, serving as marks of level.

The tube containing the gas and the float is placed in the mercury so that the level of the mercury coincides with the mark on the tube; the float then is not visible through a telescope directed at the mark. The stopcock is now opened, and the gas allowed to escape through the aperture, the float rising with the mercury. During this time the observer must watch the level of the mercury through the telescope. Directly the black disc appears observations of time must be made by a pendulum beating half seconds.

These observations are concluded directly the lower black ring appears; the top of the float and the upper black ring showing the approach of the two marks when observations have to be made.

By this means the time of effusion, of a column of gas of the constant length between the black disc and the lower ring, is obtained, issuing under pressures, the average value of which is constant.

The calculation of the specific gravity is based on the fact that the specific gravities of two gases, which stream out of a fine opening in a thin plate, are very nearly proportional to the squares of the times of effusion.

Thus the squares of the times of effusion give the relation between the specific gravities of the gases.

96. Victor Meyer' vapour density apparatus. *Price 5s.*

1886. *Exhibited by Townson & Mercer.*

The interior glass tube with enlarged end is heated by the water or other liquid in the outer tube, until no more air passes out of the delivery tube at the side, which is placed under water in a pneumatic trough. The cork closing the tube is then removed, and a weighed quantity of the substance, whose vapour density is required, is dropped in, and the cork quickly inserted. As the substance volatilises it displaces air which passes out of the delivery tube, and is collected in a graduated tube. From the volume of the air displaced we get the volume of the vaporised substance, and knowing its weight can calculate its vapour density.

B.—APPARATUS DESIGNED FOR SPECIAL INVESTIGATIONS.

97. Apparatus for preparing small quantities of liquid carbon dioxide, or liquid hydrochloric acid gas, and examining its action upon various substances.
1876. *Lent by George Gore, F.R.S.*

(Philosophical Transactions of the Royal Society, 1861, and Proceedings of the Royal Society, May 1865.)

98. Vessels and Articles of baked and fused fluoride, cryolite, fluor-spar, native graphite, gas carbon, and wood charcoal, for researches on Fluorides.
1876. *Lent by George Gore, F.R.S.*

99. Portable differential barometers (2) used by Prof. Mendeleef in his investigations on the tension of gases. See Transactions of the Imperial Russian Technical Society, 1875.
1876. *Lent by Prof. Mendeleef, St. Petersburg*

100. Pasteur's bottle with funnel-shaped stopper. *Price* 1*s.*
1886. *Exhibited by Townson & Mercer.*

101. Pasteur's tubes (2). *Price* 1*s. each.*
1886. *Exhibited by Townson & Mercer.*

102. Pasteur's flasks (3); one of 125 c.c.'s capacity, and two others of 36 ozs. capacity.

The latter form of flask was used by Pasteur in his researches upon grape fermentation. *Prices* 8*d. and* 3*s.*
1886. *Exhibited by Townson & Mercer.*

103. Iridio-platinum apparatus to illustrate the mode of preparing anhydrous hydrofluoric acid and the electrolytic method of obtaining fluorine.
E. 17.—1888. *Made by Johnson, Matthey & Co.*

The apparatus consists of a platinum U-tube, with fluor-spar stoppers and platinum delivery tubes, the positive electrode consisting of an alloy of platinum with 10 per cent. of iridium. Potassium hydrogen fluoride prepared by Fremy's method dried at 100° and then over sulphuric acid and potash in a vacuum is used; this salt is much less deliquescent than the normal fluoride. The dried salt is heated in the platinum retort and the hydrogen fluoride is condensed in the receiver cooled with ice and salt. The liquid is then introduced into the U-tube cooled with methyl chloride boiling at −23° and subjected to the action of a current from 20 large Bunsen's elements coupled in series. Any small quantity of water present is decomposed with liberation of ozone at the positive pole, but as the water disappears the resistance increases rapidly, until, when the hydrogen fluoride is perfectly pure, a current from even 25 cells no longer passes. To obtain the necessary conductivity, a small quantity of perfectly dry potassium hydrogen fluoride is dissolved in the liquid. Under these conditions hydrogen is given off at the negative pole, whilst at the positive pole a gas is evolved in which crystallized silicon, adamantine boron, arsenic, antimony, sulphur, and iodine take fire spontaneously.

This gas is fluorine

104. Bunsen's absorptiometer.

E. 220.—1877. *Made by C. Desaga, Heidelberg.*

This apparatus is used for the determination of the absorption of the more insoluble gases. The absorption tube within the large tube is divided into millimeters and accurately calibrated, it has a small iron band furnished with a screw, luted on its lower and open end, this fits into another screw attached to a small iron stand with a plate of caoutchouc covering the bottom. By this means the open end can be screwed down on the plate, and the tube thus completely closed. Two grooves on each side of the stand permit of a sliding movement on two vertical pieces on the foot of the apparatus inside the glass tube, so that the small iron stand can be raised or depressed, but not turned horizontally on its axis.

The outer glass tube is provided with ground glass edges at the bottom end, which can be pressed against caoutchouc rings inserted in the foot and in the rim, by means of the two nuts at each side of the top of the apparatus, working on screws on the two vertical side rods. The tube at the side is for pouring in mercury, a cock being provided for letting it out, so that any desired pressure is obtained in the absorption tube by raising or depressing the level of the mercury in the inner glass cylinder. The temperature of the surrounding water is determined by a thermometer placed in the outer tube. The upper end of the large glass tube is closed by an iron lid, hinged at one side and fastened down by the nut and screw. The tube is rendered water-tight by a band of caoutchouc inside the lid.

The absorption tube is filled with mercury at the trough, and a quantity of gas passed into it. The volume of the gas is determined with all due precautions. A quantity of water perfectly free from air is passed up into the tube, which is then tightly screwed against the caoutchouc plate in the small stand, and the whole placed in the large tube containing some mercury, and filled up with water. The pressures within and without the tube are equalised by slightly unscrewing the tube from the caoutchouc plate, and it is again closed. The iron lid is fastened down and the apparatus vigorously agitated. The tube is again released to equalize the pressure, screwed down again and the apparatus agitated; this operation being repeated until no further diminution of the volume of the gas is perceptible. The volume of the water is determined by reading off its upper and lower level in the absorption tube. The diminution of the original volume of the gas corrected for the pressure it is under in the absorptiometer gives the amount absorbed by the water at the temperature given by the thermometer.

105. Bunsen's thermostat.

E. 92.—1888. *Made by C. Desaga.*

Is an air bath of tolerably large dimensions, in which almost perfectly constant temperatures can be kept up for any desired length of time.

It consists of a cylinder of sheet copper closed at the lower end; its section is an ellipse. From this cylinder at 11 places, equally distant from each other, project thick copper wires which are riveted and brazed into the copper cylinder. The wires pass through the lamp chimneys in such a manner that they lie at right angles to the vertical axes of the cones of the non-luminous flames, and are placed at the point where the temperature is highest and most uniform. By this arrangement it is seen that the temperature of the interior of the copper vessel is rendered very nearly independent of the height of the flame, and is almost entirely regulated by the distance of the lamps from the cylinder. To avoid irregularities in the distribution of heat in this way, a somewhat smaller copper vessel, also closed below, is firmly connected to the outer one, in such a manner that a thin layer of air separates the one from the other; this effectually prevents irregularities from radiation from the outer vessel. The upper ends of both copper vessels can be closed with covers pierced with three corresponding holes; through two of which project the points of the glass vessels which are being heated, and through the third a thermometer. The whole apparatus is protected from draughts, and the gas supply is governed by a regulator. The flames can be arranged in three different positions equidistant from the copper vessel, and these may be recognised by notches on the conducting rod, and correspond to certain temperatures. After having taken full precautions, the temperature of the air bath during one hour will not vary more than one degree.

106. Apparatus used in an investigation by Messrs. Lawes, Gilbert, and Pugh, to determine whether plants assimilate free or uncombined nitrogen. *See* Philosophical Transactions, Part 2, p. 493, 1859; and Journal of the Chemical Society, new series, vol. i.; Entire Series, vol. xvi., 1863.

1876. *Lent by Sir John Bennet Lawes, Bart.*

The tap being opened, and water allowed to flow from a raised reservoir into the large stoneware Woulff's bottle, air passes from it by the small leaden exit tube, through two glass Woulff's bottles containing sulphuric acid, then through the long tube filled with fragments of pumice saturated with sulphuric acid, and, lastly, through a Woulff's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, it enters the glass shade, from which it passes by an exit tube through an eight-bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air is prevented. Entering the shade at the side opposite to this exit tube is a tube for the supply of water or solutions to the soil, but which is at other times closed. In front of the shade is a bottle connected by a tube with the bottom of the earthenware lute-vessel, for the collection of the condensed water, which is from time to time withdrawn from the bottle by suction, and returned to the soil. The shade enclosing the pot and plant stands in the groove of a specially made, hard-baked, glazed, stoneware lute-vessel, mercury being the luting material. Carbonic acid is supplied as occasion may require, by adding a measured quantity of hydrochloric acid to the bottle containing fragments of marble, the envolved gas being, as will be seen, washed through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade. The short leaden pipe, bent and opening downwards externally to the large stoneware bottle, passes nearly to the bottom of it inside, and is a safety tube for the overflow of the water when the vessel is full, and so prevents it passing into the wash bottles, &c. When full, the cork near the bottom of the stoneware vessel is withdrawn, and the water flows by means of a drain back into a tank, from which it is pumped into the raised reservoir for re-use. It will be observed that, by the arrangement described, the washed air is forced, not aspirated, through the shade, and the pressure being thus the greater within the vessel, the danger of leakage of unwashed air from without inwards is lessened. In 1857 twelve sets of such apparatus were employed, in 1858 a larger number, some with larger lute-vessels and shades, in 1859 six, and in 1860 also six. The whole were arranged side by side in the open air on stands of brickwork, as indicated.

C.—COLLECTIONS OF APPARATUS SPECIALLY ARRANGED FOR INSTRUCTION.

APPARATUS FOR SPECIALLY IMPORTANT ILLUSTRATIONS. NOS. 107 to 126. (Similar collections are lent by the Department to teachers of Science Classes.)

107. Apparatus to decompose steam by a stream of electric sparks.

E. 52.—1874.

Consisting of a five-cell Grove's battery, a Ruhmkorff coil, a globe fitted with platinum wires for the passage of the spark, and a leading tube for gas, mounted upon a flask, in which to generate steam. The flask is half filled with water, which is made to boil, and the steam driven slowly through the globe, led into the pneumatic trough, and condensed. When the air is completely displaced from all parts of the interior, the platinum wires are connected with the coil, which is then set in action. A portion of the steam passing through the globe is thus decomposed, and the mixed oxygen and hydrogen gases can be collected over the pneumatic trough.

108. Apparatus for gas analysis.

E. 53.—1874.

Intended to submit a mixture of gases to the successive action of absorbents, and so to determine its composition volumetrically. The *modus operandi,* divested of minor details, is simply this. The gas to be analysed is placed over mercury in the reservoir I, then drawn by the descent of a column of mercury into the measuring tube C, where its volume is determined. Being returned into the reservoir I, into which an absorbing agent is thrown, which deprives it of one constituent, the gas is brought back to the tube C and measured again, and this process is repeated until the composition of the mixture is ascertained. An equable temperature is maintained in the measuring tube C by the vessel H being filled with water, which can be agitated, if necessary. The pressure is regulated by the mercury cistern B, which is raised or lowered as may be necessary, and it is measured by the column of mercury in the tube A.

Instructions for using the Apparatus.

Let the gas to be analysed be common air, or the gas evolved by ebullition from natural waters, consisting usually of carbon dioxide, oxygen, and nitrogen. First, the gas is carefully transferred without loss to the jar I, and thence drawn by lowering the mercury reservoir and opening the stopcocks into the tube C, where the apex of the mercury is brought to coincide with any graduation mark. Suppose the following observations to be made :—

Height of mercury in C	250 mm.
Corresponding volume of gas as per calibration table	19·2 c.c.
Height of mercury in A	130·4 mm.
Temperature of water in H	16·4° C.
Height of barometer	763·1 mm.

From these data the pressure upon the gas is calculated as follows :—

Height of barometer		763·1 mm.
Deduct height of mercury col. in A from height in C, viz., 250—130·4	119·6	
Plus tension of aqueous vapour (the interior of C being moist) at 16·4° C.	13·9	133·5
Pressure on dry gas		629·6

Hence we have 19·2 c.c. of dry gas at 16·4° C. and 629·6 mm. pressure.

Absorption of Carbon Dioxide.—This is effected by passing up into the jar I, by means of a small pipette, two or three drops of a concentrated solution of caustic potash. The gas is driven from the measuring tube C into contact with the potash solution by raising the mercury reservoir and opening the stopcocks. A few minutes' exposure secures the absorption of the carbon dioxide, and the residual gas, a mixture of oxygen and nitrogen, is drawn back into C and measured as before.

Absorption of Oxygen.—A few drops of a concentrated solution of pyrogallic acid are added to the solution of caustic potash in the jar I, and the gas driven from C as before. The alkaline potassic pyrogallate immediately absorbs oxygen, becoming of a deep blood-red colour. By careful manipulation the jar I may be slightly agitated, so as to promote the absorption, which is known to be complete when the dark-coloured liquid thus thrown upon the sides of the glass runs off again without leaving a dark blood-red stain.

The remaining operation is to determine in C the volume of the residual nitrogen, and the analysis is finished.

Three uncorrected gaseous volumes are thus obtained, viz. :—

A = volume of three mixed gases ;
B = volume of mixed oxygen and nitrogen ;
C = volume of nitrogen.

By the formula given below these volumes may be reduced to 0° C. and 760 mm. pressure, and then from the corrected volumes A′, B′, and C′, so obtained, the quantity of each gas in the mixture may be deduced.

$A' - B'$ = vol. of carbon dioxide.
$B' - C'$ = vol. of oxygen.
C' = vol. of nitrogen.

The centesimal composition of the mixture is then very easily calculated.

The following formula may be used to bring the observed volumes to standard temperature and pressure :—

$$\frac{VP}{(1 + \cdot 003665\ t)\ 760.}$$

V=observed volume of gas in cubic centimetres.
P=pressure upon the dry gas.
t=temperature at the time the volume was measured.

For further details, *see* "Chemical Society's Journal," vol. xxi. p. 109.

109. Apparatus for the determination of vapour densities by Gay-Lussac's process, and by Dumas' process.

E. 54.—1874.

See also Nos. 93 *and* 94.

Gay-Lussac's Process.—The principle of this method is to convert a known weight of a substance, confined over mercury, into vapour, the volume of which being measured at known temperature and pressure, can be readily reduced by calculation to that at standard temperature and pressure.

Dumas' Process is the reverse of the preceding. A known volume of a vapour is first measured, and its weight then ascertained; from these data the vapour density under standard conditions is calculated.

Further details may be found in Miller's "Chemical Physics."

110. Apparatus for showing that hydrogen and chlorine do not contract when they unite to form hydrochloric acid.

E. 55.—1874.

This consists of a glass tube having a stopcock at each end, and filled with a mixture of hydrogen and chlorine in equal volumes. By opening one end of this tube under mercury it is proved to be completely full of gas. Then, either by the light of burning magnesium wire, or by an electric spark passed between two platinum wires fused into the tube, the gases are caused to combine. On opening the tube a second time under mercury, after cooling, the volume of the contained gas is shown to be the same as before combination, and solution of the hydrochloric acid gas in blue litmus-water proves that no hydrogen or chlorine is left. (*See* Hofmann's "Modern Chemistry," Lecture iii.)

111. Apparatus for the decomposition of ammonia by electric sparks, and for the subsequent combustion of the liberated hydrogen by cupric oxide.

E. 56.—1874.

A certain volume of dry ammonia gas is confined in the closed limb of the tube, and the height of the mercury therein, after equalisation of pressure in both limbs, carefully marked. Electric sparks are then passed for some minutes between the two platinum wires; the high temperature of the spark decomposes the gas, which expands to exactly double its original volume. Then the voltaic current from five or six cells of a Grove's battery is passed through the spiral of platinum wire, so as to ignite some included pieces of cupric oxide. The hydrogen is thus gradually removed, and nitrogen alone is left to the amount of one-half in bulk of the ammonia originally taken. Hence it is proved that two volumes of ammonia gas are composed of one volume of nitrogen and three volumes of hydrogen. In noting the volumes, the level of the mercury must be equalised in both limbs of the tube.

112. Apparatus for the decomposition of marsh-gas.
E. 57.—1874.

A convenient volume of marsh-gas is introduced into the closed end of the tube, and, after equalising the pressure, its bulk is marked. It is then decomposed by sparks from an induction coil, with an occasional reversal of the current. Carbon is deposited upon the platinum terminals, and the gas, after decomposition, occupies double its original volume. This product of decomposition can be shown to be hydrogen by igniting it at the jet, when it burns with a flame, which is, however, more or less luminous, on account of the formation of a small quantity of acetylene during the process of decomposition.

113. Apparatus for showing when carbon or sulphur burns in oxygen no alteration of volume takes place.
E. 58.—1874.

This consists of a **U**-tube with a bulb blown in one limb, capable of being closed with a stopper, through which are passed copper wires sustaining a deflagrating ladle of bone-earth to contain charcoal or sulphur, which may be ignited by the transmission of a galvanic current through a fine platinum wire. The bulb being filled with dry oxygen, and the level of the mercury being marked, ignition of the charcoal or sulphur is effected, and on the cooling of the gas it will be observed that no change of volume has occurred on conversion of oxygen into carbon or sulphur dioxide.

114. Ozone apparatus.
E. 59.—1874.

This is intended to ozonise oxygen by induction. It consists of a glass tube coated outside with tinfoil; within this is placed a narrower tube lined with tinfoil or silvered inside. The two metallic coatings are connected with the two ends of the secondary wire of an induction coil, and while a "silent discharge" is made to pass between the two tubes, a current of dry oxygen is slowly driven through from a gasholder. A portion of the oxygen is converted into ozone, which can be detected by means of iodised starch paper at the exit end of the tube. It is important that the oxygen should be perfectly dry, otherwise the quantity of ozone formed will be very small.

115. Galvanometer.
E. 60.—1874.

The action of this instrument depends upon the fact that a magnetic needle, freely suspended at its centre, and placed in the neighbourhood of a wire or other conductor along which a current of electricity is passing, tends to place itself at right angles to the line of the current. In practice two parallel needles are mounted the one above the other upon the same pivot, with their poles in contrary directions, so that the action of the earth's magnetism upon them shall be reduced to a minimum. The lower needle is then adjusted within a coil of silk-covered copper wire, and the upper one above a cardboard disk on which is marked an arc graduated into degrees. On a current of electricity traversing the coil of wire, even though it be the feeble current produced by a slight variation of temperature on the face of a thermopile, the motion of the upper needle at once indicates the existence, and to some extent the force, of the current.

116. Thermopile.
E. 61.—1874.

An instrument for producing feeble currents of electricity by warming at their points of junction bars of bismuth and antimony soldered together. A number of couples of this kind are packed in a brass case, so that half the joints may be on one side and half on the other. The slightest variation of temperature between the two sets of joints is enough to excite a current of electricity, which may by means of wires attached to the terminal bars be conducted to a galvanometer, and measured. The heat given off by the human body at a distance of 10 yards is sufficient to affect a delicate instrument.

117. Daniell's hygrometer.
E. 62.—1874.

This is an instrument for determining the "dew-point," or the temperature at which the aqueous vapour contained in the air begins to be condensed. It consists of a glass siphon connecting two bulbs. One of the bulbs is blackened, and contains ether, into which dips a small thermometer for the determination of the temperature of the liquid. The instrument is mounted on a stand bearing another thermometer to take the temperature of the surrounding air. The empty bulb is covered with muslin tied tightly round it. To use the hygrometer, a little ether is poured upon the muslin, and the cold produced by its rapid evaporation condenses the ether vapour inside the empty bulb as fast as it is formed in the blackened bulb. By this action the temperature in the blackened bulb is lowered. As soon as the dew-point is reached, aqueous vapour from the air condenses as dew on the black bulb, and at that instant the readings of the two thermometers must be observed.

118. Eudiometer to estimate oxygen in air.

E. 63.—1874.

This instrument is first filled with water. The air to be examined is then introduced, and the level of the water adjusted to the zero of the scale marked on the tube. A few drops of water being now removed from the open end of the eudiometer by a tube, their place is supplied by an equal quantity of solution of potassic pyrogallate, or, what is the same thing, solutions of caustic potash and pyrogallic acid are separately used to refill the open end. The instrument is now closed with the thumb and violently shaken to promote absorption, and then opened under water so that the liquid may rise and its level be ascertained. All measurements must be taken after the eudiometer has been immersed in a glass cylinder containing water, so as to counteract the expansion caused by the warmth of the hand, and while the water is standing at the same level both within and without the tube.

119. Diffusion tube.

E. 64.—1874.

This is a tube closed at one end by a porous plug of plaster of Paris, and open at the other. In using it the plug must on no account be wetted. Hydrogen is the gas usually employed in diffusion experiments, owing to its greater rapidity of motion. The tube may be filled with hydrogen by displacement, first closing the top of the tube by a cork so that no gas may escape through the plug. On then placing the open end of the tube in coloured water, the rise of the liquid on removing the cork shows that the hydrogen escapes through the porous plug more rapidly than the air enters the tube in the opposite direction. Or the open end of the tube may be dipped into water, and a cylinder of hydrogen lowered over the plugged end. The diffusion of hydrogen into the tube is so much in excess of the diffusion of air out of it, that bubbles are forced through the water as if they were violently blown out of the tube.

120. Oxyhydrogen blowpipe and gas bags.

E. 65.—1874.

The use of these is sufficiently understood. The chief precaution to be observed is, that the hydrogen must always be ignited before the oxygen is turned on, and an excess of oxygen is to be carefully avoided. Twice as much hydrogen as oxygen (by measure) should be burned.

121. Cavendish's eudiometer (so called).

E. 66.—1874.

This is used for demonstrating the production of water by the explosion of a mixture of oxygen and hydrogen. It is filled by first exhausting it of air at the air-pump, turning off the stopcock, and then connecting it with a receiver standing over water and containing a mixture of hydrogen and oxygen in the proportions requisite to form water. The stopcock being first opened and then closed, the mixture is exploded by the electric spark. After the explosion, the interior will be perceptibly moistened by minute drops of water.

122. Apparatus to prepare acetylene from hydrogen and carbon.

E. 67.—1874.

This is a globe, designed to contain hydrogen, with two carbon electrodes nearly meeting in the centre. A Grove's battery of 20 cells is to be connected with these electrodes, which must first be pushed together and afterwards separated so as to produce the voltaic arc. Under the influence of the heat thus generated, combination ensues between the carbon and hydrogen, and acetylene in small quantity is formed.

123. Twenty cells of Grove's battery.

E. 68.—1874.

To be used with the preceding.

124. Apparatus for preparing acetylene from coal-gas by a stream of electric sparks.

E. 69.—1874.

This much resembles No. 16, a current of coal-gas being substituted for one of hydrogen, and the sparks obtained from the coil No. 1.

125. Model apparatus for coal-gas.

E. 70.—1874.

Intended to illustrate the manufacture of coal-gas. The copper retort is to be charged with coal and heated to redness in a charcoal furnace. The Woulff's bottle is intended to arrest tarry matter; the gas is then conducted through slaked lime or ferric hydrate to remove sulphuretted hydrogen, and is afterwards collected in jars or in a gasholder, from which it may be burnt at a jet. Care must be taken that all the air is expelled from the apparatus before the gas is collected.

126. Apparatus for exposing equal volumes of hydrogen and marsh-gas to various temperatures and pressures.

E. 71.—1874.

Equal volumes of two gases are placed in the two limbs of the **U**-shaped tube. The pressure may be increased by addition of mercury in the open tube, or diminished by running off mercury from the pinchcock at the bend. A glass cylinder surrounding the **U**-tube containing the gases forms a steam jacket, and affords the means of rapidly raising the temperature of the enclosed gases to 100° C.

127. Illustrations of the elementary course of inorganic chemistry. *See* "Outline of experiments suitable for " illustrating elementary instruction in chemistry." 1890.

The apparatus is arranged to show :—

A colourless gas different from air is formed when a taper burns.

Water is formed when a candle burns.

Water and carbonic acid gas result from the burning of coal gas.

Air has weight.

Air diminishes in bulk when phosphorus is burned in it.

Some diminution takes place slowly when a stick of phosphorus is exposed to the air at ordinary temperatures.

Phosphorus increases in weight on burning.

Iron filings increase in weight on oxidising.

Oxygen is given off when the red substance obtained by gently heating mercury in the air is strongly heated.

There is a difference in the air before and after its passing through the lungs.

Ordinary articles of food contain carbon.

The decomposition of water by the electric current.

The synthesis of water by exploding a mixture of hydrogen and oxygen.

Hydrogen is formed by the action of sodium upon water.

Hydrogen is the gas obtained by the passage of steam over red-hot iron.

Hydrogen may be obtained by the action of dilute sulphuric acid upon zinc.

The combustibility of hydrogen.

A candle will not burn in hydrogen.

The lightness of hydrogen.

Copper increases in weight if, when in a red-hot state, oxygen is passed over it.

Water is formed, and the copper oxide reduced, when hydrogen is passed over the latter substance.

The separation of impurities from water by distillation.

The separation of impurities from water by filtration.

The preparation of oxygen from strongly heated potassium chlorate, or a mixture of potassium chlorate and manganese dioxide.

The formation of ozone by the silent electric discharge.

If sulphur is burnt in a current of oxygen the product fumes slightly in the air.

Preparation of hydrogen by the acting upon sodium hydroxide with zinc.

Water is without any action upon copper at any temperature.

The diffusibility of hydrogen.

The reducing power of hydrogen.

Hydrogen bubbled through ferric chloride does not reduce it, but if hydrogen is generated in the solution of ferric chloride it does.

The formation of hydrochloric acid by the action of sulphuric acid on common salt.

The action of hydrochloric acid upon red-hot iron.

The preparation of chlorine by the action of hydrochloric acid upon manganese dioxide.

Hydrogen burns in chlorine, and when it does so the yellow colour disappears.

The decomposition of hydrochloric acid solution by the electric current.

The preparation of ammonia.

The combination of ammonia and hydrochloric acid.

The reduction of red-hot copper oxide by ammonia.

The formation of nitrogen by the passing of air and ammonia over red-hot copper.

The formation of nitric peroxide by the passing of electric sparks through air.

The oxidising action of nitric acid upon tin.

The deflagration of nitre and charcoal.

The formation of oxygen by heating nitre, and the formation of nitric oxide by treating the residue with dilute sulphuric acid.

The preparation of nitric oxide by the action of nitric acid upon copper turnings.

The preparation of nitrogen by heating a mixture of potassium nitrite and ammonium chloride.

Combustion in sulphur vapour of copper and distillation of sulphur.

The formation of hydrogen sulphide (sulphuretted hydrogen) by the passing of hydrogen through sulphur vapour; and its action on lead acetate paper.

Preparation of sulphuretted hydrogen by the action of dilute sulphuric acid upon ferrous sulphide.

Preparation of sulphur dioxide by heating copper with sulphuric acid.

Preparation of carbon dioxide by acting on marble with a dilute acid.

Preparation of carbon monoxide.

128. Illustrations of the alternative syllabus for Stage I. of Inorganic Chemistry.

1888.

Apparatus to show the disappearance (solution) of bodies, such as salt and sugar, in water.

Apparatus to show that there is no loss of weight on solution of salt in water.

Apparatus to show how to recover salt dissolved in water.

Apparatus to show that nitre is more soluble in hot than in cold water.

Plate containing crystals of nitre produced by the slow evaporation of an aqueous solution intermediate in strength, between a hot and a cold saturated solution.

Apparatus to show the removal by filtration of substances in suspension.

Apparatus to show that ordinary water contains solid matter in solution.

Apparatus to show that water expands on heating.

Apparatus to determine the boiling point of a liquid, and to show that when substances are dissolved in water the boiling point is raised.

Apparatus to show the solution of camphor in alcohol.

Method of showing the different effects produced by the admixture of oil of vitriol with water, and of olive oil or mercury with water.

Apparatus by which to show that ordinary water contains air in solution.

Apparatus to show that air occupies space.

Apparatus to show that a given amount of air is reduced in volume when the pressure is increased.

Apparatus to show that air has weight.

Apparatus to show that a continued supply of fresh air is necessary in order that combustion may continue.

Apparatus for removing the oxygen from the air, and showing the resulting diminution in bulk.

Deflagrating spoon for showing that phosphorus will not burn in the gas produced in the last experiment.

Apparatus for showing the formation of a compound of phosphorus and oxygen.

Apparatus for making an approximate estimation of the oxygen in the air.

Apparatus for preparing oxygen, and showing that a piece of charcoal or sulphur burnt in it forms a new body in each case.

Apparatus to show that equal volumes of hot and cold water do not weigh the same.

Apparatus to show that hydrogen is combustible, but does not support combustion.

Apparatus to decompose steam by red-hot iron turnings.

Apparatus to show the condensation of the water formed by burning hydrogen.

Apparatus for showing that hydrogen is lighter than air.

Apparatus for exploding a mixture of oxygen and hydrogen.

Apparatus for showing convection currents by heating water.

Apparatus for showing that water is capable of existing as a solid, a liquid, and a gas.

Specimens of:—

- Caustic potash.
- Caustic soda.
- Potassium chlorate.
- Reduced iron.
- Potassium nitrate.
- Calcium chloride.

Apparatus to show that respired air contains carbon dioxide.

Apparatus for the preparation of carbon dioxide.

Apparatus for distilling water and other liquids.

Apparatus to show approximately the amount of carbon dioxide in a given weight of marble.

Apparatus for making charcoal.

Apparatus for showing the properties of charcoal.

Apparatus for showing that carbon dioxide is heavier than air.

Apparatus to show that carbon dioxide is produced by the flame of coal gas, of spirit, and of a candle.

Apparatus to show that when air is passed over charcoal, no action takes place until the charcoal is heated.

Apparatus for showing that carbon dioxide is soluble in water.

Apparatus to show that when reduced iron is burnt its weight is increased.

Specimens of:—

- Sodium carbonate.
- Graphite.
- Graphite in sticks.
- Marble.
- Washing soda.
- Limestone.
- Animal charcoal.
- Wood charcoal.

Apparatus for preparing sulphur trioxide.

Apparatus for preparing sulphur dioxide, and for showing its solubility in water.

Tube containing chlorine.

Apparatus for preparing chlorine.

Apparatus for showing the spontaneous combustion of phosphorus in chlorine.

Apparatus for showing that oil of turpentine will burn spontaneously in chlorine.

Apparatus for showing that sodium will burn in chlorine.

Apparatus for showing that chlorine has bleaching properties.

Apparatus for showing the bleaching process with a solution of bleaching powder.

Apparatus to show the increase of weight of calcium chloride by the absorption of moisture from the air.

Apparatus to show that chlorine is soluble in water.

Apparatus to show the action of sulphuric acid on sugar.

Apparatus to show the melting of sulphur.

Apparatus to show the flame and demonstrate the smell of burning sulphur.

Apparatus for showing approximately the specific gravity of sulphuric acid.

Specimens of:—

Roll sulphur.
Flowers of sulphur.
Native sulphur.
Black oxide of manganese.
Lead sulphide. (Galena.)
Mercury sulphide.
Sulphuric acid.
Rock salt.
Copper pyrites.
Antimony sulphide.
Iron pyrites.
Phosphorus.
Copper sulphate.

Apparatus for showing the solubility of ammonia gas in water.

Apparatus for preparing a solution of ammonia.

Apparatus for showing that lime is soluble in water, while limestone is not.

Apparatus for showing the slaking of lime.

Apparatus for showing that copper is not attacked by hydrochloric acid, but is dissolved when mixed with black oxide of manganese and warmed.

Apparatus for showing that ammonia alum contains alumina.

Plate containing crystals of sulphate of potash from the neutralisation of sulphuric acid by a solution of caustic potash.

Apparatus for the reduction of oxide of iron to the metallic state by a current of hydrogen.

Apparatus for preparing ammonia.

Apparatus for showing the formation of ammonium chloride, and its volatility on being heated. The dish contains ammonium chloride.

Apparatus for showing the volatility of ammonia.

Specimens of clay in different states:—Clay in rough state. Clay prepared for use. Clay kneaded into the form of a basin to show that it will hold water. Three vases of clay.

Apparatus for neutralising an acid by an alkali.

Apparatus for showing that the liquid obtained by distilling coal is alkaline.

Specimens of:—

Cadmium.
Zinc.
Magnesium.
Tin.
Gold leaf.
Platinum foil and wire.
Manganese.
Ammonium chloride.
Silica.
Ammonia solution.
Sodium crystals.
Potassium crystals.
Aluminium, sheet and wire.
Ammonia alum.
Alumina.
Antimony.

Method of showing that lead is more soluble in water than oxide of lead.

Apparatus for showing that lead can be cast.

Wash bottle used in preparing chloride and sulphate of lead.

Apparatus for obtaining the oxygen and the mercury from red mercuric oxide.

Apparatus for obtaining a mirror of mercury from mercuric chloride.

Apparatus for showing approximately the specific gravity of mercury.

Apparatus for the preparation of hydrogen by the action of sodium on water.

Apparatus to show the formation of oxide of copper by heating sheet copper.

Apparatus for showing the reduction of black oxide of copper to the metallic state by a current of hydrogen.

Apparatus to show the further oxidation of litharge, and the formation of red lead.

Apparatus for reducing oxide of lead to the metallic state.

Piece of thin iron wire, with which to show that a very high temperature is required to fuse iron.

Apparatus for showing approximately the specific gravity of lead.

Specimens of:—

- Magnetic iron ore.
- Hæmatite.
- Wrought iron.
- Steel.
- Cast iron.
- Camphor.
- Iodine.
- Silver.
- Copper acetate.
- Clay ironstone.
- Copper.
- Brass.
- Bell metal
- Gun metal.
- Slag from copper smelting.
- Lead (sheet and wire).
- Mercuric chloride.
- Litharge.
- Oxide of iron.
- Mercuric oxide.
- Lead nitrate.
- Copper oxide.

Apparatus for preparing starch and gluten.

Apparatus for showing the conversion of sugar into alcohol by fermentation.

Apparatus to show the carbon which remains on heating sugar.

Apparatus for preparing stearic acid from ordinary soap.

Apparatus for showing the action of acetic acid on iron.

Apparatus to show the distillation of beer.

Apparatus for showing that spirit is contained in beer.

Apparatus for showing the presence of carbon in tartaric acid.

Apparatus for the preparation of soap, and a specimen of the soap so formed.

Apparatus for separating the fat and membraneous matter in beef or mutton fat.

Apparatus for preparing a solution of soap.

Apparatus for showing the difference in action of soap solution on ordinary tap water and distilled water.

Apparatus for showing the liberation of acetic acid from sodium acetate by the action of sulphuric acid.

Specimens of:—

Glucose.
Sugar candy.
Tartaric acid.
Sodium acetate.
Barley-sugar.
Argol.
Starch.
Alcohol
Acetic acid.
Vinegar.
Sweet oil.
Ether
Turpentine.
Glycerine

129. Cabinet and box containing the whole of the apparatus and chemicals necessary to perform the experiments illustrating the alternative first stage or elementary course of inorganic chemistry. *See* Science and Art Directory.
1888.

130. Set of apparatus designed to meet the requirements of the "Outline of experiments suitable for illustrating elementary instruction in chemistry." (Similar collections are lent by the Department to teachers of Science Classes.)
1889.

Spirit lamp.
Bunsen burner, rose and blowpipe jet.
Bunsen burner with spreading flame.
Mouth blowpipe.
Crucible tongs.
Iron spoon.
Retort stands (2), each with a clamp and three rings.
Iron tripod.
Sand bath.
Wire gauze (2 pieces).
Pipeclay triangle.
Test tube brush.
Spatula.
Triangular file in handle.
Round file in handle.
Cork borers (6) and iron rod.
Clips, one spring and one screw.
India-rubber tubing:—6 feet of $\frac{5}{16}$ inch; 3 feet of $\frac{1}{4}$ inch; 3 feet of $\frac{3}{16}$ inch; 3 feet of $\frac{1}{8}$ inch.
India-rubber stoppers (30), various sizes.

Pneumatic trough.
Deflagrating spoon.
Mortar and pestle.
China basins (2).
China plates (2).
Porcelain crucible and lid.
Porcelain evaporating basin.
Glass rod (one specimen).
Tubing (18 specimens); of potash and of soda glass.
Glass bulb with long neck.
Glass tube with bulb for reduction experiments.
Calcium chloride tube.
U-tubes (2).
Tumblers (2).
Aspirator.
Glass crystallizing dish.
Gas jars (3).
Stoppered bottles, wide mouthed, for gases (5).
Bell jar, stoppered.
Ground glass plates:—One of 5 inches, three of 3½ inches, two of 3 inches.
Soda-water bottle.
Funnel.
Filter papers:—Packets of 5½ and 4½ inches.
Thistle funnels (2).
Flasks:—Two of 24 oz., three of 16 oz., three of 8 oz.
Beakers, lipped, nest of four.
Clock glasses:—One of 4 inches and one of 3½ inches.
Watch glasses:—One of 3 inches and one of 2¾ inches.
Test tube stand with holes and pegs for 12 tubes.
Boiling tubes (4), 7 inches × 1 inch.
Test tubes (12), 6 inches × ¾ inch.
Retorts (3):—16 oz. stoppered, 8 oz. unstoppered, 4 oz. unstoppered.
Apothecaries' scales and weights (17):—2 oz., 1 oz., ½ oz., ¼ oz., 2 drachms, 1 drachm, 2 scruples, 1½ scruples 1 scruple, ½ scruple, 6 grains, 5 grains, 4 grains, 3 grains, 2 grains, 1 grain, ½ grain. In box.
Stand for suspending the scales.
Measures and weights of the metric system:—1 metre, 1 cubic decimetre, 1 cubic centimetre, 1 kilogram, 1 hectogram, 1 decagram, 1 gram, 1 decigram, 1 centigram, 1 milligram.
Grove's battery, 5 cells; two conducting wires.
Ruhmkorff's coil with two conducting wires.
Apparatus to show there is no destruction of matter when a candle burns.
Apparatus for burning air in an atmosphere of coal gas.
Globular flask to show that air has weight.
Horseshoe magnet and tin tray to suspend from the beam of the scales.

Apparatus for the electrolysis of water and of hydrochloric acid; stand; pair of platinum and of carbon poles.

Apparatus for generating ozone.

Blocks (8) to illustrate combination in multiple proportions.

Apparatus for preparing nitric peroxide from air.

Clay tobacco pipe with long stem.

131. Lecture diagrams prepared for use in the Chemical Laboratory, Royal College of Science, South Kensington.

1887.

Troost and Deville's vapour density apparatus.

The safety lamp.

Manufacture of carbon bisulphide, Girard's process.

Preparation of iodine.

Mode of extracting sulphur in Sicily.

Sulphur refinery.

Manufacture of fuming oil of vitriol.

Concentration of sulphuric acid (3 diagrams).

Manufacture of boric acid in Tuscany.

Manufacture of boracic acid.

Salterns.

Concentration of brine.

Manufacture of potassium.

Stalactites and stalagmites.

Distillation of mercury.

Manufacture of mercury, Alberti furnace.

Liquefaction of oxygen, Cailletet's apparatus (2 diagrams).

Liquefaction of oxygen, Pictet's apparatus (3 diagrams).

Liquefaction of carbonic acid, Deleuil's apparatus.

Lavoisier and Laplace's calorimeter.

Lothar Meyer's curve of the elements.

Periodic system of the elements.

Composition of gunpowder.

Composition and illuminating power of the coal and cannel gases used in different towns.

Dumas' and Stas's method of determining the atomic weight of carbon.

132. Johnston's Illustrations of Chemistry, Sheet No. 1.

"Elementary bodies with their symbols, atomic weights, and their quantivalence."

1888. *Exhibited by W. and A. K. Johnston.*

133. Johnston's Standard Series of School Diagrams, No. 1.

"Chemical apparatus."

1883. *Exhibited by A. Johnston.*

134. Diagrams (11) illustrative of mineral chemical analyses after Fresenius.
1879. *By C. Desmazures, Paris.*

135. Brown's diagrams of apparatus, past and present. In three frames. Compiled and drawn by J. F. Brown, F.C.S.

Sheets 1 and 2. Vapour densities.
Sheet 3. Regulators.
1880. *Given by J. T. Brown, F.C.S.*

136. Diagram showing the relative amount of organic matter present in the water supply of London. 1868 to 1883.

Lent by Dr. E. Frankland, F.R.S.

137. Diagrams of fittings for a chemical laboratory (4). In frames.
1883. *Prepared for the Science and Art Department.*

138. Model of the Chemical Laboratory of the Secondary Town School, Leyden. Constructed by J. Noest, custodian of the building.

Acquired from Dr. D. de Loos, Lecturer on Chemistry, and Director of the Secondary Town School, Leyden.
E. 1.—1876.

A. Forcing-pump. The pump fills a large cistern in the upper part of the building. This cistern discharges its contents into the *white* pipes, and supplies the laboratory and the other parts of the building with water. The *red* pipes carry off the drainage from the laboratory into a sink constructed below the surface. The large *black* pipes, as also the small ones over the pupil's work-tables, are the gaspipes.

B. Register stove.

C. Chimney with three passages; one to conduct off the smoke of the stove, the others to carry off the bad gases disengaged in chemical operations.

D. Pump for rain water and well water.

E. Cupboards for twenty-two pupils, in which they keep reagents; the largest, which is open, is for the use of the lecturer on chemistry.

F. Drawer for small apparatus, as spoons, glass tubes, &c.

G. Small cupboards for the use of the pupils, in which to keep chemical preparations still in progress.

H. Bunsen's pump to filter under reduced pressure. The water, running through the red pipe from the top to the bottom of the laboratory, carries the air from the bottle along with it.

I. Entrance to the balance-room.

K. Collection of implements for performing chemical experiments.
L. Large cupboard for chemical preparations and apparatus.
M. Table with apparatus for blowing glass.

139. Receipt by John Dalton for instruction in chemistry.
1876. *Lent by C. Law.*

D.—Chemical Specimens.

140. Specimens of chemicals.
1885. *Exhibited by A. Boake & Co.*

Solutions of :—

Sulphite of alumina ($Al_2\ 3\ SO_3\ xSO_2$).
Bisulphite of soda ($Na\ H\ SO_3$).
Sesqui-sulphite of soda ($Na_4\ (SO_3)_3\ 9\ H_2O$).
Bisulphite of manganese ($Mn\ SO_3\ x(SO_2)$) (2).
,, nickel ($Ni\ SO_3\ x(SO_2)$).
,, chromium ($Cr_2\ 3\ (SO_3)\ x(SO_2)$).
,, magnesia ($Mg\ SO_3\ x(SO_2)$).
,, cobalt ($Co\ SO_3\ x(SO_2)$).
Vanadium blue oxide.
Bisulphite of lime ($Ca\ SO_3\ x(SO_2)$).
,, ammonia ($NH_4\ HSO_3$).

Solid specimens of:—

Sesqui-sulphite of soda ($Na_4\ (SO_3)_3\ 9\ H_2O$).
Anhydrous sulphite of soda ($Na_2\ SO_3$).
Sulphite of soda ($Na_2\ SO_3,\ H_2O$).
Bisulphite of soda ($Na\ H\ SO_3$).
Sulphite of nickel ($Ni\ SO_3\ 6\ H_2O$).
,, magnesia ($Mg\ SO_3\ 6\ H_2O$).
,, manganese ($Mn\ SO_3\ 2\ H_2O$).
,, potash ($K_2\ SO_3$).
,, lime ($Ca\ SO_3$).
,, strontium ($Sr\ SO_3$).
,, barium ($Ba\ SO_3$).
,, lithium ($Li\ SO_3$).
,, uranium ($Ur_2\ (SO_3)_3$).
,, ammonia ($(NH_4)_2\ SO_3$).
,, zinc ($Zn\ SO_3\ 2\ H_2O$).
,, cobalt ($Co\ SO_3$).
Anhydro-bisulphite of potash ($K_2\ SO_3,\ SO_2$).
Cuproso-cupric sulphite ($Cu_2\ SO_3\ Cu\ SO_3\ 2\ H_2O$) (2).
Calcium hyposulphite.
Ammonio-cuprous sulphite ($NH_4\ Cu\ SO_3$).
Anhydrous sulphurous acid in syphon bottles (4).

141. Series of specimens illustrating the chemical transformations of uric acid.

E. 7 to 12.—1887. *Prepared by Dr. Schuchardt, Görlitz.*

- Allantoin.
- Alloxan.
- Alloxantin.
- Hydantoin.
- Parabanic acid.
- Biuret.

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2. APPARATUS AND SPECIMENS ILLUSTRATING THE APPLICATION OF CHEMISTRY TO THE ARTS AND MANUFACTURES.

A.—Chemicals employed in or resulting from various Manufactures and Models to Illustrate Methods of Production.

142. Model of sulphuric acid works.

E. 8.—1890. *Made by B. L. F. Potts.*

A complete plant for the manufacture of sulphuric acid is represented on a scale of ½ inch to the foot.

On the left are a set of 18 pyrites burners placed in two rows back to back; here the sulphur of the pyrites is burnt, sulphur dioxide being formed by its combustion. Before burning, the pyrites is broken up into convenient sizes by the crushing-machine placed before the burners.

The hot gases from the burners pass over sets of nitre pots, where nitric acid is disengaged by the action of sulphuric acid on Chili saltpetre (sodium nitrate), and then into a large chamber whence they pass into the base of the circular Glover's tower (30 ft. high, 9 ft. diameter).

In this tower the hot gases come first into contact with comparatively weak acid, which suffers loss of a portion of its water, and so becomes sufficiently concentrated to be used in the Gay-Lussac's tower, as indicated below; as the still hot gases pass up through the packing of the tower they meet near the top the mixture of nitrous vitriol (from the base of the Gay-Lussac's tower) and chamber acid; this diluted nitrous acid, by the combined action of the heat and the sulphur dioxide, is deprived of the nitrogen oxides held in solution.

The fumes here liberated pass on to the chambers along with the burner gases (sulphur dioxide, oxygen, and nitrogen), and the nitrogen fumes from the nitre pots.

The distribution of the nitrous vitriol and chamber acid at the head of the Glover's tower is accomplished by means of a system of lead pipes leading from a divided tank, fed by a reaction wheel distributor, through the upper lead plate of the tower.

The chambers, through which the mixed gases pass in succession, are each about 132 ft. long, 20 ft. 6 in. wide, and 16 ft. 6 in. high.

They are formed of thin sheet lead supported on a stout wooden framework ; the sheets of metal are united at the edges by autogenous soldering, *i.e.*, the overlapping edges of adjoining sheets are fused together by careful heating with the hydrogen-air blowpipe.

The chambers are each supplied with windows in the sides and man-holes and gauging recesses at each end. Steam enters each chamber by pipes from the boiler as shown in the model.

The steam, sulphur dioxide, nitrogen oxides, and oxygen (from excess of air admitted through the burners) react in the chambers and produce sulphuric acid.

The residual gases from the third chamber of the series pass through the long leaden pipe into the square Gay-Lussac tower (7 ft. by 7 ft., height 51 ft.).

Here any nitrogen oxides remaining are absorbed by strong acid from the Glover tower distributed by similar apparatus to that described above.

The waste gases from the top of the Gay-Lussac tower pass thence to the chimney, which also serves the boiler seen on the left.

Between the boiler and the burners are placed the pumping engine and reservoirs for distributing the chamber acid, Glover acid, and nitrous vitriol contained in the tanks beneath the chambers.

143. Specimens illustrating the manufacture of soda.

1876. *Exhibited by Sullivan & Co.*

No. 1. Common salt. From the salt works of Northwich, Cheshire ; used in the manufacture of salt cake or sulphate of soda.

No. 2. Salt cake, or commercial sulphate of soda, containing about 98 per cent. of real sulphate ; made by decomposing common salt with vitriol in an iron pan heated externally. When about three-fourths of the decomposition has been effected, the charge is pushed upon the bed of a " muffle " furnace, maintained at a bright red heat till the decomposition is completed. The gaseous hydrochloric acid evolved during the process is conducted away through pipes or flues to condensing towers, where, being absorbed by water, it assumes the form of liquid acid.

No. 3. Limestone, or native carbonate of lime from Derbyshire ; used in combination with slack or small coal for converting salt cake or sulphate of soda into carbonate of soda.

No. 4. Slack, or small coal from the Lancashire coalfield; used in combination with limestone for converting salt cake or sulphate of soda into carbonate of soda.

No. 5. Black ash, or ball soda, containing about 24 per cent. of soda, produced by fluxing together in a suitable furnace a mixture of salt cake or sulphate of soda, limestone, and slack, by which means the sulphate of soda is converted into carbonate of soda, the carbonate of lime of the limestone into calcium sulphide, and the slack into coke.

No. 6. Vat liquor. A saturated solution of soda produced by lixiviating "black ash" or "ball soda" with warm water in iron tanks or vats; when the solution is saturated it is run off into iron pans to be boiled down, the calcium sulphide and unburnt coke of the "black ash" being left behind in the vat as "tank" or "vat waste."

No. 7. Salts, or crude carbonate of soda, obtained by boiling down "vat liquors" in iron pans, heated either externally or by passing the flame over the surface of the liquor in the pan.

No. 8. Soda ash, or finished carbonate of soda of commerce, containing 58·5 per cent. of real alkali, produced by gradually heating to redness in a reverberatory furnace "salts" or crude carbonate of soda.

No. 9. Salt, as used in the "Hargreaves" process. The salt is placed in a moist state on drying floors, and when dried into hard flat pieces is broken by machinery.

No. 10. Salt cake, or sulphate of soda containing 99 per cent. of real sulphate, made without the use of sulphuric acid by the "Hargreaves" direct action process. Salt maintained at a red heat in iron cylinders is exposed to the direct action of sulphur dioxide, air, and steam. The hydrochloric acid from the salt is condensed as in the ordinary process.

144. Soda crystals and concentrated crystal soda.
1888. *Exhibited by Brunner, Mond, & Co.*

145. Group of soda crystals of large size. Under glass shade.
1888. *Exhibited by Gaskell, Deacon, & Co.*

146. Caustic soda ash, containing about 12 per cent. caustic soda, 76–80 per cent. carbonate of soda, total strength about 54–56 per cent. Na_2O. Black ash is lixiviated in iron tanks, the liquor thus obtained is boiled down in open wrought-iron pans, and, as the crystals fall, they are fished out and calcined in an open furnace.
1876. *Exhibited by James Muspratt & Sons.*

147. Products obtained in the manufacture of soda at the Widnes Alkali Works.
1888. *Exhibited by Gaskell, Deacon, & Co.*

Caustic soda (white), 60 per cent.
„ (cream), 60 per cent. (2).
„ (white), 70 per cent.
Chloride of calcium.
Bicarbonate of soda.
Soda ash, 58 per cent.
„ 30 per cent.
Refined alkali, 58 per cent.
„ 30 per cent.
Bleaching powder.
Crystal carbonate.

148. Collection of chemicals.
1885 and 1887. *Exhibited by Gamble & Son.*

Chlorate of baryta, $Ba(Cl\,O_3)_2 + H_2O$ (4).

Chlorate of potash (crystals), $K\,Cl\,O_3$.

Chlorate of soda ($Na\,Cl\,O_3$) (4). Made by Pechiney's patent process.

Sulphide of sodium ($Na_2S + 9\,H_2O$) (3). Made by Schaffner and Helbig's patent process.

149. Specimens of silicates of the alkalis.
1876. *Exhibited by William Gossage & Sons.*

No. 1. Alkaline silicate of soda (glass), suitable for soap making.

Composition :—

100 parts, Na_2O.
180 „ SiO_2.

No. 2. Silicate of soda (glass), suitable for calico printing.

Composition :—

100 parts, Na_2O.
310 „ SiO_2.

No. 3. Silicate of potash (glass).

Composition :—

100 parts, K_2O.
310 „ SiO_2.

No. 4. Solution of alkaline silicate of soda. Made from No. 1. 1·500 specific gravity.

No. 5. Solution of silicate of soda, 1·375 specific gravity. Made from No. 2.

No. 6. Solution of silicate of potash, 1·350 specific gravity. Made from No. 3.

150. Manganate and permanganate of soda.
1887. *Exhibited by Widnes Alkali Co.*

151. Bicarbonate of soda (lump), prepared by exposing crystals of carbonate of soda to a current of carbon dioxide till saturated, and drying the product.
1876. *Exhibited by John Hutchinson & Co.*

The dry lump bicarbonate ground in a mill and dressed to separate coarse particles, as in grinding and preparing flour from wheat.

152. Bicarbonate of soda. Carbonate of soda of the shops, used in medicine and for making effervescing drinks.
1876. *Exhibited by John Hutchinson & Co.*

Soda crystals, or carbonate of soda, made by dissolving the soda ash of Leblanc's process in hot water, and, after settling, allowing to cool and crystallise, are put in an air-tight iron chamber, and carbon dioxide (prepared by decomposing limestone with waste hydrochloric acid from the condensers) turned in by a pipe on the roof of the chamber. After some hours the crystals are changed into bicarbonate of soda, part of the water of crystallisation escaping during the process.

The moist bicarbonate is dried in kilns heated not over 100° Fahrenheit.

153. Chemicals illustrating the recovery of sulphur from alkali waste.
1876. *Exhibited by John Hutchinson & Co.*

No. 1. Soda waste, alkali waste, black ash waste, or tank waste. Insoluble residue formed in the second or black stage of Leblanc's process for obtaining soda from common salt.

From the appended analysis by Kopp of a sample it will be seen that a large quantity of sulphur is present in the waste. A part of this can be profitably extracted by Mond's and other processes.

Sodium sulphide	2,880
Carbonate of lime	13,636
Silicate of lime	5,680
Hydrate of lime	8,588
Monosulphide of calcium	22,162
Alumina, magnesia	1,466
Sulphide of iron	2,670
Carbon	1,800
Sand	2,000
Water	36,700
Combined water and loss	2,418

No. 2. Oxidised soda, alkali, or vat waste.

In Mond's process a current of air at the ordinary temperature is forced through the waste as it lies in the vats, directly the last soda liquors are drained away. The waste becomes hot, oxidising, and forming polysulphides of calcium, thiosulphate and hydrosulphate of calcium. The waste is then lixiviated, and the liquid removed, the residue being again treated as above several times.

No. 3. Sulphur liquor, the soluble portion of oxidised alkali, or tank waste.

The oxidised waste, lixiviated in the vats with warm water, gives a yellow solution containing polysulphides of calcium, thiosulphate of calcium, and hydrosulphate of calcium.

Liquor generally contains equal to 5·0 of sulphur, distributed as follows :—

2·0 calcium thiosulphate.
2·0 polysulphide of calcium.
1·0 hydrosulphate of calcium.

No. 4. Precipitated sulphur, formed when sulphur liquor and hydrochloric acid are mixed.

Sulphur liquor is mixed with common hydrochloric acid from the condensers, the mixed liquors being heated to 140° Fahrenheit, and well stirred.

The hydrochloric acid forming chloride of calcium in the liquor, sulphur is deposited as a yellow flocculent precipitate.

In a good sample of liquor all the sulphide of hydrogen disengaged by decomposition of the sulphides reacts on the sulphurous acid liberated at the same time from the thiosulphate, sulphur and water being the products.

No. 5. Lump sulphur, prepared by melting the moist sulphur of a previous stage of the process in a strong cast-iron vessel.

After washing out the chloride of calcium from the moist sulphur, the drained product is put into a strong cast-iron cylinder, the filling-in aperture screwed down, and steam of a pressure of 35 lbs. admitted through a coil of cast-iron pipe. The sulphur rapidly melts, and at the expiration of a certain time, found out by experience, the whole charge is forced by the pressure of the steam through the discharge pipe into tight wooden waggons, and when cool broken up for sale.

No. 5*a*. Roll sulphur. The roll brimstone of commerce used in medicine. Melted sulphur run into round wooden moulds and allowed to cool.

154. Illustrations of the manufacture of chlorate of potash.

1876. *Exhibited by James Muspratt & Sons.*

No. 1. Muriate of potash containing about 90 per cent. potassium chloride, and some impurities consisting of sodium chloride, sulphates of potash, soda, lime, and magnesia.

No. 2. Milk of lime of about 1·08 specific gravity, made by well stirring up about 18 ctr. slacked lime in about 6,800 litres water in a cast-iron vessel. The sample contains a small quantity of chlorate and of chloride of calcium from the previous solution made in the same vessel.

No. 3. Solution of chlorate of lime of about 1·15 specific gravity, containing at the same time calcium chloride in the molecular proportion of about 1·5. Obtained by saturating milk of lime with chlorine gas. Towards the end of the process the temperature rises, when permanganate of lime is formed owing to the small quantity of manganese contained in the lime, by which the liquor obtains its pink colour. One litre contains 45–48 grammes of chlorate of lime.

No. 4. First mother liquor of chlorate of potash, of about 1·3 specific gravity. The solution of chlorate of lime is boiled down with a sufficient quantity of muriate of potash, and allowed to cool and crystallise for 8–10 days.

No. 5. Last mother liquor of chlorate of potash, of 1·35–1·40 specific gravity. The first mother liquor is boiled down still further, and allowed to cool and crystallise again for 8–10 days. It contains 30–40 grammes of chlorate of potash, about 520 grammes of calcium chloride, and 3–5 grammes potassium chloride in the litre.

No. 6. First crystals of chlorate of potash, containing about 85 per cent. chlorate of potash, and 3–4 per cent. calcium chloride.

No. 7. Finished crystals of chlorate of potash, containing about 0·0502 per cent. calcium chloride.

No. 8. Finished ground chlorate of potash, containing about 0·022 per cent. calcium chloride, and about 0·125 per cent. moisture.

155. Crystals of chlorate of potash with specimens showing iridescence.

1888. *Exhibited by Widnes Alkali Co.*

156. Nitre cake, obtained in the manufacture of sulphuric acid by decomposing sodium nitrate with sulphuric acid. It is composed of sodium sulphate, together with small quantities of sulphate of iron, lime, and magnesia, of sodium chloride, undecomposed sodium nitrate, and free sulphuric acid.

1876. *Exhibited by James Muspratt & Sons.*

157. Specimens illustrating the manufacture of the bichromates of potash and soda. Chrome compounds.

1888. *Exhibited by John and James White.*

Patent pure bichromate of soda (2).
Patent bichromate of ammonia (2).
Chromic acid.
Sesqui-chloride of chromium (2).
Chloro-chromate of ammonia.

Patent chromate of ammonia.

A curious form of plate sulphate coloured with a trace of sulphate of chromium.

Chromate of calcium.

Patent pure crystallised bichromate of soda (as packed in casks).

Chromate of barium.

Chromate of potash.

Chrome iron ore.

Chrome iron ore (Russian).

Chromate of soda (2) calcined and crystallised.

Chromate of strontium.

Pyrites.

Patent bichromate of soda.

Chromic oxide.

Limestone.

White chemical salt.

Burnt pyrites.

Salt cake.

Nitre cake.

Sulphate of potash.

Black ash.

Solutions of:—

Bichromate of soda (saturated) (sodium bichromate).

Bichromate of potash (saturated) (potassium bichromate).

Muriatic acid (hydrochloric acid).

Vitriol (sulphuric acid).

Muriate of potash (kelp) (potassium chloride).

Muriate of potash (German) (potassium chloride).

Trichromate of potash (potassium trichromate).

Chloro-chromate of potash (potassium chloro-chromate).

Bichromate of potash, large crystals.

Bichromate of potash, crystals in form of a crown on pedestal.

Bichromate of soda, large crystals.

Chrome alum crystal in form of an octahedron.

158. Specimens of bichromate of potash and bichromate of soda.

Exhibited by Eglinton Chemical Company, Glasgow.
1885.

159. Collection of chemical substances.
1876. *Messrs. Bouck & Co.*

Sulphate of copper; copper precipitate; copper oxide; agricultural sulphate of copper; nitrate of lead; sulphate of ammonia; sulphate of zinc; red prussiate of potash; yellow prussiate of potash; crude sulphur; roll sulphur; flour sulphur; crude carbolic acid; coal tar solvent naphtha; coal tar creosote; benzole, 50 per cent.; anthracene; anthracene oil; naphthalene; pitch.

160. Drawings of Hargreaves and Robinson's apparatus for the patent salt cake process. In three frames.
1876. *Exhibited by the Widnes Metal Company.*

161. Borax crystals in the form of a column.
1888. *Exhibited by G. Pursell & Co.*

162. Products obtained from kelp and seaweed, and other chemicals manufactured at the Whitecrook Chemical Works.
Exhibited by the North British Chemical Company.
1889.

Sulphur.
Caustic soda.
Sulphate of soda (salt cake).
Carbonate of potash.
Chlorate of potash.
Sulphate of potash.
Muriate of potash.
Bleaching powder.
Common salt.
Kelp.
Kelp salt.
Tangle.
Tangle charcoal.
Tangle charcoal (lixiviated).
Iodine (commercial).
Iodine, pure (re-sublimed).
Iodide of potassium.
Bromide of potassium.

163. Iodine (re-sublimed). Specimen under glass shade.
Exhibited by the North British Chemical Company.
1888.

164. Illustrations of the manufacture of the algin compounds.
1889. *Exhibited by the Algin Company.*

Kelp substitute (water extract carbonised).
Cellulose (from seaweed).
Cellulose (for turning).
Sodium alginate (soluble soda algin) (2).
Iron alginate (with ammonia).
Iron alginate.
Barium alginate (insoluble).
Copper alginate (with ammonia).
Ammonium alginate (combined with shellac).
Ammonium alginate (soluble ammonia algin).
Aluminium alginate.
Aluminium alginate (with soda, soluble).
Alginic acid (insoluble algin) (2).

165. Specimens of native rock salt from Afghanistan; Wiclicska, in Poland; and Erfurt, in Prussia.
1876. *Lent by George Gore, F.R.S.*

166. Process of extracting copper, silver, and gold from burnt pyrites.

1876. *Exhibited by the Widnes Metal Company.*

No. 1. Cupreous iron pyrites, employed in the manufacture of sulphuric acid.

Water	·70
Sulphur	49·00
Arsenic	·47
Iron	43·55
Copper	3·20
Zinc	·35
Lead	·93
Lime	·10
Siliceous residue	·63
Oxygen, and traces of various metals	1·07
	100·00

No. 2. Burnt ore, or cinder remaining after the almost complete elimination of the sulphur from the pyrites as sulphur dioxide.

Water	3·85
Sulphur	3·76
Arsenic	·25
Iron	58·25—83 per cent. Fe_2O_3.
Copper	4·14
Zinc	·37
Cobalt	traces.
Silver	traces.
Lead	1·14
Lime	·25
Oxygen and loss	26·93
Insoluble residue	1·06
	100·00

No. 3. Mixture of burnt ore and salt (the latter being about 12 per cent. of the whole), ground and passed through sieve of about 16 holes per square inch.

This mixture is furnaced during a period of 5¾ hours, at the expiration of which time the copper has usually been almost entirely converted into a soluble chloride of that metal.

No. 4. Mixture of salt and burnt ore after calcination during 5¾ hours.

No. 5. Purple ore, or residue left from No. 4 after the extraction of the copper by lixiviation with hot water and dilute hydrochloric acid.

This residue is chiefly employed for the "fettling" of puddling furnaces.

Ferric oxide	96·20 = iron 67·35 per cent.
Lead	·86
Copper	·18
Cobalt	trace.
Alumina	·45
Lime	·46
Soda	·10
Phosphoric anhydride	none.
Arsenic	trace.
Sulphuric anhydride	·49
Sulphur	·16
Chlorine	·03
Silica	1·22
	100·15

No. 6. Purple ore compressed into blocks for use in the blast furnaces (the brick exhibited was made by Messrs. N. Mathieson & Co., of Widnes).

No. 7. Solution of copper as drawn from the lixiviators, containing, in addition to copper, &c., from three to four grains of silver per gallon, with traces of gold.

A quantity of potassium (or zinc) iodide sufficient to precipitate the silver present is added to this solution, and the precipitate formed is allowed to subside, the supernatant liquor being passed into vessels in which the copper is precipitated by means of metallic iron.

No. 8. Precipitate caused by addition of a soluble iodide to solution of copper, &c. (Claudet's process), consisting of silver iodide mixed with various salts of lead chiefly sulphate.

No. 8A. Silver precipitate, obtained by the reduction of the iodide by means of metallic zinc.

Silver	5·95
Gold	·06
Lead	62·28
Copper	·60
Zinc oxide	15·46
Ferric oxide	1·50
Lime	1·10
Sulphuric anhydride	7·68
Insoluble residue	1·75
Oxygen and loss	3·62
	100·000

No. 8B. Zinc iodide, obtained by reduction of silver iodide by metallic zinc, and used for the treatment of a further quantity of argentiferous copper solution.

No. 9. Copper precipitate thrown down by the immersion of thin scrap iron in the cupreous solutions. (Contains on an average 75 to 80 per cent. of metallic copper.)

No. 10. Spent liquor, or liquid remaining after complete precipitation of copper from solution. This liquor is run to waste.

167. Specimens illustrating the wet process of copper extraction.
1888. *Exhibited by McKechnie, Duncan, & Sons.*

- Salt.
- Burnt pyrites.
- Calcined ore.
- Copper precipitate.
- Lead precipitate.
- Silver precipitate.
- Silver residue.
- Purple ore.
- Best select copper (two bars).
- Refined lead.

168. Specimens illustrating the manufacture of sulphate of copper.
1888. *Exhibited by McKechnie, Duncan, & Sons.*

- Copper shot.
- Sulphuric acid.
- Sulphate of copper (solution).
- Cupric chloride (solution).
- Sulphate of copper (crystals), ordinary.
- Sulphate of copper (crystals), telegraphic.
- Sulphate of copper, large mass of crystals.

169. Model of apparatus employed for the manufacture of chlorine, by Weldon's process. Scale, $\frac{1}{2}$ in. = 1 ft.
E. 8.—1889. *Made by B. L. F. Potts.*

The leading idea of Weldon's process is the following. We start with a solution of manganous chloride, *i.e.*, ordinary still liquor, after preparing chlorine by the action of HCl on MnO_2. This liquor is deprived of free acid by agitation with calcium carbonate, and to this neutral solution is added milk of lime more than sufficient to precipitate all the manganese as $Mn(OH)_2$. The pasty mixture is treated with a strong current of slightly heated air when MnO_2 is precipitated; after settling the mud which consists of MnO_2 and CaO is again used in the chlorine stills as if it were manganese ore.

The following is a description of the model which illustrates the arrangements for carrying out the above process.

The three octagonal chambers on the ground, one of which is shown in section, are called "mud stills." There is alongside another smaller oblong still, which is used for treating manganese ore only to make up for the loss in recovery. There is a circular well near the mud-stills in which an agitator is worked by the bevel gear above; this is the neutralising well in which the manganese liquor is mixed with limestone dust. The donkey pump forces the neutralised liquor into the three chloride of manganese settlers on the top, which are fitted with swivel pipes for running off the liquid to any depth without disturbing the sediment. From these tanks the liquor passes to one of the two circular towers which are the oxidisers, and in these the liquor is mixed with milk of lime, and air and steam are blown through it. From the oxidisers the pasty mixture is conveyed to the mud-settlers, which are just above the level of the stills, so that the settled mud is conveniently transferred to the stills. The horizontal twin engine is used for blowing, &c., and near it is the tank in which the milk of lime is made.

170. Specimens illustrating manufacture of bleaching powder, employing Weldon's method of chlorine generation.

1876. *Exhibited by N. Mathieson & Co.*

No. 1. Native peroxide of manganese (Spanish), containing 80 per cent. of peroxide.

No. 2. Hydrochloric acid, obtained by absorbing the gaseous acid in water.

No. 3. Chloride of manganese from native "manganese" stills *after* neutralisation with carbonate of lime.

No. 4. Limestone dust. Crushed carbonate of lime.

No. 5. Manganese mud, as precipitated *before* blowing with air.

No. 6. Manganese mud, *after* oxidation by blowing.

No. 7. Burnt lime, from Buxton, Derbyshire. This lime is unslaked.

No. 8. Hydrate of lime, sifted and ready for the bleaching powder chambers.

No. 9. Bleaching powder, containing 38 per cent. of chlorine.

171. Deacon's apparatus for exposing porous materials and currents of gases to mutual action. Sectional working model, illustrating the application of one form of the apparatus to Deacon's process for producing chlorine.

1876. *Exhibited by Henry Deacon.*

In this example, the layer or "wall" is vertical and circular, and forms a section of a cylinder. The frames resemble those of venetian blinds, with the laths inclined at an angle of 45°, and so far apart, that an imaginary line joining the upper edge of each lath and the lower edge of the one above it is more horizontal than the natural angle of repose of the porous material itself, which is thus retained and supported by each lath in succession. A "wall" of this kind on being raised in height adds to the pressure on the bottom layers only so long as the height is less than that of a cone whose base is the width of the "wall," and whose sides are at the same angle as the natural angle of repose of the material. This increase of pressure diminishes in inverse proportion to the height, and ceases when the height of the imaginary cone is reached, all the weight of additional height above that point being borne by the retaining frames. In the model, the "wall" and framework are in a cast-iron vessel, which is heated in a brick furnace. The porous material is distributed to, and gathered from, the wall, by covering and inverted cones from, and to, central pipes. The gaseous current passes from the outside of, and through, the "walls" to the space they and the covering cone enclose, and is withdrawn from this space, or the direction of the current is reversed at pleasure.

172. Carbolic acid, chemically pure, free from taste and smell of tar, and fusing at 108° Fahrenheit. Specially prepared for internal medicinal use.
1876. *Exhibited by F. C. Calvert & Co.*

173. Carbolic acid, commercial, fusing at 95° Fahrenheit. Specially prepared for external medical application.
1876. *Exhibited by F. C. Calvert & Co.*

174. Cressylic acid, used for disinfecting purposes.
1876. *Exhibited by F. C. Calvert & Co.*

175. Sulpho-carbolates. A series of pharmaceutical products, comprising sulpho-carbolates of potash, soda, ammonia, lime, iron, copper, zinc, and alumina.
1876. *Exhibited by F. C. Calvert & Co.*

176. Carbolic acid preparations, comprising carbolic acid soap, carbolic acid disinfecting powder, and carbolised tow.
1876. *Exhibited by F. C. Calvert & Co.*

177. Picric acid crystals and paste used in the arts.
1876. *Exhibited by F. C. Calvert & Co.*

178. Crystalline aurine.
1876. *Exhibited by F. C. Calvert & Co.*

179. Oxalic acid. Two specimens. One crystallised from a solution containing sulphuric acid, the other from an aqueous solution.
1876. *Exhibited by Roberts, Dale, & Co.*

This product is made by the action of caustic potash, or a mixture of caustic potash and caustic soda on woody fibre (sawdust). The result of this action is oxalate of potash. The oxalic acid is isolated by precipitation as oxalate of lime, and the subsequent decomposition of this latter product by sulphuric acid. Specimen No. 2 is crystallised from water. A comparison will show the marked difference in crystalline form due to the presence of sulphuric acid.

180. Binoxalate of potash.
1876. *Exhibited by Roberts, Dale, & Co.*

181. Spence's process for the manufacture of alum. Specimens to illustrate the process.
1876. *Exhibited by Peter Spence & Sons.*

(1.) Shale of the coal measures before calcination (source of alumina).

(1*a*.) Shale after calcination.

(2.) Two samples of pyrites or bi-sulphide of iron (source of sulphur for the manufacture of sulphuric acid).

(2*a*.) Nitrate of soda, for oxidising the sulphur dioxide produced from the pyrites into sulphuric acid.

(2*b*.) Sulphuric acid, specific gravity 1·6, as used in the manufacture of alum.

(3.) Gas liquor (source of ammonia).

(3*a*.) Sulphate of ammonia (2 specimens).

(4.) Sulphate of alumina.

(5.) First crystals of ammonia alum (a double salt or compound of sulphate of ammonia and sulphate of alumina).

(6.) Ammonia alum. Second crystallisation.

(7.) Large group of alum crystals.

182. Alum octahedra showing typical form of alum crystals (2).
E. 191*c*. and *e*.—1888. *Given by Peter Spence & Sons.*

183. Chemicals for use in various manufactures.
1876. *Exhibited by W. J. Norris & Brother.*

Liquid archill, made from Orchella weed, for dyers and printers.

Sulphate of alumina, for sugar refiners, paper makers, and dyers.

Aluminous cake, for paper makers.

Cudbear, made from Orchella weed, for dyers.

Bichromate of potash, with samples of chrome ore, limestone, and sulphate of potash, from which it is made.

184. Samples of dye-stuffs.
1876. *Exhibited by J. Marshall, Son & Co.*

Orchella weed Ceylon.
Orchella weed, California.

Cudbear, red shade.
Cudbear, violet shade.

Orchella weed, Zanzibar.	Orchill liquor.
Orchella weed, C. de Verde.	Orchill paste.
Moss Téneriffe.	Three dyed patterns.

185. Chrysoïdine, a basic orange dye for silk, wool, cotton, leather, &c., and specimens of dyed silk and worsted yarn. Manufactured by the exhibitors.

1876. *Exhibited by Williams, Thomas, & Dower.*

Chrysoïdine is, according to quality, the sulphate or hydrochloride of a bi-acid base, belonging to the benzene series. It is a valuable orange-yellow, and, owing to the readiness with which it crystallises, can be obtained in a state of perfect purity. It dyes in neutral or slightly basic baths, and has a great affinity for silk, wool, and even for unmordanted cotton. Mordanted cotton is dyed a yellow or orange shade according to the mordant employed. It combines readily with magenta and other red colours, giving rise to very clear and beautiful scarlets. Chrysoïdine was discovered by Dr. Otto N. Witt.

186. Paraffin oil and other products obtained from the distillation of bituminous shale.

Exhibited by Young's Paraffin Light and Mineral Oil
1885. *Company.*

Bituminous shale, curly.
Bituminous shale, plain.
Residual carbon from distillation of crude oil.
Crude oil.
Burning oil (three varieties).
Lubricating oil (three varieties).
Tar removed by sulphuric acid.
Tar removed by caustic soda.
Spent shale.
Sulphate of ammonia.
Alum from spent shale and acid tar.
Sulphate of iron from spent shale and acid tar.
Chrysene.
Crude paraffin scale.
Refined paraffin (six specimens). Melting points 65°, 90°, 120°, 126°, 130°, 150° Fahrenheit.

Basic oils:—

Leucoline.	Cryptidine.
Iridoline.	Tetracoline.

Phenols or Creosotes:—

Phlorol.	Compound ether of pyrogallic acid (3 specimens).
Cymol Phenol.	

Paraffins :—

- Heptane.
- Octane.
- Nonane.
- Decane.
- Undecane.
- Dodecane.
- Tridecane.
- Tetradecane.
- Pentadecane.
- Hexadecane.
- Heptadecane.

Oxalic acid, got from burning oil by the action of nitric acid.

187. Artificial fruit essences, being solutions of various organic ethers in rect. spirit of wine.

1876. *Exhibited by Hirst, Brooke, & Hirst.*

They are nearly identical in flavour with the flavouring principles of the fruits they are intended to imitate :—

- Jargonelle pear.
- Pine apple.
- Apple.
- Strawberry.
- Raspberry.
- Greengage.
- Peach.
- Cherry.

188. Wine lees. Specimens of Italian, Spanish, and St. Antimo.

Deposits upon sides of vats, being principally acid potassium tartrate.

Lemon juice, concentrated.
Citrate of lime from lemon juice.
Tartrate of lime.
Tartaric acid, granulated and crystalline.
Sulphate of potash.
Citric acid, crystalline and granulated.

1876. *Lent by Sir J. Bennet Lawes, Bart.*

189. Collection of preparations resulting from technical and scientific research. Contributed by members of the German Chemical Society. (The names of the members are given below their contributions.)

- Anthracene.
- Anthraquinone.
- Dinitrobenzene.
- Eosine potassium.
- Methyl Violet.
- Rubin (Rosaniline hydrochloride).
- Benzylchloride.
- Aniline.
- Safranine hydrochloride.
- Hofmann's Violet (Iodine Violet).
- Toluene.
- Coralline (Ammonium - rosolate).
- Nitrobenzene.
- Phenylene Brown.
- Azobenzene.
- Phosphine (Chrysaniline nitrate).

Nitronaphthalene.
Picric acid.
Diphenylamine.
Rosaniline (Base).
Methyl Green, crystallised.
Nitrotoluene, solid.
Phthalic acid.
Toluidine, liquid.
Aniline Blue, soluble (Sodium-triphenylrosaniline - sulphonate).
Toluidine, crystallised.
Phenol, crystallised.
Dimethylaniline.
Aniline Blue (Triphenylrosaniline hydrochloride).
Martius Yellow (Dinitronaphtholcalcium).
Dinitrocresol potassium.
Benzene, crystallised.
Naphthol.
Naphthylamine.
Methyldiphenylamine.
Naphthalene.
Aurantia.
Nigrosin, soluble in spirits.
Nigrosin, soluble in water.
Magdala-Red.

Actien-Gesellschaft für Anilinfabrikation, Rummelsburg,
E. 178–217.—1877. *near Berlin.*

$$\left.\begin{array}{l}\text{Chloralhydrate, large crystals}\\ \text{Chloralhydrate, small crystals}\\ \text{Chloralhydrate, in powder -}\\ \text{Chloralhydrate, in crusts -}\end{array}\right\} C_2HCl_3O + H_2O.$$

Chloroform $CHCl_3$, from Chloral.

All these preparations are perfectly pure, the chloralhydrate being a special product of the manufactory.

1876. *Prepared by Saame & Co., Ludwigshafen on the Rhine.*

Phenol, pure, is perfectly free from creosol, and therefore *perfectly* soluble in 20 times its quantity of water.

Phosphoric acid, chemically pure; the commercial so-called fused phosphoric acid contains up to 25°/$_0$ sodium-pyrophosphate.

Salicylic acid cryst., perfectly soluble in water, alcohol, and ether.

Tannin leviss. contains only a very trifling quantity of glucose, and is therefore, according to H. Schiff, nearly pure digallic acid.

Monobromcamphor.

Trichloride of carbon.

Quinine salicylate.

Chloralhydrate in plates.

Chloralhydrate in crystals, prepared according to the special directions of O. Liebreich, perfectly free of other chlorinated compounds, and is unchangeable for years.

Chloralide.

Butylchloral.

Saccharate of iron, soluble, not containing any free sugar, but a pure chemical compound of ferric oxide, soda, and sugar.

Bromide of potassium, entirely unaffected by barium salts.

Iodide of potassium, like the above, and free from iodic acid, therefore entirely unchangeable.

Salicylate of sodium, easily soluble in water and alcohol.

1876. *Prepared by E. Schering, Berlin.*

190. Model of Netherfield Chemical Works, Duke Street, Glasgow.

1888. *Exhibited by R. and J. Garroway.*

191. Models of stoneware distilling apparatus as used by manufacturing chemists and others, and comprising still, still head, false arm, dip arm, condensing worm, three receivers with connecting pipes and taps, mixing pan, and stone jar. Made of improved vitrified stoneware, and warranted to resist the action of the strongest acids. (Two sets.)

1876. *Exhibited by James Stiff & Sons, London.*

192. Diagrams of a blast furnace, gasworks, and glasshouse.

1857. *Exhibited by J. J. Griffin & Sons.*

193. Models of furnaces (2) for a brewing copper and a brewing pan.

E. 125 and 126.—1868. *Made by J. Schröder, Darmstadt.*

194. Model of Hofmann's circular kiln.

1876. *Lent by Hermann Wedekind.*

This kiln is used for calcining lime, drying bricks, and similar processes. It is circular in form with a chimney in the centre, and is capable of being divided by iron doors sliding in vertical grooves; in practice, however, only one door is used. Each compartment is provided with an external door for charging in material, and a flue leading from the lower right-hand corner into the central chimney.

The iron door is placed on the right-hand side of the chamber which has been last charged, the chamber on the other side of the door being empty, or being charged, while the one next to that contains material which has been in the kiln longest. The external doors of these last two chambers are the only ones which are open, and all the flues are shut except the one belonging to the chamber last charged, that is, the one on the left side of the iron partition. Thus, the air entering the external doors passes from left to right, going first through the material which has been in the kiln longest, gathering heat from this, and passing on through fresher and fresher material, gaining heat from that which has been in some time, and giving it up again to the material which has been lately charged in, escaping finally, through the flue in the last chamber. It will thus be seen that material is cooled down by the entering air before removing, and that the working is continuous. The iron door is moved round the kiln from left to right, following the course of the air, the flue, which is left open, being the one immediately to the left of the door.

B.—Analytical Apparatus.

195. Bunte's gas burette for the analysis of furnace gases. *Price* 15*s.*
1886. *Exhibited by Townson & Mercer.*

The burette is filled with water from below until it begins to enter the funnel at the top. The side opening of the three-way cock at the top is now put in connexion with the gas to be analysed; the gas is allowed to enter until the water passes below the zero mark, and the upper tap is closed. Water is now forced in from below till it reaches the zero mark; the upper cock is opened momentarily so that the excess of gas escapes through the water filled to the mark on the upper funnel, and then the tap is closed, so that in the burette there is now 100 c.c.'s of gas at a pressure equal to the height of water in the funnel added to the atmospheric pressure. In order to dissolve any constituent of the gas a suitable absorbing liquid is run in, thus :—the water in the burette is nearly all sucked out through the bottom tap, and the tap closed, and the end of the burette introduced into the absorbing liquid, which will rise into the burette nearly up to the zero mark on opening the tap again; the burette is well shaken, and the tip again introduced into the absorbing liquid, and when the tap is opened more will enter. The tap is now closed, and the shaking repeated. The gas is again put under proper pressure by running water in from the funnel above, and filling the funnel up to the mark whilst the tap is open. The amount of gas absorbed is then read off, and the number of c.c.'s gives the per-centage of the absorbed gas in the mixture.

196. Orsat's apparatus for the technical analysis of gases.
E. 66.—1888. *Made by C. Gerhardt, Bonn.*

The graduated measuring tube contains from the zero mark at its bottom to the upper capillary exactly 100 c.c., and is graduated in $\frac{1}{5}$ c.c. up to 50 c.c., and above that in $\frac{1}{10}$ c.c. The burette is surrounded by a water jacket so as to withdraw the gas in it from the influence of changes in the temperature of the external air. The jacket is closed at the top and bottom by india-rubber stoppers, and is provided with a white background of opaque glass so as to make the divisions on the burette distinctly visible. The bottom of the burette is connected by an elastic tube with a level bottle filled two-thirds with water; the top end is connected by a glass capillary bent at a right angle, and ending in a three-way cock. This tube carries at a right angle three glass taps, each possessing capillary tubes, and connected by india-rubber joints with the three U-shaped absorption vessels filled with bundles of glass tubes. The first of these is filled with a solution of caustic potash, the second with an alkaline solution of pyrogallol, and the third with a strong solution of cuprous chloride in hydrochloric acid. Copper spirals are placed in the glass tubes in this vessel so as to keep the solution unchanged. These solutions are for the absorption of carbon dioxide, oxygen, and carbon monoxide respectively. The outer ends of the absorption vessels are closed by tubes communicating with an empty gas bag. The apparatus may be completely closed by sliding doors at the back and in front.

100 c.c. of gas at normal pressure are drawn into the burette. The gas is then forced backwards and forwards between the burette and the absorption vessel nearest to it, containing caustic potash; the carbon dioxide is absorbed, the gas is finally all drawn into the burette and the reading taken, the levels of the water in the burette and level bottle being made the same. This reading indicates directly the per-centage of carbon dioxide. In the same way the oxygen is absorbed in the centre vessel and the carbon monoxide in the third. The unabsorbed residue represents the nitrogen.

The whole apparatus is specially intended for the analysis of combustion gases.

(*See* Winkler's Technical Gas Analysis.)

197. Winkler's apparatus for determining the amount of carbon dioxide present when ventilating mines.

E. 53.—1884. *Made by F. Hugershoff, Leipsic.*

This apparatus is used for estimating relatively small quantities of carbon dioxide. The graduated measuring tube is closed at the top by a three-way cock. Its capacity is 100 c.c.; most of this is contained in the globular part. The narrow cylindrical part only contains 5 c.c., and is divided into twentieths of a cubic centimetre. The lower end of the burette is connected by a narrow elastic tube with the level-bottle to the right containing pure water; from the upper part a glass capillary tube leads to the absorbing vessel which is filled with a solution of caustic potash up to the mark. The burette is filled with the gas to be examined through the pinch-cock attachment of the three-way cock. The apparatus is manipulated in a similar manner to Orsat's, described above.

(*See* Winkler's Technical Gas Analysis.)

198. Tintometer. An instrument for measuring colour.
E. 42.—1889. *Made by J. W. Lovibond.*

This is an instrument by which the depths of colour in liquids and solids are measured accurately in degrees.

It consists of a series of standard scales formed by choosing a glass faintly tinted of the colour to be standardized and considering this a single unit or degree of colour (basing it where possible on a per-centage solution of some known substance similar in colour) then building up a scale by the addition of successive units of the same colour value; and an instrument for holding the glasses and object to be measured.

The instrument consists of two tubes side by side, both open at one end, one tube giving a view of the object to be measured and the other a view of the standard glasses. At the other end of the instrument is a single eye piece commanding a clear vision at the same time of the object on one side and measuring glasses on the other under exactly similar conditions uninfluenced by the nature and colour of the surroundings.

For measuring solids a white back ground of plaster of Paris (pure) pressed in a tray, is used for the standard glasses to work against.

In the case of woollen fabrics, &c., the fabric is wound on a block and measured against a white fabric of similar texture on another, the white being first measured against pure plaster of Paris.

For liquids the instrument is placed opposite the white reflecting mirror.

The liquid is poured into one of the gauged glasses, choosing a size which will give a medium reading (under 12 degrees is best for very critical examination). Standard glasses are then placed in the grooves on the other side until equality is obtained, when the numbers on the glasses will indicate the colour with its combinations and depth of tint, as in the case of solids.

If the colour is not matchable by glasses of a single series or colour, the deficient colour must be guessed and added.

In reading, the small figures on the slip indicate the colour, and the large figures give the degrees of colour in each glass.

For measuring opaque fabrics, the instrument is fixed in a sloping stand, with the light equal on both sides, and is then used as described above for solids.

199. Soxhlet's fat extraction apparatus. *Price* 1*l*. 2*s*. 6*d*.
1886. *Exhibited by F. E. Becker & Co.*

This apparatus is used for extracting oils from seeds, &c., but is capable of numerous other applications. A flask containing ether or other volatile solvent substance is heated by a spirit lamp. Fitted to the neck of the flask is the Soxhlet tube, which is a kind of large test-tube, furnished with a siphon externally and a side tube. Above this tube is an upright Liebig's condenser. The vapour generated in the flask passes by means of the side tube into the condenser and drops back upon the sample, and the condensed solvent with the oil now in solution passes through the siphon into the flask, to be again evaporated until the fat or oil is completely extracted from the sample.

200. Fat extraction apparatus, six forms, namely, Tollens', Kreussler's, Schwarz's, Gawalowsky's, Gawalowsky's with Dreschel funnel, and Soxhlet's. *Prices* 3*s*., 9*s*., 7*s*., 9*s*., 11*s*., *and* 5*s*.
1886. *Exhibited by Townson & Mercer.*

These are arrangements by which a volatile solvent, such as ether, benzine, &c. is brought upon a fatty body and after extracting some fat is distilled and brought back upon the body, thereby using the same solvent repeatedly in one operation.

201. Fat extraction apparatus, Jago's. *Price* 3*s*. 6*d*.
1886. *Exhibited by J. Orme & Co.*

202. Sacker's viscosity apparatus for testing lubricating oil. *Price* 2*l*. 10*s*.
1886. *Exhibited by Townson & Mercer.*

The viscosity or fluidity of oils is determined by ascertaining the rate at which they flow through a given aperture. 100 c.c. or some other definite volume of the oil to be tested should be poured into a burette furnished with a glass stopcock. The burette is surrounded with a glass cylinder fitted with an arrangement by which steam can be made to circulate through it, and bring the burette to a definite temperature, which is indicated by a thermometer. When the oil has reached the desired temperature, the top of the burette is fully opened and the number of seconds required for the emptying of the burette noted. The time which elapses gives a relative measure of the viscosity of the oil.

203. Specific gravity bottle with thermometer, designed for butter testing. *Price* 7*s*. 6*d*.
1886. *Exhibited by J. Orme & Co.*

204. Soleil-Scheibler polarimeter for the determination of sugar in an aqueous solution.
E. 65.—1888. *Made by Schmidt & Haensch, Berlin.*

This apparatus consists of a brass stand on which rests, with horizontally rotating motion, a blackened metal trough, in which the experimental tube is laid, the upper part of the trough serving as a cover, to be shut down to exclude extraneous light. The end of the trough next the light is connected with a brass tube, containing the regulator with its nicol near the opening and the quartz plate behind it. The rotation of the tube is effected by the wheel and pinion worked by the rod and milled head.

The ocular part of the instrument contains, next to the trough, the quartz plate of the compensator, and next to this on the other side from the trough, two quartz wedges. Each wedge is cemented to a similar wedge of glass so as to form two plano-parallel plates, which are set in brass frames. One of these plates is fixed while the other has a horizontal sliding motion for which purpose it is provided at the bottom with a side to side rack and pinion motion worked by the milled head underneath. The frame on the upper edge of the movable plate carries the divided scale and that of the fixed plate a vernier. For reading the latter an inclined mirror throws the image of the scale along the axis of the small tube above, fitted with an eye-piece.

The remainder of the ocular part contains the analyser and telescopic lenses, the eye-glass being movable.

The small screw-head, projecting to the right of this part, admits of the analyser being adjusted to its proper position in relation to the fixed polariser. It is only used in the original adjustment or re-adjustment of the instrument, *i.e.*, when we cannot by any movement of the quartz wedges bring a uniform tint into the two halves of the field. To re-adjust, both wedges together with the fixed plate are removed, and the screw turned until a uniform tint prevails. To fix the zero another screw is attached to the quartz wedge frame carrying the scale, and allows a certain amount of adjustment of the latter. The length of the solution tube must be accurately known.

In using the polarimeter, it is set up at least two inches from a gas or paraffin lamp with a metal chimney having a side opening.

A tube empty or filled with water is laid in the instrument, and the eye-piece of the telescope drawn out until the joining line bisecting the circular bi-quartz appears sharply defined, the movable quartz wedge is then adjusted by the milled head underneath, until both halves of the field have a uniform tint. The regulator is then moved by the milled head fixed on the long horizontal rod so as to bring into view that sensitive tint, which, with the slightest displacement of the movable quartz wedge, produces the most distinct colour differentiation in the two semi-circles. For most eyes the best tint is the nearest approach to white.

Having decided upon the sensitive tint the quartz wedge is adjusted to give the greatest similarity in colour in the two halves, and the reading on the scale noted. This should be repeated several times, the mean being taken as the zero of the instrument. If the zero of the scale does not coincide with this point it must be adjusted to it by the screw fixed on the brass frame of the wedge.

If the tube be now filled with the solution of sugar and laid in its place, colour dissociation takes place, and may be made to vanish again by moving the quartz wedge so that the 100 point on the scale approaches the zero on the fixed vernier. If the solution be perfectly colourless the screw fixed on the horizontal rod turning the regulator need not be touched. If the solution is coloured, the screw must be turned to the right or left until the tint used in fixing the zero is obtained. By several adjustments of the quartz wedge to the point of colour-uniformity we arrive at an accurate determination of the rotation. The percentage of sugar may then be calculated from the following propositions :—

(1.) The amount of deviation of the plane of polarisation is proportional to the length of the liquid column in the tube.

(2.) The deviation is proportional to the concentration, *i.e.*, to the number of grammes of sugar in the unit volume (100 or 1,000 c.c.) of solution.

Accordingly by determining once for all the angle of rotation given by a single saccharine solution of known concentration in a tube of a certain length, we are able by simple proportion to calculate the number of grammes of sugar in 100 c.c. of any solution of unknown strength, from its observed angle of rotation.

See Handbook of the Polariscope (Macmillan and Co., 1882).

205. Lunge's nitrometer, graduated to 50 c.c.'s, is used to estimate the amount of oxides of nitrogen in a gaseous mixture or a nitrate, &c. *Price* 18*s.* 6*d.*

1886. *Exhibited by Townson & Mercer.*

The oxides of nitrogen must first be absorbed in strong sulphuric acid and then submitted to analysis in the nitrometer, where the whole of the nitrogen is liberated as nitric oxide. The manipulation is as follows :—The level tube is raised, and the burette filled with mercury until the latter enters the stopcock. The tap is now closed, so that its ways communicate neither with the inside nor outside of the burette, and a certain volume of nitrous vitriol is poured into the cup. The level tube is now lowered and the tap cautiously opened so that the acid may enter the burette, and is suddenly closed when all the acid is run in, except a small drop, and no air has entered. The cup is rinsed and re-rinsed with a few c.c.'s of pure sulphuric and the acid allowed to enter the burette, but no air. The burette is then shaken, so that the acid and mercury intermix, when the gas is evolved. The mercury in the two tubes is brought to same level and allowance made for the acid in the burette tube, and the volume read, also the temperature and barometric pressure at the time. Each c.c. of gas, reduced to 0° and 760 m.m. is equal to 0·627 mg. N.

206. Schwarz's nitrogen apparatus. *Price* 16*s*.
1886. *Exhibited by Townson & Mercer.*

This is merely a convenient and portable modification of Lunge's nitrometer, without india-rubber connexions. It is used exactly in the same manner as the latter, with the advantage of more conveniently producing levels by aid of the tap at the bottom.

207. Brady's nitrometer; same principle as Lunge's apparatus. *Price* 8*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

208. Crum's nitrogen tube, used for the estimation of nitrogen in the same way as Lunge's apparatus. *Price* 3*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

209. Knop's improved azotometer.
E. 136.—1877. *Made by F. Hugershoff, Leipsic.*

210. Staedel's apparatus for the collection of nitrogen. *Price* 1*l*. 9*s*.
1886. *Exhibited by Townson & Mercer.*

The nitrogen and carbonic acid obtained by the combustion of a nitrogenous body are led by means of the side tube into the bulb immediately below the graduated measuring tube. This bulb contains potash, and when all the CO_2 has been absorbed the nitrogen is displaced upwards into the measuring tube, and its volume read.

211. Hüfner's apparatus for the estimation of urea. *Price* 16*s*.
1886. *Exhibited by F. E. Becker & Co.*

A solution of sodium hypobromite is used, which is made by dissolving 100 grams of NaHO in 250 c.c. of water, and adding 25 c.c. of bromine when cold. The urea is dissolved and placed in the lower part of the mixing apparatus and shut off from the hypobromite solution by a large bore stopcock. The upper portion of the mixing vessel is large enough to hold 100 c.c. of hypobromite solution, with its own volume of water. The glass cup is filled with a saturated solution of common salt, and the measuring cylinder, filled with distilled water, is inverted in this, and over the orifice of the mixing vessel. On turning the stopcock the specifically heavier hypobromite mixes rapidly with the urea solution, and a brisk evolution of gas ensues. The decomposition is assisted towards the end by plunging the lower end of the apparatus into hot water. The nitrogen evolved contains a small quantity of oxygen, which is determined in the usual way by transferring the gases over mercury and absorbing the oxygen with an alkaline solution of pyrogallol. The presence of sugar renders the evolution of nitrogen more complete.

212. Urinometer; set of apparatus for the use of medical men, consisting of mahogany stand with drawer and draining pegs for test-tubes. Six narrow-mouth stoppered bottles. *Price* 1*l*. 5*s*.
1886. *Exhibited by Townson & Mercer.*

213. Urinometer. Set of apparatus for travelling; in stout japanned tin case, with lock and key. Dimensions, 8 in. by 6 in. by 3¾ in. *Price* 1*l*. 10*s*.
1886. *Exhibited by Townson & Mercer.*

214. Urinometer test-tubes (2), Veale's and Esbach's. *Prices* 1*s*. *and* 2*s*. 6*d*.
1886. *Exhibited by Townson & Mercer.*

215. Model of spongy iron filter, with filtering materials employed.
1876. *Exhibited by Gustav Bischof.*

LIST OF CONTRIBUTORS, WITH ADDRESSES.

Actien-Gesellschaft für Anilinfabrikation, Rummelsburg, near Berlin; 58.

Algin Co., Whitecrook Works, Clydebank, Glasgow; 49.

Becker, F. E., & Co., 33, Hatton Wall, Hatton Garden; 62, 66.

Bischof, Gustav, 4, Hart Street, Bloomsbury; 67.

Boake, A., & Co., Stratford; 40.

Bouck & Co., Miles Platting, Manchester; 48.

Brady, Rev. N., Rainham Hall, Romford; 1.

Brown, Jas. T., 534, King's Road, Chelsea; 39.

Brunner, Mond, & Co., Northwich; 43.

Calvert, F. C., & Co., Tower Chemical Works, Bradford, near Manchester; 54.

Chemical Laboratory, Royal College of Science; 16, 38.

Deacon, H., Widnes, Lancashire; 53.

De Loos, Dr. D., Secondary Town School, Leyden; 39.

Desaga, C., Heidelberg; 17, 20, 21.

Desmazures, C., Paris; 39.

Eglinton Chemical Co., 27, St. Vincent Place, Glasgow; 48.

Fletcher, Thos., Museum Street, Warrington; 6, 7.

Frankland, Dr. E., F.R.S., The Yews, Reigate Hill; 39.

Gamble, J. C., & Son, Gerard's Bridge Chemical Works, St. Helen's; 44.

Garbutt, J., 3, Trinity Street, Leeds; 8.

Garroway, R. & J., Netherfield Chemical Works, Duke Street, Glasgow; 59.

Gaskell, Deacon, & Co., Widnes, Lancashire; 43, 44.

Gerhardt, C., 90, Bornheimer Strasse, Bonn; 60.

Gonzalez, M., Madrid; 1.

Gore, G., F.R.S., Inst. Sci. Research, Birmingham; 19, 49.

Gossage, W., & Sons, Widnes, Lancashire; 44.

Griffin, J. J., & Sons, 22, Garrick Street, Covent Garden; 59.

Herbst, A., 26a, Kraut Strasse, Berlin; 3.

Hirst, Brooke, & Hirst, Leeds; 57.

Hugershoff, F., 3, Schiller Strasse, Leipsic; 61, 66.

Hutchinson, J., & Co., Widnes, Lancashire; 45.

Johnson, Matthey, & Co., Hatton Garden, E.C.; 19.

Johnston, A., 6, Paternoster Buildings, E.C.; 38.

Johnston, W. & A. K., 5, White Hart Street, E.C.; 38.

Law, C., Champion Park, Camberwell; 40.

Lawes, Sir J. Bennet, Bart., Rothamsted, St. Albans; 22, 57.

Lentz, E. A., 36 & 37, Spandauer Strasse, Berlin; 9.

Lovibond, J. W., Salisbury; 62.

McKechnie, Duncan & Sons, St. Helen's; 52.

Markownikoff, Prof., University of Moscow; 7.

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PART IV.

METALLURGY.

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METALLURGY.

1.—ASSAYING PROCESS ; ANALYTICAL APPARATUS.

1. Old cupellation furnace, supposed to have been the one used by Sir Isaac Newton, when Master of the Mint, in some experiments on the cupellation of silver.
1876. *Lent by the Master of the Mint.*

In general construction it is precisely similar to those now in use, the only difference being that, in modern forms, more perfect means are adopted for regulating the draught.

2. Touchstone for the assay of gold, formerly used in the Royal Mint.
1876. *Lent by the Master of the Mint.*

The method is based on the fact that the greater the amount of gold contained in an alloy, the brighter is the gold yellow colour of a streak drawn with it on a black ground, and the less is it attacked by pure nitric acid or by a "test" acid. In ascertaining the richness of the alloy under examination its streak is compared with marks drawn with alloys whose richness is accurately known.

3. Muffle furnace used by gold and silver assayers.
Presented by the Morgan Crucible Company, Limited,
E. 96.—1885. *Battersea.*

4. Gold melting furnace. (French pattern.)
Presented by the Morgan Crucible Company, Limited,
E. 97.—1885. *Battersea.*

5. Case showing successive processes of gold assaying.
1876. *Lent by the Master of the Mint.*

The process of gold assaying comprises six distinct operations.

1st Process.—The portion of metal to be assayed is adjusted to an exact weight by cutting and filing (*see* specimen A. in Case). Such accurately weighed portions of alloy are wrapped, together with definite weights of pure silver (B), in capsules of lead foil (C C^1), and placed in order on a tray.

2nd Process.—The packets are transferred to porous cups or "cupels" of phosphate of lime (bone ash), which are arranged in rows, corresponding to those on the tray, in the muffle, or small oven, No. 8, which is fixed in a suitable furnace and maintained at a bright red heat. The lead oxidises and is absorbed by the cupel, together with the copper and other oxidisable metals present, and the silver and gold remain behind in the form of a button (D), which may also contain platinum, iridium, or other metals possessing similar properties.

3rd Process.—These buttons are hammered out into discs (E) which, after being annealed, are rolled into thin strips (F), and these are again annealed and bent into loose coils or " cornets " (G). The annealing takes place in an iron tray.

4th Process.—The cornets are placed in small perforated cups of platinum arranged in a perforated tray of the same metal. The whole is then introduced into a platinum boiler, which contains boiling nitric acid of specific gravity 1·26, in which it is allowed to remain for 15 minutes; it is then transferred to a similar boiler with acid of specific gravity 1·31. The silver is removed by the action of the acid, and the gold remains in a spongy state (H).

5th Process.—The gold sponge (which retains the original form of the cornet) is rendered coherent by annealing at a dull red heat. This is accomplished by introducing the platinum tray into the muffle. The cornets then assume the appearance of (I).

6th Process.—The final operation consists in weighing the cornets. This is done in a specially constructed " assay " balance, which is capable of indicating about $\frac{1}{3000}$th of a grain when loaded with 7·5 grains in each pan. The weights employed bear a decimal relation to the original weight of the piece of metal operated upon. The percentage of gold, therefore, present in the alloy, is at once indicated without calculation. The weighing in the first process was of course conducted on the same or a similar balance.

6. Appliances used in the assay of silver.

1. Pipette for " standard " salt solution used in silver assaying.

2. Pipette for " decimal " salt solution.

1876. *Lent by the Master of the Mint.*

The assay of silver can be conducted by cupellation, an operation similar to that already described in the second process of the assay of gold, the only differences being that no pure silver is added to the assay piece, and the operation terminates when the button (D) has been obtained and weighed. The wet method of Gay Lussac is, however, now usually employed for the assay of silver when the " standard " is approximately known, and the alloy contains not less than 50 per cent. of silver. It consists in precipitating the precious metal from the solutions of a known weight of the alloy to be assayed, the weight being so adjusted that sufficient silver is present to neutralise a given volume of the solution employed as a precipitant. This solution is usually one of common salt, but hydrochloric acid or hydrobromic acid may sometimes be used with advantage. The assay pieces, having been carefully weighed, are placed in numbered bottles, and a definite amount of moderately dilute nitric acid is added to each, the bottles being then gently heated to assist solution. The standard solution is then carefully introduced by means of a pipette, and the bottles are vigorously shaken until the precipitate coheres and the solution becomes clear. A cubic centimetre of "decimal" solution, which is $\frac{1}{10}$th as strong as the "standard" solution, is then added to each bottle, and they are again shaken. This is repeated until the decimal solution produces either no cloud or a very slight one. This indicates the conclusion of the operation, as the amount of silver present can be calculated when the weight of salt which is required to saturate it is known.

From the above description it will be seen that the only special apparatus required in assaying silver by the method of Gay Lussac is a pipette for measuring out the "standard" solution, and one for adding "decimal" solution. 1 and 2 are the forms of these used in the Royal Mint. The pipette for standard solution, 1, is fixed in a vertical position and filled by an indiarubber tube from below. The opening at the upper end of the pipette is closed by the finger, the indiarubber tube is removed, and the solution thus accurately measured is added to the contents of a bottle. No. 2 is divided into cubic centimetres, and the additions made by means of it as already described.

7. Gay Lussac's apparatus for assaying silver by the wet way.

E. 98.—1885.

Copper cistern lined with resinous cement to contain the normal solution of salt, 100 standard measures of which correspond with 896-thousandths of fine silver in the assay. Funnel for use in filling the cistern. Pipette of 100 c.c., for use with normal solution. Pipette for use with decimal salt solution. Pipette for use with the decimal silver solution. Cage for conveying the bottles to the shaking apparatus. Shaking apparatus, filled with 10 assay bottles in position for use. Dark case for bottle, containing the decimal silver solution. Case in which the assay bottle is placed during the addition of the normal solution to the assay. Hollow pillar, with sponge for absorbing the excess of liquid from the front pipette during the adjustment of the level to gauge mark. Water bath used for heating assay bottles during the solution of assay pieces. Bellows used for removing the nitrous fumes from the assay bottles. Whisk used for stirring the salt solution in the cistern.

8. Muffle containing cupels.

1876. *Lent by the Master of the Mint.*

9. Muffle furnace. *Price* 40*s*.
1884. *Exhibited by Thomas Fletcher.*

10. Gas muffle furnace, requiring neither blast nor attention; for temperatures up to fusing point of cast iron.
1876. *Exhibited by Thomas Fletcher.*

11. Patent injector gas furnace, with blower, for the treatment of refractory substances at very high temperatures.
1876. *Exhibited by Thomas Fletcher.*

This furnace will burn perfectly in the same space any available gas supply from 10 to 50 ft. per hour, or more, if required, giving temperatures in exact proportion. With ½ inch gas supply, day pressure, starting with a cold furnace, silver can be melted in three minutes, cast iron in eight minutes, and cast steel in 25 minutes. The highest temperature obtained is 2,500° Fahrenheit. Although a foot blower is used, it must not be classed as a furnace, for the air supply required is very small. Owing to the great heating power of London gas, furnaces stated to give certain results are not verified elsewhere.

12. Gas crucible furnace for temperatures up to white heat, and requiring neither blast nor attention.
1876. *Exhibited by Thomas Fletcher.*

13. Draft crucible furnace, to melt two pounds of brass. *Price*, 30*s*.
1884. *Exhibited by Thomas Fletcher.*

14. Set of apparatus for the estimation of carbon in steel (Eggertz colour test). *Price*, 9*l*.
1879. *Exhibited by J. Preston, late Cubley & Preston.*

Balance with agate centre, knife edges, and agate planes, in glass case, to take 20 grammes, and turn to one milligramme.

Copper carbon bath, with thermometer and tripod stand.

Three dozen test-tubes accurately picked to one size.

Test-tube stand for 24 tubes with draining pegs.

Three burettes to hold 30 c.c. divided in $\frac{1}{10}$ c.c., with three tubes matched to same size, and with the same graduations.

Screen of finest ground patent plate glass on stand.

Set of weights in polished mahogany case, 10 grammes to one milligramme.

Two Bunsen burners.

Archimedian drill for sampling.

Hydrometer and hydrometer tube.

15. Eggertz carbon test. Copper bath, test-tubes (12); graduated tubes (2). *Price*, 18*s*. 6*d*.
1876. *Exhibited by J. Orme & Co.*

16. Stead-Robson's apparatus for the analysis of blast furnace and other gases, with photograph of the apparatus. *Price*, 4*l*. 10*s*.
1886. *Exhibited by J. Crosby Robson.*

Description of working in testing blast furnace gases.

Having raised the mercury reservoir above the level of the capillary tubes, the cock at the top right-hand end of the apparatus is opened, and the mercury forced to the extremity of the glass tube seen at the top right-hand end of the apparatus. The indiarubber tube which is connected with the gas to be tested is slipped over the open end. By opening the stopcock mentioned above and lowering the mercury reservoir a sample of gas is rapidly transferred into the measuring tube; and when a sufficient quantity, namely, about 150 mm., has passed into it, the stopcock is shut off. We now raise the mercury reservoir until the mercury in the measuring tube and the one next to it is at the same level, which point is ascertained by the spirit level fixed in a wooden frame in front of the tubes, and sliding up and down in guides. After carefully noting down the volume of gas enclosed, the mercury reservoir must be raised and the left-hand stopcock on the top of the apparatus opened; and the gas forced into the chamber containing potash, *i.e.*, one of the vessels on the left of the apparatus. In about two or three minutes the carbonic acid is completely removed and by lowering the mercury reservoir and opening the left-hand stopcock, the gas may be returned to the measuring tube, where its volume is again carefully noted. The difference between the first and the second volumes is the amount of carbonic acid absorbed. Before, however, the gas is drawn back from the laboratory vessel, the minute amount of gas which remains in the capillary tube on the right, which escapes measurement, is expelled by opening the right-hand stopcock. Oxygen gas is now connected to the end of this tube, and a sufficient quantity of it drawn into the measuring tube. In order to thoroughly mix the two gases, they are forced into the potash laboratory and again drawn into the measuring tube, and the exact volume carefully noted. An electric spark is now passed through the mixture, and the contracted volume, after cooling, is noted. The resulting carbonic acid is absorbed again by transferring the ignited gases into the potash chamber, and after finally obtaining it in the measuring tube the remaining volume is carefully noted.

As the gases remain throughout saturated with aqueous vapour, it is not necessary to make any correction for its tension.

The calculations are simple and easily made.

a = corrected volume of gas taken.

b = corrected volume of gas taken, after absorbing CO_2.
c = contraction after explosion with oxygen.
d = volume of CO_2 produced by the explosion.
$a - b = CO_2$.
$d = CO$.
$\frac{2}{3}(c - \frac{1}{2}d) = H$.
$a - (CO_2 + CO + H) = N$.

Such is the rapidity with which the analyses are executed that frequently three complete analyses of blast furnace gases have been made in one hour, sometimes four. This form of apparatus is specially adapted for the analysis of blast furnace gases; but by the aid of the three laboratory vessels on the left, analyses of any mixture can be made.

The second and third chambers may contain any absorbent material which may be required in other than blast furnace gases.

17. Ridsdale's rotary chromometer for testing low carbons by Stead's alkali method. Copper in steel, &c. 1886. *Exhibited by J. Crosby Robson.*

The apparatus consists of the following parts:—

Three glass tubes of equal bore throughout. The centre one is sealed at the bottom. Each of the outside ones is drawn out fine and prolonged about 3 inches, passing through an indiarubber cork to within ½ inch of the bottom of the bottle. In each tube is loosely fitted a small cylinder, about 1 inch in length, of glazed china clay or porcelain or a sealed glass tube containing white powder. Two syringes, one for each bottle, are connected therewith either directly or by a piece of indiarubber tube, to a short glass tube which just passes through the cork. There is also a third tube with a tap on it which passes from the lowest point of the bottle through the cork, and bends over for about 2 inches towards the back of the apparatus. Above the three comparison tubes is a small mirror which can be turned to any angle, so as to enable the operator to see down them.

On one side is a scale for measuring the height of the column of liquid in the tubes, on the other a pointer which slides on a brass rod. There is a framework of mahogany for the above, the whole of which revolves on a circular bottom weighted with lead.

The apparatus can thus be readily turned round, for better comparison of colour, &c. without sacrificing its stability.

Directions for use.

Fill the centre tube up to 20 divisions with the liquid to be tested.

The tubes on each side are for the standards which may be of different depths of tint, thus enabling better comparison to be made than if only one standard is used.

To fill the bottles with standard.

Open the cock on the bent tube, close the top of the comparison tube with a cork or the finger. Then hold the standard in a little beaker, so that the bent tube dips into it, and draw up the syringe, when the liquid will at once rush into the bottle.

To make the comparison.

Turn off the tap of the bent tube, remove the cork or finger from the comparison tube, and force the liquid up till the depth of tint, as shown by the mirror at the top, is equal to that of the 20 divisions of liquid being tested.

Read off the height of the column on the scale.

$$\frac{\textit{Number of divisions of standard} \times \textit{percentage of standard}}{20} = \text{Per cent.}$$

To empty out old standard.

Close the top of the comparison tube, open the tap of the blow-out tube, and force the liquid out of the bottle by pressing down the syringe.

To clean out the bottles.

When a new standard is to be used it is better, after emptying the bottle as completely as possible, to suck a little of the new standard in and force it out again.

If necessary, from time to time, the bottles can be cleaned out in the same way with dilute HCl and water.

2.—MODELS AND DRAWINGS SHOWING THE CONSTRUCTION OF FURNACES USED IN METALLURGICAL OPERATIONS.

18. Model of a blast furnace, with open breast, from the series of models intended for technical instruction.
E. 129.—1868. *Made by J. Schroeder, Darmstadt.*

19. Model of a blast furnace, with closed breast, from the series of models intended for technical instruction.
E. 130.—1868. *Made by J. Schroeder, Darmstadt.*

20. Model of a blast furnace boiler, upon elastic supports.
1876. *Lent by Jeremiah Head, M.I.C.E.*

Long plain cylinder boilers, when hung as ordinarily upon rigid supports, are found to rise clear of the latter at their ends when in use, and in the middle when out of use. This leads to seam rips, and frequently explosion. By turning the small hand wheel right or left it will be seen that, by the method exhibited, the boiler is able to modify its form without straining, and consequently without danger.

21. Fox, Head, & Co.'s patent puddling furnace, Middlesbrough-on-Tees, England.

An improved furnace for puddling iron.

1876. *Lent by Jeremiah Head, M.I.C.E.*

The object is to utilise a portion of the waste heat which ordinarily is discharged from the chimney, by causing it to heat air to be afterwards supplied for the combustion of the fuel. Part of the chimney is enlarged into a chamber, having a vertical partition extending nearly to the top. One half of the chamber thus divided contains a cast-iron stove pipe, and the other half is provided with a damper.

When the damper is withdrawn the heated products of combustion take the nearest route to the chimney, but when it is closed they are obliged to pass by the more circuitous route, heating the stove pipe on the way.

The air for combustion is injected, by means of a steam jet, into a funnel connected with one side of a divided box, upon which the stove pipe stands. Moistened with the steam it becomes a powerful absorber and radiator of heat. It passes through the heated stove pipe, and afterwards through the back of the furnace into a closed ash-pit, and a portion through tuyeres into the space above the fuel.

It has then attained a temperature of about 650° Fahr. The consumption of coal of this furnace has averaged 12 cwt. 2 qrs. 11 lbs. per ton of puddled bar over two months of ordinary work, including lighting up and lost heats. This is about one half of the usual consumption of fuel. The iron (refined) used per ton of puddled bar in the same time averaged 20 cwt. 2 qrs. 26 lbs. The heating chamber is surmounted by a boiler, intended still further to utilise the waste heat. This, however, is not essential, and is hardly worth the extra expense. An ordinary iron-cased chimney is preferable.

22. Drawing of Siemens' rotative furnace for the production of wrought iron.

1876.

23. Model of a double iron-fining ground forge with double blast, smoke shaft, &c. From the series of models intended for technical instruction.

E. 127.—1868. *Made by J. Schroeder, Darmstadt.*

24. Diagram of Price's retort furnace.

1876. *Lent by W. Price.*

25. Model, after Karsten, of a lead-smelting furnace, with coal firing. From the series of models intended for technical instruction.
E. 128.—1868. *Made by J. Schroeder, Darmstadt.*

26. Photograph of the general plan of the quicksilver mines of Almaden, Spain. Made in 1796, by Dr. Diego Larrañaga.
1876.
Presented by the Royal School of Mines, Madrid.

27. Photograph of a plan, made in 1830, by Dr. V. Romoro, of Watts' steam engine, which was used at the mines for extracting water.
1876.
Presented by the Royal School of Mines, Madrid.

28. Photograph of a plan of some quicksilver furnaces.
1876.
Presented by the Royal School of Mines, Madrid.

29. Photograph of plan, outline, and sections of the boilers of the steam engines used in the quicksilver mines at Almaden, drawn by Vicento Romoro, in 1830.
1876.
Presented by the Royal School of Mines, Madrid.

30. Model of a coking furnace, after Scheerer.
E. 131.—1868. *Made by J. Schroeder, Darmstadt.*

31. Model of a coking furnace.
E. 133.—1868. *Made by J. Schroeder, Darmstadt.*

32. Diagrams of Bull's patent semi-continuous kiln for coking (2).
1876. *Lent by H. Wedekind.*

33. Model of Simon-Carvés' coke oven.
E. 67.—1888. *Made by H. Simon.*

In this oven the coal is coked in comparatively thin layers, the heat being obtained by the combustion of the products of distillation of the coal in spaces around the walls of the coking spaces.

No air being admitted to the coking spaces, no surface burning of the coke takes place, and, consequently, no loss, as in open forms of oven.

The coking spaces are vertical, placed side by side, and surrounded by flues on both sides. The products of combustion are drawn off through a pipe at the top of the oven, the tar and other valuable matters extracted, and the waste gases brought back to a grate in front of the oven, on which a small fire is kept burning. The waste gases immediately ignite on entering this grate, pass on, and burn in the flues around the coking spaces, passing first to the top of the oven, then in a zigzag course to the bottom, and away through a flue underneath the oven to the chimney.

The ovens are charged from trucks travelling on rails on top of the ovens, the charging holes being afterwards covered and luted up.

The whole mass of coke is usually pushed out by means of a ram.

Only a very small fire is necessary to be kept burning on the grate, it being made up once in 12 hours.

34. Model of a charcoal annealing furnace.
E. 134.—1868. *Made by J. Schroeder, Darmstadt.*

35. Model of a calcining furnace.
E. 132.—1868. *Made by J. Schroeder, Darmstadt.*

36. Metallurgical diagrams showing the construction of different types of furnaces and various methods of production of steel, iron, and fuel. Set of 22. Size 3 ft. 4 in. by 2 ft. 5½ in. Prepared by Professor William H. Greenwood.
1890. *Published by Chapman & Hall.*

3.—METALS AND METALLIC ORES.

37. Collection formed by the late Dr. Percy, F.R.S., illustrative of his treatise on Metallurgy.

This collection, which contains some 3,700 specimens, was acquired during the period extending from 1842 to 1889, and comprises examples of fuels, ores, metals, and their alloys, also illustrations of processes and of the adaptability of various metals to industrial purposes.

A full description of each object is contained in a catalogue specially prepared by Prof. J. F. Blake for the South Kensington Museum, of which the following is a List of Contents :—

Fuels :
- Fuels of modern origin.
- Lignites and brown coals.
- Bituminous substances and oil shales.
- British coals.
- Foreign coals.
  - European coals.
  - American coals.
  - Asiatic coals.
  - Australasian coals.
  - African coals
- Cokes.
- Patent fuels.

Refractory Materials for Furnaces, &c. :
- Clays, bricks, and sandstones.
- Graphite.
- Casting materials.

Copper :
- Experiments showing the properties of copper.
- Copper ores.
- Products of English copper smelting :
  - Early stages.
  - Experiments on blue metal.
  - Products rich in copper.
  - Ore furnace and metal slags.
  - Special furnace products.
  - Moss copper.
  - Kernel roasting.
- Products of the refinery furnace :
  - Refinery slags.
  - Special refinery products.
- Illustrations of foreign copper smelting—Saxony.
- Copper smelting at the Rammelsberg, Harz :
  - Primary smelting.
  - Drying the residual copper.
  - Refinery process.
  - Treatment of waste products.
  - Treatment of the furnace accretions.
- "Saiger" processes at Hettstedt :
  - Leading process.
  - Liquidation process.
  - Cupelling process.
  - Drying process.
  - Refining process.

Copper—*continued.*

Treatment of the refinery slag.
Kratz smelting.
Miscellaneous foreign operations.
Various forms of copper.
Results of treating copper in various ways.
Defects in copper.
Wearing of copper sheathing in use in Her Majesty's Navy.
Alloys of copper.
Copper and its alloys in use.
Defects and wearing of brass.
Special applications of copper.

Zinc:

Experiments.
Zinc ores.
Products of the operations for the extraction of zinc.
Metallic zinc.
Alloys of zinc.
Products of the process of "galvanizing" iron with zinc.

Lead:

The properties of lead experimentally illustrated.
Ores of lead.
Illustrations of lead smelting.
Accidental products.
Pattinson's process for the extraction of silver from lead.
Parke's process of desilverization.
Cordurié's process.
Purification of hard lead.
Lead fumes.
Illustrations of the smelting of complex ores containing lead and other metals, as carried on in the Harz.
Lead working near Freiberg.
Miscellaneous foreign lead smelting.
Samples of metallic lead.
Defects and corrosions of lead.
Alloys of lead.
Various uses of lead and its alloys.
Type metals.

Silver:

Experiments.
Silver ores.
The smelting of silver ores.
Amalgamation processes.
Refining silver by cupellation.

Silver—*continued.*

Abnormal products in silver works.
The metal in various forms.
Alloys of silver.
Alloys of silver in use.

Gold :

Experiments on gold.
Specimens showing the wide distribution of gold.
Ores of gold.
Various forms of the metal.
Weights used in dealing with gold.
Alloys of gold.
Gold and its alloys in use..

Noble Metals, other than Gold :

Platinum.
Palladium.
Iridium.
Osmium.
Ruthenium.
Rhodium.

Cadmium.

Tin :

Laboratory experiments.
Ores of tin, and their preparation for smelting.
Tin smelting.
Refining of tin.
Various forms of the metal.
Alloys of tin.
Uses of tin.
Decay of tin.

Antimony :

Experiments.
Ores of antimony.
Extraction of antimony.
Metallic antimony in various forms.
Alloys of antimony.
Other special compounds of antimony.

Bismuth.

Mercury.

Arsenic.

Chromium.

Molybdenum.

Tungsten.

Uranium.

Tantalum and Yttrium.

Metals of the Cerium Group:

- Cerium.
- Lanthanum.
- Didymium.

Magnesium:

- General experiments.
- Experiments on the production of phosphide of magnesium.
- Alloys of magnesium.

Glucinum.

Aluminium:

- Experiments.
- Various forms of the metal.
- Alloys of aluminium.
- Illustrations of the process of making aluminium alloys by means of Cowle's electric furnace.

Indium.

Miscellaneous Metals.

Various Non-metals occurring in Metallurgical Operations:

- Selenium.
- Tellurium.
- Boron.
- Silicon.

Manganese:

- Metal and compounds.
- Alloys.

Nickel:

- Ores of the metal.
- Speiss and regulus obtained in the extraction of nickel from its ores.
- Slags produced in the extraction of nickel.
- Furnace bottoms and bye products.
- Various forms of the metal.
- Alloys of nickel.

Cobalt:

- The ores of cobalt.
- Preparation of cobalt.
- The reduced metal.
- Compounds of cobalt.

Iron and Steel:

- Experiments on the character and compounds of iron.
- Alloys of iron.
- Special cases of the reduction and cementation of iron.
- Experiments on meteoric iron.
- British iron ores:
  - Magnetic iron ores.
  - Hæmatites.
  - Brown hæmatites.
  - Spathic iron ores.
  - Argillaceous ores.
- Foreign iron ores:
  - Iron ores from France.
  - Iron ores from Germany.
  - Iron ores from Holland.
  - Iron ores from Spain.
  - Iron ores from Portugal.
  - Iron ores from Sweden and Norway.
  - Iron ores from other European countries.
  - Iron ores from Africa.
  - Iron ores from the East Indies.
  - Iron ores from China and Japan.
  - Iron ores from Australasia.
  - Iron ores from Canada.
  - Iron ores from America.
- Iron ores from unknown localities.
- False iron ores.
- The production of pig iron.
  - Materials used as fluxes.
  - Slags produced in the manufacture of pig iron.
    - Non-crystalline slags.
    - Foreign slags.
    - Crystalline slags.
  - Ancient slags.

Iron and Steel—*continued.*

- Miscellaneous products in the smelting of iron ore in blast furnaces.
- Varieties of pig iron obtained by smelting British ores.
- Foreign pig iron.
- Ancient pig iron.
- Spiegeleisen.
- Special crystallizations of iron.
- Slags produced in the fining of pig iron to obtain wrought iron.
- Slags produced in the puddling furnace.
- Slags from the re-heating furnace.
- Special process in the production of iron.
- Samples of wrought iron.
- Special forms of iron.
- Iron subjected to special treatment.
- Special processes of steel production:
    - Bessemer process.
    - Thomas-Gilchrist process.
    - Siemens' process.
    - Heaton's process.
    - Price and Nicholson's process.
    - Parry's process.
    - Process for refining iron for tin plates.
    - Polish methods of steel making.
    - Indian methods of steel and iron making.
- Various forms of steel.
- Foreign made steel.
- Composite bars, &c. of separate layers of iron and steel.
- Irregularities in steel.
- Iron and steel specially treated.
- Special adaptations of iron and steel to various uses:
    - Watchmakers' steel.
- Defects in iron and steel.
- Wearing and decay of iron.

Miscellaneous.

38. Collection of pure chemical elements, comprising many of the rarer metals.

This collection was prepared by his late Highness Prince Louis Lucien Bonaparte, and bequeathed by him to South Kensington Museum. The bequest was the result of a promise made to Prof. Roberts-Austen on the occasion of the Prince's visit to the Percy Metallurgical Collection, November 1890.

Amongst the specimens are to be found :—

Aluminium.
Antimony.
Arsenic.
Barium.
Beryllium.
Bismuth.
Cadmium.
Calcium.
Cerium.
Chromium.
Cobalt.
Copper.
Didymium.
Erbium.
Gallium.
Germanium.
Gold.
Indium.
Iridium.
Iron.
Lanthanum.
Lead.
Lithium.
Magnesium.
Manganese.
Mercury.
Molybdenum.
Nickel.
Niobium.
Osmium.
Palladium.
Platinum.
Potassium.
Rhodium.
Rubidium.
Ruthenium.
Silver.
Sodium.
Strontium.
Tantalum.
Thallium.
Thorium.
Tin.
Titanium.
Tungsten.
Uranium.
Vanadium
Yttrium.
Zinc.
Zirconium.

39. Collection of gold ores from the United States of Colombia, South America.
1883. *Lent by R. Blake White.*

A.—*From the State of Antioquia.*

2–8, 11–13, 21, 36. Remedios district.
14. Sonson district.
15, 17, 19, 33. Yarumal district.
16, 34, 35, 38. Rio Dulce mine, Sonson.
18. Combia mine.
22. Rosario mine, Remedios district.
23. Gold with ruby silver, Rio Dulce mine.
24, 25. 27, 30. Gold from quartz lode, Bolivia mines.
26. Gold from quartz lode, Arnalfi district.
28. Crystallized gold on pyrites, Faucudo mine.
29. Gold from lode in porphyry, Sonson district.
31. Crystallized gold, red silver, and pyrites, Rio Dulce mine.
32. Crystallized gold on pyrites, Silucio mine, Remedios district.

B.—*From the State of Cauca.*

1. Supia district.
9. Marmato district.
10. Marmato district (in cubes).
20. Loaisa mine, Marmato district.
37. Crystallized gold, lode of Pital mine, near Marmato.

40. Collection of metallic ores from the United States of Colombia, South America.
1883. *Lent by R. Blake White.*

41. Set of specimens of coal, ironstone, limestone, and cold blast iron. Illustrating the exact proportions, both in weight and bulk, of the minerals, coal, ironstone, and limestone consumed in the blast furnaces for the production of one cubic inch of cast iron at the Bowling Ironworks.
1876.
Exhibited by the Bowling Iron Company, Limited.

The coal is coked and the ironstone calcined preparatory to their introduction into the blast furnace.

42. Specimens of steel, &c. produced by the Basic or Thomas-Gilchrist process.
1887. *Exhibited by Percy Gilchrist, F.R.S.*

43. Microscopical photographs of sections of iron and steel.
1876. *Lent by Dr. H. C. Sorby, F.R.S.*

The above were photographed by means of strong surface illumination, and show structures due to the arrangement of crystals of iron combined with a varying amount of carbon, of portions of slag, and of crystalline plates of graphite. Note the contrast between the structure of cast iron, cast steel, and meteoric iron, although all have solidified from fusion.

44. Specimens of native iron.
1876. *Lent by George Gore, F.R.S.*

45. Specimens of native antimony.
1876. *Lent by George Gore, F.R.S.*

4.—MODELS, APPARATUS, AND SPECIMENS TO ILLUSTRATE THE PRODUCTION OF IRON, STEEL, AND OTHER METALS.

The following are shown in the Machinery and Inventions' Section of the Science Collections, and are fully described in the catalogue of that division.

Model of early blast furnace and blowing engine.
Model of Ayresome Iron Works, 1890.
Specimens of pig iron, &c.
Model of Whitwell's hot-blast stove.
Root's blower, by Thwaites.
Sectional model of Root's blower, by Samuelson.
Sectional model of Baker's blower.
Sectional model of Stewart's foundry cupola and receiver.
Specimens of malleable iron castings.
Fletcher's crucible furnace.
Morgan s graphite and salamander crucibles.
Model of a reverberatory puddling furnace.
Model of Thornycroft's rotary squeezer for puddled balls.
Model of Sheffield steel plant for producing and working crucible steel.
Specimens of Swedish iron and steel.
Siemens' open-hearth steel melting furnace.
Model of plant of Bessemer Steel Works, 1860.
Sectional model of converter, used in the Bessemer process.
Tuyere for converter.
Specimens of Bessemer steel.
Model of Bessemer Steel Works, 1890.
Diagrams of plant for compressing fluid steel.
Hadfield's manganese-steel castings.
Drawing of Swedish gas-welding furnace.
Siemens' electric pyrometer.
Cupellation furnace for separating silver from lead.
Drawing illustrating the separation of silver and lead by the Pattinson process.
Model of plant for the Pattinson process.
Ladle for the Pattinson process.
Ingot moulds for lead.
Lead fume condenser.
Model of Cornish tin smelting furnace.

LIST OF CONTRIBUTORS.

Bonaparte Bequest; 20.
Bowling Iron Co., Limited, Bradford, Yorkshire; 22.
Chapman & Hall, 11, Henrietta Street, Covent Garden, W.C.; 14.
Fletcher, T., Museum Street, Warrington; 8.
Gilchrist, Percy, F.R.S.; 22.
Gore, George, F.R.S.; 22.
Head Jeremiah, M.I.C.E., Middlesbrough; 11, 12.
Master of the Mint; 5 to 7.
Morgan Crucible Co., Limited, Battersea; 5.
Orme, J., & Co., 65, Barbican, E.C.; 9.
Percy Collection; 14 to 20.
Preston, J. (late Cubley & Preston), 4, High Street, Sheffield; 8.
Price, W., 181, Burrage Road, Plumstead; 12.
Robson, J. Crosby, 37, Linthorpe Road, Middlesbrough; 9, 10.
Royal School of Mines, Madrid; 13.
Schroeder, J., Darmstadt; 11 to 14.
Simon, H.; 20, Mount Street, Lancaster; 13.
Sorby, Dr. H. C., F.R.S.; 22.
Wedekind, Hermann, Great Tower Street, E.C.; 13.
White, R. Blake; 21, 22.

The Catalogue of the Science Collections for Teaching and Research in the South Kensington Museum will comprise the following Sections, all of which are in preparation and will shortly be issued:

1. Mathematical and Mechanical Models (*ready*).
2. Physics.
3. Chemistry (*ready*).
4. Metallurgy (*ready*).
5. Physiography and Nautical Astronomy.
6. Mineralogy and Geology (*ready*).
7. Biology (*ready*).