46. Cavendish's Original Counting Machine.
Council of King's College, London.

47. "The Motometer," a machine to indicate the number of revolutions made per minute, or other portion of time, by a steam engine or revolving shaft or other body having intermittent motion, so that by simple inspection of a dial the rate of speed may be seen. *H. Faija.*

This instrument is constructed so as to indicate by a positive motion direct from the engine or other moving body to which it is attached, and is of purely mechanical construction independent of all centrifugal and other forces of an indirect nature. The indication is consequently absolute and not comparative.

The instrument is made in four different forms according to requirements; for instance,—

No. 1 is intended for slow motions, as in pumping engines, &c., where each separate revolution is indicated.

No. 2. For all ordinary marine and stationary engines with speed varying from 20 to 100 revolutions per minute, in which case the speed is indicated at every tenth revolution.

No. 3. To indicate extremely high speeds, such as locomotives, &c.

No. 4. To indicate at the termination of each minute the exact number of revolutions made during that minute.

The machine exhibited is No. 2, being the form adapted to most general purposes.

III.—MISCELLANEOUS.

48. Apparatus for the Statistical Treatment of large numbers of Seeds, &c., to sort them rapidly into classes differing by regular gradations of magnitude, with the view of testing how far the relative numbers in the several classes accord with the results of the Law of Error or Dispersion.

Francis Galton, F.R.S.

It consists of a box, with bars parallel to one another, and having a bevelled edge, fixed horizontally across its top. There is also a frame of other bars, held together like those in a gridiron, that lie on the top of the box between these. Consequently, when the frame is pulled forwards as far as it can go, each of its bars closes along its whole length against one of the fixed bars, and when it is pushed gently back the framework bars separate simultaneously and equally from the fixed bars, and any objects that may have been laid in the bevel between their edges, and are small enough, will drop through. The framework is moved by a screw turned by a ratchet wheel, which is itself moved by the to-and-fro action of a handle between stops, one of which is adjustable at pleasure. Hence, every time the handle is worked, the space between the bars is widened by a definite space, and all the seeds, &c., whose diameter is greater than the original and less than the final space, will drop

through. A tray, divided into compartments, slides beneath the box; it is pushed forward through the space of one compartment before giving a fresh movement to the handle, and thus the seeds become sorted into the different compartments. (This instrument was used to illustrate a lecture before the Royal Institution on Friday evening, February 27, 1874.)

49. Apparatus affording Physical Illustration of the action of the Law of Error or of Dispersion.

Francis Galton, F.R.S.

Shot are caused to run through a narrow opening among pins fixed in the face of an inclined plane, like teeth in a harrow, so that each time a shot passes between any two pins it is compelled to roll against another pin in the row immediately below, to one side or other of which it must pass, and, as the arrangement is strictly symmetrical, there is an equal chance of either event. The effect of subjecting each shot to this succession of alternative courses is, to disperse the stream of shot during its downward course under conditions identical with those supposed by the hypothesis on which the law of error is commonly founded. Consequently, when the shot have reached the bottom of the tray, where long narrow compartments are arranged to receive them, the general outline of the mass of shot there collected is always found to assimilate to the well-known bell-shaped curve, by which the law of error or of dispersion is mathematically expressed. (This arrangement was devised, by the exhibitor, to illustrate a lecture before the Royal Institution on Friday evening, February 27, 1874.)

50. Practical Approximation to the value of the circumference in terms of the diameter, by means of a right angled triangle having one acute angle $=27° 35' 49{\cdot}636''$.

Edward Bing, Riga.

For the purpose of effecting this object, as well as for answering kindred questions, use is made of a triangle, specimens of which are here exhibited, and of which one angle is a right angle and another is defined by an equation.

71a. Instrument for tracing with accuracy ellipses and spirals up to 25 centimetres. *M. Adrian Gavard, Paris.*

72. Instrument for drawing **Conic Sections.**
Edward Uhlenhuth, Anclam, Pommerania.

This instrument, which was invented by the exhibitor, shows in the first place the formation of the parabola. By altering the arrangement according to the instructions given in the sketches on the drawing board, the construction of the ellipse and hyperbola easily follows.

73. Elliptic Compass. *Renaud-Tachet, Paris.*

74. Colonel Peaucellier's Compound Compass.
Conservatoire des Arts et Métiers, Paris.

75. Compound Geometric Chuck, producing the kinematic retrogressive parabola, by continuous motion; either on a moving plane by a fixed point, or on a fixed plane by a moving point. *Henry Perigal, F.R.A.S.*

76. Machine for **Compounding two Simple Harmonic Curves.**
Invented and constructed by A. E. Donkin, M.A., Rugby School.

A strip of paper is wound round the cylinder; the little glass pen moving backwards and forwards on it draws one curve, a similar motion of the cylinder the other. Since both move at once the curves are combined, and the result rendered visible to the eye by the revolution of the cylinder.

A. Eccentric for giving simple harmonic motion to pen.
B. " " " cylinder C.
D. } wheels for determining relative numbers of vibrations of pen and
E. } cylinder.
F. Wheel for transmitting slow motion to pinion G which turns the cylinder.
H. Idle wheel.
I. Change wheels to supply different ratios of vibration of pen and cylinder.

76e. Spherical Rules and Squares for Spherical Drawing. *Dumoulin Froment, Paris.*

76a. Working Model of a Trace-Computer, designed by the Exhibitor, for the use of the Meteorological Office.
Francis Galton, F.R.S.

Given two ordinates having the same abscissa, the instrument, of which this is a working model, pricks out a third ordinate that shall be some desired function of the other two. The original instrument was contrived for the use of the Meteorological Office, where it is employed to derive a trace for humidity from the traces of the dry and wet bulb thermometers. It consists of a hori-

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SPACE.

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SECTION 6.—SOUND.

WEST GALLERY, UPPER FLOOR, ROOM (Q).

I.—SOURCES.

688. Apparatus used by M. Rijke to cause a tube to emit sounds when wire gauze placed in the interior is heated.

Professor Dr. P. L. Rijke, Leyden.

689. Whistles for producing shrill notes, within and beyond the limits of ordinary audition. *Francis Galton, F.R.S.*

These whistles were designed for testing the limits of the power of men and animals of hearing very shrill notes. The plugs that close the whistles can be screwed up and down, and the length of the whistle, and therefore the number of vibrations per second, can be ascertained by the attached graduations. The whistles are of three forms: (1) a small cylindrical tube, which gives a pure note, but of small power; (2) a flat, wide and narrow whistle, of which the plug is a broad thin plate of metal; (3) an instrument which is externally a cylinder of 2½ inches in diameter, but of which the effective part is merely an annulus; the plug of this is a cylindrical sheet of brass; it gives a powerful note, but not a very pure one.

690. Brass Tube to sound the constant proper tone of the *mouth*, characterising the vocal sound.

Professor Donders, Utrecht.

This consists of a brass tube ending in a broad slit, at the other end with an india-rubber tube to be placed on a blower "*soufflеur*." (Donders.) The blast, directed by the slit on the borders of the lips, sounds during the time a vocal sound is sung in different tones, the constant proper tone of the mouth characterising the vocal sound. (Compare Donders, Uber die Natur der Vocale, Holl. Beit. zur Nat. u. Heilk. 1846.)

691. Set of Vowel Forks and Resonance Globes. *Frederick Guthrie, F.R.S.*

692. Set of Organ Pipes. *Frederick Guthrie, F.R.S.*

693. Set of Tuning Forks. *Frederick Guthrie, F.R.S.*

694. Photograph of a Chemical Harmonica of glass for gas-flames, with eight pipes (major-scale from d^1 to d^2 inclusive), with double regulating cocks, and key-board for playing. With a copy of a few melodies executed on the same for two and three voices.

Professor J. Joseph Oppel, Frankfort-on-the-Maine.

If held in such a position that the sun's light falls in the solid angle between the face of the mirror and the two small polished surfaces, a portion of the sun's light that falls upon the face of the mirror is refracted at the first surface, reflected internally at each of the small surfaces, and finally emerges through the space from which the silver has been removed, in a direction parallel to, but opposite to, that in which the reflected light travels from the large plane of the mirror.

Hence, any point with which the faint image of the sun appears to coincide will receive the light of the sun reflected from the mirror.

3136. Sun Signals, for the use of travellers.

Francis Galton, F.R.S.

The difficulty in sun-signalling is to direct the flash aright. The rays of the sun are reflected from a mirror, in a cone of light precisely similar to that which reaches it, the mirror itself (whose size may be disregarded) being the apex of the latter cone, and the sun's disc its base. It follows that to the signaller, whose eye is near the mirror, the place where the cone of reflected rays falls on the distant landscape would always appear to him as a disc of precisely the same shape and size as the sun itself. In other words, his accuracy of aim must be within 30 minutes of a degree. In the author's heliostat an image of the sun is produced, which overlies the area on which the flash of the mirror falls. A lens is fixed in the instrument at right angles to the line of sight; half of the lens lies within the tube through which the observer looks, and occupies a portion of his field of view, the other half is external to his field of view; it projects beyond the side of the eye tube, and receives the flash of the mirror. The mirror turns on an axis attached to the tube, which allows it movement in one direction, while the rotation of the entire instrument in the hand gives movement in the other. When the mirror is so adjusted that the reflected (parallel) rays from any one point of the sun's disc impinge on the lens, they are brought to a focus on the screen, and form a minute speck of light upon it. Rays radiate from this speck in all directions, and those that strike the part of the lens inside the eye tube are reduced by its means back again to parallelism with the rays that originally left the mirror. Consequently the eye, looking down the tube, sees a bright speck through the lens, which it refers to the same distant point in the landscape seen to the side of it as that to which the unobstructed rays from the mirror are being flashed. If a telescope be fitted to the tube the speck would overlie the spot on the landscape. Now what is true for any one point in the sun's disc is true for every point, therefore the signaller sees a luminous disc in his field of view, and this exactly overlies the *locus* of the flash. By gently rotating the hand the image can be made to cover or to forsake any point in the landscape that may be desired, and when that is done an observer stationed at that point will see a succession of flashes. Morse's alphabet can be adopted. A flash passing through a square hole of only one-third of an inch in the side is visible to the naked eye at a distance of 10 miles, if the background be dull and the air perfectly clear.

3137. Optical Telegraph, by Colonel Laussédot, composed of a transmutor and of a receiver, with their stands.

Colonel Laussédot, Paris.

3138. Models illustrating two methods of **verifying Sextants** employed at the Kew Observatory:—

1st. By flashing the sun's rays to distant mirrors, whereby stars of light were visible to the operator at the testing table.

This was ceased to be employed on account of the rarity of sunshine. Designed by F. Galton, Esq., F.R.S.

2nd. A system of five collimators, fixed firmly to a wall on a circular arc, arranged so as to send parallel rays across the testing table at known angles. Designed and constructed by J. Cooke, and described in the Proceedings of the Royal Society, vol. XVI., page 2.

Kew Committee of the Royal Society, Kew Observatory.

3139. Spectacles for **Divers,** for use in water.

Francis Galton, F.R.S.

When we look down into still clear water we see all objects in it with perfect distinctness, but on bending down the head with the eyes open, the moment that they touch the water all distinctness of vision ceases. The convex surface of the eyeball has indented the plane surface of the water with a plano-concave lens, and, if we desire to restore distinctness of vision, we must use convex glasses of sufficient power, when immersed in water, to neutralise this effect. A double convex flint glass, each of whose surfaces has a radius of about half an inch, is therefore required. By means of the glasses exhibited it is possible to read the smallest type under water, with perfect ease. The principle of these glasses was described in a memoir read before the British Association in 1865.

3140. Ground Tongs for **Sea Soundings;** invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the line. *Lieut. Hopfgartner.*

A hole is bored lengthways through the centre of an ordinary plummet. In this hole is inserted a movable metal rail, at the lower end of which there are attached two ladles or spoons, opening and closing by means of a hinge or link. At the upper end there are two movable bows which are joined to the ladles by small chains. If the plumb-lead is suspended to these hook-like bows by means of two short auxiliary lines, the ladles are opened and the apparatus is then ready to be let down into the water. On reaching the ground the bows will fall back, dropping the auxiliary lines, the weight of the lead presses the ladles into the ground, and by pulling up the main plumb-line, which is now acting directly on the metal rail, the ladles are closed and drawn into the hole of the lead so far as to be securely closed.

3141. Ground Tongs for **Sea Soundings,** with dropping weight; invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the Line. *Lieut. Hopfgartner.*

Two ladles or spoons, intended for securing specimens of the sea bottom, are opened and closed like a pair of tongs by means of two levers. A peculiar metal cover, in which the ladles will fit, secures the closing of the same. At the upper ends of the two limbs of the tongs there are two hook-like movable bows, on which the lead is placed, which, on the apparatus being let down into the water, keeps the ladles in an open position. On reaching the ground the bows will drop back, the weight (stone or a ball) will fall off, and the metal cover will encase the ladles, and keep them closed while the apparatus is being pulled up.

3199. Ancient Maps of the Sources of the Nile.

1.	1508	-	By Ptolemy.
2.	1650	-	Sebn. Munster.
3.	15th century	-	?
4.	1618	-	?

3200. Miscellaneous Contributions by the Geographical Society.

Three cases of select specimens of Cartography (105 in No.).
Educational models, various.
Engraved Portraits of celebrated explorers.
Barent's relics, 1597; water-coloured drawing.
Pizigani's Map of the World, 1367.

MAPS, GLOBES, AND MISCELLANEOUS OBJECTS BY VARIOUS CONTRIBUTORS.

3201. Models to illustrate the arts of Camp Life.
Francis Galton, F.R.S.

This case of models and specimens was made at the same time as 10 others that were constructed in 1858, by order of the War Office, after the design of a set which Mr. Galton caused to be made, and had presented to the Royal Institution at Woolwich in the previous year. Their object was not only to interest and instruct individual soldiers, but rather to suggest to instructors the precise subjects on which practical classes in the arts of camp life may most usefully be engaged. A catalogue accompanies the case in which the models are contained, and in this an asterisk is placed opposite to those objects which Mr. Galton's experience leads him to prefer for the purpose. "An old campaigner's acquirements consist partly in knowledge and partly in handiness. "Field lectures, illustrated by experiments, may convey the first to an "intelligent novice, and it was hoped that these models might serve to "explain what kind of things must be made by his hands, before he can "acquire the latter."

The examples illustrate the various modes of the production of fire, the procuring, purifying, and carriage of water, cooking, the uses of portable food, substitutes for boats, cattle enclosures, expedients for tools and appliances in various handicrafts, tenting, hutting, and various other needs of camp life.

3202. Stereoscopic Maps, taken photographically, from models in relief. *Francis Galton, F.R.S.*

A much clearer notion of the physical features of a country may be obtained from a model in relief than from an ordinary map, however carefully executed, but the great weight and cumbrousness of models makes them unsuitable for the library or for travel. The chief advantages of both methods of illustration may in great measure be secured by stereoscopic maps taken photographically from models. The accompanying specimens were exhibited in illustration of a memoir read before the Royal Geographical Society in 1865, a copy of which is placed beside the photographs. It is there shown that the proposed plan has two other unexpected advantages. First, owing to causes there explained, we are able to deal with models of considerable dimensions both laterally and longitudinally, for when such a model has been photographed stereoscopically in separate squares, and the prints have been properly united,

it becomes possible to view any part of the map with pseudo-stereoscopic if not with stereoscopic effect. Secondly, it is shown, that the insertion of names improves the appearance of relief in models, and consequently in stereoscopic representations of them, while it spoils the effect of shading in ordinary maps.

3202c. Perspective Map of Africa, according to French, English, and German travellers.

M. Launay, Professor at the Lyceum of Caen.

This map was executed previously to the publication of the accounts of Mr. Stanley, respecting Lake Ukériné, of Lieut. Cameron respecting Lake Tanganiyka, and of M. Grandidier respecting Madagascar.

3203. Map of **Gaul,** showing by different coloured tracings the relative antiquity and importance of the Roman roads.

M. Hayaux du Tilly, Paris.

3203a. Old Spanish Map of the Province of Aragon, &c., with the roads, bridges, hill-shading, &c., inserted in MS. by Captain H. Bristow, by means of the pocket-sextant, No. 3107a.

H. W. Bristow, F.R.S.

During the Peninsular War, great difficulty was experienced in getting accurate maps of Spain for the British army.

The most accurate Spanish maps then procurable were old, very defective, and nearly useless as route maps, owing to the roads, hill-shading, &c. not being shown upon them. These details had to be supplied for the use of the army, by the officers attached to the Quartermaster-General's department, the engraved maps serving as the groundwork for the new survey.

The old Spanish map of the province of Aragon and surrounding districts is one of those maps upon which the roads, bridges, the defences of Saragossa, and other details, were so supplied in MS. by Captain Bristow, by means of the pocket-sextant, No. 3107a.

3204. Photographs from the original surveys, representing the present mode of reproducing the ground by equi-distant curves :—

1. Half a Norwegian square mile, on the scale of 1·25000, used in lower tracts, well cultivated and more densely inhabited. The curves representing a rise of 25 feet.
2. A Norwegian square mile, on the scale of 1·50000, used in the higher and less inhabited parts of the land. The equi-distant curves represent here a rise of 100 feet.

Survey Office, Christiania, Norway.

3204a. Specimen Sheets of the two most important Productions of the Topographical Department at St. Petersburg. Copper plate.

The Topographical Department of the Imperial Russian General Staff at St. Petersburg.

1. Topographical map of the western part of European Russia in 507 sheets. Scale, 1:126,000.