The necessity of having circles truly tangent when they ought to be, or claim to be, is nowhere more apparent than in the drawing of outlines which are made up of arcs of circles of different radii. And this has very often to be done, especially in mechanical subjects: for when such circular arcs will answer the purpose as well as other curves, it is better to use them, so that the mechanic who is to work from the drawing can readily lay them out with the tools always at hand. We give an example of this in Fig. 114. A B C D, C D E F, are two equal squares. Drawing first the diagonals in these squares, take C as a centre, and draw the arc A E, with radius C A; then

Fig. 116.

with D as a centre, and the same radius, draw the arc B F. Next about centre G, with radius G A, draw the arc A B, and about H describe the arc E F. The two arcs last drawn should be tangent to the other two, forming a closed figure, which has some resemblance to an ellipse; and this outline should appear perfectly smooth and continuous, without break or variation in thickness, the junctions of the different arcs of which it is made up being entirely imperceptible. And simple as the construction is, it will be found that the production of such a line requires considerable care and some skill: when it has been accomplished, but not before, the student may go on to surround it by others as shown, keeping the same cen-

Fig. 117.

tres, C, D, G, H, but increasing the radii, producing the diagonals of the squares so as to determine the points of tangency. By adding the shadow lines, as in the figure, we have a drawing of a picture frame, such as sometimes mis-called oval, made of a broad band with two narrow raised mouldings of a square section. We say *mis-called* oval—this form more nearly approximates to the elliptical, and is, it will be noticed, composed of four precisely similar parts, being symmetrical as to both the vertical and the horizontal lines. In order to make the distinction clear, we have in Fig. 115 given a section of a form frequently given to sewer pipes—which is symmetrical about the vertical line, but not about the horizontal, being larger at one end than at the other, like an

Fig. 118.

egg, whence the name *oval* is properly applied to this figure. About O, the intersection of the indefinite centre lines, describe a circle with any diameter A B, cutting the vertical centre line in C; draw A C, B C, and produce them: then about A, with radius A B, describe the arc B E, about B with the same radius describe A D, and with centre C and radius C D describe D E completing the oval. The external outline is drawn as in the preceding case,—that is to say, by describing arcs about the same centres with greater radii; the cross-lining, or *sectioning*, is then done, care being taken to have the lines finer than the outlines, so that the latter may be

prominent, and the shadow lines put in at the very last. The remaining figures accompanying this lesson, being exercises for right-line work only, and drawn from the same source which has furnished several of the preceding ones, should require no explanation; as the student who has once familiarized himself with the principles involved in the construction of those, will find no difficulty in extending their application. And that extension is all that is involved in the drawing of these—they are more complex, fuller of detail, but that is all. Some of the first of these may have appeared exceedingly elementary—and so they were, and were selected with the definite purpose of pointing out the principles of construction—and yet, simple as they are, they will be found excellent practice, if they are drawn on a small scale—the perfection of their forms, and the beauty of the drawings, depend so largely on their symmetry, that the eye as well as the hand will be unconsciously trained in reference to that feature—a training too often neglected, and one which the draughtsman will find of great value.

ON REPULSION RESULTING FROM RADIATION.*

By WILLIAM CROOKES, F.R.S., etc.

In this paper the author describes experiments on the repulsion produced by the different rays of the solar spectrum. The apparatus employed is the horizontal beam, suspended by a glass fibre and having square pieces of pith at each end coated with lampblack. The whole is fitted up and hermetically sealed in glass, and connected with an improved mercury pump. In front of the square of pith at one end a quartz window is cemented on to the apparatus, and the movements of the beam, when radiation falls on the pith, are observed by a reflected ray of light on a millimetre scale. The apparatus was fitted up in a room specially devoted to it, and was protected on all sides, except where the rays of light had to pass, with cotton-wool and large bottles of water. A heliostat reflected a beam of sunlight in a constant direction, and it was received on an appropriate arrangement of slit, lenses, prisms, etc., for projecting a pure spectrum. Results were obtained in the months of July, August, and September; and they are given in the paper graphically as a curve, the maximum being in the ultra-red, and the minimum in the ultra-violet. Taking the maximum at 100, the following are the mechanical values of the different colors of the spectrum:

Ultra-red.....	100
Extreme red.....	85
Red.....	73
Orange.....	66
Yellow.....	57
Green.....	41
Blue.....	22
Indigo.....	8½
Violet.....	6
Ultra-violet.....	5

A comparison of these figures with those usually given in text-books to represent the distribution of heat in the spectrum, is a sufficient proof that the mechanical action of radiation is as much a function of the luminous rays as it is of the dark heat-rays.

The author discusses the question "Is the effect due to heat or to light?" There is no real difference between heat and light; all we can take account of is difference of wave-length, and a ray of a definite refrangibility can not be split up into two rays, one being heat and one light. Take, for instance, a ray of definite refrangibility in the red. Falling on a thermometer it shows the action of heat, on a thermo-pile it produces an electric current, to the eye it appears as light and color, on a photographic plate it causes chemical action, and on the suspended pith it causes motion. But all these actions are inseparable attributes of the ray of that particular wave-length, and are not evidences of separate identities.

The author enters into some theoretical explanations of the action of the different parts of the spectrum, but these can not well be given in abstract.

An experiment is given by which sunlight was filtered through alum, glass, and water screens, so as to cut off the whole of the ultra-red or dark heat-rays. The ray of light which was thus freed from dark heat was allowed to fall on the pith surface of the torsion apparatus, when it produced a deflection of 105°. When a solution of iodine in disulphide of carbon was now interposed the deflection fell to 2°, showing that the previous action was almost entirely due to light. With a candle tried under the same circumstances, the light filtered from dark heat produced a deflection of 37°, which was reduced to 5° by interposing the opaque solution of iodine.

In order to obtain comparative results between disks of pith coated with lampblack and with other substances, a torsion apparatus was constructed, in which two or more disks could be exposed one after the other to a standard light. One disk always being lampblackened pith, the other disks could be changed so as to get comparisons of action. Calling the action of radiation from a candle on the lampblackened disk 100, the following are the proportions obtained:

	Degrees.
On Lampblackened pith.....	100
Iodide of palladium.....	87.8
Precipitated silver.....	56
Amorphous phosphorus.....	40
Sulphate of baryta.....	37
Milk of sulphur.....	31
Red oxide of iron.....	28
Scarlet iodide of mercury and copper.....	22
Lampblackened silver.....	18
White pith.....	18
Carbonate of lead.....	13
Rock-salt.....	6.5
Glass.....	6.5

In consequence of some experiments tried by Profs. Tait and Dewar, and published in *Nature*, July 15th, 1875, the author fitted up a very sensitive apparatus for the purpose of carefully examining the action of radiation on alum, rock-salt, and glass. The source of radiation was a candle. Perfectly transparent and highly polished plates of the same size were used, and the deflection was made evident by an index-ray of light. Taking the action on the alum at 100, that on the rock-salt in five successive experiments was 81, 77.3, 71, 62.5, 60.4. This increasing action on the alum was found to be caused by efflorescence, which took place rapidly in the vacuum, and rendered the crystal partially opaque. A fresh alum plate being taken, this and the rock-salt were coated with lampblack and replaced in the apparatus, the black side away from the source of radiation, so that the radiation would pass through the crystal before reaching the lampblack. The action of radiation was in the proportion of blacked alum 100 to blacked rock-salt 73.

The author describes a torsion-balance in which he is en-

abled to weigh the force of radiation from a candle, and give it in decimals of a grain. The principle of the instrument is that of W. Ritchie's torsion-balance, described in the *Philosophical Transactions* for 1830. The construction is somewhat complicated, and can not be well described without reference to the diagrams which accompany the original paper. A light beam, having two square inches of pith at one end, is balanced on a very fine fibre of glass stretched horizontally in a tube, one end of the fibre being connected with a torsion-handle passing through the tube, and indicating angular movements on a graduated circle. The beam is cemented to the torsion-fibre, and the whole is inclosed in glass and connected with the mercury-pump and exhausted as perfectly as possible. A weight of 0.01 grain is so arranged that it can be placed on the pith or removed from it at pleasure. A ray of light from a lamp reflected from a mirror in the centre of the beam to a millimetre-scale four feet off shows the slightest movement. When the reflected ray points to zero, a turn of the torsion-handle in one or the other direction will raise or depress the pith end of the beam, and thus cause the index-ray to travel along the scale to the right or to the left. If a small weight is placed on one end so as to depress it, and the torsion-handle is then turned, the tendency of the glass fibre to untwist itself will ultimately balance the downward pressure of the weight, and will again bring the index-ray to zero. It was found that when the weight of the 1-100th of a grain was placed on the pith surface, the torsion-handle had to be turned twenty-seven revolutions and 358°, or 10,073° before the beam became horizontal. The downward pressure of the 1-100th of a grain was therefore equivalent to the force of torsion of the glass thread when twisted through 10,073°.

The author next ascertained what was the smallest amount of weight which the balance would indicate. He found that 1° of torsion gave a very decided movement of the index ray of light, a torsion of 10,073° balancing the 1-100th of a grain, while 10,074° overbalanced it. The balance will therefore turn to the 99-100,000,000th of a grain.

Divide a grain weight into a million parts, place one of them on the pan of the balance, and the beam will be instantly depressed.

Weighed in this balance the mechanical force of a candle twelve inches off was found to be 0.000444 grain; of a candle six inches off, 0.001772 grain. At half the distance the weight of radiation should be four times, or 0.007088 grain; the difference between theory and experiment being only four millionths of a grain is a sufficient proof that the indications of this instrument, like those of the apparatus previously described by the author, follow rigidly the law of inverse squares. An examination of the differences between the separate observations and the mean shows that the author's estimate of the sensitiveness of his balance is not excessive, and that in practice it will safely indicate the millionth of a grain.

One observation of the weight of sunlight is given: it was taken on December 13th; but the sun was so obscured by thin clouds and haze that it was only equal to 10.2 candles six inches off. Calculating from this datum, it is seen that the pressure of sunshine is 2.2 tons per square mile.

The author promises further observations with this instrument, not only in photometry and in the repulsion caused by radiation, but in other branches of science in which the possession of a balance of such incredible delicacy is likely to furnish valuable results.

COLORS AND THEIR EFFECTS UPON THE HUMAN SYSTEM.

In relation to Dr. Ponz's statement of the curious effects of colors and the curative power of the solar rays upon lunacy and other mental diseases, accounts of which we recently published, Dr. Newbery, of this city, in a lecture before the Polytechnic American Institute, states that he advanced the same ideas several years ago:

"I stated that as early as the year 1831 I first announced my discovery, which I have promulgated with additional facts from time to time, that there are but three—not seven—elementary colors; namely, pink, yellow, and blue; and those are the elements of darkness (black), not elements of light. Synthetically speaking, the mixture of all colors makes black; analytically, light. The elementary colors are most perfectly illustrated by carmine, gamboge, and Prussian blue. The yellow and blue rays are more easily seen through the prism, where the elements of their impurities are thrown off into their respective lines or angles in relation to light. The pink ray, being scarcely visible, mingles on each side with the darkness because it has the least affinity with light, and is better seen in binary compounds; as, for instance, with yellow in the red and orange, and with blue in the violet and purple. And in order to be able to distinguish any colors, we have the three elementary colors organized in the eye, forming a membrane called *pigmentum nigrum* (black pigment), behind which there is a luminous membrane; both, in combination, are the recipients of the influence of color and light.

"The colors and rays of light also relate to the physical temperaments as stimulants: the yellow color, or ray of light, to the nervous temperament, which is distinguished by a large brain and prominent motor, sensitive and sympathetic nerves; the pink color, or ray of light, relates to the nutritive temperament, characterized by large, glandular negative and assimilating parts and superabundance of blood; and the blue color, or ray of light, relates to what I denominate the locomotive temperament, indicated by large bones and muscle, and predominance of the gelatinous tissue. The various temperaments may be stimulated by the colors or rays to which, as I indicated, they respectively relate, and are, therefore, capable of producing either a healthy or morbid influence upon different individuals. A person in whom the nervous system is dominant may have it increased or excited to prostration by the influence of yellow color, or ray of light. A nutritive-locomotive system may be developed so as to counterbalance the excessive nervousness by the use of purple color, or ray of light. A weak nutritive system may be developed by the influence of pink color, or ray of light, while the same would be injurious to any one of plethoric nature. A weak locomotive temperament may be strengthened by the influence of blue color, or ray of light, while the same would excite a strong person to work or make him irritable. The green color, or ray of light, excites the nervous-locomotive system; the red color, or ray of light, the nervous-nutritive. So that sick or unbalanced persons should have the color of the walls, ceiling, carpets, window-shades, etc., of their particular apartments properly adapted to develop an equilibrium of their physical temperaments, which is the only condition of perfect health and long life required by nature and overlooked by man. All our public assembly-rooms should be of neutral colors, with pictures of various subjects to suit the different tastes, so as to produce a neutral effect in the aggregate, in order that each individual might be suited according to his sympathetic and comprehensive attraction."

* Abstract of a paper read before the Royal Society, February 10th, 1876.