

IRWELL RIVER BRIDGE, MANCHESTER, ENG.

AMONGST the various and important improvements that have recently been made in the city of Manchester is the erection of another bridge over the river Irwell, thereby increasing the means of communication with Salford, and relieving New Bailey street, Albert Bridge, Bridge street, John Dalton street, and Princess street from the greater part of the heavy coal traffic and merchandise from the adjacent goods stations of the Lancashire and Yorkshire Railway. From the position of the bridge, and the requirements of the parties interested in the navigation, to preserve a sufficient headway, and the necessity for easy gradients for the approaches, it was requisite, in order to comply with the severe conditions respecting the thickness of the roadway platform, to display more than ordinary ingenuity in preparing the designs, so as not to impair the strength of the structure in any part. The bridge is slightly on the skew, one of the main girders being 130 ft. and the other 127 ft. in length; the width of the roadway between the parapets is 48 ft.

Owing to the heavy traffic the girders are of more than the usual strength, and extra allowance is also made for the corrosion of the wrought iron, due to the exceptional atmospheric impurities which rise from the river. The main girders are on the bow-string principle, with double triangular lattice and vertical bars. They are 15 ft. deep in the centre, the arch being a true parabola. The top and bottom booms are trough-shaped, the top being composed of seven flange plates $\frac{1}{4}$ in. thick, and the bottom of six plates of the same thickness, 3 ft. 6 in. in width, attached by four angle irons, 4 in. by 4 in. by $\frac{1}{2}$ in., to two rows of web plates consisting of two plates 2 ft. deep by $\frac{1}{2}$ in. thick, increasing in thickness towards the ends. Gusset plates are attached at intervals inside the two webs; and to these webs are riveted the diagonal and vertical bars. The rivets are $\frac{1}{2}$ in. diameter, the holes in every case being drilled through the various plates in position, the holes in the outer plates being rimmed out and countersunk. This was done by the contractor, who first marked the web carefully out, bolted a section of it together, and passed it forward under the radial drilling machines. The flange plates and angle irons were drilled in position by means of portable drilling machines having fourteen spindles.

The vertical struts are each composed of a flat plate between two T-irons braced together. The diagonals are also braced together to prevent buckling. The main girders rest on cast iron bed-plates with gun-metal strips, the bottom plate of the flange and the gun-metal strips being planed, so as to enable the girder to slide when expanding or contracting. Although differing from the usual practice, this system has been found to act very well, as special notice was taken in the exceptionally hot weather which occurred during the construction of the bridge, the girders expanding and contracting to the extent of $\frac{1}{2}$ in.

The cross girders are 55 ft. 6 in. long, 3 ft. 5 in. deep in the centre, and 2 ft. 8 in. deep at each end. The flanges are curved both on the top and bottom at one end of the bridge, and at the bottom at the other end, each girder varying in shape, owing to the required inclination of the roadway and the maintenance of the requisite headway over the river. The holes in the cross girders are all drilled in a similar manner to those of the main girders, and the work was riveted up and tested in the contractor's yard. The cross girders are suspended from the main girders under each vertical, by 24 in. bolts, 1 in. in diameter, at each end. Each bolt was made in one piece without welding, and tested previous to erection with a dead weight of four tons. After the bolts were screwed up the ends were riveted over the nuts. The ends of the cross girders are surmounted by ornamental castings.

The distance apart of the cross girders is 8 ft. 4 in. from center to center, and each one is capable of bearing a safe load of 50 tons in the center. The roadway is composed of wrought iron curved plates $\frac{1}{2}$ in. thick, supported on short longitudinal roadway girders riveted to the cross girders, each of such girders being capable of bearing a safe load of 15 tons in the center. The parapet is constructed of wrought iron boiler plates with diagonal strips riveted over the joints, bolted to a cast iron moulded plinth. The whole is surmounted by an ornamental moulded cast iron capping with malleable iron spikes. The bridge is so designed that with the heaviest loads that can be brought on it no load will set up a strain in any part greater than $4\frac{1}{2}$ tons to the square inch either in tension or compression.

Nearly the whole of the iron is "Cleveland," and great care was taken in testing all the iron, both for its tensile strength and its elasticity. No iron was used that had a permanent set after 13 tons per square inch of tension was applied, or that broke with less than 24 tons to the square inch. The bridge was designed and executed under the direction of Mr. J. G. Lynde, M. Inst. C. E., Engineer to the Corporation of Manchester; the details having been worked out and the working drawings made by his assistant, Mr. Jerram. The contractors for the ironwork were the Stockton Forge Company, Stockton-on-Tees; and for the abutments, Messrs. Ellis and Hinchliffe, of Manchester.—*Engineer.*

A BALL ON A JET OF AIR, STEAM, OR WATER.

By W. F. DUFFEE, C.E.

THE numerous communications that have appeared in your own and other scientific journals during the past six months, relative to supporting a ball on a blast of air, are evidence that the interest excited by the curious experiment exhibited at the Centennial by the proprietors of the Westinghouse air brake is not confined solely to the comparative few who witnessed that experiment, but that it is receiving attentive consideration from a large number of persons interested in scientific and mechanical pursuits; and, therefore, a few notes relative to the history of the jet-supported ball may be of interest at this time.

The experiment of sustaining a ball, by means of a vertical jet of steam, water, or air is a very old one, and from it the very much more remarkable illustration of the supporting power of induced currents of air, afforded by the ball and inclined jet, is undoubtedly derived; and though this form of the experiment has been regarded as of recent date, having been brought to public notice from time to time during the last seventy years, it does not seem probable that more than two thousand years, prior to the beginning of the present century, should have elapsed since the first recorded experiment with the ball and vertical jet, without some investigator (either accidentally, as was the case at the Centennial, or purposely) inclining the jet, and thus at once demonstrating that its verticality was not essential to the support of the ball. The exact date of the first observation that a jet of steam, air, or water would cause a ball placed therein

to be sustained in opposition to the force of gravity is not known; for Hero, of Alexandria, who lived about 200 years before Christ, states in the preface to his "Pneumatics" (which work contains the earliest mention of this experiment) that he "has thought proper to arrange what has been received from former writers, and to add thereto his own inventions;" but, with a novelty which is not always an attribute of inventors, he fails to designate, among the numerous mechanisms which he describes, "his own" from those of "former writers," and owing to the fact that there are no copies of the works of these worthies in existence, it is at this time impossible to say with certainty whether Hero was the inventor of the jet-sustained ball or not; and all that is known in regard to his claims is that, in the work named, he describes and illustrates it. Fig. 1 is a reproduction of the

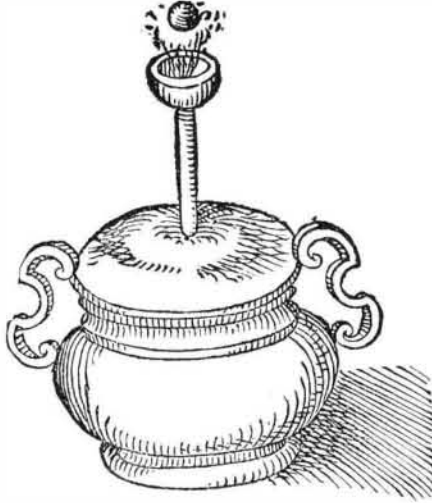


FIG. 1.—BALL ON AN AIR STEAM CURRENT.

engraving found on page 149 of Commandine's Latin edition of the "Pneumatics," which was published in 1575. The text accompanying this illustration may be translated as follows: "Balls are made to dance in the following manner: A copper vessel of water having a covered mouth is fired from below; from the cover proceeds a tube having on its end a small hemispherical cup, perforated by the tube. If a light ball is thrown into the cup, it is acted upon by the steam which comes out of the copper vessel through the upright tube, and the ball is elevated so as to be seen to dance." Hero believed that steam was a species of air; for he says, in the preface to the above-named work, that "water, when corrupted by fire, is changed into air;" and as he was well acquainted with the air compression pump, and the elastic force of condensed air, having made use of both (in a number of his recorded inventions, which have for their object the elevation of water for various purposes, among which several forms of fountains are conspicuous), it appears probable that he knew of the fact that a jet of air or water would make a ball "dance" as well as a jet of steam. In many of the

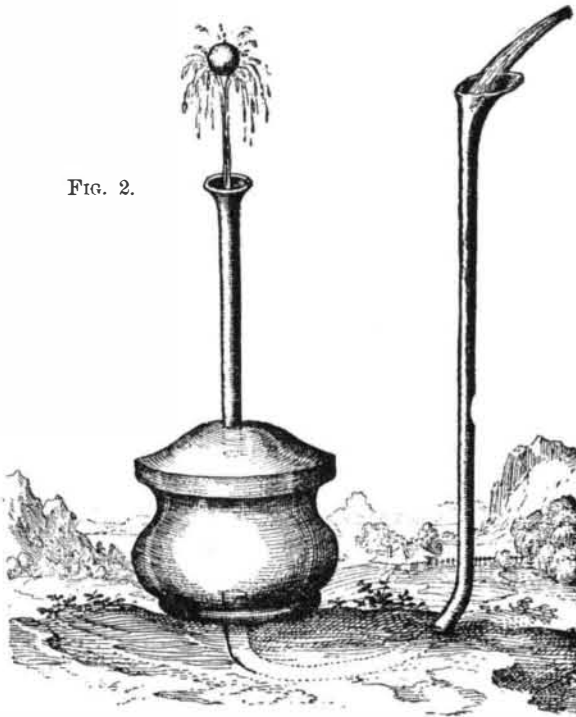


FIG. 2.

older works on architecture and hydraulics, we find the water jet and ball figured, and in the absence of proof to the contrary, it is allowable to suppose that the idea is of direct descent from Hero.

In Flud's "Macrocosmi Historia," published in 1617, we find engravings, of which Figs. 2 and 3 are copies. Fig. 2 requires no explanation; but the motive force in Fig. 3 is not so evident, and, therefore, I translate the explanation as follows: "The quality which cold air has of being expounded by heat, and then lifting and sustaining a solid body, is frequently demonstrated by the following experiment: Water is violently thrown upwards in a jet out of a vessel (A, B, C, D), through the tube E, and by this jet a wooden ball is thrown into the air so that it is seen to dance, and as long as the water is thrown out the ball will dance and leap." The source of the heat used for expounding the air is evidently intended to be the sun, the tube E extending nearly to the bottom of the vessel. This experiment, though it substitutes a jet of water for one of steam, as used in the invention of Hero, is clearly derived from the writings of that mechanician, the final effect produced being the same as is described by Hero, and some parts of the explanation of each writer are identical, and from its being spoken of as a "frequent demonstration," we have a right to believe that it was well known to the learned at the time Flud was writing. The inventions illustrated in the works of Hero and Flud were, without doubt, of great suggestive value in connection with the early attempts to utilize the power of steam.

The first Latin edition of the "Pneumatics" of Hero (translated from the original Greek by Commandine), was published in 1575, and the "Macrocosmi Historia" of Flud in 1617. As these works were printed in the Latin tongue—the universal language of the science of that time—they must have been well known to the learned of the early part of the seventeenth century. At the date of the publication of Flud's work, the Marquis of Worcester was but sixteen years old, and the often-quoted work of De Caus ("Raisons des Forces Mouvantes") was not published until 1624, and the (at this day) less known work of Bronca ("Machine"), in 1629. Therefore, it does not seem at all improbable that the inventive faculties of De Caus, Bronca, and the Marquis of Worcester may have been stimulated, if not inspired, by the perusal of the works of one or both of the older writers before named.

For two hundred years, following the middle of the sixteenth century, water was employed for ornamental purposes in the parks and pleasure grounds of royalty and nobility, and even in the more modest gardens attached to the residences of the wealthier class of citizens, to an extent rarely, if ever, attempted at the present time; nearly all of the most famous artificial fountains, cascades, and jets d'eau which are found on the Continent of Europe, having been constructed during the period named. In fact, waterworks were quite the fashion; and, as was natural, a spirit of emulation was excited in the engineers and architects of the time, sparing neither their own ingenuity nor their patron's money in the invention and construction of novel forms of water display. Some of the works published in the seventeenth century abound with curious designs for the exhibition of water, many of which are elegant, some elaborately clumsy, and in others the water is so employed as to ingeniously challenge our disgust. From a work published in Latin at Nuremberg, in the year 1664 ("Architectura Curiosa Novu"), containing upwards of two hundred large copper plates, illustrating various forms of fountains, Figs. 4 and 5 are taken, in each of which will be seen the ball supported by the jet.

The author of this work (Georgium Andream Böcklern) was well acquainted with the writings of Hero, and devotes considerable space to a discussion of them. I translate the description accompanying these figures. Fig. 4 is called "A round fountain with seven jets and a leaping ball. To erect

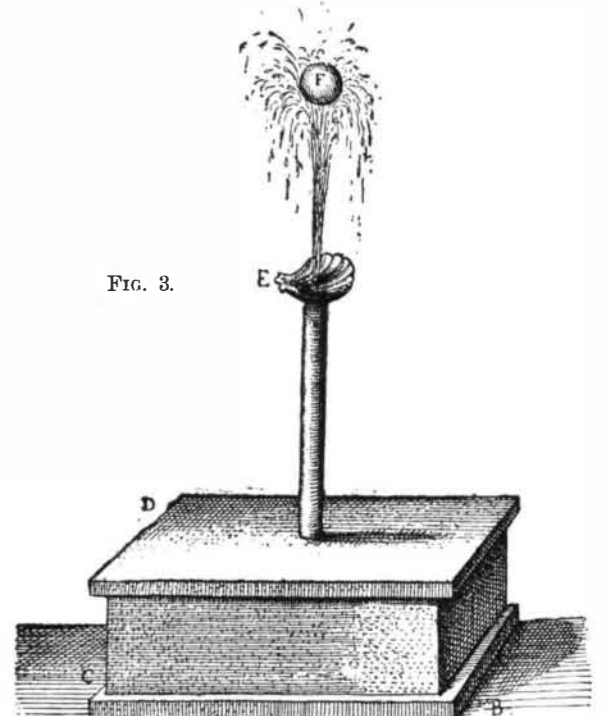


FIG. 3.

this fountain, provide six equally divergent tubes, as a greater number will require a large amount of water; these are placed, as shown, below the water basin, which is provided with turned-up lips drawn out of thin copper and joined together ornamentally; or it may be decorated with skillfully applied color, as you prefer, or may be able. It is proper to observe that there should be no tube erected in the middle (as is erroneously shown in our figure), but a concave cup is preferred, which must be placed concentric with the central hole; this cup, from which the ball leaps, is made of thin copper or brass. Care must be taken in uniting the several parts that the equilibrium is preserved. As soon as the several parts of the fountain are united, the ball in the center of the cup is thrown forcibly upwards by the rush of air which precedes the water, and as it falls back of itself, the jet of water strikes it, and it is again thrown up as was intended. The effect of the ball thus leaping and playing in the air is most beautiful as an ornament to a level garden."

Fig. 5 is described as follows: "Another fountain tossing five of the same kind of water balls. This fountain is much more elegant and graceful in appearance than the preceding; in fact, it throws five of the same kind of balls, one from the central and the others from collateral outlets. In the center of the last fountain but one ball is lifted; but in this, others spring from the extremities of the spokes of a wheel-shaped arrangement which requires considerable skill to unite together gracefully. This figure is drawn with the same disagreeable error as is seen in that immediately preceding; it is evidently necessary to omit the drawing out of the tubes in order that the balls may descend into the funnels in the center and at the extremity of the arms. The designer is certainly to blame for this, and must have been naturally ignorant of hydraulic constructions, since where a funnel is required to receive the ball in case it descends outside of the perpendicular, he has placed a tube. Though composed of a great number of parts, the whole of this work may be gracefully assembled together. Note: This large structure requires a great pressure of water, and its main supply pipe should be so calculated as to be large enough to supply the other nine tubes so that the water will flow through them abundantly; experience will advise the constructor in this matter."

Many more examples of the jet-sustained ball might be cited, but the foregoing are sufficient to illustrate its early history. In the latter part of the last century, the "principles of the lateral communication of motion in fluids" were investigated very thoroughly by Professor Venturi, of Modena, and it is the action of the jet on the surrounding air, in accordance with the principles elucidated by him, that the

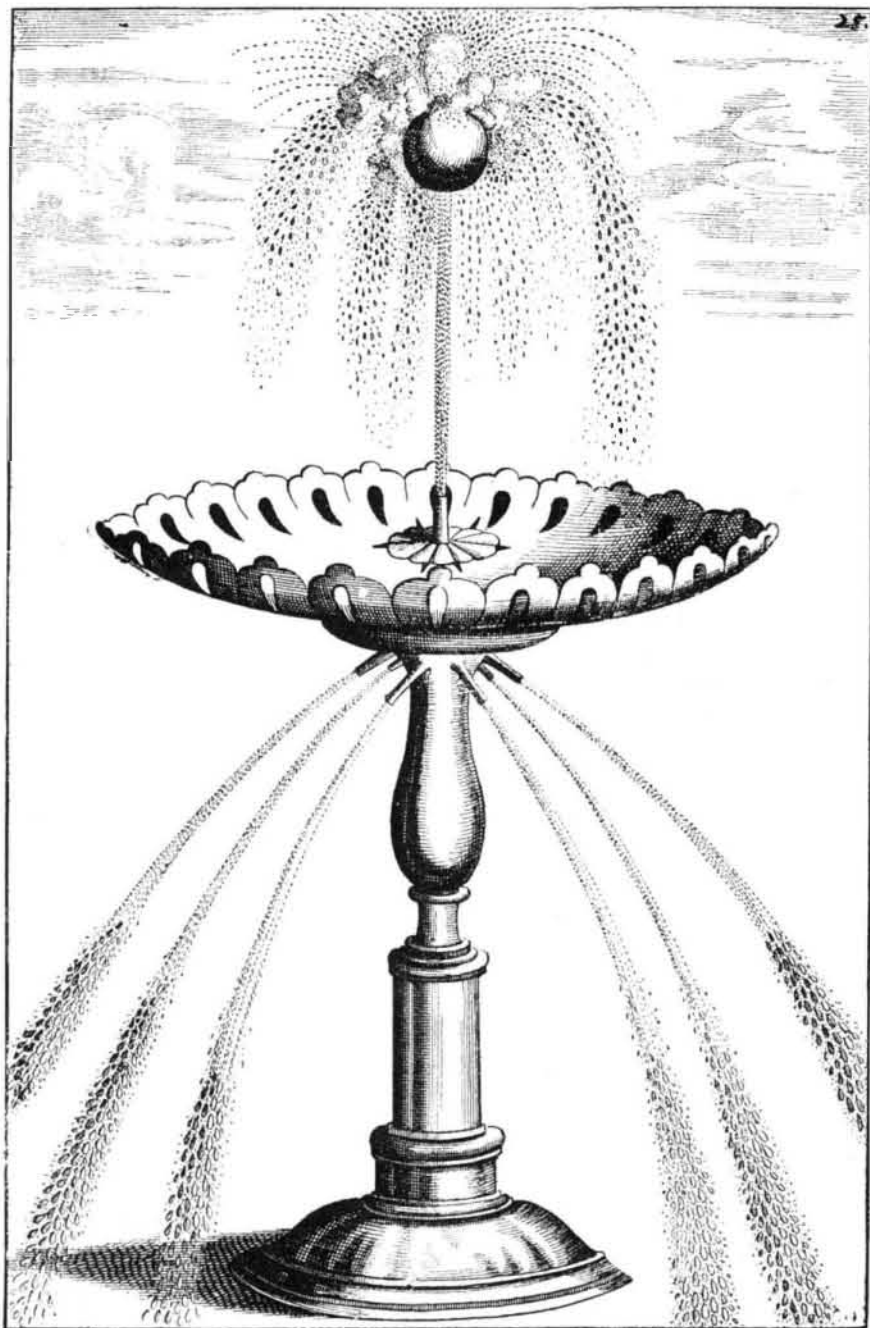


FIG. 4.

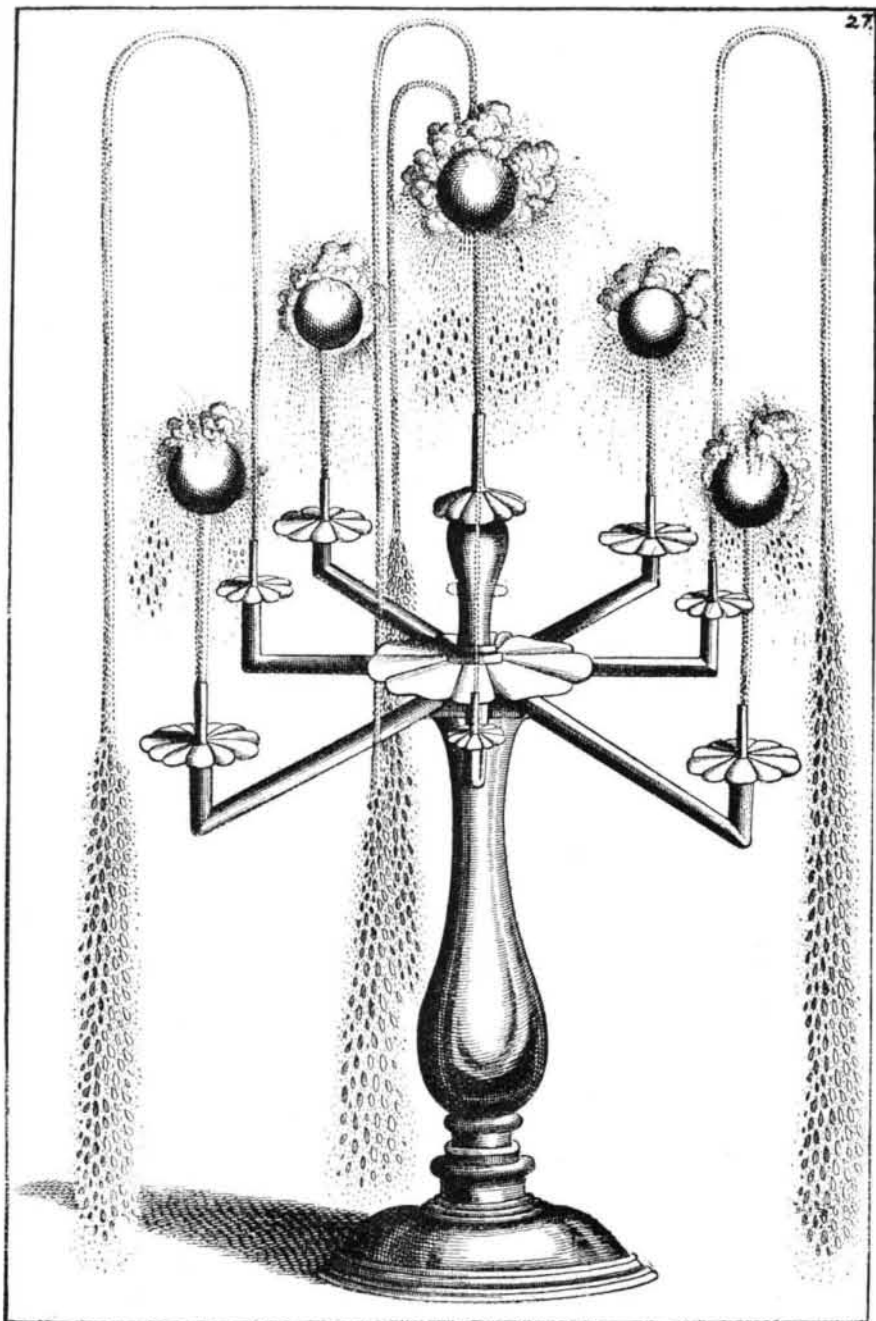
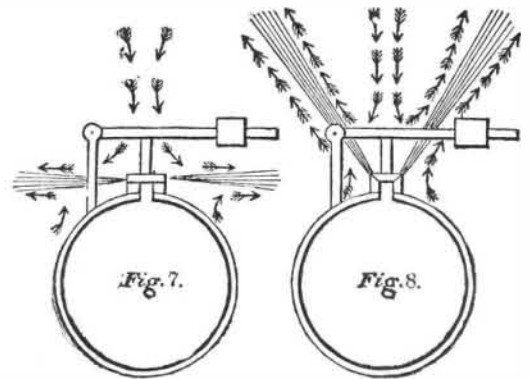


FIG. 5.



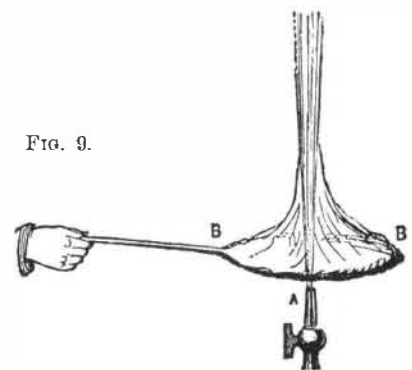
support of the ball in all cases depends. The peculiar action of "induced lateral currents" of air is well illustrated by a simple experiment: Take a piece of ordinary writing paper, roll it around a common lead pencil, and confine its outer edge with paste or gum, and on withdrawing the pencil you have a paper tube. Cut a circle of about $2\frac{1}{2}$ inches across, out of a stiff card, and pierce its center with a hole about $\frac{1}{4}$ of an inch in diameter, now attach the paper tube to the center of the card by some sealing wax, and near the edge of the side opposite to that occupied by the tube, place three small drops of sealing wax at equal distances from each other; then cut another circle of card of the same size as the first; on putting this card on the drops of wax before named,



inverting the whole apparatus, and blowing forcibly through the tube, as shown in Fig. 6, it will be found to be impossible to displace the card, but as soon as the blast of air ceases the card will drop of itself; this is one form of the "pneumatic paradox" so-called, and the support of the card is due entirely to the action of "lateral" or "induced currents" of air.

In a communication of M. Clement Desormes to the Academy of Sciences of Paris, dated 4th of December, 1826, he observes "that when steam is compressed in a boiler so that a strong current is made to blow out through a small orifice, that a metal plate or disk on being presented at a little distance from the orifice is forcibly repulsed; but if it is brought near, and pressed so as nearly to close the orifice and cause the steam to escape in a star-like form round the outside of

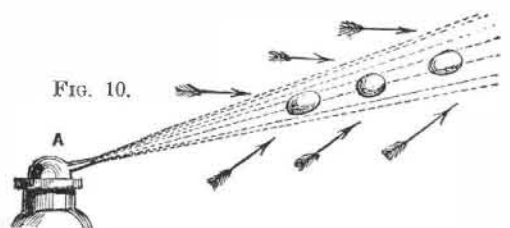
FIG. 9.



the disk in radiant directions, an external pressure will be found to act upon the disk, and it can only be set at liberty by forcibly raising it."

In the facts observed by M. Desormes, Mr. Jacob Perkins makes the following remarks: "The steam forces off horizontally in every direction, as M. Clement observes, in a star-like form. Now, as a strong current of air will be created by the velocity of the steam and pass off with it, the surrounding air will follow, and in its course, as in Fig. 7, it will impinge on the disk and cause a pressure, and that in proportion to the height or velocity of the steam. When the safety valve is so constructed, which is sometimes the case,

FIG. 10.



as to allow the steam to pass off in a horizontal direction, the pressure will be greater than when the valve is conical, which gives a different direction to the steam, as in Fig. 8, making it more difficult for the air to impinge upon the valve."

The peculiar behavior of a ball placed within the influence of either a vertical or inclined jet was noticed by Professor Leslie, of Edinburgh, in 1825, as already mentioned in your columns, and Professor Faraday delivered a lecture at the Royal Institution, some time between the years 1825 and 1829 (of the exact date I am not certain), in which the general action of jets upon the surrounding air, and through this medium upon balls and disks, was discussed. The "pneumatic paradox" in various forms was illustrated in vols. 9 and 11 of the *London Mechanics' Magazine* for the years 1828 and 1829, and received the attention of Professor Hare and other writers in the early volumes of "Silliman's Journal" and the "Journal of the Franklin Institute." In the second

edition of "The Boys' Playbook of Science," published in 1860, Professor Pepper, in speaking of "currents of air that are dragged into an escaping jet of steam," says, "This tendency of the air to rush into a jet of steam was discovered by Faraday, and explains those curious experiments with a jet of steam by which balls, empty flasks, and globular vessels are sustained and supported either perpendicularly or horizontally. If steam at a pressure of about sixty pounds per inch is allowed to escape from a proper jet, and a large lighted circular torch, composed of tow dipped in turpentine, held over it, the course of the external air is shown by the direction of the flames, which are forcibly pulled and blown into the jet of steam with a roaring noise indicating the rapidity of the blast of air moving to the steam jet."

Fig. 9, A, jet discharging high pressure steam. B B, lighted torch held around the escaping steam, the flames from the latter all rush into the former. Egg shells, empty flasks, india-rubber or light copper and brass balls, are suspended in the most singular manner inside an escaping jet of high pressure steam; and before the explanation of Faraday, reams of paper were used in the discussion of the possible theory to account for this effect; and what made the explanation still more difficult was the fact that the jet of steam might be inclined to any angle between the horizontal and perpendicular, and still held the ball, egg shell or other spherical figure, firmly in its vapory grasp.

Fig. 10, A, ball and socket jet at an angle, and discharging steam. The egg shells are supported by the enormous currents of air moving into the jet in the direction of the arrows.

WOOL DYEING.*

By GEORGE JARMAN.

(Continued from SUPPLEMENT No. 75.)

EXTRACTS OF INDIGO (INDIGO CARMINE.)

These are sulphuric acid derivatives of indigo obtained by dissolving indigo in strong, or even fuming, sulphuric acid. The extract, having a purple color, contains chiefly sulphopurpuric acid, $C_{12}H_7N_2O_2SC_2$, the blue extract contains sulphindigotic acid, $C_{12}H_7NO_2SO_3$. The production of these two varieties depends upon the strength of the acid used, and the temperature and time of contact.

The acid, or "sour extract," may be made by gradually adding 1 lb. of well powdered indigo to 12 lbs. of the strongest commercial sulphuric acid, stirring well during the addition. The mixture is then kept for two days, at a temperature of about 140° F. A little of the mixture dropped into water should completely dissolve. The mixture is poured into water, and is then ready for use. The best qualities of indigo and the refined article should be used in these preparations.

The sweet extract is made by neutralizing an acid extract with carbonate of soda and chalk, adding also salt. The sulphopurpuric and sulphindigotic acids form soda salts, which are insoluble in solutions of alkaline salts; the coloring matter can therefore be precipitated, filtered off, and washed. The following process gives a good sweet extract: Add gradually 9 lbs. of the strongest sulphuric acid to 1 lb. of the finest quality of indigo finely ground and sifted, stirring well all the time; set aside for a week at from 60° to 70° F.; then add a solution of 10 lbs. of common salt and 15 lbs. of soda crystals, then $\frac{1}{2}$ lb. of powdered chalk may be added, and the whole well stirred up and thrown upon a filter, and washed with a solution of salt, till the washings run through colorless.

The purple extract is made by using one third as much acid and leaving them in contact only a short time.

These dyes require no mordant for wool; they dye best in an acid bath, and the addition of sulphate of soda is found to be beneficial in clearing the liquid and producing evenness of shade.

They are not used as self colors on woolen goods, but enter largely into the composite colors of goods which do not require to be scoured afterwards.

They are not therefore fast colors, and cannot be compared with indigo colors dyed by vat processes, which possess a degree of permanence which has long given them a deserved popularity, as they remain unaffected alike by heat and cold, sunshine and rain, acid and alkali.

YELLOW COLORS.

The yellow coloring matters which I have now to describe are complementary to those which I have already brought under your notice, as they enable the dyer to complete the range of colors which are employed in the dyeing of cloths, the colors of which are required to be fast and permanent in the sense in which I have used these terms.

We will confine our attention, at the present, to the following yellow colors: Fustic, American bark, flavine, turmeric, Persian berries.

Fustic is the wood of a tree called *Morus tinctoria*. It is imported chiefly from Central America and the West Indies. It is known to the dyer under the names of old fustic and yellow wood. It is prepared for the use of the dyer as chipped fustic, rasped fustic, fustic extract. It is used extensively in all three forms. When the chips are used they are placed in a bag in the boiling water, in the same way as that in which logwood is used. Rasped fustic may be thrown into the pan along with the goods to be dyed.

The tinctorial principles contained in fustic consist of moritannic acid, a pale yellow crystallizable substance, freely soluble in water, morin or moric acid, a crystallizable substance nearly insoluble in water. As moric acid is but slightly soluble even in boiling water, the moritannic acid is the principal available coloring agent in fustic. Fustic gives a yellow color on wool which has been mordanted with chloride of tin, alum, or bichromate of potash, and olive green with a mordant of sulphate of copper or copperas. Fustic is rarely or never used as a self color, but it is very extensively employed along with logwood and the red woods in producing that infinite variety of shades of composite colors, known as blacks, browns, olives, drabs, etc., for which it is eminently adapted. Dyed on wool, with a bichromate of potash or copperas mordant, it produces a fast and beautiful and permanent color.

In the heavy woolen cloth districts, where pilots, beavers, naps, reversibles, fancy trousseings, and such like goods are manufactured, it is more extensively used than any other yellow dye-ware.

Its use and modifying action on other colors, such as logwood and the red woods, are best studied by dyeing equal weights of mordanted wool or cloth with varying quantities of fustic, and of the woods I have just named.

As examples of its modifying influence, I have placed before you samples dyed with the following quantities:

* A lecture before the Society of Arts.

Mordanted with two per cent. bichromate of potash; boiled one hour.

Sample.	Fustic.	Barwood.	Logwood
1. Dyed with	60	0	
2. "	30	30	
3. "	60	30	
4. "	20	40	
5. "	0	60	
6. "	40	20	3
7. "	40	20	saddened with copperas.

Sample.	Fustic.	Madder.	Logwood.
1. Dyed with	60	0	
2. "	40	20	
3. "	20	40	
4. "	0	60	
5. "	40	20	3
6. "	20	40	saddened with copperas.

Sample.	Fustic.	Sanderswood.	Logwood.
1. Dyed with	60	20	5
2. "	60	20	10
3. "	60	20	15
1. "	80	10	3
2. "	80	30	3
3. "	80	50	3
4. "	50	80	3
5. "	10	80	3

Sample.	Fustic.	Logwood.
1. "	60	5
2. "	60	10
3. "	60	20
4. "	60	30

It will be observed that each of the red woods and madder imparts its own special tone of color along with the fustic, and as the practical dyer has generally to dye to a pattern, it is almost useless to give any special formula for particular shades.

My purpose will be better served if I endeavor to indicate to you the specific purpose the dyer has before him, when he makes a selection of the red woods to be used: As a rule, the different shades of brown are obtained by using more than one red color, and sometimes three or four of the red colors are required in order to produce shades exactly like a given pattern. In my opinion there is no department of dyeing which requires such an amount of skill and practical experience, and knowledge of the modifying action of colors upon one another, as in the dyeing of the different tones of blacks, browns, and drabs, and it is wonderful to see with what precision some of our practical dyers can arrive at any particular tone or shade.

In the use of the red woods as modifying agents, the following points should be borne in mind:

1. Camwood is stronger, faster, and brighter than either barwood or sanders.
2. Barwood gives brightness and lustre, but lacks body.
3. Sanderswood gives a more yellow red than camwood or barwood. It contains more color than barwood, but its color is not so bright.
4. Madder gives the finest, brightest, and fastest color; it contains more yellow color than the red woods, but its red coloring matter is superior to those of the red woods.
5. Sumac gives a fine olive yellow shade to brown, and helps to sadden when copperas is used.
6. Logwood in small quantities, say one, two, or three per cent., saddens or dulls the colors of the red and yellow woods.
7. Cudbear has a brightening effect, giving a purple tone to colors.

Incidentally, I may mention a particular effect which is frequently met with in dyeing of wool. The tips of the locks of wool often take a deeper shade of color than the remaining portion of the lock, and as the wool becomes thoroughly mingled in the processes of carding, scribbling, and spinning, to which it has to be subjected preparatory to its final manufacture into cloth, the dyer has to take into account the effect which will be produced by such admixture of color.

In cases of this kind, the general effect produced by the dye may be ascertained by teasing out in the hand a small sample, so that the whole is made as even as possible. On comparing this with the pattern, it will be seen whether the proper effect has been obtained, or whether some additional color, and what color, is required.

There is another effect which is often perplexing to a young dyer; the red and yellow colors have different affinities for the mordanted wool; the red wool colors partially displace the yellow colors. If wool, in the course of dyeing, appears to have received a sufficient amount of yellow, but there is a deficiency of red, and the dyer proceeds to add what he conceives to be a sufficient quantity of red to make up the deficiency, and bring the goods up to sample, he will frequently find that he will then have on too much red and too little yellow. The additional quantities of wood required are added in the form of rasped or ground wood, which is well worked up with the goods, or a solution of the extract may be employed for the same purpose.

The following receipts are examples of the use of several woods which were found to be required in order that a particular shade of color might be obtained:

TAN BROWN.

Mordant—	Per cent.
Bichromate of potash.....	1
Boiled for one hour.	
Dye—	Per cent.
Madder.....	3.2
Fustic.....	4.8
Camwood.....	2
Barwood.....	1.75
Sumac.....	2.2
Boiled two hours.	

TAN BROWN, REDDER SHADE.

Mordant—	Per cent.
Bichromate of potash.....	1
Boil one hour.	
Dye—	Per cent.
Fustic.....	7.2
Madder.....	4.8
Camwood.....	2.8
Sumac.....	2.4
Boil two hours.	

CALIFORNIA.

Mordant—	Per cent.
Alum.....	1
Bichrome.....	1
D.O.V.....	$\frac{1}{2}$
Boil one hour.	

Dye—	Per cent.
Fustic.....	25
Madder.....	2
Camwood.....	3
Boil one hour and a half.	

DARK DRAB.

Dye—	Per cent.
Camwood.....	6.5
Sumac.....	2
Madder.....	2.5
Fustic.....	4
Logwood.....	2.5

Boil one hour and a half. Sadden with one per cent. copperas.

OLIVE DRAB.

Mordant—	Per cent.
Bichromate of potash.....	1
Boil one hour.	

Dye—	Per cent.
Fustic.....	10
Sumac.....	2
Madder.....	5
Logwood.....	2
Boil two hours.	

MADDER BROWN.

Mordant—	Per cent.
Bichromate of potash.....	1
Boil one hour.	

Dye—	Per cent.
Fustic.....	22.7
Madder.....	11.35
Logwood.....	1.13
Boil two hours.	

DRAB.

Dye—	Per cent.
Fustic.....	1.7
Madder.....	4
Cudbear.....	1
Sumac.....	8

Boil one hour and a half, and sadden with 2 per cent. copperas.

QUERCITRON BARK.

Quercitron bark is the inner bark of *Quercus tinctoria*, another species of oak indigenous to North America. For the use of the dyer the bark is dried and ground.

The principal coloring matter contained in it is quercitrin, a glucoside which is capable of breaking up into a sugar, and quercetin. Both quercitrin and quercetin are yellow coloring matters which, in their effect upon mordanted wool, act very much like the coloring matter of fustic.

In woolen dyeing the use of "bark," as quercitron bark is frequently called, was introduced by Bancroft, to whom we are also indebted for the most original work on dyeing we possess in the English language.

The use of the bark is not as extensive as that of fustic, but it may be used for the same purpose, though it does not give the same amount of body of color.

FLAVIN

A preparation of bark known under the name of flavin is often used, when shades brighter than what can be obtained with fustic or bark are required.

Flavin consists mainly, if of good quality, of the coloring principle itself, namely, quercitrin or quercetin; its coloring power is therefore far greater than that of bark. One ounce of good flavin is equal in tinctorial power to 1 lb. of bark.

The best qualities of flavin are imported from America, where it is believed to be made from the fresh bark, but there seems to be some mystery about its mode of preparation.

Flavin is used for the yellow part of scarlets and oranges, and for almost any color where a good bright yellow is required.

The coloring matters of fustic, quercitron bark, and flavin may be described as fast and permanent dyes for wool.

YOUNG FUSTIC.

This is the wood of the *Rhus cotinus*, a tree which grows in southern Europe and the West Indies. It is prepared in the form of chips for the use of the dyer. Young fustic contains an astringent principle and two coloring matters, a yellow and a red.

The name fustin has been given to the yellow color, which possesses many of the characteristics of quercitron, but there are some slight differences. On wool mordanted with a tin salt it produces a fine and tolerably fast yellow orange. Its chief employment in woolen dyeing is for the production of scarlets and oranges along with cochineal, for which purpose it is extremely well adapted.

The two remaining yellow dye-ware which I have to describe, on account of their loose and fugitive character, cannot be used with advantage for the dyeing of woolen cloths for men's wear. They are turmeric and Persian berries.

TURMERIC.

Turmeric is the underground stem of *Curcuma tinctoria* and *Curcuma longa*, and is imported from India, China, Java, and Barbadoes. The Indian variety is the most valued. For the use of the dyer the stems or tubers are dried and ground to a fine powder. The powder has a powerful odor, and a strong aromatic taste. The coloring principle contained in turmeric is called curcumin. In wool dyeing, the use of turmeric is confined to the dyeing of a certain class of browns on stuffs, and is often associated with colors of a fugitive character like itself. It finds no use in the heavy cloth districts, and if its employment were altogether discontinued as a woolen dye material, it would be no