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[Illustration]

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IMPROVED DYNAMO MACHINE.

The continuous current and the alternating current generators invented by Dr. J. Hopkinson and Dr. Alexander Muirhead are peculiarly interesting as being probably the first in which the bobbins of the armature were wound with copper ribbon and arranged on a disk armature much in the same way as was afterward done by Sir William Thomson and by Mr. Ferranti. In the Muirhead-Hopkinson machine the armature coils are attached to a soft iron ring, whereas in the Ferranti the iron core is dispensed with, and a gain of lightness in the armature or rotating part effected; this advantage is of considerable importance, though Messrs. Hopkinson and Muirhead can of course reduce the weight of this iron core to insignificant proportions.

[Illustration: HOPKINSON & MUIRHEAD’S DYNAMO-ELECTRIC GENERATOR.]

The general form of this generator is clearly shown by the side and end elevation.

The armature is made by taking a pulley and encircling it with a rim of sheet-iron bands, each insulated from the other by asbestos paper. On one or both sides of the rim thus formed, radial slots are cut to admit radial coils of insulated copper wire or ribbon, so that they lie in planes parallel to the plane of the pulley. In the continuous current machine coils are placed on both sides of the iron rim and arranged alternately, that on the one side always covering the gap between two on the other side. In this way, when a coil on one side of the rim is at its "dead point" and yields its minimum of current, the corresponding coil on the other side is giving out its maximum.

The field magnets are made in a similar manner to the armature and run in circles parallel to the rim of the latter. The cores may be built up of wrought iron as the rim of the armature is; but it is found cheaper to make them of solid wrought or cast iron. To stop the local induced currents in the core, however, Messrs. Muirhead and Hopkinson cut grooves in the faces of the iron cores, and fill them up with sheet-iron strips insulated from each other, similar to the sheet-iron rim of the armature.

The coils, both in the armature and electro-magnets, are packed as closely as they may to each other, and have thus a compressed or quadrilateral shape. The arrangement is shown in Figs. 1 and 2, which represent, in side view and plan, the armature pulley with the soft iron rim and coils attached. There a is the pulley which is keyed to the shaft of the machine, and is encircled with bands of sheet iron, b, insulated from each other by ribbons of asbestos paper laid between every two bands. When the rim has been built up in this way, radial holes are drilled through it from the outer edge inward, and the whole rim is bound together by bolts, d, inserted in the holes and secured by cottars, e. Radial slots are then cut on each side of the rim all round, and the coils of wire mounted on them.

Figs. 3 and 4 show the armature of the continuous current dynamo, with the coils on one side of the rim, half way between the coils on the other side, so as to give a more continuous current. In the alternating current machine the slots on the opposite faces are face to face.

Figs. 5 and 9 illustrate the complete continuous current machine, Fig. 9 showing the internal arrangement of the field magnets, and Fig. 5 the external frame of cast iron supporting them. In these figures a is the armature already described, b b are the cores of the electro-magnets with a strong cast iron backing, c c; d d are the exciting coils or field magnets, so connected that the poles presented to the armature are alternately north and south, thus bringing a south pole on one side of the armature opposite a north pole on the other side.

The commutator, e, is arranged to prevent sparking when the brushes leave a contact piece. This is done by splitting up the brushes into several parts and inserting resistances between the part which leaves the contact piece last and the rest of the circuit. This resistance checks the current ere the final rupture of contact takes place.

Figs. 6 and 7 will explain the structure of the commutator. Here a a a are the segments or contact pieces insulated from each other, and b’ b b are the collecting brushes carried on a spindle, c c’. One of these brushes, b’, is connected to the spindle, c, through an electrical resistance of plumbago, arranged as shown in Fig. 7, where d e are metal cylinders, d being in contact with the brush, b’, while e is in contact with the spindle, c. The space, f, between these two cylinders, d e, is filled with a mixture of plumbago and lampblack of suitable resistance, confined at the ends by ivory disks. The brush, b’, is adjusted by bending till it remains in contact with any segment of the commutator for a short time after the other brushes have left contact with that segment, and thus instead of sudden break of circuit and consequent sparking, a resistance is introduced, and contact is not broken until the current has been considerably reduced.

The contact segments are supported at both ends by solid insulating disks; but they are insulated from each other by the air spaces between them, where the brushes rub upon them.

The alternating current dynamo of Drs. Hopkinson and Muirhead differs little in general construction from that we have described; except that the commutator is very much simplified, and the armature bobbins are placed opposite each other on both sides of the rim. Instead of forming the coils into complete bobbins, Dr. Muirhead prefers to wind them in a zigzag form round the grooved iron rim after the manner shown in Fig. 8, which represents a plan and section of the alternating current armature. This arrangement is simpler in construction than the bobbin winding, and is less liable to generate self-induction current in the armature. Sir William Thomson has adopted a similar plan in one of his dynamos. In Fig. 8, a is the pulley fixed to the spindle of the machine, b b is the iron rim, and c c are the zigzag coils of copper ribbon. The field magnets are also wound in a similar manner.

It will be seen from our description that Drs. Hopkinson and Muirhead have scarcely had sufficient credit given them for this interesting machine, which so closely approximates to the Ferranti. One of their alternating dynamos has been built, and was shown at the Aquarium Exhibition. It works well, and is capable of supporting 300 Swan lights, while in size and appearance it resembles the Ferranti machine in a very striking manner. Drs. Muirhead and Hopkinson have also designed a magneto-electric alternating current machine; but as it closely resembles the machines described, with the exception that permanent magnets are employed as field magnets, we need not dwell upon it further.--_Engineering_.

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AN IMPROVED MANGANESE BATTERY.

By GEORGE LEUCHS.

The Leclanche battery is distinguished for its simplicity, its small internal resistance (0.7 to 1.0 Siemens unit), and that all chemical action ceases when the current is broken, that it is not sensitive to external influence, and by the self-renewal of the negative electrodes. But on the opposite side the action is not very great (= 1.20 or 1.48 D.), and the zinc as well as the sal ammoniac are converted into products that cannot be utilized.

I replace the solution of sal ammoniac by one of caustic potash or soda (12 to 15 per cent.), and the thin zinc rods by zincs with larger surfaces. In this manner, I obtain a powerful and odorless battery, having all the valuable qualities of the Leclanche, and one that permits of a renewal of the potash solution as well as of the negative electrode.

The electromotive power of this element may be as high as 1.8 D. The same pyrolusite (binoxide of manganese) cylinder used with the same thin rod of zinc will precipitate 75 per cent. more copper from solution in an hour when caustic potash is used than when sal ammoniac is employed. But by replacing the thin zinc rod by a zinc cylinder of large surface, 2‰ times as much copper is precipitated in the same time.

The more powerful action of such a pair is explained by the stronger excitation and more rapid regeneration that the negative electrodes undergo from the oxidizing action of the air in the potash solution, as well as by the fact that this solution is a better conductor than the sal ammoniac solution. The potash solution does not crystallize easily, hence the negative electrode remains free from crystals and does not require filling up with water. Zinc dissolves only while in contact with negative bodies, hence there is no unnecessary consumption of zinc either in the open or closed circuit.

When the potash lye has become useless, I regenerate it by removing the zinc in the following manner: I pour the solution from the cells, put it in a suitable vessel, where I add water to replace that already evaporated, and then shake it up well at the ordinary temperature with hydrated oxide of zinc (zincic hydrate). Under this treatment the greater portion of the zinc that had been chemically dissolved by the potash is precipitated in the form of zinc hydrate, along with some carbonate. The liquid is now allowed to settle, and the clear supernatant solution is poured back again into the battery cells. The battery has rather greater electromotive force when this regenerated lye is used, because certain foreign matters from the carbon, like sulphur, chlorine, sulphuric acid, etc., are removed by this treatment.

The regeneration of the (brown coal) carbon goes on of itself, beneath the lye, through the oxidizing action of the atmospheric air; it is advantageous to have a part of the carbon sticking out of the liquid. Of course the regeneration takes place much more quickly if the electrodes are taken out and exposed to the air. In this case the carbon electrode need not be very thick, and can be flat or of tubular form. In the former case it must have a large volume, and the massive cylindrical form is recommended. The zinc electrode must be kept covered deeply with potash. The cells must have free access of air, and the potash must be replaced as soon as it is exhausted.--_Chem. Zeit_.

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[Concluded from SUPPLEMENT No. 390, page 6217.]

THE CAUSE OF EVIDENT MAGNETISM IN IRON, STEEL, AND OTHER MAGNETIC METALS.

[Footnote: Paper lately read before the Society of Telegraph Engineers and Electricians.]

By Professor D. E. HUGHES, F.R.S., Vice-President.

NEUTRALITY.

The apparatus needed for researches upon evident external polarity requires no very great skill or thought, but simply an apparatus to measure correctly the force of the evident repulsion or attraction; in the case of neutrality, however, the external polarity disappears, and we consequently require special apparatus, together with the utmost care and reflection in its use.

From numerous researches previously made by means of the induction balance, the results of which I have already published, I felt convinced that in investigating the cause of magnetism and neutrality I should have in it the aid of the most powerful instrument of research ever brought to bear upon the molecular construction of iron, as indeed of all metals. It neglects all forces which do not produce a change in the molecular structure, and enables us to penetrate at once to the interior of a magnet or piece of iron, observing only its peculiar structure and the change which takes place during magnetization or apparent neutrality.

The induction balance is affected by three distinct arrangements of molecular structure in iron and steel, by means of which we have apparent external neutrality.

Fig 1 shows several polar directions of the molecules as indicated by the arrows. Poisson assumed as a necessity of his theory, that a molecule is spherical; but Dr. Joule's experimental proof of the elongation of iron by one seven-hundred and-twenty-thousandth of its length when magnetized, proves at least that its form is not spherical; and, as I am unable at present to demonstrate my own views as to its exact form, I have simply indicated its polar direction by arrows--the dotted oval lines merely indicating its limits of free elastic rotation.

In Fig. 1, at A, we have neutrality by the mutual attraction of each pair of molecules, being the shortest path in which they could satisfy their mutual attractions. At B we have the case of superposed magnetism of equal external value, rendering the wire or rod apparently neutral, although a lower series of molecules are rotated in the opposite direction to the upper series, giving to the rod opposite and equal polarities. At C we have the molecules arranged in a circular chain around the axis of a wire or rod through which an electric current has passed. At D we have the evident polarity induced by the earth's directive influence when a soft iron rod is held in the magnetic meridian. At E we have a longitudinal neutrality produced in the same rod when placed magnetic west, the polarity in the latter case being transversal.

In all these cases we have a perfectly symmetrical arrangement, and I have not yet found a single case in well-annealed soft iron in which I could detect a heterogeneous arrangement, as supposed by Ampere, De la Rive, Weber, Wiedermann, and Maxwell.

We can only study neutrality with perfectly soft Swedish iron. Hard iron and steel retain previous magnetizations, and an apparent external neutrality would in most cases be the superposition of one magnetism upon another of equal external force in the opposite direction, as shown at B, Fig. 1. Perfectly soft iron we can easily free, by vibrations, from the slightest trace of previous magnetism, and study the neutrality produced under varying conditions.

[Illustration: FIG. 1.]

If we take a flat bar of soft iron, of 30 or more centimeters in length, and hold it vertically (giving while thus held a few torsions, vibrations, or, better still, a few slight blows with a wooden mallet, in order to allow its molecules to rotate with perfect freedom), we find its lower end to be of strong north polarity, and its upper end south.

On reversing the rod and repeating the vibrations, we find that its lower end has precisely a similar north polarity. Thus the iron is homogeneous, and its polarity symmetrical. If we now magnetize this rod to produce a strong south pole at its lower portion, we can gradually reverse this polarity, by the influence of earth's magnetism, by slightly tapping the upper extremity with a small wooden mallet. If we observe this rod by means of a direction needle at all parts, and successively during its gradual passage from one polarity to the other, there will be no sudden break into a haphazard arrangement, but a gradual and perfectly symmetrical rotation from one direction to that of the opposite polarity.

If this rod is placed east and west, having first, say, a north polarity to the right, we can gradually discharge or rotate the molecules to zero, and as gradually reverse the polarity by simply inclining the rod so as to be slightly influenced by earth's magnetism; and at no portion of this passage from one polarity to neutrality, and to that of the opposite name, will there be found a break of continuity of rotation or haphazard arrangement. If we rotate this rod slowly, horizontally or vertically, taking observations at each few degrees of rotation of an entire revolution, we find still the same gradual symmetrical change of polarity, and that its symmetry is as complete at neutrality as in evident polarity.

In all these cases there is no complete neutrality, the longitudinal polarity simply becoming transversal when the rod is east and west. F, G, H, I, J, Fig. 1, show this gradual change, H being neutral longitudinally, but polarized transversely. If, in place of the rod, we take a small square soft iron plate and allow its molecules freedom under the sole influence of the earth's magnetism, then we invariably find the polarity in the direction of the magnetic dip, no matter in what position it be held, and a sphere of soft iron could only be polarized in a similar direction Thus we can never obtain complete external neutrality while the molecules have freedom and do not form an internal closed circle of mutual attractions; and whatever theory we may adopt as to the cause of polarity in the molecule, such as Coulomb's, Poisson's, Ampere's, or Weber's, there can exist no haphazard arrangement in perfectly soft iron, as long as it is free from all external causes except the influence of the earth; consequently these theories are wrong in one of their most essential parts.

We can, however, produce a closed circle of mutual attraction in iron and steel, producing complete neutrality as long as the structure is not destroyed by some stronger external directing influence.

Oersted discovered that an external magnetic needle places itself perpendicular to an electric current; and we should expect that, if the molecules of an iron wire possessed inherent polarity and could rotate, a similar effect would take place in the interior of the wire to that observed by Oersted. Wiedermann first remarked this effect, and it has been known as circular magnetism. This circle, however, consists really in each molecule having placed itself perpendicular to the current, simply obeying Oersted's law, and thus forming a complete circle in which the mutual attractions of the molecules forming that circle are satisfied, as shown as C, Fig. 1. This wire becomes completely neutral, any previous symmetrical arrangement of polarity rotating to form its complete circle of attractions; and we can thus form in hard iron and steel a neutrality extremely difficult to break up or destroy. We have evident proof that this neutrality consists of a closed chain, or circle, as by torsion we can partially deflect them on either side; thus from a perfect externally neutral wire, producing either polarity, by simple mechanical angular displacement of the molecules, as by right or left handed torsion.

If we magnetize a wire placed east and west, it will retain this polarity until freed by vibrations, as already remarked. If we pass an electric current through this magnetized wire, we can notice the gradual rotation of the molecules, and the formation of the circular neutrality. If we commence with a weak current, gradually increasing its strength, we can rotate them as slowly as may be desired. There is no sudden break or haphazard moment of neutrality: the movements to perfect zero are accomplished with perfect symmetry throughout.

We can produce a more perfect and shorter circle of attractions by the superposition of magnetism, as at B, Fig. 1. If we magnetize a piece of steel or iron in a given direction with a strong magnetic directing power, the magnetism penetrates to a certain depth. If we slightly diminish the magnetizing power, and magnetize the rod in a contrary direction, we may reduce it to zero, by the superposition of an exterior magnetism upon one of a contrary name existing at a greater depth; and if we continue this operation, gradually diminishing the force at each reversal, we can easily superpose ten or more distinct symmetrical arrangements, and, as their mutual attractions are satisfied in a shorter circle than in that produced by electricity, it is extremely difficult to destroy this formation when once produced.

The induction balance affords also some reasons for believing that the molecules not only form a closed circle of attractions, as at B, but that they can mutually react upon each other, so as to close a circle of attractions as a double molecule, as shown at A. The experimental evidence, however, is not sufficient to dwell on this point, as the neutrality obtained by superposition is somewhat similar in its external effects.

We can produce a perfectly symmetrical closed circle of attractions of the nature of the neutrality of C, Fig. 3, by forming a steel wire into a closed circle, 10 centimeters in diameter, if this wire is well joined at its extremities by twisting and soldering. We can then magnetize this ring by slowly revolving it at the extremity of one pole of a strong permanent magnet; and, to avoid consequent poles at the part last touching the magnet, we should have a graduating wedge of wood, so that while revolving it may be gradually removed to greater distance. This wire will then contain no consequent points or external magnetism: it will be found perfectly neutral in all parts of its closed circle. Its neutrality is similar to C, Fig. 3; for if we cut this wire at any point we find extremely strong magnetic polarity, being magnetized by this method to saturation, and having retained (which it will indefinitely) its circle of attractions complete.

I have already shown that soft iron, when its molecules are allowed perfect freedom by vibration, invariably takes the polarity of the external directing influence, such as that of the earth, and it does so even with greater freedom under the influence of heat. Manufacturers of electro-magnets for telegraphic instruments are very careful to choose the softest iron and thoroughly anneal it; but very few recognize the importance as regards the position of the iron while annealing it under the earth's directing influence. The fact, however, has long since been observed.

Dr. Hooke, 1684, remarked that steel or iron was magnetized when heated to redness and placed in the magnetic meridian. I have slightly varied this experiment by heating to redness three similar steel bars, two of which had been previously magnetized to saturation, and placed separately with contrary polarity as regards each other, the third being neutral. Upon cooling, these three bars were found to have identical and similar polarity. Thus the molecules of this most rigid material, cast steel, had become free at red heat, and rotated under the earth's magnetic influence, giving exactly the same force on each; consequently the previous magnetization of two of these bars had neither augmented nor weakened the inherent polarity of their molecules. Soft iron gave under these conditions by far the greatest force, its inherent polarity being greater than that of steel.

I have made numerous other experiments bearing upon the question of neutrality, but they all confirm those I have cited, which I consider afford ample evidence of the symmetrical arrangement of neutrality.

SUPERPOSED MAGNETISM.

Knowing that by torsion we can rotate or diminish magnetism, I was anxious to obtain by its means a complete rotation from north polarity to neutrality, and from neutrality to south polarity, or to completely reverse magnetic polarity by a slight right or left torsion.

I have succeeded in doing this, and in obtaining strong reversal of polarities, by superposing one polarity given while the rod is under a right elastic torsion, with another of the opposite polarity given under a left elastic torsion, the neutral point then being reached when the rod is free from torsion. The rod should be very strongly magnetized under its first or right-hand torsion, so that its interior molecules are rotated, or, in other words, magnetized to saturation; the second magnetization in the contrary sense and torsion should be feebler, so as only to magnetize the surface, or not more than one-half its depth; these can be easily adjusted to each other so as to form a complete polar balance of force, producing, when the rod is free from torsion, the neutrality as shown at B, Fig. 1.

The apparatus needed is simply a good compound horseshoe permanent magnet, 15 centimeters long, having six or more plates, giving it a total thickness of at least 3 centimeters. We need a sufficiently powerful magnet, as I find that I obtain a more equal distribution of magnetism upon a rod or strip of iron by drawing it lengthwise over a single pole in a direction from that pole, as shown in Fig. 2; we can then obtain saturation by repeated drawings, keeping the same molecular symmetry in each experiment.

In order to apply a slight elastic torsion when magnetizing rods or wires, I have found it convenient to attach two brass clamp keys to the extremities of the rods, or simply turn the ends at right angles, as shown in the following diagram, by which means we can apply an elastic twist or torsion while drawing the rod over the pole of the permanent magnet. We can thus superpose several and opposite symmetrical structures, producing a polar north or south as desired, greatly in excess of that possible under a single or even double magnetization, and by carefully adjusting the proportion of opposing magnetisms, so that both polarities have the same external force, the rod will be at perfect external neutrality when free from torsion.

[Illustration: FIG. 2.]

If we now hold one end of this rod at a few centimeters distance from a magnetic directive needle, we find it perfectly neutral when free of torsion, but the slightest torsion right or left at once produces violent repulsion or attraction, according to the direction of the torsion given to the rod, the iron rod or strips of hoop-iron which I use for this experiment being able, when at the distance of five centimeters from the needle, to turn it instantly 90° on either side of its zero.

The external neutrality that we can now produce at will is absolute, as it crosses the line of two contrary polarities, being similar to the zero of my electric sonometer, whose zero is obtained by the crossing of two opposing electric forces.

This rod of iron retains its peculiar powers of reversal in a remarkable degree, a condition quite different to that of ordinary magnetization, for the same rod, when magnetized to saturation under a single ordinary magnetism, loses its evident magnetism by a few elastic torsions, as I have already shown; but when it is magnetized under the double torsion with its superposed magnetism, it is but slightly reduced by variations or numerous torsions, and I have found it impossible to render this rod again free from its double polar effects, except by strongly remagnetizing it to saturation with a single polarity. The superposed magnetism then becomes a single directive force, and we can then by a few vibrations or torsions reduce the rod to its ordinary condition.

The effects of superposed magnetism and its double polarity I have produced in a variety of ways, such as by the electro-magnetic influence of coils, or in very soft iron simply by the directive influence of the earth’s magnetism, reversing the rod and torsions when held in the magnetic meridian, these rods when placed magnetic west showing distinctly the double polar effects.

It is remarkable, also, that we are enabled to superpose and obtain the maximum effects on thin strips of iron from … to ‰ millimeter in thickness, while in thicker rods we have far less effect, being masked by the comparatively neutral state of the interior, the exterior molecules then reaching upon those of the interior, allowing them to complete in the interior their circle of attractions.

I was anxious to obtain wires which would preserve this structure against the destructive influence of torsion and vibrations, so that I could constantly employ the same wires without the comparatively long and tedious process of preparation. Soft iron soon loses the structure, or becomes enfeebled, under the constant to and fro torsions requisite where we desire a constant change of polarity, as described later in the magnetic bells. Hard steel preserves its structure, but its molecular rigidity is so great that we obtain but mere traces of any change of polarity by torsion. I have found, however, that fine cast drill steel, untempered, of the kind employed by watchmakers, is most suitable; these are generally sold in straight lengths of 30 centimeters. Wires 1 millimeter in diameter should be used, and when it is desired to increase the force, several of these wires, say, nine or ten, should be formed into a single rod or bunch.

The wire as sold is too rigid to give its maximum of molecular rotation effect. We must therefore give it two entire turns or twists to the right, and strongly magnetize it on the north pole of the magnet while under torsion. We must again repeat this operation in the contrary direction, after restoring the wire to its previous position, giving now two entire turns to the left and magnetizing it on the south pole. On restoring the wire to its original place, it will be extremely flexible, and we may now superpose several contrary polarities under contrary torsions, as already described.

The power of these wires, if properly prepared, is most remarkable, being able to reverse their polarity under torsion, as if they were completely saturated; and they preserve this power indefinitely if not touched by a magnet. It would be extremely difficult to explain the action of the rotative effects obtained in these wires under any other theory than that which I have advanced; and the absolute external neutrality that we obtain in them when the polarities are changing, we know, from their structure, to be perfectly symmetrical.

I was anxious to show, upon the reading of this paper, some mechanical movement produced by molecular rotation, consequently I have arranged two bells that are struck alternately by a polarized armature put in motion by the double polarized rod I have already described, but whose position, at three centimeters distant from the axis of the armature, remains invariably the same. The magnetic armature consists of a horizontal light steel bar suspended by its central axle; the bells are thin wine glasses, giving a clear musical tone loud enough, by the force with which they are struck, to be clearly heard at some distance. The armature does not strike these alternately by a pendulous movement, as we may easily strike only one continuously, the friction and inertia of the armature causing its movements to be perfectly dead beat when not driven by some external force, and it is kept in its zero position by a strong directive magnet placed beneath its axle.

The mechanical power obtained is extremely evident, and is sufficient to put the sluggish armature in rapid motion, striking the bells six times per second, and with a power sufficient to produce tones loud enough to be clearly heard in all parts of the hall of the Society. As this is the first direct transformation of molecular motion into mechanical movement, I am happy to show it on this occasion.

There is nothing remarkable in the bells themselves, as they evidently could be rung if the armature was surrounded by a coil, and worked by an electric current from a few cells. The marvel, however, is in the small steel superposed magnetic wire producing by slight elastic torsions from a single wire, one millimeter in diameter, sufficient force from mere molecular rotation to entirely replace the coil and electric current.

ELASTIC NATURE OF THE ETHER SURROUNDING THE MAGNETIC MOLECULES.

During these researches I have remarked a peculiar property of magnetism, viz., that not only can the molecules be rotated through any degree of arc to its maximum, or saturation, but that, while it requires a comparatively strong force to overcome its rigidity or resistance to rotation, it has a small field of its own through which it can move with excessive freedom, trembling, vibrating, or rotating through a small degree with infinitely less force than would be required to rotate it permanently on either side. This property is so marked and general that we can observe it without any special iron or apparatus.

Let us take a flat rod of ordinary hoop iron, 30 or more centimeters in length. If, while holding this vertically, we give freedom to its molecules by torsions, vibrations, or, better still, by a few blows with a wooden mallet upon its upper extremity, we find, as is well known, that its lower portion is strongly north, and its upper south. If we reverse this rod, we now find it neutral at both extremities. We might here suppose that the earth’s directing force had rotated the molecules to zero, or transversely, which in reality it has done, but only to the limit of their comparatively free motion; for if we reverse the rod to its original position, its previous strong polarity reappears at both extremities, thus the central point of its free motion is inclined to the rod, giving by its free motion great symmetrical inclination and polarity in one direction, but when reversed the inclination is reduced to zero.

In Fig. 3, D shows the bar of iron when strongly polarized by earth’s magnetic influence, under vibrations, with a sufficient force to have rotated its elastic center of action. C shows the same bar with its molecules at zero, or transversal, the directing force of earth being insufficient without the aid of mechanical vibration to allow them to change. The dotted lines of D suppose the molecule to be in the center of its free motion, while at C the molecules have rotated to zero, as they are prevented from further rotation by being at the extreme end of its free motion.

If, now, we hold the rod vertically, as at C, giving neutrality, and give a few slight blows with a wooden mallet to its upper extremity, we can give just the amount of freedom required for it to produce evident polarity, and we then have equal polarity, no matter which end of the bar is below, the center of its free rotation here being perfect, and the rod perfectly neutral longitudinally when held east and west. If, on the other hand, we have given too much freedom by repeated blows of the mallet, its center of free motion becomes inclined with the molecules, and we arrive at its first condition, except that it is now neutral at D and polarized at C. From this it will be seen that we can adjust this center of action, by vibrations or blows, to any point within the external directing influence.

[Illustration: FIG. 3.]

We can perceive this effect of free rotation in a limited space in all classes of iron and steel, being far greater in soft Swedish iron than in hard iron or steel. A similar phenomenon takes place if we magnetize a rod held vertically in the direction of earth’s magnetism. It then gives greater polarity than if magnetized east or west, and if magnetized in a contrary sense to earth’s magnetism, it is very feebly magnetized, or, if the rod is perfectly soft, it becomes neutral after strong magnetization. This property of comparative freedom, and the rotation of its center of action, can be demonstrated in a variety of ways. One remarkable example of it consists in the telephone. All those who are thoroughly acquainted with electro-magnetism, and know that it requires measurable time to charge an electro-magnet to saturation (about one-fifteenth of a second for those employed in telegraphy), were surprised that the telephone could follow the slightest change of timbre, requiring almost innumerable changes of force per second. I believe the free rotation I have spoken of through a limited range explains its remarkable sensitiveness and rapidity of action, and, according to this view, it would also explain why loud sounding telephones can never repeat all the delicacy of timbre that is easily done with those only requiring a force comprised in the critical limits of its free rotation. This property, I have found, has a distinct critical value for each class of iron, and I propose soon to publish researches upon the molecular construction of steel and iron, in which I have made use of this very property as a guide to the quality of the iron itself.

The elastic rotation (in a limited space) of a molecule differs entirely from that known as mechanical elasticity. In perfectly soft iron we have feeble _mechanical_ elasticity, while in tempered steel we have that elasticity at its maximum. The contrary takes place as regards _molecular_ elasticity. In tempered steel the molecules are extremely rigid, and in soft iron its molecular elasticity is at its maximum. Its free motion differs entirely from that given it by torsion or stress. We may assume that a molecule is surrounded by continuous ether, more of the nature of a jelly than of that of a gas; in such a medium a molecule might freely vibrate through small arcs, but a rotation extending beyond its critical limit would involve a much greater expenditure of force.

The discovery of this comparatively free rotation of molecules, by means of which, as I have shown, we can (without in any degree disturbing the external mechanical elasticity of the mass) change the axes of their free motion in any direction desired, has led me into a series of researches which have only indirectly any relation with the theory of magnetism. I was extremely desirous, however, of finding an experimental evidence which in itself should demonstrate all portions of the theory, and the following experiment, I believe, answers this purpose.

Let us take a square soft iron rod, five millimeters in diameter by thirty or more centimeters in length, and force the molecules, by aid of blows from a wooden mallet, as previously described, to have their centers of free motion in one direction; the rod will (as already shown) have polarity at both ends, when held vertically; but if reversed, both ends become completely neutral.

If now we turn the rod to its first position, in which it shows strong polarity, and magnetize it while held vertically, by drawing the north pole of a sufficiently powerful permanent magnet from its upper to its lower extremity, we find that this rod, instead of having south polarity at its lower portion, as we should expect from the direction of the magnetization, is completely neutral at both extremities, but if we reverse the rod its fullest free powers of magnetization now appear in the position where it was previously neutral. Thus, by magnetization, we have completely rotated its free path of action, and find that we can rotate this path as desired in any direction by the application of a sufficient directing power.

If we take a rod as described, with its polarities evident when held vertically, and its neutrality also evident when its ends are reversed in the same magnetic field, we find that its polarity is equal at both ends, and that it is in every way symmetrical with a perfect magnet. If we _gradually_ reverse the ends and take observations of its condition through each degree of arc passed over, we find an equal symmetrical diminution of evident external polarity, until we arrive at neutrality, when it has no external trace of inherent polarity; but its inherent polarity at once becomes evident by a simple return to its former position. Thus the rod has passed through all the changes from polarity to neutrality, and from neutrality to polarity, and these changes have taken place with complete symmetry.

The limits of this paper do not allow me to speak of the numerous theoretical evidences as shown by the use of my induction balance. I believe, however, that I have cited already experimental evidences to show that what has been attributed to coercive force is really due to molecular freedom or rigidity; that in inherent molecular polarity we have a fact admitted by Coulomb, Poisson, Ampere, De la Rive, Weber, Du Moncel, Wiedermann, and Maxwell; and that we have also experimental evidence of molecular rotation and of the symmetrical character of polarity and neutrality.

The experiments which I have brought forward in this paper, in addition to those mentioned in my paper read before the Royal Society, will, I hope, justify me in having advanced a theory of magnetism which I believe in every portion allows at least experimental evidences of its probable truth.

* * * * *

THE WESTINGHOUSE BRAKE.

Below we illustrate the main parts of the Westinghouse brake as applied to a vehicle. The supplementary reservoir brake cylinder and triple valve are shown in position, and as fitted upon the engine, tender, and each vehicle of the train. Air compressed by a pump on the locomotive to, say, 70 lb. or 80 lb. to the square inch fills the main reservoir on the engine, and flowing through the driver's brake valve and main pipe, also charges the supplementary reservoirs throughout the train. When a train is running, uniform air pressure exists throughout its length--that is to say, the main reservoir on the engine, the pipe from end to end of train, the triple valves and supplementary reservoirs on each vehicle, are all charged ready for work, the brake cylinders being empty and the brakes off. The essential principle of the system is, that maintaining the pressure keeps the brakes off, but letting the air escape from the brake pipe, purposely or accidentally, instantly applies them. It follows, therefore, that the brake may be applied by the driver or any of the guards, or if necessary by a passenger, by the separation of a coupling, or the failure or injury to a vital part of the apparatus, whether due to an accident to the train or to the brake; and as the brake on each vehicle is complete in itself and independent, should the apparatus on any one carriage be torn off, the brake will nevertheless remain applied for almost any length of time upon the rest of the train.

The triple valve, as will be seen, is simply a small piston, carrying with it a slide valve, which can be moved up or down by increasing or decreasing the pressure in the brake pipe. As soon as the air from the main reservoir is turned into the brake pipe, by means of the driver's valve, the piston is pushed up into the position shown, and air is allowed to feed past it through a small groove into the reservoir. At the same time the slide valve covers the port to the brake cylinder, and is in such a position that the air from the latter may exhaust into the atmosphere. The piston has now the same air pressure on both sides; but if the pressure in the brake pipe is decreased, the piston and slide valve are forced down, thereby uncovering the passage through which air from the reservoir flows into the brake cylinder between the pistons, thus applying the brakes. The brake pipe is shut off as soon as the triple valve piston passes the groove. To release the brakes, the piston and slide valves are again moved into the position shown, by the driver turning air from the main reservoir into the brake pipe. The air in the brake cylinder escapes, and at the same time the reservoir is recharged.

[Illustration: THE WESTINGHOUSE BRAKE.]

Fig. 2 represents two Westinghouse couplings connected. They are exactly alike in all respects, and an air tight joint is made between them by means of the rubber washers. These couplings are so constructed that the air pressure within serves to tighten the joint, and they may be pushed apart by the separation of the train without any injury. Such an occurrence as already explained leads to the instant application of all the brakes on the train.

By closing the small tap shown between the brake pipe and the triple valve, the brake on any vehicle, if out of order, can be cut out of the system. A release valve is also placed upon each cylinder as shown, so that in the event of the brakes being applied by the separation of the train, or the breaking of a pipe, or when the locomotive is not attached, they can be released by allowing the air to escape from each brake cylinder direct. The Westinghouse brake has been made to comply thoroughly with the Board of Trade conditions. Many people, however, do not appear to understand all that is involved in the second requirement, which runs as follows: In case of accident, to be instantaneously self-acting. This clearly implies: First, that accident to the train, or to any of its vehicles, shall cause the instant application of the brakes to the wheels of every vehicle in the train without the intervention of the driver or guards. Secondly, that any injury, however caused, which may impair the efficiency of the brake apparatus, shall, in like manner, lead to the instant application of all the brakes on the train. It then becomes impossible for a driver to run his train in ignorance of any defect in his brake apparatus because such defect at once discloses itself by applying the brakes and stopping the train. Thirdly, that each vehicle shall carry its own brake power in such a manner that the destruction of the brake apparatus on one or more of the carriages shall not affect the efficiency of the brakes upon any of the others. No continuous brake which does not comply with such conditions can ever be satisfactory.--_The Engineer_.

*   *   *   *   *

HYDRAULIC ELEVATORS AND MOTORS.

[Footnote: Read at Buffalo meeting of the American Water-Works Association May 15,1883.]

By B. F. JONES, Kansas City.

What I have to say in relation to elevators and motors will be mostly in regard to questions that their uses necessarily bring up for settlement at the water-works office; also to show how I have been able in a measure to overcome some of the many difficulties that have presented themselves, as well as to discuss and seek information as to the best way of meeting others that still have to be dealt with. At the outset, therefore, let me state that I am not an hydraulic engineer, nor have I sufficient mechanical knowledge to undertake the discussion of the construction or relative merits of either elevators or motors. This I would respectfully suggest as a very proper and interesting topic for a paper at some future meeting by some one of the many, eminent engineers of this association.

The water-works of Kansas City is comparatively young, and my experience only dates back six or seven years, or shortly after its completion. At this time it was deemed advisable on account of the probable large revenue to be derived from their use, to encourage the putting in of hydraulic elevators by low water rates. With this end in view a number of contracts were made for their supply at low special rates for a period of years, and our minimum meter rate was charged in all other cases, regardless of the quantity of water consumed. In most instances these special rates have since been found much too low, parties paying in this way being exceedingly extravagant in the use of elevators. However, the object sought was obtained, and now they are very extensively used. In fact, so much has their use increased, that the question is no longer how to encourage their more general adoption, but how to properly govern those that must be supplied. A present our works furnish power to about 15 passenger and 80 freight elevators, and the number is rapidly increasing.

Before going into details it seems proper to give at least a brief description of our water-works, as my observations are to a great extent local.

On account of the peculiar topography of Kansas City (and I believe it has more topography to the square foot than any city in the country) two systems of water supply have been provided, the high ground being supplied by direct pumping, and a pressure of about 90 pounds maintained in the business portion, and the lower part of the city being supplied by gravity, from a reservoir at an elevation of 210 feet, thus giving the business portions of the city, on high and low ground, about the same pressure. By an arrangement of valves, a combination of these two systems is effected, so that the Holly machinery can furnish an increased fire pressure at a moment’s notice, into either or both pipe systems. Thus at some points the pressure is extremely high during the progress of fires, causing difficulties that do not exist where the gravity system of works is used exclusively.

Elevators have become an established institution, and in cities of any commercial importance are regarded as a necessity, hotels, jobbing houses, factories, and office buildings being considered as far behind the times when not thus provided, as a city without a water supply or a community without a "boom." The use of elevators has made it practicable and profitable to erect buildings twice as high as were formerly thought of. Perhaps some of the most notable examples of this are in New York city, where such structures as the Mills building, the buildings of the _Tribune, Evening Post_, and Western Union Telegraph Co.. tower high above the surrounding blocks, monuments of architecture, that without this modern invention would reflect little credit upon their designers. It is now found less labor to go to to the fifth, sixth, or even tenth floors of these great buildings than it was to reach the second or third, before their use. In these days, merchants can shoot a ton of goods to the top of their stores in less time than it would take to get breath for the old hoist or "Yo, heave O" arrangement. Thousands of dollars are sometimes expended on a single elevator, the cars are miniature parlors, and the mechanism has perhaps advanced to nearly the perfection of the modern steam engine. If then they have become such a firmly established institution, their bearing upon the water supply of cities is a subject to be carefully considered.

As before intimated, there are many questions involved in the use of hydraulic elevators, that particularly concern towns supplied by direct pumping, and perhaps other places where the supply by gravity is somewhat limited. In a few larger cities supplied by ample reservoirs and mains, some of the difficulties suggested are not serious. Very little power is necessary to perform the actual work of lifting, with either steam or hydraulic elevators, but on account of the peculiar application of the power, and the great amount of friction to be overcome, a very considerable power has to be provided. It has been estimated, by good authorities, that not more than one-quarter of the power expended in most cases is really utilized.

With all hydraulic elevators of which I have cognizance, as much water is required to raise the empty cars as though they were loaded to maximum capacity. Still, to be available for passenger purposes elevators must have capacity of upward of 2,500 pounds, particularly in hotels, where the cars are often arranged with separate compartments underneath for baggage. In general use it is exceptional that passenger elevators are fully loaded; on the contrary less than half a load is ordinarily carried, and for this reason it would appear that no actual benefit is derived from at least one-half of the water consumed. In this connection it has occurred to me that passenger elevators could be built at no great additional cost, with two cylinders, small and large, the two piston rods of which could be connected so as to both operate the same cable, either or both furnishing power, the smaller cylinder to be used for light loads, the larger for heavy work, and the two together for full capacity, this independent valve arrangement to be controlled by a separate cable running through the car. Whether this plan is practicable or not must be left to elevator manufacturers, but it seems to me that with the Hale-Otis elevator for instance (which is conceded to be one of the best) it could easily be accomplished. Certainly some such arrangement would effect a great saving of water, and perhaps bring water bills to a point that this class of consumers could afford to pay.

Hydraulic elevators where the water is used over and over again, by being pumped from the discharge to elevated tanks, cut little or no figure in connection with a city’s water supply. When fuel, first cost, attendance of an engineer, and the poor economy of the class of pumps usually employed to perform this work are considered, the cost of operating such elevators is greatly in excess of what it would be if power were supplied direct from water mains, at any reasonable rate. The following remarks will then relate almost exclusively to that class of hydraulic elevators supplied with power directly from the water mains.

Let us now consider whether they are a desirable source of revenue, and in this my knowledge does not exceed my actual experience. Few elevator users appreciate the great quantity of water their elevators consume. Even in Kansas City, where, on account of the high pressure carried, much smaller cylinders than ordinarily are required, it is found that passenger elevators frequently consume 500,000 to 800,000 gallons of water per month, which will make a very considerable bill, at the most liberal rates. I have, therefore, concluded that the quantity of water was so large that, unless liberal concessions were made, it would be a hardship to consumers to pay their water bills, and have therefore made a special schedule, according to quantity, for elevators and motors, these rates standing below our regular meter rates, and running to the lowest point at which we think we can afford to furnish the water. This schedule brings the rate below what we would receive for almost any other legitimate use of water; and, in view of our rapidly increasing consumption, and the probability of soon having to increase all our facilities, it is an open question whether this will continue a desirable source of revenue.

In Kansas City we have elevators of various manufacture: the Hale-Otis, Ready, Smith & Beggs, O'Keefe, Kennedy, and perhaps others, each having its peculiarities, but alike demanding large openings in the mains for supply. These large openings are objectionable features with any waterworks, and especially so with direct pumping. An occurrence from this cause, about two years ago, is an experience I should not like repeated, but is one that might occur whenever the pressure in the mains is depended upon to throw fire streams. In this instance a large block of buildings occupied by jobbing houses and having three elevators was burned down, and the elevator connections broken early in the fire, allowing the water to pour into the cellars in the volume of about twelve ordinary fire streams. This immense quantity of water had to be supplied from a 6-inch main, fed from only one end, which left little pressure available for fighting the fire, and as a matter of course failure to subdue the fire promptly was attributed to the water-works. We have since had up hill work to restore confidence as to our ability to throw fire streams, although we have demonstrated the fact hundreds of times since.

From this time we have been gradually cutting down on the size of openings for elevator supply, but under protest of the elevator agents, who have always claimed that they should be allowed at least a 4-inch opening in the mains, until we have found that under 80 to 90 pounds pressure two to four 1-inch taps will answer the purpose, provided the water pipes are of ample size.

The "water hammer" produced by the quick acting valves of elevators has always been objectionable, both in its effect at the pumping-house and upon water mains and connections. To obviate this, Engineer G. W. Pearson has suggested the use of very large air chambers on the elevator supply, and still smaller openings in the mains, his theory being that the air chambers would not only materially decrease the concussion or "water hammer," but that they would also act as accumulators of power (or water under pressure) to be drawn from at each trip of the elevator, and replaced when it was at rest. This plan I have never seen put to actual test, but believe it to be entirely practicable, and that we will have to ultimately adopt it.

All things considered, the plan of operating elevators from tanks in the top of buildings, supplied by a small pipe connected with the water-mains and arranged with a float valve to keep the tank filled, I believe to be the best manner of supply, except for the great additional cost of putting up such apparatus. By this arrangement the amount of water consumed is no less, in fact it would ordinarily be more than with a direct connection with the mains, but it has the advantage of taking the water in the least objectionable manner. Still, if this mode of supply were generally enforced, the large first cost, an additional expense of operating, would undoubtedly deter many from using elevators.

Another evil in connection with the use of elevators, and which no doubt is common, is the habit many parties have of keeping a key or wrench to turn on and off the water at the curb. This we have sought to remedy by embracing in our plumbers' rules the following: "All elevator connections in addition to the curb stop for the use of the Water Company must be provided with another valve where the pipe first enters the building for the use of occupants of the building." Without this extra valve it was found almost impossible to keep parties from using the curb valve. In most cases the persons were perfectly responsible, and as there was no intent to defraud the company by the act, they would claim this privilege as a precaution against the pipes bursting or freezing. This practice was very generally carried on, and was the direct cause in at least two cases of very serious damage. In the instances referred to, the pipes burst between the elevator and the area wall of buildings, and the valves outside had become so worn from frequent use that they would not operate, allowing the water to literally deluge the basements before the water main could be turned off.

One of the greatest causes of waste from elevators is the wearing out of the piston packing, this being particularly troublesome in most of the Western cities, where the water supplied is to a large extent from turbid streams, carrying more or less fine sand or "grit," which cuts out the packing of the pistons very rapidly. The only practicable remedy for this is close inspection, to see that the pistons do not allow water to pass, a fact that can readily be determined from the noise made in the cylinder when the elevator is in motion going upward.

I have reserved one of the most annoying features of elevator supply for the last, hoping to work myself into a mood to do the subject justice, but doubt if it can be done in language proper to use before this dignified body. I remember on one occasion the mayor of our city, in discussing a job of plumbing, said that it seemed to him "that even a plumber ought to know something about plumbing." Now it would seem that even elevator agents ought to know something about elevators, but from the following incident, which is but one of many, I am led to believe that they are not infallible to say the least. Only a short time since, one of these very reliable (?) agents reported at our office that he had just attached a new indicator to the elevator of a leading hotel. He was asked: "What does it register?" and promptly replied, "Cubic feet." In this case our inspector had already made an examination, and had correctly reported as follows: "Hale elevator; indicator started at zero February 28; internal diameter of cylinder, 12 inches; travel of piston for complete trip 30… feet; indicator registers for complete trip, 4."

When it is understood that we had for a long time been assuming that elevator agents knew about all there was to know on the subject, a comparison of statements of this agent and our inspector is somewhat startling. Now let us see what the difference amounted to: At the end of the month the indicator had registered 12,994; calling it cubic feet, this register would equal 97,195 gallons. According to our inspector, this same register would equal 578,233 gallons, or a difference of nearly half a million of gallons for a single month. Our experience with the agents in Kansas City has shown that they will, if allowed, put any kind of an indicator on the most convenient point of any sort of an elevator, without the slightest regard as to what it was intended to indicate; then report it as registering cubic or lineal feet, whichever they find the indicator marked. On the same principle they could as well change the fulcrum of a Fairbanks scale, and then claim it weighed pounds correctly, because pounds were marked upon the bar. We have lately prepared a blank, upon which these agents are required to make a detailed report upon the completion of an elevator before the water will be turned on, which it is hoped will to some extent correct this trouble.

I have come to regard an elevator indicator with a feeling of wonder. Some years ago, when the "planchette" first came out, I remember that it acquired quite a reputation as a particularly erratic piece of mechanism, but for real mystery and _innate cussedness_, on general principles, commend me to the indicator. Why, I have known an indicator after registering a nice water bill, to deliberately and without provocation commence taking it all off again, by going backward. This crab-like maneuver the agent readily explained by saying the "ratchet had turned over," but even he was unable to show us how to make the bills after these peculiar gyrations. I also find that it is quite a favorite amusement for indicators to stop entirely, like a balky horse, after which no amount of persuasion will bring them to a realizing sense of their duty.

Even at the best, these indicators are very apt to get out of order, necessitating greater watchfulness in supplying elevators than for any other purpose for which water is furnished.

Accidents in connection with the use of elevators are common throughout the country, and in Kansas City had, until within a short time, become of altogether too frequent occurrence. The great cause of this I believe to be due to the fact that the parties who usually operate elevators are the very ones who know least about them; the corrosion of pistons, crystallization and oxidation of cables, and many other disorders common to elevators, being matters they do not comprehend. The frequency and fatality of these accidents in Kansas City finally led the city authorities to appoint an Elevator Inspector, who is under heavy bond, and whose duty is to examine every elevator at least once a month, and to grant license to run only such as he deems in safe condition. Thus far since the establishment of this office we have had no serious accidents, which leads me to the belief that in most cases a monthly examination will discover in time the causes of many terrible casualties; also that it is not safe to operate elevators unless so inspected by some competent person.

The hatchways of elevators in large buildings are points greatly feared by firemen. They well know that when a fire once reaches this shaft, it takes but a moment for it to be carried from floor to floor, until the building is soon past saving. Although this great danger is well known, it is the exception rather than the rule to provide elevators with fire-proof hatches. A properly constructed elevator should, it seems to me, be provided with hatches, or better still, built within brick fire-proof walls, with openings to be kept closed when not in use. In this way costly buildings, valuable merchandise, and many lives would be saved from fire every year.

Although considerable has been said on the subject of elevators, I am aware that the ground has not been covered, and that difficulties have been pointed out more than remedies suggested. There is much yet to be brought out by the engineers, to whom the subject more properly belongs.

In the mean time, although elevators claim many of the objectionable features in the business of water supply, most of them are not of a nature that should condemn their use; on the contrary, I hope that with the joining of our experience there will be an improvement in the methods of their supply. Inasmuch as they must be furnished with water, all that can be done is to adopt such rules and fix such rates as will compensate in some degree for their objectionable qualities.

WATER MOTORS.

My remarks on this subject I trust will be more to the have been point than they upon the questions already discussed. Certainly my ideas are more decided, so far at least as supplying water motors is concerned.

In many respects I believe water motors furnish as nearly perfect power as it is possible to attain. A motor, for instance, properly connected and supplied by the even pressure from a reservoir is probably the most reliable and steady power known, not excepting the most improved and costly steam engines. The convenience and little attendance necessary in operating make them especially desirable for many purposes. Where only small power is required, or even where considerable power for only occasional use is desired, they are particularly well adapted, and can be driven at small expense. Even for greater power they possess advantages over steam engines which, to a considerable extent, compensate for the large water rates that ought to be paid for their supply. These advantages are in the first cost of a motor, as compared with a steam engine, the saving in attendance and fuel, the convenience and cleanliness, and in some cases a saving in insurance by reason of their being no fire risks attendant upon its use. At just what point steam becomes preferable, however, is a question depending considerably upon water rates, but to some extent on other circumstances, leaving it largely a question of judgment. As with elevators, there are difficulties involved in their supply that unless carefully guarded make water motors anything but a desirable source of revenue. How often is the argument advanced: "Why, I only use water for a quarter of an inch jet!" Showing how little people who use motors or elevators or fountains realize the quantity of water they consume. This class of consumers may be placed on one footing, to wit, a class who, in spite of the fact that they are supplied with water for much less than any other, feel that they are imposed upon, and cannot be made to think otherwise.

Though not as large as for elevator supply, water motors require liberal openings in the mains, and frequently the fault of having too small supply pipes is sought to be remedied by openings in the water mains much larger than needful. A table prepared by an engineer who had given the matter study, or by some motor manufacturer, showing the size of taps, or openings, for the proper supply of motors, with the various jets, under different pressures, would be of general use to water-works people. In order to use water to the best advantage, the full pressure in the main, so far as practicable, should be had at the jet, but in order to accomplish this it is not necessary to use as large taps as are ordinarily demanded, but to provide supply pipes of sufficient capacity to deliver the water to the point of discharge with the least possible friction. Lately this theory has been put in practice to some extent by us, and the result has shown that in this manner we are able to supply motors through smaller taps than beforehand with as satisfactory results.

It is a general practice throughout the country to make annual or monthly rates for water motors, and from my observation I believe I can safely venture the assertion that in three-quarters of the cases the rates charged will not equal 50 per cent. of the lowest meter rates in force in these places. Although the Kansas City Water-Works has not perhaps been generally accorded the reputation of being the most liberal "monopoly" in the country, still I have had occasion at times to make some such claims as an inducement to its generous support. But with all its liberality, I am free to say that we cannot begin to meet the rates for motors that parties claim to have paid almost everywhere else.

The St. Louis Water-Works, where the rates are substantially the same as in Kansas City, have been quoted as having the following motor rates, but whether correct or not my inquiries have failed to determine:

"On the supposition that motors are to be used ten hours per day for 300 days per year, motors are assessed for--

1/4 inch jets	$120 per annum.
3/8 "	198 " "
1/2 "	300 " "

These rates based upon a charge of 50 cents per 1,000 gallons."

From Col. Flad's Report as Engineer of Public Works, May 1, 1876, p.70, it is found that with 42 pounds pressure a ‰ inch orifice will discharge 2,160 gallons per hour, 21,600 gallons in 10 hours, or 6,480,000 gallons in 300 days, which at 20 cents per 1,000 gallons would amount to $1,296, for which they assess the rate $300. From all of which I would conclude that there must be a lack of harmony somewhere between the engineering and office departments.

I have made some estimates myself for water motors, basing rates upon the number of hours it was claimed the motors would be in use, and afterward supplied the same motors by meter measurement; in every case found that at least twice as much water was used as had been estimated. Although estimates were carefully made upon what was believed to be a reliable basis, these repeated similar results have led me to the conclusion that the only way to supply motors is to make it an object to the users of them to be economical. In other words, I believe the way to supply water motors is upon an estimate that they will run 24 hours per day and 365 days per year, or, more properly still, supply them only by meter measurement. At all events this is henceforth my policy; or, in other words, "on this rock I stand," believing it the only equitable way out of this difficulty.

That class of motors or water engines operated by water pressure in close cylinders upon pistons as with steam in a steam engine, I believe could be easily supplied by measurement of water without a meter. This could be accomplished by the use of "revolution counters" or indicators, as the amount of water required per revolution could be readily determined, and when once computed the cylinders would measure out the water as accurately as a meter. The only objection to this plan is the expense of counters, which is considerable; and as to indicators, it may have been observed that I have little faith in their reliability. With cheap revolution this class of motors would be free from many of the objections raised in regard to motors generally.

The practical conclusion that I would draw from a consideration of this subject is that the question of whether the supply of hydraulic elevators and motors is desirable in its effects upon the water supply is one that hinges so delicately upon their being carefully governed, connected, and restricted, that while on the one hand they may be made the source of large profit, and at the same time a public benefit, on the other hand, unless all the details of their supply be carefully guarded by the wisest rules and greatest watchfulness, their capacities for waste are so great and the rates charged necessarily so low, that they may become the greatest source of loss with which we have to contend. I therefore trust that this discussion will be continued until an interest is felt that will result in our all receiving much useful information upon two most important factors of our business.

As this paper has been long for the information contained, I will close with the earnest wish that it may at least be of service in bringing these important but often neglected subjects to the attention of the thinking and intelligent body of men, of whom many have had much longer and more general experience in relation to these matters, and whose views when expressed will consequently be of more interest and have greater weight. Thus as a result may we all derive the benefit of whatever useful information there is to be gained by this annual interchange of experiences in the all-important business of public water supply.

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WATER SUPPLY OF SMALL TOWNS.

We now describe the new waterworks lately erected for supplying the town of Cougleton, Cheshire. The population is about 12,000, and the place is a seat of the silk manufacture. After various expensive plans had been suggested, in the year 1879 a complete scheme for the supply of the town with water was devised by the then borough surveyor, Mr. Wm. Blackshaw, now borough surveyor of Stafford. These we now illustrate above by a general drawing, and a separate drawing of the tower. With respect to the mechanical arrangements, the Corporation called in Mr. W. H. Thornbery, of Birmingham, consulting engineer, to decide on the best design of those submitted, and this, with modifications made by him, was carried out under his inspection. The water, for the supply by pumping, is obtained from springs situated at the foot of Crossledge Hill, about a mile from the town. It does not at present require filtering, but space enough has been allowed for the construction of duplicate filtering beds without in any way interfering with the present appliances. These filter beds are shown in our perspective illustration, but they are not yet built or required.

[Illustration: WATER SUPPLY OF SMALL TOWNS--CONGLETON WATERWORKS.]

The waterworks are situated very near the springs, from which they are only separated by a road, under which the collecting pipes run. There are two circular collecting tanks of brickwork, two pumping wells, engine-house, boiler-house, chimney stack, and engine-driver’s dwelling-house, all inclosed by a wall. On the top of Crossledge Hill is erected a circular brick water tower 35 ft. high to the underside of the service tank, which is of cast iron 30 ft. internal diameter, supported on rolled girders. The tank is capable of containing 50,000 gallons of water, and it is provided with the usual rising and service mains, overflow and washout pipes. There is an arrangement for pumping direct into the mains in case the tank should require cleaning or repairing.

The pumping machinery is in duplicate, and each set consists of a horizontal condensing engine, with cylinder 18 in. diameter, stroke 30 in., fitted with Meyer’s expansion gear, governor, fly-wheel 12 ft. diameter, weighing 4 tons, jet condenser with a single acting vertical air pump, situated below the engine room floor, and between the end of the cylinder and the main pump. Each main pump is 10 in. diameter, horizontal, double-acting, worked by a prolongation backward of the piston-rod. The valves and seats are of gun metal, 8‰ in. diameter. The capacity is 350 gallons per minute, raised 206 ft. The air vessel is 21 in. internal diameter and 6 ft. high, and is fitted with a hand pump for renewing the supply of air if necessary. The rising main from the air vessel to the service tank is 9 in. diameter, and 307 yards long, laid up the steep slope of the hill on which the water tower is built. The boilers, two in number, are of the ordinary Cornish single-flued type, 5 ft. diameter by 18 ft. long, with flue 2 ft. 9 in. diameter, with three Galloway tubes. They were made by Messrs. Hill & Co., of Manchester. The engines and pumps were made by Mr. Albert Scragg, of Congleton, and the brick, stone, and builder’s work was executed by Mr. Thomas Kirk. The waterworks were opened in the autumn of 1881, and since then have constantly afforded an abundant supply of water. There is also an independent gravitation system, also arranged by Mr. Blackshaw, for supplying an outlying part of the town. The cost of the works was exceedingly moderate, being not more than £12,000, including the water mains for distribution.

PROCESS FOR SOFTENING HARD WATER.

The available water of many villages and small towns is that of the chalk beds, but it is invariably very hard, and should be softened. We have received so many inquiries respecting a simple means of carrying out Clarke’s water-softening process, that the following description of a set of apparatus devised for this purpose by Messrs. Law and Chatterton, MM.I.C.E., may interest many besides those who contemplate the construction of small waterworks supplied by the chalk springs.

The apparatus, as made in various sizes by Messrs. Bowes, Scott, and Read, of Broadway-chambers, Westminster, we illustrate by the accompanying engravings.

Softening hard water.--The disadvantages attending the use of hard water either for drinking purposes, steam generation, lavatory purposes, and for many manufacturing purposes, are well known, but as there are several methods of softening waters which are hard in different degrees by different substances, we may be pardoned if we here reproduce, for the convenience of some of our readers, a few passages from the sixth report of the River Pollution Commission, 1874, pages 21 and 201-16, which give some very valuable information on the relative merits of hard and soft waters in domestic and trade uses. "Some of the mineral substances which occur in solution in potable waters communicate to the latter the quality of hardness. Hard water decomposes soap, and cannot be efficiently used for washing. The chief hardening ingredients are salts of lime and magnesia. In the decomposition of soap these salts form curdy and insoluble compounds containing the fatty acids of the soap and the lime and magnesia of the salts. So long as this decomposition goes on the soap is useless as a detergent, and it is only after all the lime and magnesia salts have been decomposed at the expense of the soap, that the latter begins to exert a useful effect. As soon as this is the case, however, the slightest further addition of soap produces a lather when the water is agitated, but this lather is again destroyed by the addition of a further quantity of hard water. Thus the addition of hard water to a solution of soap, or the converse of this operation, causes the production of the insoluble curdy matter before mentioned. These facts render intelligible the process of washing the skin with soap and hard water. The skin is first wetted with the water and then soap is applied; the latter decomposes the hardening salts contained in the small quantity of water with which the skin is covered, and there is then formed a strong solution of soap which penetrates into the pores, and now the lather and impurities which it has imbibed require to be removed from the skin by wiping the lather off with a towel or by rinsing it away with water. In the former case the pores of the skin are left filled with soap solution; in the latter they become clogged with the greasy, curdy matter which results from the action of the hard water upon the soap solution which had previously gained possession of the pores of the cuticle. As the latter process of removing the lather is the one universally adopted, the operation of washing with soap and hard water is analogous to that used by the dyer and calico printer for fixing pigments in calico, woolen, or silk tissues. The pores of the skin are filled with insoluble greasy and curdy salts of the fatty acids contained in the soap, and it is only because the insoluble pigment produced is white, or nearly so, that so repulsive an operation is tolerated. To those, however, who have been accustomed to wash in soft water, the abnormal condition of skin thus induced is for a long time extremely unpleasant.

Of the hardening salts present in potable water, carbonate of lime is the one most generally met with, and to obtain a numerical expression for this quality of hardness a sample of water containing 1 lb. of carbonate of lime, or its equivalent of other hardening salts, in 100,000 lb.--10,000 gallons--is said to have 1° of hardness. Each degree of hardness indicates the destruction and waste of 12 lb. of the best hard soap by 10,000 gallons of water when used for washing. Hard water frequently becomes softer after it has been boiled for some time. When this is the case, a portion at least of the original hardening effect is due to the bicarbonate of lime and magnesia. These salts are decomposed by boiling into free carbonic acid, which escapes as gas, leaving carbonates of lime and magnesia; the latter being nearly insoluble in water, ceases to exert more than a very slight hardening effect, and produces a precipitate. As the hardness resulting from the carbonates of lime and magnesia is thus removable by boiling the water, it is designated temporary hardness, while the hardening effect which is due chiefly to the sulphates of lime and magnesia, and cannot be got rid of by boiling, is termed permanent hardness. The total hardness of water is therefore commonly made up of temporary and permanent hardness. A constant supply of hot water is now almost a necessity in every household, but great difficulties are thrown in the way of its attainment by the supply of hard water to towns forming thick calcareous crusts in the heating apparatus.

Waters with much temporary hardness are most objectionable in this respect, and the evil is so great where the heating is effected in a coil of pipe, as practically to prevent, in towns with hard water, the use of this most convenient method of heating water. The property of being softened by boiling which temporarily hard water possesses is not of much domestic use, for water is, as a rule, either not raised to a sufficiently high temperature or not kept at it for a long enough time. Seeing then the disadvantages attendant on the use of hard water, it remains to be considered how best to soften it. Four processes are known to the arts. They are: Distillation, carbonate of soda, boiling, lime. Of these processes the first and second are the most effective, but owing to their expense are not applicable on a large scale. The third and fourth processes are efficient only with certain classes of water, rendered hard by the presence of the bicarbonate of lime, magnesia, or iron. The fourth is, however, a very cheap process, and is easily applicable to the vast volumes of water supplied to large cities, provided the hardening ingredients are of the character described.

Softening by distillation.--By evaporation, water is completely separated from all fixed saline matters, and consequently from all hardening matters. Distilled water, however, has a vapid and unpleasant taste, due partly to deficient aeration and partly to the presence of traces of volatile organic matter; and though filtration through animal charcoal will remove this, and the aeration can begin chemically, the process is too expensive, except in certain cases, as on board ship, or at military or naval stations where no potable water exists.

Softening by carbonate of soda.--The hardness of water, as already explained, being principally due to the presence in solution of bicarbonates and sulphates of lime and magnesia, can be reduced by addition of carbonate of soda, which decomposes these salts slowly in cold water but quickly in hot, forming insoluble compounds of lime and magnesia, which are slowly precipitated as a fine mud, leaving the water charged, however, with a solution of bicarbonate and sulphate of soda. This process, on account of expense, is only applicable on a small scale to the water for laundry purposes, as the water acquires an unpleasant taste from the presence of the soda salts. For laundry purposes it is, however, valuable, as it effects a great saving of soap.

The softening of water by boiling.--That portion of the hardness of water due to the presence of bicarbonate of lime, magnesia, or iron, is corrected by boiling the water for half an hour. During ebullition the bicarbonates, which are soluble, become carbonates, which are insoluble, giving off their carbonic acid as gas, rendering--by the precipitate produced, but not allowed in a boiler time to settle--the water muddy, but incapable of decomposing soap. To raise the temperature of 1,000 gallons of water to the boiling point and to maintain it for half an hour requires the consumption of about 2‰ cwt. of coal, or by the wasteful appliances found in households, probably three times that amount. Softened by boiling, then, 1,000 gallons of water would cost about 7s. 6d., while the cost of softening the same amount by soap is 9s., at £2 6s. 6d. per cwt.

The softening of water by lime.--The economy which carbonate of soda exhibits in comparison with soap as a softening material is far surpassed by the use of lime. Lime costs about 8d. per cwt., and this weight of lime will soften the same volume of water as would require the use of 20… cwt. of soap. From the above it is evident--so soon as it is conceded that there is an advantage in using soft water--that the lime process is by far the most economical. Besides the chemical action affecting the hardness, it has another most important mechanical action, in consequence of the weight of each particle composing the precipitate produced by it. These particles during subsidence become attached to the almost microscopical organic impurities present in all river water, and drag them down to the bottom of the settling tank, whereby the water is rendered, after some eight hours, clear as crystal. The average cost of the water supplied by the leading metropolitan water companies is £10 10s. 9¾d. per million gallons. The charge made by the companies to consumers is about 6d. per 1,000 gallons, or £25 per million gallons. It has been found that water can on a large scale be softened from 14° hardness to 5° at a cost of 20s. per million gallons--that is, 10 per cent. on the cost of the water to the companies, or 4 per cent. as the price charged to consumers. This estimate does not take into account the value of the precipitated chalk, which has a market price, and is used for many purposes, being, in fact, whiting of the purest quality. The operations necessary in Clarke's process are four in number: (1) The preparation of milk of lime; (2) the preparation of a saturated solution of lime; (3) the mixture of this solution with the water to be softened; (4) the classification of the softened water by the separation of the precipitated substances Messrs. Law and Chatterton effect these processes by simple mechanical means which are so far automatic that they only require the presence of a person, without technical knowledge, once in each twenty-four hours. No filtering medium whatever is required, which is a great advantage for the following reasons: (1) Filtering materials require periodical cleaning and renewal, which not only occasion much trouble and mess, but are also frequently inefficiently performed. (2) Experience has shown that the filtering material, whether cloth, charcoal, or other substance, is extremely liable to become mouldy or musty, which makes the wafer both unwholesome and unpalatable. This system is especially adapted for small water supplies and for use in country houses, there being no operation to perform requiring either technical, chemical, or mechanical knowledge, nor producing dust or dirt.

[Illustration: Fig. 1.--LAW AND CHATTERTON'S WATER-SOFTENING APPARTUS.]

The following is a description of this apparatus as fitted at the Hoo, Luton, Bedfordshire, for the supply of Mr. Gerard Leigh's house, grounds, and home farm. The mixing of the lime and the subsequent stirring of the water is effected by water power obtained from a turbine. The whole of the apparatus and tanks occupy a space 60 ft. square, 3,600 ft. area, and soften a daily supply of 50,000 gallons.

[Illustration: Fig. 2]

A pump driven from the turbine forces the water to a reservoir in the park and on to the house, an ingenious automatic arrangement worked by the overflow from the cistern throwing the pump out of gear when the tank is full. A, B, and C. Figs. 1 to 6 herewith, are three tanks in which the water remains to be softened, each capable of holding one day’s supply. D and E are two smaller tanks in which the lime water is prepared; X is the automatic valve apparatus by which the connections between the several tanks are effected in the order and at the times required; H and H show the positions in which two pumps should be placed, the former for pumping unsoftened water into the tanks, the latter to pump the softened water into the supply cistern. J is the pipe from the well or other source of supply--in case the supply is at a higher level, one pump can be dispensed with. The operation consists in adding to the water to be softened a certain quantity of lime water, depending upon the degree of hardness, and in then allowing the mixture to rest in a state of perfect quiescence until the whole of the lime has been deposited and the water has become perfectly clear. The tank, A, has been filled with unsoftened water. Tank B contains the water and lime in process of clarification by subsidence after mechanical agitation by the screw. Tank C contains the softened water--and the precipitate--in process of removal for consumption. The mode of working is as follows: The milk of lime, prepared by slaking new lime in a "Michele mixer"--not shown. One of the tanks, D, having been filled with softened water, run by gravity from one of the tanks, A, B, or C, the requisite amount of milk of lime is allowed to flow into it from the lining machine, and the whole having been thoroughly mixed by the patent agitator, G, is left in a quiescent state for some hours, when the superabundant lime falls to the bottom, and the tank contains a perfectly clear and saturated solution of lime. The requisite quantity of lime water is then suffered to flow by gravity into whichever of the three tanks is empty. In the mean while, the softened water is being withdrawn by pumping or gravitation, as the case may be, from the tank C, until, upon the water being lowered to within a certain distance of the bottom, an automatic arrangement shifts the valve, X, so that the supply then commences from B, the unsoftened water flows into C, and the water is in process of clarification in A, and thus the operation proceeds continuously. Where the water can be supplied by gravitation, and the tanks can be placed at a sufficient elevation to command the service cistern, no pumps are required, the softening process, in fact, in no way necessitating pumping. The space occupied by the whole of the tanks and apparatus is 60 ft. square, 3,600 ft. area, and softens 50,000 gallons per day. For the daily softening of quantities less than 1,000 gallons, the tanks are made of galvanized sheet iron, and the whole apparatus and tanks are self-contained, so as only to require the making of the necessary connections with the existing supply and delivery pipes, and fixing in place. No expensive foundations are required, and the entire cost of an apparatus--see Figs. 2, 3, 4, 5, and 6--capable of softening 500 gallons per day is about £75. Annexed is a more detailed description of the manner of fixing and working the smaller apparatus.

[Illustration: Fig. 3]

The tank must, of course, be set up perfectly level. The pipe from the source of supply--in the present case from the hydraulic ram--must be attached to the upper three way cock at A, on the accompanying engravings, and the pipe to supply softened water is to be connected to the lower three-way cock at B, and should be led into the elevated cistern with a ball cock so as to keep it always filled. The three ball cocks in C, D, and E should be adjusted to allow the tanks to fill to within 3 in. of the top. The nuts at the upper extremity of the three rods, F, G, and H, should be so adjusted that when the water in the several tanks has been drawn down to within 15 in. of the bottom the rocking shaft, I I, is drawn down and the vertical rod, J, lifted so as to allow the wheel, K, and spindle, L, to revolve by the action of the weight, M. The length of the chain is such that when the weight, M, rests upon the floor the face of the raised rim on the wheel, K, should not quite touch the rod, J, and if necessary, a thin packing should be put for the weight to drop upon. The lime to be used should be pure chalk lime free from clay, mixed with water to a smooth, creamy consistency, and then poured into the small tank, N. This tank should then be filled with water to within 3 in. of the top, and the small air pump worked until the lime has become thoroughly mixed and diffused throughout the water. Care must be taken that previous to filling the tank the float, O, is raised up, as shown by the dotted lines in Fig. 3. After the lime has been thoroughly mixed it should be left for at least eight hours for the superabundant lime to subside, leaving the supernatant fluid a perfectly clear saturated solution of lime. At the end of this time the float, O, should be lowered, so that it may float upon the lime water, and the three-way cock, P, should be turned in such a position as to allow the contents of the tank, N, run into the tank, Q, until the necessary quantity has been supplied, the mode of determining which is hereinafter described.

[Illustration: Fig. 4]

The spindle, L, should then be turned into the position which allows the water from the source of supply to be discharged into the tank, Q, the float, R, having first been raised into the position shown in Figs. 2 and 5. A second quantity of the lime should now be added to the tank, N, mixed with water, and after agitation, another eight hours allowed for the contents of both the tanks, Q and N, to subside. At the end of this time the three-way cock, P, should be turned through a third of a circle, so as to discharge the lime water into the tank, S; and the spindle, L, should be turned in the contrary direction to the hands of a watch through the third of a circle, so as to allow the water from the source of supply to be discharged into the tank, S, care being taken as before to raise the float, T, out of the water. A third quantity of lime must be added to the tank, N, and now mixed with water to be drawn from the tank, Q, by the tap, U, and after agitation again left for eight hours to subside. The float, R, may now be lowered into the water in the tank, Q, when it will be found that the clear softened water contained in the tank, Q, will be discharged through the pipe attached to the bottom of the three way tap, B. The weight, M, must now be lifted about 5 in., so as to allow the ring at the end of the chain to be moved back to the next stud on the wheel, K. The lime water in the tank, N, must next be discharged into the tank, V, and then another quantity of lime must be added to the tank, N, and filled up with softened water from the tank, S, by means of the tap, W, and after being duly agitated and left to subside. As soon as the softened water from the tank, Q, has been drawn down to within 15 in. of the bottom, the rod, H, will move the rocking shaft, I, and lift the rod, J, so releasing the wheel, K, and allowing the weight, M, to descend and turn the spindle, L, and the upper and lower three-way cocks through a third of a circle; the effect of which movement will be to continue the supply of softened water from the tank, S, and to fill up the tank, V, with water from the source of supply.

[Illustration: Fig. 5]

The apparatus will now be in the condition to afford a regular supply of softened water; all that will be necessary to insure its continuous action will be that at certain stated intervals dependent upon the rapidity with which the water is used--but which interval should not be less than eight hours--the following things should be done: (1) The float must be raised out of the tank last emptied. (2) The float must be lowered into the tank last filled. (3) The weight, M, must be raised, and the ring of the chain shifted to the next stud on the wheel, K. (4) The clear lime water found in the tank, N, must be turned into the tank last emptied. (5) The requisite quantity of lime must be put into the tank, N. (6) The requisite quantity of water must be drawn off from the tank last filled into the tank, N. (7) The contents of tank, N, must be thoroughly mixed by means of the air pump. The quantity of lime to be used for each tankful of water must depend upon the hardness of the water, ¾oz. being required for each tankful for each degree of hardness. It is desirable, however, always to have an excess of lime in the tank, N, so as to insure obtaining a saturated solution of lime. When first mixed the contents of the tank, N, will have a creamy appearance, but when the superabundant lime has subsided the supernatant liquid will be a perfectly clear saturated solution of lime. Therefore, in the first instance, 3 lb. of lime should be put into the tank, N, and subsequently each time such a quantity of lime should be added as is found to be necessary by the method hereinafter described. The quantity of the saturated lime water to be run into each of the softening tanks, Q, S, and V, will depend upon the hardness of the water. For every degree of temporary hardness a depth of 1-6/10 in. of the contents of the tank, N, will be required; so that if the water has 14 deg. of temporary hardness, then 22‰ in. in depth of lime water must be run off into each of the tanks, Q, S, and V. In the first instance an excess of lime may be used, and the softened water tested by means of nitrate of silver in the following manner: A solution of 1 oz. of nitrate of silver in a pint of twice distilled water should be obtained. Having let two or three drops of this solution fall on the bottom of a white tea cup, slowly add the softened water; then if there be any excess of lime, a yellow color will show itself, and the quantity of lime water used must be reduced until only the faintest trace of color is perceptible.--_The Engineer_.

[Illustration: Fig. 6]

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IMPROVED WATER METER.

We annex illustrations of a meter designed by Mr. A. Schmid, of Zürich, and which, according to _Engineering_, is now considerably used on the Continent, not only for measuring water, but the sirup in sugar factories, in breweries, etc. It consists of a cast iron body containing two gun-metal-lined cylinders, and connected by an intermediate chamber. Round the body are formed two channels, one for the entrance and the other for the discharge of the water, etc., to be measured. Within the cylinder are placed two long pistons, provided with openings in such a way that each piston serves as a slide valve to the other, the flow being maintained through the ports in the connecting chamber. The arrangement of openings in the piston is shown in Figs. 5, 6, 7, and the intermediate passages in Figs. 1, 2, and 3. To the upper side of each piston is attached a cross-head working on a disk placed at each end of a horizontal shaft. To one of the disks is added a short connecting rod that drives the spindle of a counter.

[Illustration: SCHMID'S WATER METER.]

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WASHING MACHINE FOR WOOL.

The washing machines in use for wool on the rake principle have during the last few years experienced many improvements in the details of their arrangement, which we have illustrated at different times in our columns. The introduction of these improvements and alterations shows that the washing of wool has attracted more attention on the part of observant manufacturers and machine makers, and demonstrated at the same time that the machines hitherto in use, with all their advantages, left much to be desired in other respects. The main difficulty with all washing machines for wool has been the avoidance of felting of the wool, which tendency is increased by the use of warm water for washing and by the agitation that some consider necessary for a thorough cleansing of the wool and removal of the adhering impurities, but which agitation is deprecated by others.

[Illustration: IMPROVED WOOL WASHING MACHINE.]

Referring to our different illustrations of improvements in this direction, our subscribers will observe that the tendency of all these has been to keep the wool floating in the water, and to apply all mechanical appliances required for its cleansing and pressing as much as possible while it is in this suspended condition. The success which the different appliances and improvements mentioned by us have had when used for the class of wool for which they are intended, has induced us to look up any attempts in a similar direction which have been made on the Continent, where the subject has attracted attention, as well as with us. We therefore give the annexed illustration of a machine invented by a German woolen manufacturer, which in many respects is a wide departure from the acknowledged type in use in this country. As with the English machines, the wool enters from a creeper at one end, passes through a long trough, filled with water or lye, ascends an inclined plane, and passes out through a pair of squeezing rollers. The invention mentioned applies to the treatment in the trough which latter is shown in our illustration at K. It has a second bottom, a little distance from a false one, at K. The false bottom is traversed in its whole length by an air pipe, communicating with the atmospheric air outside the trough. From this longitudinal pipe other pipes branch off at right angles at stated intervals, as shown in section in Fig. 2. These smaller pipes contain a number of small perforations on their upper part, through which the air ascends into the water in innumerable small bubbles. This is one of the principal aims of the invention, for in ascending the bubbles lift the wool more or less to the surface and tend to open it out without the risk of doing so by any mechanical means liable to produce felting. This is the same effect that is produced in many cases so successfully in boiling. Instead of rakes the inventor has placed four hexagonal drums into the trough, marked D, E, F, G. The flat parts of these drums are made of perforated metal and set back a little. This produces an alternate passing of the water into and out of them during their revolution and consequent sucking and repulsing of the wool, which also likewise agitates it. These drums are made wide at the entrance end of the trough and gradually narrower toward the delivery end. The pipe, V V, is the usual steam pipe for heating the water.

We have said before that the improvements introduced into the wool washing machines nearer home have been of advantage for the wools for which they are intended, and possibly the invention just described will also be valuable in some cases.--_Tex. Manuf._

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INCREASING THE ILLUMINATING POWER OF GASES, ETC.

By V. POPP, of Paris.

This invention relates to lighting by mixing air or other gaseous supporter of combustion with illuminating or other hydrocarbon gas or vapor, and burning the mixture (at a suitable pressure) in a burner of special construction, shown in the accompanying illustrations.

[Illustration]

The burner is constructed as shown in Figs 1 and 2. It consists of a central tube, i, screwing upon the pipe by which the gaseous mixture is supplied. Upon this tube is screwed a cup, k, of metal or refractory material which supports a cap, l, of fire-clay in the shape of a thimble (or of other form, according to the intended use of the burner). The flanged base of this cap is perforated with a ring of holes, m, as small and numerous as possible, and the sides of the cap are pierced with oblique perforations, n. The top of the tube, i, is provided with four small projections, upon which rests a copper cone, o, soldered to the tube at a point below the perforations in the base of the thimble. The cone is perforated at its lower end with small holes, p, the sum of whose areas is at least equal to the area of the tube. The thimble, l, is surrounded by an envelope, q, of platinum wire netting or other refractory material of the same form. The gaseous mixture arriving by the pipe, i, escapes at the upper orifices, r, and passes down against the interior surface of the cone, o, out at the orifices, p, and escapes through the orifices in the cap, l, at which it is burned. The cap is thereby raised to a high temperature; and the platinum wire sheath becoming incandescent radiates the light. The gaseous mixture, by coming first in contact with the copper cone and then with the refractory cap, becomes raised to an exceedingly high temperature before it is consumed.

In the modified burner represented in Fig. 3, the metal cone and the fire-cap are truncated. The tube, i, is provided with a number of small perforations, r, at its upper end, the sum of whose areas is at least equal to the area of the tube, and by which the gaseous mixture is distributed within the chamber, k. Upon the upper closed end of the tube is fixed a cup or inverted thimble, o, of fire-clay. A refractory cone, l, surrounds this cup and rests by its base upon the cup. This flanged base is perforated with small vertical holes, m, and upon it is fixed a platinum wire cage or envelope, q. An annular space is left between the cone and cup for the passage of the gaseous mixture, which, on escaping from the orifices, r, passes over the exterior surface of o, the interior of which is already heated by the flame which has not passed through the wire gauze, and has been forced by the pressure of the mixture into the interior of o. The gaseous mixture before passing through the annular space thus attains such a temperature that on escaping from the orifice its combustion is greatly promoted.

*   *   *   *   *

PREVENTING IRON FROM RUSTING.

In the present state of civilization the use of iron has reached a very wide extension, and in a great number of cases iron is used where wood or stone was formerly used. It is certainly an important question how this metal can be protected under all circumstances against rust or oxidation, so that the many costly iron structures may retain their usefulness and strength, and be handed down uninjured to posterity.

Wherever bright iron comes into contact with air and moisture it immediately begins to rust, and this rust is not content to continually rob it of its substance in its persistent progress by scaling off the surface, but at the same time it injures the remainder of the iron by making it brittle. Attempts have hitherto been made to protect the iron by covering it with other and less easily oxidizable metals. For this purpose tin was first selected, then lead and zinc, and recently nickel. Furthermore, earthy glazings and enamels, such as are used on stone ware, have been applied to iron vessels, and they have already found extensive use in the household. In most cases these coatings, either metallic or vitreous, are inapplicable, either because they cannot be applied or are too expensive, so that on a large scale recourse must be had to paints made by mixing oils with metallic oxides, earths, etc., for protecting the surface of the iron from air and moisture.

It has been observed that iron does not rust in _dry_ air, not even in dry oxygen. In like manner it frequently happens that unpainted iron, such as weather vanes, fences, etc., is exposed to the air for a century with very little injury, being covered with a thin coating of the magnetic oxide (proto-sesquioxide), which acts as a protection and prevents farther action. Hence it has been proposed to produce a layer of this magnetic oxide on the surface artificially, and it was found that superheated steam furnished the means for doing this. But it is not to be supposed that such a process would find use on a large scale, and besides this protection could only serve for iron tolerably exposed to the open air and not for that in direct contact with carbonic acid and water.

An interesting observation has been made on railways that the iron rails, ties, bolts, etc., rust until the road begins to be used. Here we must assume that anything made of iron is more inclined to rust when at rest than if occasionally caused to vibrate, when an electrical action probably comes into play and decreases the affinity of iron for oxygen.

In tearing down old masonry iron bonds and clamps are often found which are as free from rust, so far as they are covered with mortar, as they were the day they left the blacksmith’s hands. A French engineer met with such a phenomenon when he uncovered the anchor plates of several chain bridges which had been built about thirty years. Where the anchors were covered with the fatty lime mortar of the masonry they showed no traces of rust, but the prolongations of the anchors in empty spaces were rusted to such an extent that they were only one-third of their original thickness.

It has been repeatedly observed that iron does not rust in water in which are dissolved small quantities of caustic alkalies or alkaline earths, which neutralize every trace of acid. It seems that these experiences are the basis of A. Riegelmann's (Hanau) new protection against rust. The paint that he uses contains caustic alkaline earths (baryta, strontia, etc.), so that the iron is in a condition similar to the iron anchors of the chain bridges that were embedded in lime mortar. Although a paint is not thick enough to inclose so much alkali as the masonry did that the iron was embedded in, nevertheless the alkaline action will make itself felt as long as the coating has a certain consistence. Under all circumstances, however, these new paints will be free from active acids, which is more than can be said of our iron paints hitherto in use. Besides this, the rust protector has such a composition that it could serve its intended purpose without the addition of any alkali. If experience confirms this claim, it will be an interesting step forward in the preservation of iron, and contribute to an extension in the use of iron.--_Polytechn. Notizblatt_.

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[Illustration: SUGGESTIONS IN DECOTATIVE ART.--A CUPBOARD IN ITALIAN WALNUT WITH DARKER PANELING.--_From The Workshop_.]

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AN ELASTIC MASS FOR CONFECTIONERS' USE.

It should be made in a well glazed earthen crock; metallic vessels are not good, as the gelatine burns too easily on the sides, and dries out where it gets too hot. Nor is a water bath to be recommended for dissolving the gelatine, for the sides get too hot and dry out the gelatine.

A quart of water is put in the crock and heated to boiling; it is then taken off the open fire and two pounds of the finest gelatine stirred in, a little at a time. After the gelatine is completely dissolved there is to be added eight or ten pounds (according to the quality of the gelatine) of the finest white sirup previously warmed, and constantly stirred. The mass must not boil, as it would easily burn, or turn brown and acquire a bad color.

Thirty or forty pounds of a beautiful white elastic mass can be made by this recipe in an hour at a cost of ten or twelve cents. Its chief use is for making figures and ornaments to put on bridal cakes and other fanciful productions of the confectioner. It contains no harmful ingredients and can be eaten without danger. If coloring is added, cochineal, plant green (chlorophyl), and turmeric are safer than aniline colors.

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CAOUTCHOUC.

A. Levy contributes the following brief account of this subject to the _Moniteur Scientifique_:

The crude gum cut in irregular strips is passed five or six times between two strong rolls sixteen inches in diameter, and making two or three revolutions per minute. These rolls are kept wet by water trickling on them. This broad strip of gum is perforated with foreign substances and looks like a sieve. It is next put in the cutting machine, a horizontal drum provided with an axle having knives on it. So much heat is produced by this cutting that the water would soon boil if it were not renewed. A second machine of this kind completes the cutting and subdividing, and expels the air and water from it. The mass is then pressed in round or quadrangular blocks.

The vulcanization of thin articles from one twenty-fifth to one-sixteenth inch thick, is done by Parkes' patented process, that is, dipping it in carbon disulphide for a short time, to which chloride or bromide of sulphur has been added, and when the solvent has evaporated the sulphur remains behind. Balls, ornamental articles, and surgical apparatus are dipped into melted sulphur at 275° or 300° Fahr.

The third most important process consists in mixing in the sulphur mechanically with the gum in the cutting machine.

After the pieces have received the form they are to have they are heated with steam or hot air to 275°. Flat articles are vulcanized between press plates heated by steam. This vulcanization is said to have been discovered accidentally by searching different colored stuffs, some of which were dyed yellow with sulphur; the latter stood well.

Hard rubber contains more sulphur, and is heated longer and higher. Small or fine tubes and hose are made by a continuous machine that presses it through a hole with a core to it. Large hose is made by wrapping strips around iron rods or tubes. The little air balloons are made in Paris (their value is $300,000) by Brissonet from English Mackintosh cloth. Powdered soapstone is strewed over it in cutting. The edges are united by hammering on a horn anvil, or by machinery through simple adhesion, and the cut surfaces are smooth.

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PHOTOGRAPHIC ACTION STUDIED SPECTROSCOPICALLY.

At the last meeting of the Chemical Society Captain Abney gave a lecture on the above subject to a large audience. We may premise by saying that the demonstrations he gave were carried out principally by means of experiments on paper, to enable his hearers to understand the different points he wished to enforce. The lecture was commenced by insisting on the fact that all photographic action took place within the molecules of the compound acted upon and not on the molecule itself, and from this he deduced that the absorption of radiation which take place by such compounds is principally caused by the atoms composing the molecule. This was found to be the case in the organic liquids, which the lecturer to some extent had investigated, where he had further traced the absorption to the vibrating atoms of hydrogen in those bodies. In order to properly investigate the action of light it was necessary to ascertain which components of light in the spectrum were the chief agents in causing it, and this led him to consider the means to be employed to obtain a spectrum.

The effects of diffraction gratings were first discussed, and in two which were shown it was found that in some spectra the visible portions were dimmed; in others the ultra-violet and the infra-red were almost entirely absent. It thus became necessary to investigate the condition of a grating before placing any confidence in the results obtained. This was the first pitfall into which an experimentalist was liable to fall. If prisms were used for obtaining the spectrum, then precautions had also to be taken, since all glass absorbed a portion of the ultra-violet rays and some the infra-red. On the whole, he considered that the best glass to use was pure white flint glass for the collimator, the prisms, and the camera lens. Another inquiry that was necessary was the source of radiation which it was proposed to use. Diagrams showed the unsatisfactory nature of solar radiation, and a photograph of the whole spectrum, taken with it under certain atmospheric conditions in which the effect of the green rays were almost _nil_, demonstrated the false conclusions that might be deduced as to the sensitiveness of any particular compound.

Captain Abney also showed the satisfactory conditions which existed in using the crater of the positive pole of the electric arc light as a source, and by diagrams illustrated the inferiority of an incandescent light for the purpose, owing to the deficiency of violet and ultra-violet rays. Having thus settled the source of illumination and the kind of apparatus to employ, he next considered the conditions under which the sensitive salts were to be exposed. The action of ordinary sensitizers was explained and demonstrated by experiments, from which point the results of certain colored sensitizers were considered. Thus, various aniline dyes were proved to be bromine absorbents, and likewise, more or less, to be capable of being acted upon by light in those regions of the spectrum they absorbed. The result of the two effects was to produce a developable image of the spectrum just in those parts to which the salt of silver was sensitive, and also in the parts where the dye itself was acted upon. The latter effect was traced to the organic matter being oxidized in the presence of the sensitive silver salt.

The sensitizing effect of one silver compound upon another was then gone into, and experiments and photographs showed where two salts of silver were in contact with one another, and without an energetic sensitizer being at hand, that the one when acted upon by light absorbed the halogen liberated from the other through the same cause and that a new molecule was formed. This was of importance, since in photographic spectroscopic researches a conclusion might be arrived at that a body suffered absorption in those regions of the spectrum where this interesting reaction took place, whereas in reality the phenomenon might be due to the silver salts employed. This was another pitfall for the unwary. Again, it became necessary in studying photographic action to make sure that the effect of radiation was only a reducing action, and that the results were not vitiated by some other action.

The destruction by oxidizing agents of the effect produced by light was then experimentally demonstrated, and photographs of the spectrum showed that this effect was increased by the action of light itself. Thus, when immersing a plate sensitive to all radiations, visible and invisible, in a very dilute solution of nitric acid, bichromate of potash, or hydroxyl, it was shown that if the plate were exposed to light, first the parts acted upon by the red rays were reduced before the parts not acted upon at all by the spectrum, thus conclusively proving that light itself helped forward the oxidation or so-called solarization of the image. It thus became a struggle, under ordinary circumstances, between the reducing action on the normal salt and the oxidizing action on the altered salt as to which should gain the mastery. If the reducing action of any particular ray were the most active, then a negative image resulted, whereas if the oxidizing action were in the ascendant, a positive image resulted. Thus, in determining the action of light on a particular salt, this antagonism had to be taken into account, and exposure made with such precautions that no oxidizing action could occur, as would be the case if an inorganic sensitizer, such as sulphite of soda, were used.

The reversal of the image by soluble haloid salts, such as bromide of potassium, was then dwelt upon with experimental demonstration. It was shown that the merest trace of soluble haloid would reverse an image by the extraction of bromine from it, and the fact that the most refrangible part of the spectrum was principally efficacious in completing this action showed how necessary it was to avoid falling into error when analyzing photographic action by the spectroscope. A reference was next made to gelatine plates, in which, owing to their preparation, reversal through the above cause was most likely to take place, and a plate soaked in sulphite of soda and exposed in the camera for a couple of minutes--a time largely in excess of that necessary to give a reversal under ordinary circumstances--proved the efficacy of the oxygen absorber, the image remaining in its normal condition after development.

The lecturer closed his remarks by showing the different molecular states of iodide, bromide, and chloride of silver, as produced by different modes of preparation. The color of the film by transmitted light in every case indicated the effect which was likely to be produced on them, and the photographed spectrum in each of them showed the remarkable differences that were found. The points raised by Captain Abney at different times are well worthy the study of scientific photographers, since strict attention to the modes of exposure to the spectrum, to the instruments employed, and to the source of light used can alone insure accuracy in comparative experiments.--_Br. Jour. of Photo_.

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SALT AND LIME.

M.F.K. communicates the following interesting circumstance to _Neueste Erfindung_.: A few years ago it was decided to whitewash the walls and ceiling of a small cellar to make it lighter. For this purpose a suitable quantity of lime was slaked. A workman who had to carry a vessel of common salt for some other purpose stumbled over the lime cask and spilled some of his salt into it. To conceal all traces of his mishap he stirred in the salt as quickly as possible. The circumstance came to my knowledge afterward, and this unintentional addition of salt to the lime excited my liveliest curiosity, for the whitewash was not only blameless, but hard as cement, and would not wash off.

After this experience I employed a mixture of milk of lime and salt (about three parts of stone lime to one part of salt), for a court or light well. To save the trouble and expense of a scaffold to work on, I had it applied with a hand fire engine (garden syringe?) to the opposite walls. The results were most satisfactory. For four years the weather has had no effect upon it, and I have obtained a good and cheap means of lighting the court in this way.

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RENEWING PAINT WITHOUT BURNING.

It is stated in the _Gewerbeblatte fur Hessen_ that paint can be renewed and refreshed in the following manner:

When cracks and checks appear in the paint on wooden articles, this usually indicates that the varnish has cracked. If this is the case, the article can easily be prepared for a fresh coat by sponging it over with strong ammonia water, and two or three minutes later scraping off the varnish with the broad end of a spatula before the ammonia has dried up.

In this way the first coat is removed. If it is necessary to remove the next coating, the same operation is repeated. After the last coat has been scraped off that is to be removed, it must be washed with sufficient water to render the ammonia inactive, and then the surface is rubbed with pulverized pumice to make it smooth. Any desired paint or varnish can be applied to a surface prepared in this way.

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TESTING OLIVE OIL.

By DR. O. BACH.

There is no department in analytical chemistry in which so little success has been attained as in the testing of commercial fats and oils. All methods that have been proposed for distinguishing and recognizing the separate oils, alone or mixed, bear upon them the stamp of uncertainty.

The facts observed by J. Koenig, and described by him in his excellent book entitled "_Die Menschlichen Nahrungs und Genussmittel_" (p. 248), excited great expectations; viz., that the quantity of glycerine in vegetable fats was much less than the amount required to combine with all the fatty acids, and that the quantity of oleic acid in the oils that he examined exhibited essential differences. Koenig himself asserts that the fats have hitherto been too little investigated to found upon it a method for distinguishing them, but that nevertheless it may possibly do good service in some cases.

My own estimation of the amount of glycerine in different olive oils, by Koenig’s method, has shown, unfortunately, that the percentage may vary from 1.6 to 4.68, according to the origin and quality of the oil. In like manner the estimation of the oleic acid, which was conducted essentially in the manner proposed by Koenig, showed that the amount of oleic acid in different olive oils varied from 45 to 54 per cent. But since cotton seed oil, for example, which is most frequently used to adulterate olive oil, contains 5 per cent. of glycerine, and 59.5 per cent. of oleic acid, it is easy to see an admixture of cotton seed oil cannot be detected by this method, which appeared to be so exact.

The method of analysis that I am about to describe is based chiefly upon the determination of the melting point of the fatty acids contained in the oils, and upon their solubility in a mixture of alcohol and acetic acid.

The oils employed in adulterating olive oil, and to which regard must be had in testing it, are the following: Cotton seed oil, sesame, peanut, sun flower, rape, and castor oils. The tests for the two last named have hitherto never presented any difficulty, as rape seed is easily detected, owing to the sulphur in it, by saponifying it in a silver dish, and castor oil by its solubility in alcohol. But in recent times another product has come into the market called sulphur oil or pulpa oil, obtained by extracting the pressed olive cake with sulphide of carbon. This also gives a sulphur reaction when saponified, while it resembles castor oil by its solubility in alcohol. When this oil is mixed with ordinary olive oil, it can easily deceive any one who uses the ordinary tests.

My method of testing olive oil is as follows:

First, the so-called elaidine test is made, and then the test with nitric acid. About 5 c. c. (a teaspoonful) of the oil is mixed in a test tube with its own volume of nitric acid, spec. gr. 1.30, and shaken violently for one minute. At the expiration of this time the oils will have acquired the following colors: Olive oil, pale green; cotton seed oil, yellowish brown; sesame, white; sun flower, dirty white; peanut, rape, and castor oils, pale pink or rose.

As soon as the color has been observed, the test glass is put in a water bath at the full boiling temperature and left there five minutes. It was found that the action of nitric acid upon cotton seed and sesame oil was the most violent, sometimes so violent as to throw the oil out of the glass. At the end of another five minutes after the test tube is taken out of the water bath, the following colors are seen: olive and rape oils are red; castor oil is golden yellow; sun flower oil, reddish yellow; sesame and peanut, brownish yellow; cotton seed, reddish brown.

After standing 12 to 18 hours at about 60° Fahr. the olive, rape, and peanut oils will have solidified; sun flower, castor, and cotton seed will be like salve (sticky), while sesame will remain perfectly liquid. Mixtures of olive oil with small quantities of cotton seed or sesame are distinguished by this characteristic--that, although the whole mass, which is darker in color than olive oil, solidifies at first, at the end of 24 or 36 hours a brown oil will be found floating upon the surface of the solid mass, while the lower strata exhibit the yellow color of pure olive oil. Oil of rosemary has no effect when shaken with cold nitric acid, and imparts to it only a slightly darker color on heating. Oils treated with lye act just like pure oils.

Far the purpose of determining the melting point of the fatty acids, 10 grammes of oil were saponified with 5 grammes of caustic potash on the water bath; some water and alcohol being added. After all the alcohol had been expelled the soap was dissolved in hot water, and the fatty acids separated from the clear solution by adding hydrochloric acid. After prolonged heating these acids will swim on the salt solution as a perfectly clear oil, a portion of which is then put into a little, narrow, thin walled tube and allowed to solidify. The point at with it melts and solidifies is determined by putting this tube in a beaker glass filled with water and warming with a small flame. A thermometer is placed _in_ the fatty acids and moved gently about during the observation, and the point accurately observed at which the whole mass becomes perfectly clear, and also when the mercury bulb begins to be clouded. It was found that the acids from pure olive oil melt between 26‰ and 28‰° C. (= 80° to 83° Fahr.) and solidify at a point not lower than 22° C. (72° Fahr.). The melting point of the fatty acids in the oils used to adulterate olive oil differs considerably from this. The melting and solidifying points of the acids in cotton seed, sesame, and peanut oils lie considerably higher, those of sunflower, rape, and castor oils decidedly lower than those of olive oil.

The melting and solidifying points of these acids are as follows:

Cotton seed	melts at	38.0℃.	solidifies	35.0℃.
Sesame	do.	35.0 do.	do.	32.5 do.
Peanut	do.	33.0 do.	do.	31.0 do.
Sunflower	do.	23.0 do.	do.	17.0 do.
Rape	do.	20.7 do.	do.	15.0 do.
Castor oil	do.	13.0 do.	do.	2.0 do.

The above figures differ so much from those of olive oil, that adulteratious carried to the extent that they are in trade can easily be detected by the aid of an estimation of the melting point, for a Gallipoli olive oil, mixed with 20 per cent. of sunflower oil, melted at 24° C. and solidified at 18° C. (of course, the fatty acids are meant). A Nizza oil, mixed with 20 per cent. cotton seed oil, melted at 31‰° C. and solidified at 28° C. A Gallipoli oil with 33-1/3 per cent. of rape oil melted at 23‰° C. and solidified at 16‰° C. When 0.50 per cent. of rape is added, it melts as low as 20° and solidifies at 13‰° C., etc.

In testing the solubility of the fatty acids in alcohol and acetic acid, I employ the method proposed by David (in _Comptes Rendus_, 1878, p. 1416) for estimating stearic acid.

It depends upon the principle that when acetic acid is poured drop by drop into an alcoholic solution of oleic acid, there comes a time when all the oleic acid separates, but stearic acid, which is insoluble in a mixture of alcohol and acetic acid, remains insoluble if the mixture contains oleic acid.

The following manipulations are adopted in testing olive oil: Equal parts of glacial acetic acid and water are mixed in a bottle. Then 1 c.c. of pure oleic acid, 3 c.c. of 95 per cent. alcohol, and 2 c.c. of acetic acid are put in a small tube graduated in tenths of cubic centimeters. The solution should remain clear; on adding another one-tenth c.c. of acetic acid it becomes turbid, and when 1 c.c. of oleic acid (or at first even more) floats on the mixture of acid and alcohol, the liquid is ready for use. If this is not the case, the proportions (of acetic acid and alcohol?) must be varied until the addition of one-tenth c.c. of the former will cause all the oleic acid to separate. The proportions having been ascertained from these preliminary experiments, the alcohol and acid are then mixed accordingly, e.g., 300 of alcohol to 225 of acid. One or two grammes of stearic acid are added to the alcoholic acetic acid, and the clear supernatant liquid used for the experiments.

One cubic centimeter of the oil (acids) to be tested is put in the tube, and 15 c.c. of alcoholic acetic acid added, well shaken, and the whole left to stand quietly at 15° C. (60° Fahr). If the olive oil is pure, the acids dissolve to a clear solution that remains so. Cotton seed oil is insoluble, and the solution obtained by heating the solution solidifies at 60° Fahr. to a white jelly. Sesame and peanut oil react in a similar manner. Sunflower oil dissolves, but at 60° a granular precipitate falls. Rape oil is entirely insoluble and floats like oil on the surface. Castor oil on the contrary dissolves completely, just like olive oil, and hence cannot be detected therein by this method. To detect this oil we must take the melting point of the acids along with the solubility of the oil itself in alcohol.

Olive oil when mixed with 25 per cent. of cotton seed oil yields a granular precipitate, and so does 25 per cent. of sesame. Smaller quantities cannot be detected by these methods. For rape oil the limit is 50 per cent., and in smaller quantities the oil does not collect on the alcoholic solution. The decided lowering of the melting point of the fatty acids in combination with the sulphur reaction, and the insolubility of the oil in alcohol, also furnish a method of detecting when present in smaller quantities in olive oil.

Although I am well aware that I am making public a research that is by no means free from objections, I nevertheless believe that it may be of use to those who have to undertake the ticklish and intricate analyses of commercial fats.--_Translated from the Chemiker Zeitung_, p. 355.

Leipsic, Jan., 1883.

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ON THE THEORY OF THE FORMATION OF COMPOUND ETHERS.

In a note presented to the Industrial Society of Mulhouse, A. Pabst discusses the different stages in the formation of compound ethers, as Williamson has explained the production of ordinary ethers by the action of sulphuric acid upon alcohol. Pabst has observed that the compound ethers are formed in an analogous manner. If alcohol, sulphuric acid, and acetic acid are heated together, acetic ether, we know, is formed.

Pabst has shown that it takes place in three stages. In the first stage, ethyl sulphuric acid and water are formed; in the second, acetate of ethyl with the reproduction of sulphuric acid, which again converts a fresh quantity of alcohol into ethyl sulphuric acid.

(1) $C_{2}H_{5}OH+HO,SO_{2}OH = C_{2}H_{5}O,SO_{2}OH+H_{2}O.$
(Alcohol.) (Sulphuric acid.) (Ethyl sulphuric acid.)

(2) $C_{2}H_{5}O,SO_{2}OH+C_{2}H_{3}O,OH =$

(Ethyl sulphuric acid.) (Acetic acid.)

$C_{2}H_{5}O,C_{2}H_{3}O+HO,SO_{2}HO.$
(Acetate of ethyl.) (Sulphuric acid.)

Pabst proved this by letting methyl sulphuric acid act upon a mixture of acetic acid and ethyl alcohol. He obtained by this process acetate of methyl and ethyl sulphuric acid. By the continued action of ethyl alcohol and acetic acid upon this mixture, of course, acetate of ethyl was formed. At the conclusion of the operation there was no longer any methyl sulphuric acid present in the liquid.

In the course of his investigations, Pabst was led to a very practical method for preparing acetate of methyl, which consists in heating ethyl sulphuric acid to 135° or 140° C, and allowing a mixture of equal molecules of strong alcohol and acetic acid to flow into it.

The details of his experiments and the method of purification will be published by the society.

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A GREEN OR GOLDEN COLOR FOR ALL KINDS OF BRASS.

By E. PULCHER.

The French brass castings and articles of sheet brass are made of cheap, light colored brass, and possess a fine golden color which is not produced by gold varnish, but by a coating of copper. This gives them a finer appearance, so that they sell better.

This golden color can be easily produced at very little expense and with but little trouble by the following process. Fifty grammes of caustic soda and 40 grammes of milk sugar are dissolved in a liter of water and boiled for a quarter of an hour. The solution is clear as water at first, but acquires a dark yellow color. The vessel is next taken from the fire, placed on a wooden support, and 40 grammes of a cold concentrated solution of blue vitriol stirred in. A red precipitate of suboxide of copper is at once formed, and by the time the mixture cools to 167° Fahr., the precipitate will have settled.

A suitable wooden sieve is placed in the vessel, and on this the polished articles are laid. In about one minute the sieve is lifted up to see how far the operation has gone, and at the end of the second minute the golden color is dark enough.

The sieve and articles are now taken out, and the latter are washed and then dried in sawdust. If the brass is left longer in the copper solution, in a short time a fine green luster is produced, becoming yellow at first and then bluish green. After it turns green, then the well-known iridescent colors finally appear. To obtain uniform colors it is necessary that they be produced slowly, which is attained at temperatures between 135° and 170° Fahr.

The copper bath can be used repeatedly and can be kept a long time if bottled up tightly without change. After it is exhausted it can be renewed by adding 10 grammes of caustic soda, replacing the water that has evaporated, heating to boiling, and adding 25 grammes of a cold solution of blue vitriol.

Similar operations with other well known reducing agents, such as tartrate of soda, glycerine, etc., do not give such good colors, because they do not precipitate the copper solution so rapidly and at so low a temperature.

If the rinsed and pickled brasses are dipped for five minutes in a three per cent. neutral solution of cocoa nut oil soap, and then washed with water again before they dry, the coating gains in permanence.

Brass articles that have to be cleaned frequently should be covered with oil of turpentine, or thin English copal varnish.--_Neueste Erfind_.

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VINEGAR.

Hermann Kratzer, of Leipsic, communicates the following practical information on the clarification and purification of vinegar to the _Neueste Erfindungen und Erfahrungen_:

If vinegar has an unpleasant odor, which is rarer now that the vinegar manufacture has reached such a state of perfection, it may be removed as follows: Well burned and finely pulverized wood charcoal is put into the bottles containing the vinegar, the proportions being 8 grammes of charcoal to a liter of vinegar, or one ounce to the gallon. It is shaken several times very thoroughly, then left standing three or four days, and the vinegar filtered through a linen cloth. Vinegar treated in this manner will be found to have completely lost its unpleasant odor.

I have found that when I used blood charcoal or bone coal in place of wood coal it was still more efficient; but it must be mentioned that when they are used they must be purified as follows before using: Charcoal from blood contains potash and hence it is necessary to wash it with distilled water and dry it before using it. Bone coal (also called bone black, animal charcoal, etc.) contains on an average 10 per cent. of nitrogenous and hydrogenated carbon, 8 per cent. of carbonate of lime, 78 per cent. of phosphate of lime, besides phosphate of magnesia, sulphate of lime, soluble salts, etc. Before using, it should be treated with dilute hydrochloric acid until it does not effervesce any more. The bone coal is then left to stand for 24 or 30 hours and at the end of this time is washed with distilled water until the wash water no longer reddens a blue piece of litmus paper, i.e., until every trace of hydrochloric acid has been removed from the bone coal. Wood charcoal may be treated in like manner. When this coal is perfectly dry it is employed in the same proportions as the other, 8 to 1,000, the operation being exactly the same.

He turns next to the clarification of the vinegar.

It happens everywhere that vinegar instead of being clear is sometimes turbid. This is due to particles of yeast dissolved in the vinegar that have not yet settled. To remove this kind of turbidity it is customary to use oak or beech shavings that have been washed in hot water and then dried. These shavings, which must be very long and extremely thin, are put in a barrel with a second and perforated bottom, to a depth of 12 to 34 inches. The vinegar that runs through them deposits its slimy constituents on the shavings and becomes perfectly clear, and presents to the eye a pleasing appearance.

To this generally known method I would add a few more:

1. I take a ‰ kilo of well pulverized _animal charcoal_ (black burned bones) to 7/8 of a hectoliter of vinegar (1 lb. to 20 gallons), and stir it well with a wooden rod; or, if the vinegar is in bottles, I shake it a long time after putting the animal charcoal in the bottle, and repeat it several times. After three or four days I finally filter the vinegar through linen, when the filtrate will exhibit the desired clearness.

2. The best way to clarify vinegar is with _isinglass_. It is first broken up, then swelled for a day in vinegar (17 or 18 grammes to the liter), then 2 liters of vinegar are added and the mass boiled until the isinglass is completely dissolved. Such a solution as this (‰ ounce to 3 quarts) is mixed with 10… hectoliters (250 gallons) of turbid vinegar and well stirred through it. After the expiration of five or six weeks vinegar treated in this way has a beautifully clear appearance.

3. _Albumen_ can likewise be used to clarify it. The vinegar is boiled with the albumen until the latter is completely coagulated, and then the vinegar is filtered.

4. And finally _milk_ may be employed. For this purpose the milk is skimmed, and 1 quart of milk added for every 68 quarts of vinegar, the mixture well stirred and shaken. After the caseous portion has coagulated (curdled) it is filtered as before, and in this case, too, the product is a fine, clear vinegar.

We believe that these few experiments, so easily performed, and at so small an expense, will prove useful to our readers in enabling them to put their product in the market in an excellent condition and nicely clarified.

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THE ALIZARINE INDUSTRY.

At a recent meeting of the Manchester section of the Society of Chemical Industry, Mr. Ivan Levinstein described the history and progress of the manufacture of alizarine, from which are produced fast red, purple, brown, and black dyes. He said alizarine was, until very recently, made only from the root of the madder plant, of which the yearly crop was 70,000 tons, and represented an annual value of £3,150,000, of which the United Kingdom consumed 23,000 tons, representing a value of nearly £1,000,000.

Madder is now no longer grown for this purpose. The German chemists found that alizarine produced from madder in undergoing certain treatment gave a substance identical with anthracine, one of the constituents of coal tar, and in 1869 the same chemists announced to the world that they had accomplished the synthesis of alizarine from anthracine. The effect of this discovery was to throw madder out of cultivation.

Mr. Perkin, an English chemist, and Messrs. Graebe and Liebermann, German chemists, almost simultaneously applied for patents in 1869, in England, and as their methods were nearly identical they arranged priorities by the exchanging of licenses. The German license became the property of the Badische Aniline Company, and the English license became the property of the predecessors of the North British Alizarine Company. These patents expire in about two months, and the lecturer explained that an attempt made by the German manufacturers to further monopolize this industry (even after the expiry of the patent) proved abortive. He also stated that alizarine, 20 per cent. quality, is sold to-day at 2s 6d. per lb., but that if the price were reduced by one-half there will still be a handsome profit to makers, and that the United Kingdom is the largest consumer, absorbing one-third of the entire production, and that England possesses advantages over all other countries for manufacturing alizarine--first, by having a splendid supply of the raw material, anthracine; secondly, cheaper caustic soda in England than in Germany by fully £4 per ton; thirdly, cheaper fuel; fourthly, large consumption at our own doors; and, fifthly, special facilities for exporting.

The advantages derived from the development of the alizarine manufacture here, it was stated, will benefit other collateral industries, such as manufacture of soda, of ordinary sulphuric acid, bichromatic, and chlorate of potash, articles used in this manufacture. The lecturer considered that the difficulties attending the manufacture of alizarine were now overcome, and with sufficient capital and competent chemists English manufacturers must be successful.

He then proceeded to explain the source from which nearly all the artificial coloring matters are derived, viz., gas tar; showing the principal products of this wonderful, complex mixture, of which one is anthracine. Alizarine manufacturers originally found scarcity of anthracine; at present the supply is in excess of the demand, and the price during the last 18 months has fallen from 3s. 6d. to 1s. per unit, and the probabilities are that the supply will increase. The quantity of gas tar now obtained the lecturer estimated at 500,000 tons per annum, and the coal carbonized for gas making, 10,000,000 tons. This quantity of tar suffices to produce 9,000 tons of 20 per cent. alizarine.

The lecturer then reviewed, in case of an increased demand for anthracine, the probable new sources of obtaining increased supplies of coal tar: (1) The destructive distillation of petroleum; (2) coke ovens and blast furnaces; (8) the carbonization of coal for general manufacturing purposes, using the coal and gas as fuel, and giving tar, benzine, and ammonia as residues; and (4) distillation of coal with the object of obtaining the principal products, tar and benzine, and as the residual product, gas. This part of the lecture was important to dyers and printers, the lecturer showing also, in a very interesting way, in what manner manufacturers may very considerably economize their consumption of coal.

The lecturer explained that while from one ton of coal there was obtained on an average about 17 oz. of benzine, by the new method about thirty times that amount can be got from the same quantity of coal. He also considered in great detail the different processes of the carbonization of coal, and of increasing the production of the different important residual products of gas tar, and also the best method of extracting the benzine. He showed samples of benzine which he produced from gas obtained at the Rochdale Road Gasworks, and, further, nitro-benzine, aniline, and coloring matters, which he had made from this gas benzine.

The lecturer also discussed the effect of the probable increased production of tar, ammonia, benzine, etc., as affecting gas companies, and said it was anticipated they either would raise the price of gas or change the present system of manufacture, which he considered probable. The enormous increase in the production of ammonia, of which the larger portion at present, as sulphate of ammonia, was used as a fertilizer, would no doubt considerably reduce its value. It might even replace soda for many purposes, and thus react on our alizarine industry.

He then proceeded to consider the manufacture of alizarine purpurine, and divided its manufacture into four stages: 1, the purification of crude anthracine; 2, the conversion of the purified anthracine into anthraquinone; and 3, the production of sulpho acid of anthraquinone and the conversion of this sulpho-acid into alizarine and purpurine. This part of the lecture comprised a detailed explanation of the various kinds of apparatus required, to be used which were beautifully got up, complete working models having been prepared for the occasion. The lecturer was of opinion that large consumers would be benefited if makers would offer for sale only three distinct coloring matters--iso or anthrapurpurine, and flavo-purpurine, leaving it to the dyers and printers to produce for themselves the intermediate shades by mixing the three colors; and he showed that by reason of the fastness of the shades produced by these coloring agents varying considerably, the blue shade (alizarine) being much faster then the orange shade (flavo-purpurine), consumers were in many instances losers by using mixtures of alizarine and flavo-purpurine.

In the course of the lecture many interesting specimens of various products were produced and dilated upon, the lecturer fully describing the process of purifying the crude anthracine and of the conversion of the purified anthracine into anthraquinone.

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THE PRESERVATION OF MEAT BY CARBONIC ACID.

Since 1874, when Professor Kolbe, of Leipsic, first published his results on the antiseptic action of salicylic acid, he has made many efforts to apply this acid to the preservation of meat, but he has invariably found that after the lapse of a few days an unpleasant flavor has been developed, which is not that of putridity. If putrid changes be noticed, it is a sign that salicylic acid is in insufficient quantity, for where it has turned putrid the meat is found to be no longer acid, but alkaline. This leads to the assumption that meat is protected from change by acids, even by gases of that kind; and in fact it was noticed that beef--from 2 to 5 kilos. being taken--when placed in an earthen vessel and loosely covered with a wooden cover, was long preserved from putridity if the bottom of the vessel contained some hydrochloric acid, nitric acid, or aqueous sulphurous acid. The meat, however, no longer had the taste of fresh meat, but of such as had long lain in ice. Experiments were therefore made with carbonic acid, and these proved highly successful. The meat was placed in a cylinder of metal plate, and suspended from a rod which crossed the upper part and the lower part. A small tube serves to admit a current of carbonic acid from a Kipp's apparatus. The lid, which rested in a circular trough of glycerine, was traversed by a similar tube in its center, and both tubes could be closed with India-rubber tubing and screw taps as soon as sufficient carbonic acid gas had traversed the apparatus. At the end of seven, fourteen, and twenty-one days it was found that the meat was still quite good, and the soup prepared from it was in every respect excellent. At the end of the fourth or fifth week the meat thus preserved in the gas was still quite free from all putridity; but the broth prepared from it no longer tasted so well as fresh bouillon. The experiments were not extended over a longer time. Carbonic acid is thus shown to be an excellent means of preserving beef from putridity and of causing it to retain its good taste for several weeks. Mutton does not preserve so well. In eight days it had become putrid; and veal is by no means so well preserved as beef. The comportment of beef in an atmosphere of carbonic acid, to which carbonic oxide has been added, is curious. A number of cylinders were filled in the usual way with such a mixture and opened at the end of two or three weeks; in each case the flesh had the smell and taste of good, pure meat, but it was not of the gray color which meat preserved in carbonic acid gas gradually takes, but appeared in the interior, as well as on the outside, of a bright flesh-red color, and on the surface here and there, there were white round masses of fungoid growth of the size of a 20-pfenning piece, which were removed with the slightest rubbing. The flesh lying just below these was found to have the same bright red color as that already described. Meat which had been for three weeks in such a gas mixture gave a broth which, in good taste and freshness, could hardly be distinguished from freshly-made bouillon; and the boiled meats could not be distinguished either in appearance or taste. The property of carbonic acid to preserve meat suggests a use for the large supplies of this gas evolved from the earth in many localities. And it is as interesting to determine in how far the gas could be of service as an antiseptic during surgical operations.

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REDUCTION OF OXIDIZED IRON BY CARBONIC OXIDE.

IT is well known that when the heat is sufficient, carbonic oxide reduces the oxide of iron to metal with the production of carbon dioxide (carbonic acid). On the other hand, at lower temperatures carbon dioxide oxidizes metallic iron, forming carbonic oxide. J. Lowthian Bell's celebrated researches (see SCIENTIFIC AMERICAN, p. 199, March 31, 1883) established the point of equilibrium where in the presence of both monoxide and dioxide the reducing action of the one just counterbalances the oxidizing action of the other.

At the suggestion of Prof. R. Akermann, of Stockholm, C.G. Sänstrom has conducted a similar series of forty-five experiments, the expense being borne by the Jernkontor. About 1 gramme of oxide of iron was placed in a porcelain boat, and slid in a porcelain tube 18 millimeters (¾ inch) in diameter and 635 millimeters long (25 inches). This was exposed to the action of a current of mixed carbon dioxide and monoxide made by heating oxalic acid and concentrated sulphuric acid. It was mixed with carbon dioxide as required, then analyzed, and preserved in gasometers holding 66 liters. Before using, it is passed over phosphorus and chloride of calcium, and through sulphuric acid. The porcelain tube and boat were heated to from 300° to 600° C. (572° to 1,652° Fahr.) while the gases were passing, and then the state of oxidation determined. It was found that the larger the quantity of dioxide the higher the degree of oxidation, and the larger the proportion of monoxide the lower the degree of oxidation.

The details of the experiment indicate that a saving of fuel in the blast furnace could best be accomplished by the use of a very hot blast, introducing some carbon monoxide into the blast, provided, of course, that this gas can be made outside of the blast furnace more cheaply than inside of it. Nevertheless, 643 lb. of carbon must be burned to every 1,000 lb. of iron reduced, if carbonic oxide is exclusively employed.--_Stahl und Eisen_.

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ON THE ADULTERATION OF SOAP.

By Dr. H. BRACKEBUSCH.

The importance of soap as an indispensable article in the household has not restrained the adulterators from making it a favorite object of their operations, and at the present day soap is only very rarely what it should be, the alkaline salt of a fatty acid with about 15 per cent. of water, which may be increased in case of soft soaps to 30 per cent. at most. The amount of moisture is an immediate signal for adulteration. Of all substances that can be used to adulterate soap, water is of course the cheapest, and as it is also harmless, this was the first point where manufacturers made use of their knowledge. The percentage of water was raised to 26 or 28 per cent., and now nearly all the ordinary soaps contain that amount when they leave the factory. At first the retailers objected to this method, because they had to suffer the loss so far as it dried out and lost weight in the store.

The next point was to find some substance that would prevent this rapid drying, and it was very soon discovered that those soaps that contained an excess of lye retained moisture longer. Henceforth it was only necessary to use lyes of extra strength so as to obtain a large yield of soap containing an excess of water. The results of this ingenious method are before us; in the shops of the soap dealers the bars of soap become coated with a crust of white crystals, which is nothing but soda. If a few drops of corrosive sublimate be dropped on these crystals, a red spot will at once be produced by the formation of mercuric oxide. In addition to the deception of the public who buy such soaps, this alkali destroys clothes washed with it, as the fiber of the tissues is directly attacked by it, while the proper action of the soap depends on its enveloping the particles of dirt and carrying them off.

Soap is subject to another kind of adulteration called filling, or weighting. Soapstone and similar mineral substances are added to the finished soap to increase its weight. But it may be added that this fraudulent weighting is rare. Large establishments cannot take the risk of being detected in such avaricious practices, and small ones scarcely have the apparatus at their disposal for making a uniform mixture which will not arouse suspicion.

Now soaps are frequently found in the market that scarcely deserve this name. Mineral soap, cold water soap, etc., are the names inscribed on the placards behind which is buried a preparation consisting for the greater part of water-glass. The well-known water-glass is a silicate of soda or potash dissolved in free or caustic soda, or potash. There was a time when it excited great hopes, and its introduction into the household for washing was dreamed of, but it was soon found that its caustic properties made their appearance at a relatively low temperature. Hence we often find the notice, "TO BE USED COLD," printed in bold letters on the wrappers. This product is obtained by thickening water-glass with stearine, oleine, or any other easily saponifiable fat. As it takes but very little of the substances named to make an article closely resembling soap, of course the product is very cheap. There does not seem to be any limit to the amount of water in it; at least the author found in one kind of mineral soap from Berlin 58 per cent. of water. Water-glass soaps do not dissolve readily in water, they make but little suds, and render the skin hard and unpliable. Admitting that they are suitable for many purposes, nothing can be said against their sale so long as they appear under names which preclude their being confounded with other soaps. Nevertheless, there is always this danger--that water-glass may come into general use in making soap, and this is to be deplored. Water-glass soaps are easily recognized by their insolubility in moderately strong alcohol, the water-glass remaining behind in a gelatinous form.

Great deception has been practiced under such names as "almond soap," etc. Fortunately the difference between various kinds of fat are not very great from a chemical point of view, although it is always an unpleasant thought that the fat from animals that have died may return to the house in the form of soap. A white or yellow soap having a good smell is not made from bad fat, and hence is more appetizing.

A method formerly much in use consisted in mixing green soap with starch paste, a mixture that could not be detected by the naked eye, especially if colored with caramel. On attempting to dissolve it in ordinary burning alcohol, a white coagulum forms.

From the foregoing it is sufficiently evident that those who buy soap to sell again have every reason to keep a sharp lookout on those who furnish them with soap.--_Polyt. Notiz._

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BOVINE AND HUMAN MILK: THE DIFFERENCE IN ITS ACTION AND COMPOSITION.

By C. HUSSON.

M. Meynet, in a remarkable report upon condensed milk, has raised a question which it is important to have solved in the interests of infants. This is my excuse for presenting to the French Society of

Hygiene certain observations on this subject.

Is woman’s milk richer in fatty matters and sugar in proportion to the caseine than that of the cow? Is the affirmative, sustained by a large number of chemists, a mistake that ought to be corrected?

Such is the question that needs to be answered.

In my last work on milk, my aim was to report new experiments, and hence I gave only the analysis of M. Colawell. By the side of the essays of MM. DoyŁre, Millon, Commaille, and Wurtz, I put those of Liebig, and quoted an interesting chapter written on this question by M. Caulier, in Dechambre’s Encyclopedic Dictionary. These are the authorities upon which to base any opposition to the analyses of Boussingault, Regnault, Littre, and Simon, savants of no less renown.

The differences are easily explained.

Woman’s milk is rarely to be had in sufficient abundance to make a complete analysis of it. In the country especially a few precious drops, obtained with difficulty, are carried off in a thimble to be placed under a microscope, where the number of fat globules are counted, and it is examined to see if they are not mixed with globules of colostrum.

It will be necessary at the outset to know whether the analyses given refer to milk drawn from the breast before nursing, or at the end. In the former case there will be an excess of caseine, in the second an excess of fat present. This is the reason that in nursing infants the intervals should not be too long, or the child will not be able to empty the breast completely, and it will obtain a milk too rich in caseine, too poor in butter, and one that it cannot digest.

This is the first proof of the importance of fatty matters for the alimentation of babes.

Let us turn to the second.

At birth, when the milk is still in a state of colostrum, the fluid contains a variable quantity of albumen coagulable by heat, much less caseine, and an excess of butter and sugar.

Cow’s milk, immediately after calving, contains more butter and less caseine than milk produced some time later, when the specific character of ruminants begins to appear in the calf, that is to say, when it commences to graze the milk coagulates in the stomach. As in other mammals, an excess of fat helps digestion by subdividing the caseine and emulsifying it. But the milk of an animal recently calved is reserved for its young, and it is not until the time of weaning that the lacteal fluid is offered for human consumption.

Thus it is that the nursling of a day receives milk many months old and heavily loaded with caseine. This milk it cannot digest because the emulsifying element, the fat, is not present in it in sufficient quantity in proportion to the coagulable matter. We must not forget either that the difference in coagulation holds also with respect to difference in the age and in the kind of animal. Just so the rennet of a sucking calf has a greater power of coagulating cow's milk than that of a sheep, and _vice versa_.

"Clinical observation," says Dr. Condereau, "shows that all young infants digest human milk very easily and cow's milk very imperfectly. When it is fed on the latter, in the excreta will be found numerous fragments, sometimes very bulky, of undigested caseine. In most cases this caseine suffers more or less decomposition in the alimentary canal, which gives to the feces a tainted odor recalling that of putrid Roquefort cheese.

"The excrement vary in appearance as much as they do in odor. Frequently the caseous clots are not to be seen, and the stool has a clammy look reminding one of glazier's putty, while the color varies from dirty white to pale grayish yellow. That is due to the fact that the composition of the milk from different animals is far from being constant.

"The proportions of albumen to those of caseine are especially varied. For woman's milk the proportions are as 100 to 122.72. In goat's milk the proportions are 100 to 173.09. In cow's milk it is as 100 to 289.20.

"The conclusion is this: Caseine is not a food at all for the new born during a space of time, the duration of which is to be determined experimentally.

"This substance is a harmful burden that interferes with the regular action of the digestive organs. It is a premature food, and the more abundant the more injurious.

"Albumen on the contrary remains fluid in the presence of the gastric juice; it is separated from the other aliments by coagulation of the caseine. It is absorbed entire either in its natural state or in form of peptone."

According to clinical observation, it is still the fats that give to milk its hygienic value, and the excess of caseine is an obstacle to its digestion.

However, if cow's milk is not easily digested by children, experience proves that there are other kinds of milk, from other animals, which young stomachs are able to bear more easily. There are many proofs of this fact.

M. Tarnier, speaking before the Academy of Medicine on the artificial nourishment of the new born, reports that the milk of cows and goats, pure or diluted in different ways, that of condensed milk and Biedert's cream, have always given disastrous results at the Maternite in Paris, but that the mortality of the new born was considerably reduced from the day when ass's milk was introduced as food.

Ass's milk was given pure for six weeks or two months; then cow's milk diluted with one-half water until six months old, followed by pure cow's milk. This is the most rational course of artificial feeding.

Prof. Parrot reports analogous results obtained at the nursery opened at the Hospice des Enfants Assistes. By the aid of ass's milk he saved a number of the little syphilitics.

The following are the numerical results: 86 infants with hereditary taint of syphilis have been at the nursery. Of 6 fed exclusively on cow's milk, only 1 survived and the other 5 died. Forty-two were suckled by goats, of which 8 lived, 34 are dead, which is equal to a mortality of 80.9 per cent. Thirty-eight were suckled by an ass, of which 28 lived and 10 died; a mortality of 26.3 per cent.

Certainly these figures prove eloquently enough what chemical analysis shows, that ass's milk, being better borne by the infant's stomach, ought to have a composition resembling that of woman's milk. This analogy is not found to consist in the quantity of fat, but in the small amounts of dry residue (total solids) and of caseine.

Let us now examine the objections raised by M. Meynet.

Food has a considerable influence upon the composition of milk; this fact, stated by M. Riche in his treatise on chemistry, seem to be accepted by all.

The milk of carnivoræ is excessively rich in caseine; that of herbivoræ much less.

The food of woman, who enjoys a mixed alimentation, ought to have a composition intermediate between these two, and consequently ought to contain more caseine than that of the plant eaters. This is the logical deduction.

At first this reasoning misleads one, but numerous objections present themselves.

The food, no doubt, has some influence upon the composition of the milk of animals of the same species, but every animal can secrete something independent of any food, just as one kind secretes musk, another castor, etc. Yet it would not be an anomaly if an excess of caseine in proportion to the other substances was a true characteristic of ruminants.

But we admit that the milk of all mammals ought to have identically the same composition if their food suffered no modifications.

What is the food of ruminants? Without doubt it is essentially vegetable, and the plants of the field constitute the element par excellence of their nurture. These plants contain a large excess of carbohydrates in proportion to the nitrogenous.

But what are these other substances? What role do they play in digestion?

They are composed in great part of fibers and cells that suffer no change in the animal economy, and which are not acted upon by the gastric juice, as proved by their occurrence in excreta. The carbon is found almost unchanged, so that the excrements of herbivoiæwhen dried, form a valuable fuel. Ruminants are compelled, in order to obtain nourishment from the plants that they eat, to extract their juices by repeated pressure (as in chewing the cud); and what do these soluble juices contain? Some saccharine substances, a little fat, but mostly albumen and vegetable caseine, that is to say, the substance which predominates in their lacteal secretions.

What, on the contrary, is the food of woman?

No doubt she gains much strength from the lean, muscular flesh that she eats, but besides this she has butter, oil, fats of all kinds, sugar, starches, and alcoholic beverages, all of which are favorable to the production of butter in the milk. Hence, aside from her physical constitution, the food of woman alone explains the relative excess of non-nitrogeneous substances.

Nitrogenous articles of food are expensive, while the other forms of nutriment are to be had in the form of potatoes, beans, and bread, products sold at a reasonable price. Yet logic demands that there shall be an excess of butter in proportion to caseine in the milk.

The discrepancies in analyses of woman's milk are easily explained by the mobile and impressible character of woman.

If bad treatment and bee stings are able to modify the composition of cow's milk, how much more ought the emotions of all sorts, which disturb the heart and head of woman, to change the composition of her milk?

But if new analyses seem to be needed, they ought to be made. This question is too important to rest in suspense. The mean composition of human milk for the first two months after delivery ought to be established. In chemistry, as in mathematics, figures alone are convincing. But from what has been said it is logical to conclude that an excess of caseine in milk is unfavorable to good digestion, while an excess of butter is favorable to it.--_Translated from Journal d'Hygiene, March 1, 1883_.

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CEREAL FOODS IN THEIR RELATION TO HEALTH AND DISEASE.

By F.R. CAMPBELL, A.B., M.D.

The cereals are subject to many diseases which retard their development, rendering them unfit for food, and even poisonous. The relation of unwholesome foods to the diseases of the animal body are now being thoroughly studied, recent advances in chemistry and microscopy contributing valuable aid to the prosecution of such investigations. Some enthusiastic advocates of the germ theory of disease believe that many, if not all, the so-called disease germs may be transplanted into the human system with the food ingested. But whatever may be the real truth in regard to this subject, it has been positively demonstrated that many diseases of the human body may be produced by unwholesome food. The specific symptoms produced in man by the various grain diseases are not accurately known, consequently our remarks upon this subject must be of a very general character.

Pappenheim divides the diseases of the cereals into two classes, internal and external. The internal diseases are those depending upon conditions of soil, climate, cultivation, etc., and may be neglected in our discussion, as they produce no special disease of the body, only impairing the nutritive value of the grain.

The external diseases are of much greater importance, as they probably produce some of the most fatal maladies to which the human race is subject. These external diseases of the cereals are due to parasites, which may be either of an animal or vegetable nature. Among the animal parasites may be mentioned the _weevil, vibrio tritici_, which feeds upon the starch cells of the grain. Grain attacked by this parasite was at one time supposed to be injurious to health.

In 1844 the French Commission appointed to examine grain condemned a large quantity imported with this parasite, but afterward reconsidered their decision and permitted its sale, concluding that it was deficient in nutritive properties, but not otherwise unwholesome. Rust is the most common disease of the cereals, produced by vegetable parasites. Like the other diseases of this class, it is most prevalent in warm, damp seasons.

Prof. Hensboro is of the opinion that rust is but an earlier stage of mildew or blight, the one form of parasite being capable of development into the other, and the fructification characteristic of the two supposed genera having been evolved on one and the same individual.

Blight is a term loosely applied to a number of parasitic diseases. In it are included mildew, cories, and even rust and smut. The fungi producing these diseases attack the plant and seed at various stages of its growth. The whole kernel is affected, and not merely the external coat, as is sometimes maintained. When blighted grain is sown, the disease recurs the following year, often making it necessary to import new seed before the disease can be eradicated. Various remedies have been used to destroy the spores of these fungi, but all are uncertain and some are dangerous to health. Special machinery and methods have been employed in the mills to separate the mildew from the grain. Some of these succeed in removing the fungi and discoloration from the surface of the grain, but have no effects upon the parts within. Blighted grain is soft, and has an unpleasant taste and smell, and bread made of it is liable to be heavy and sodden.

It is undeniable that the use of blighted grain as food is exceeding dangerous to health. It is a well known fact that vegetable parasites may attack animals; the silk worm disease produced by the _Botrytis baniana_, being an example. It is stated that the same vegetable parasites which produce plant diseases, when transmitted to the animal body produce special affections, the form and appearance of the germs being altered by their environments. The same germs developed under different conditions of temperature and surrounding medium, assume forms so various that they have been supposed to belong to different species and even different genera. If there is any truth, then, in the germ theory of disease, it is not so very improbable that a fungus which will produce blight in grain may cause cholera or tetanoid fever in an animal.

Hallier, the famous physiological botanist, observed in 1867 that there was a peculiar disease of the rice plant associated with an epidemic of cholera. Rice plants fertilized with the discharges of cholera patients were affected with blight. A concentrated infusion of the blighted grain would produce changes in all animal substances, blood and albumen being converted into thin odorless products resembling in every respect the material found in the kidneys of cholera patients.

The most formidable of the diseases attributed to the use of diseased grain is cerebro-spinal meningitis, commonly known as spotted or blanoid fever. The disease is rare in England, but is frequently epidemic in the United States, in Ireland, and on the Continent. In 1873, in the State of Massachusetts alone, 747 persons died of it, and other epidemics even more fatal have lately occurred in New York and Michigan. The disease is a nervous fever attended with convulsions, the pathological lesion being congestion and inflammation of the membrane of the spinal cord and brain. Dr. Richardson in writing on the nature and causes of spotted fever concludes that it is due to the use of diseased vegetable substances, especially grain, and from a careful analysis of the statistics of this disease reported by the Michigan State Board of Health considers it demonstrated that "under favoring condition for its action diseased grain received as a food is the primary cause of the phenomena which characterize the disease." These views are substantiated by the experiments of Dr. H. Day, who found that by feeding rabbits on unsound grain, spasmodic affections were produced, due to inflammation of the membranes of the spinal cord and brain.

In warm climates, pellagra or Italian leprosy is said to be produced by eating diseased maize, which forms the principal article of food among the poorer classes of the rural districts. Pellagra is epidemic in northern Italy and the south of France. The disease is manifested by a redness and discoloration of the exposed parts of the body. It is most active during the hot weather, the inflammation subsiding in the winter, leaving a pigmentation of the skin. Each year the symptoms become more alarming, nervous disorders finally setting in, and a large number die insane. The disease is most prevalent in the country. In the towns, where maize is supplemented by other articles of food, it does not exist.

Ergot is a very common disease of the cereals. The fungus producing it was discovered in 1853, but for centuries previous its injurious effects upon the human body were recognized, and it was observed that ergot of rye was the most poisonous. Taken in large doses, ergot will produce nausea, vomiting, diarrhoea, headache, and weakness of the heart. In small repeated doses it will produce contraction of all the unstriped muscles, as those of the blood vessels, the womb, and intestines. Ergotium is the name given to the disease produced by the continued use of grain affected by this fungus. Aitken describes it as "a train of morbid symptoms produced by the slow and cumulative action of a specific poison peculiar to wheat and rye, which produces convulsions, gangrene of the extremities, and death. In countries where rye bread is much used ergotium is sometimes epidemic. This was a frequent calamity before the introduction of suitable purifiers into the mills. There are two varieties of the disease, the convulsive and the gangrenous. The convulsive form begins with tingling of the extremities, drowsiness, and headache, followed by pain in the joints, violent muscular contractions, and death. The gangrenous variety begins with coldness and weakness of the extremities followed by gangrene and sloughing. This form is somewhat more fatal than the convulsive, the mortality of those affected being about 90 per cent.

Mouldy grain and bread have also caused poisoning. Prof. Varnell states that "six horses died in three days from eating mouldy oats. There was a large amount of matted mycelium, and this when given to other horses for experiment, killed them within thirty-six hours." The writer has himself seen seven hogs die within a few days while being fed on mouldy corn. Flour which has become stale may produce similar injurious effects, although most of the germs are destroyed in the process of baking. It is quite probable, however, that a poisonous substance is generated by the mould fungus, which cannot be destroyed in this way.--_Milling World_.

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MOIST AIR IN LIVING ROOMS.

The injurious effect of dry heat in inhabited rooms is quite generally known, and different methods have been suggested for moistening the air. To test the effectiveness of these methods, J. Melikow, of St. Petersburg, has estimated the quantity of moisture in the air of different rooms by means of August's psychrometer, and also tested the different methods of increasing the moisture. He arrived at the following results, which are of decided practical value:

1. When large and small open vessels filled with water are placed in the room, they do not increase the moisture of the air at all.

2. Tubs of water of the same temperature as the room and parlor fountains have very little effect.

3. When hot air is used, open vessels of water placed over the pipes have no effect at all.

4. Wolpert's revolving wheel increases the moisture but slightly.

5. The Russian tea machine and the steam pulverizer (atomizer) are effective but only for a short time.

6. Wet hand towels suspended in a room are insufficient.

7. Of all the methods tested, the most efficient seemed to be to hang up a number of wet cloths on a winch or some contrivance that permits of turning them, so as to hasten their giving out moisture to the air.--_Med. Zeitung_.

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THE DEVELOPMENTAL SIGNIFICANCE OF HUMAN PHYSIOGNOMY.

[Footnote: Abstract of a lecture delivered before the Franklin Institute of Philadelphia, Jan. 20.1881, in exposition of principles laid down in The Hypothesis of Evolution, New Haven, 1870, p. 31.]

By E. D. COPE.

The ability to read character in the form of the human face and figure is a gift possessed by comparatively few persons, although most people interpret, more or less correctly, the salient points of human expression. The transient appearances of the face reveal temporary phases of feeling which are common to all men; but the constant qualities of the mind should be expressed, if at all, in the permanent forms of the executive instrument of the mind, the body. To detect the peculiarities of the mind by external marks has been the aim of the physiognomist of all times; but it is only in the light of modern evolutionary science that much progress in this direction can be made. The mind, as a function of part of the body, partakes of its perfections and its defects, and exhibits parallel types of development. Every peculiarity of the body has probably some corresponding significance in the mind; and the causes of the former are the remoter causes of the latter. Hence, before a true physiognomy can be attempted, the origin of the features of the face and general form must be known. Not that a perfect physiognomy will ever be possible. A mental constitution so complex as that of man cannot be expected to exhibit more than its leading features in the body; but these include, after all, most of what it is important for us to be able to read, from a practical point of view.

[Illustration: FIG. 1.--Section of skull of adult orang-outang _(Simia satyrus)_. FIG. 2.--Section of skull of young orang, showing relatively shorter jaws and more prominent cerebral region.]

The present essay will consider the probable origin of the structural points which constitute the permanent expression. These may be divided into three heads, viz.:

1. Those of the general form or figure.

2. Those of the surface or integument of the body, with its appendages.

3. Those of the forms of the head and face.

[Illustration: FIG. 3.--Figure of infant at birth; _a_, front of face. (The eye is too far posterior in this figure.)]

The principal points to be considered under each of these heads are the following:

I. THE GENERAL FORM.

1. The size of the head.

2. The squareness or slope of the shoulders.

3. The length of the arms.

4. The constriction of the waist.

5. The width of the hips.

6. The length of the leg, principally of the thigh.

7. The sizes of the hands and feet.

8. The relative sizes of the muscles.

[Illustration: FIG. 4.--Portrait of a girl at five years of age.]

II. THE SURFACES.

9. The structure of the hair (whether curled or not).

10. The length and position of the hair.

11. The size and shape of the nails.

12. The smoothness of the skin.

13. The color of the skin, hair, and irides.

[Illustration: FIG. 5.--Portrait of the same at seventeen years, showing the elongation of the facial region, and less protuberance of the cerebral.]

III. THE HEAD AND FACE.

14. The relative size of the cerebral to the facial regions.

15. The prominence of the forehead.

16. The prominence of the superciliary (eyebrow) ridges.

17. The prominence of the alveolar borders (jaws).

18. The prominence and width of the chin.

19. The relation of length to width of skull.

20. The prominence of the malar (cheek) bones.

21. The form of the nose.

22. The relative size of the orbits and eyes.

23. The size of the mouth and lips.

[Illustration: FIG. 6.--Profile of a Luchatze negro woman, showing deficient bridge of nose and chin, and elongate facial region and prognathism.]

The significance of these, as of the more important structural characters of man and the lower animals, must be considered from two standpoints, the paleontological and the embryological. The immediate paleontological history of man is unknown, but may be easily inferred from the characteristics displayed by his nearest relatives of the order Quadrumana. If we compare these animals with man, we find the following general differences. The numbers correspond to those of the list above given:

I. _As to General Form_.--(3) In the apes the arms are longer; (8) the extensor muscles of the leg are smaller.

II. _As to Surface_.--(9) The body is covered with hair which is not crisp or woolly; (10) the hair of the head is short; (18) the color of the skin, etc., is dark.

III. _As to Head and Face_.--(14) The facial region of the skull is large as compared with the cerebral; (15) the forehead is not prominent, and is generally retreating; (16) the superciliary ridges are more prominent; (17) the edges of the jaws are more prominent; (18) the chin is less prominent; (20) the cheek bones are more prominent; (21) the nose is without bridge, and with short and flat cartilages; (22) the orbits and eyes are smaller (except in Nyctipithecus); (24) the mouth is small and the lips are thin.

[Illustration: FIG. 7.--Face of another negro, showing flat nose, less prognathism and larger cerebral region. From Serpa Pinto.]

It is evident that the possession of any one of the above characteristics by a man approximates him more to the monkeys, so far as it goes. He retains features which have been obliterated in other persons in the process of evolution.

[Illustration: FIG.8.--Portrait of Satanta, a late chief of the Kiowas (from the Red river of Texas), from a photograph. The predominance of the facial region, and especially of the malar bones, and the absence of beard, are noteworthy.]

In considering the physiognomy of man from an embryological standpoint, we must consider the peculiarities of the infant at birth. The numbers of the following list correspond with those already used (Fig. 3).

I. _As to the General Form_.--(1) The head of the infant is relatively much larger than in the adult; (3) the arms are relatively longer; (4) there is no waist; (6) the leg, and especially the thigh, is much shorter.

II. _As to the Surfaces_.--(10) The body is covered with fine hair, and that of the head is short.

III. _The Head and Face_.--(14) The cerebral part of the skull greatly predominates over the facial; (16) the superciliary ridges are not developed; (17) the alveolar borders are not prominent; (20) the malar bones are not prominent; (21) the nose is without bridge and the cartilages are flat and generally short; (22) the eyes are larger.

[Illustration: FIG. 9.--Australian native (from Brough Smyth), showing small development of muscles of legs and prognathism.]

It is evident that persons who present any of the characters cited in the above list are more infantile or embryonic in those respects than are others; and that those who lack them have left them behind in reaching maturity.

We have now two sets of characters in which men may differ from each other. In the one set the characters are those of monkeys, in the other they are those of infants. Let us see whether there be any identities in the two lists, i. e., whether there be any of the monkey-like characters which are also infantile. We find the following to be such:

I. _As to General Form_.--(3) The arms are longer.

II. _Surface_.--(10) The hair of the head is short, and the hair on the body is more distributed.

III. _As to Head and Face_.--(21) The nose is without bridge and the cartilages are short and flat.

Three characters only out of twenty-three. On the other hand, the following characters of monkey-like significance are the opposites of those included in the embryonic list: (14) The facial region of the skull is large as compared with the cerebral; (15) the forehead is not prominent; (16) the superciliary ridges are more prominent; (17) the edges of the jaws are more prominent. Four characters, all of the face and head. It is thus evident that in attaining maturity man resembles more and more the apes in some important parts of his facial expression.

[Illustration: Esequibo Indian woman, showing the following peculiarities: deficient bridge of nose, prognathism, no waist, and (the right hand figure) deficiency of stature through short femur. From photographs by Endlich.]

It must be noted here that the difference between the young and embryonic monkeys and the adults is quite the same as those just mentioned as distinguishing the young from the adult of man (Figs. 1 and 2). The change, however, in the case of the monkeys is greater than in the case of man. That is, in the monkeys the jaws and superciliary ridges become still more prominent than in man. As these characters result from a fuller course of growth from the infant, it is evident that in these respects the apes are more fully developed than man. Man stops short in the development of the face, and is in so far more embryonic.[1] The prominent forehead and reduced jaws of man are characters of "retardation." The characters of the prominent nose with its elevated bridge, is a result of "acceleration," since it is a superaddition to the quadrumanous type from both the standpoints of paleontology and embryology.[2] The development of the bridge of the nose is no doubt directly connected with the development of the front of the cerebral part of the skull and ethmoid bone, which sooner or later carries the nasal bones with it.

[Footnote 1: This fact has been well stated by C. S. Minot in the _Naturalist_ for 1882, p. 511.]

[Footnote 2: See Cope, The Hypothesis of Evolution, New Haven, 1870, p. 31.]

[Illustration: The Venus of the Capitol (Rome). The form and face present the characteristic peculiarities of the female of the Indo-European race.]

If we now examine the leading characters of the physiognomy of three of the principal human sub-species, the Negro, the Mongolian, and the Indo-European, we can readily observe that it is in the two first named that there is a predominance of the quadrumanous features which are retarded in man; and that the embryonic characters which predominate are those in which man is accelerated. In race description the prominence of the edges of the jaws is called prognathism, and its absence orthognathism. The significance of the two lower race characters as compared with those of the Indo-European is as follows:

Negro.--Hair crisp (a special character), short (quadrum. accel.); prognathous (quadrum. accel.); nose flat, without bridge (quadrum. retard)[1]; malar bones prominent (quadrum. accel.); beard short (quadrum. retard.); arms longer (quadrum. accel.); extensor muscles of legs small (quadrum. retard.).

[Footnote 1: In the Bochimans, the flat nasal bones are co-ossified with the adjacent elements as in the apes (ThuliØ).]

Mongolian.--Hair straight, long (accel.); jaws prognathous (quadrum. accel.); nose flat or prominent with or without bridge; malar bones prominent (quadrum. accel.); beard none (embryonic); arms shorter (retard.); extensor muscles of leg smaller (quad. retard.).

Indo-European.--Hair long (accel.); jaws orthognathous (embryonic retard.); nose (generally) prominent with bridge (accel.); malar bones reduced (retard.); beard long (accel.); arms shorter (retard.); extensor muscles of the leg large (accel.).

The Indo-European race is then the highest by virtue of the acceleration of growth in the development of the muscles by which the body is maintained in the erect position (extensors of the leg), and in those important elements of beauty, a well-developed nose and beard. It is also superior in these points in which it is more embryonic than the other races, viz., the want of prominence of the jaws and cheekbones, since these are associated with a greater predominance of the cerebral part of the skull, increased size of cerebral hemispheres, and greater intellectual power.

A comparison between the two sexes of the Indo-Europeans expresses their physical and mental relations in a definite way. I select the sexes of the most civilized races, since it is in these, according to Broca and Topinard, that the sex characters are most pronounced. They may be contrasted as follows. The numbers are those of the list already used. I first consider those which are used in the tables of embryonic, quadrumanous, and race characters:

MALE.	FEMALE.
I. _The General Form_.	
2. Shoulders square.	Shoulders slope.
4. Waist less constricted.	Waist more constricted.
5. Hips narrower.	Hips wider.

6. Legs longer.	Legs shorter (very frequently).
8. Muscles larger.	Muscles smaller.
II. _The Integuments, etc_.	
10. More hair on body, that of head shorter; beard.	Less hair on body, that of head longer; no beard.
12. Skin rougher (generally).	Skin smoother.
III. _The Head and Face_.	
16. Superciliary ridges more prominent.	Superciliary ridges low.
22. Eyes often smaller.	Eyes often larger.

[Illustration: The Wrestler; original in the Vatican. This figure displays the characters of the male Indo-European, except the beard.]

The characters in which the male is the most like the infant are two, viz., the narrow hips and short hair. Those in which the female is most embryonic are five, viz., the shorter legs, smaller muscles, absence of beard, low superciliary ridges, and frequently larger eyes. To these may be added two others not mentioned in the above lists; these are 1, the high pitched voice, which never falls an octave, as does that of the male; and 2, the structure of the generative organs, which in all mammalia more nearly resemble the embryo and the lower vertebrata in the female than in the male. Nevertheless, as Bischoff has pointed out, one of the most important distinctions between man and the apes is to be found in the external reproductive organs of the female.

From the preceding rapid sketch the reader will be able to explain the meaning of most of the peculiarities of face and form which he will meet with. Many persons possess at least one quadrumanous or embryonic character. The strongly convex upper lip frequently seen among the lower classes of the Irish is a modified quadrumanous character. Many people, especially those of the Sclavic races, have more or less embryonic noses. A retreating chin is a marked monkey character. Shortness of stature is mostly due to shortness of the femur, or thigh; the inequalities of people sitting are much less than those of people standing. A short femur is embryonic; so is a very large head. The faces of some people are always partially embryonic, in having a short face and light lower jaw. Such faces are still more embryonic when the forehead and eyes are protuberant. Retardation of this kind is frequently seen in children, and less frequently in women. The length of the arms would appear to have grown less in comparatively recent times. Thus the humerus in most of the Greek statues, including the Apollo Belvidere, is longer than those of modern Europeans, according to a writer in the Bulletin de la SociØtØ d'Anthropologie of Paris, and resembles more nearly that of the modern Nubians than any other people. This is a quadrumanous approximation. The miserably developed calves of many of the savages of Australia, Africa, and America are well known. The fine, swelling gastroenemius and soleus muscles characterize the highest races, and are most remote from the slender shanks of the monkeys. The gluteus muscles developed in the lower races as well as in the higher distinguish them well from the monkeys with their flat posterior outline.

It must be borne in mind that the quadrumanous indications are found in the lower classes of the most developed races. The status of a race or family is determined by the percentage of its individuals who do and do not present the features in question. Some embryonic characters may also appear in individuals of any race, as a consequence of special circumstances. Such are, however, as important to the physiognomist as the more normal variations.

Some of these features have a purely physical significance, but the majority of them are, as already remarked, intimately connected with the development of the mind, either as a cause or as a necessary coincidence. I will examine these relations in a future article.

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THE PRODUCTION OF FIRE.

In 1867 the AbbØ Bourgeois found at Thenay, near Pont-levoy (Loir-et-Cher), in a marly bank belonging to the most ancient part of the middle Tertiary formation, fragments of silex which bore traces of the action of fire. This fire had not been lighted by accidental causes, for, says Mr. DeMortillet (_Le Prehistorique_, p. 90), the causes of instantaneous conflagrations can be only volcanic fires, fermentations, and lightning. "Now, in the entire region there is no trace of volcanic action, and neither are there any traces of turfy or vegetable deposits capable of giving rise to spontaneous inflammations--phenomena that are always very rare and very exceptional, as are also conflagrations started by lightning. Well, in the Thenay marls, the pieces of silex that had undergone the action of fire were found disseminated at different levels, and this could not have been a simple accident, but was evidently something that had been done intentionally. There existed, then, during the Aquitanian epoch, a being who was acquainted with fire and knew how to produce it."

Mr. De Mortillet supposes that this being was an animal intermediate between man and the monkey, which he calls the _anthropopithecus_.

This precursor of man made use of fire for splitting silex and manufacturing from it instruments whose cutting edge he perfected by means of a series of retouchings produced by slight percussions upon one of the surfaces only.

I shall not enter in this place upon a discussion as to the existence of an anthropopithecus or Tertiary man, whom every one does not as yet accept, but will confine myself to giving the facts as to the use of fire in the remotest epochs, incontestable proofs of which exist from the time at which Quaternary man made his appearance. How this was discovered is indicated, according to Aryan tradition, by the Vedic hymns. The ancestors of the Aryans, these tell us, had seen the lighting dart forth from the shock of black clouds. They had seen the spark that fired the forests issue from the friction of dry branches agitated by the storm. They took a branch of soft wood, _arani_, and passing a thong around a branch of hard wood, _pramontha_, they caused it to revolve rapidly in a cavity in the _arani_, and thus evoked the god _Agni_, whom they nourished with libations of clarified butter, _soma_.

The _Pramontha_, became the _Prometheus_ of the Greeks, the Titan who stole the fire, and it is from the Sanscrit _Agni_ that is derived the Latin _Ignis_, "fire," and the Greek [Greek: Agnos], "pure," and the _Agnus Dei_ of the Christians, who purifies all.

Orientalists generally agree that the sign which is seen under the forms [inline illustration], [inline illustration], or [inline illustration], on a large number of objects of Aryan origin is a sort of sacred hieroglyphic, representing the _arani_ or _svastika_, formed of two pieces of soft wood fixed by four pins in such a way as not to revolve under the pressure of the Pramontha.

This process of producing fire is also found among a host of more or less savage peoples, and especially in India, where, during the last month of the great feast of sacrifices, the sacred fire must always be kindled three hundred and sixty times a day with nine different kinds of wood that are prescribed by the rite.

Fig. 1 shows the arrangement in use among the Eskimos, and Fig. 2 that employed by the Indians of North America.

In 1828 there still existed at Essen, in Hanover, an analogous apparatus designed to produce an alarm fire. This was a large, horizontal, round wooden bar whose extremities pivoted in two apertures formed in vertical posts, and which was provided with a cord that was wound around it several times. Several persons, by pulling on the ends of this cord, caused the bar to revolve alternately in one direction and the other, and the heat developed by the friction lighted some tow that had previously been inserted in one of the apertures in the post.

[Illustration: FIG. 1.--ESKIMO PRODUCING FIRE BY FRICTION.]

It is certain that the alternate motion must have been produced directly by hand before being effected by cords. This simpler process is still in use in Tasmania, Australia, Polynesia, Kamtschatka, Thibet, Mexico, and among the Guanches of the Canary Isles, who are supposed to be the last representatives of the inhabitants of Atlantis, which sank under the waters at the close of the Quaternary epoch.

Chamisso, who accompanied Kotzebue in his voyage, describes it as follows: "In the Caroline Islands, they rest a vertical piece of roundish wood, terminating in a point, and about a foot and a half in length and one inch in diameter, upon a second one fixed in the ground, and then give it a rotary motion by acting with the palms of the hands. This motion, which is at first slow and measured, is at length accelerated, while at the same time the pressure becomes stronger, whereupon the dust from the wood which has formed by friction and accumulated around the point of the movable piece begins to carbonize. This dust, which, after a fashion, constitutes a match, soon bursts into flame. The women of Eap are wonderfully dexterous in their use of this process."

[Illustration: FIG. 2.--PROCESS EMPLOYED IN NORTH AMERICA FOR PRODUCING FIRE.]

Fig. 3 shows another manner of obtaining fire by rotation which is employed by the Guachos, a half savage, pastoral people who inhabit the pampas of South America. Longitudinal friction must have preceded that obtained by rotation. It is still in use in most of the islands of Oceanica (Fig. 4), and especially in Tahiti and in the Sandwich Islands.

In these latter, says again Chamisso, upon the fixed piece of wood they place another piece of the same kind, about the length of the palm, and press it obliquely at an angle of about 30 degrees. The extremity that touches the fixed piece is blunt, and the other extremity is held with the two hands, the two thumbs downward, in order to allow of a surer pressure. The piece is given an alternating motion, and in such a way that it shall always remain in the same plane inclined at an angle of 30 degrees, and form, through friction, a small groove from six to eight centimeters in length. When the dust thus produced begins to carbonize, the pressure and velocity are increased. Wood of a homogeneous texture, neither too hard nor too soft, is the best for the purpose.

The Malays operate as follows: A dry bamboo rod, about a foot in length, is split longitudinally, and the pith which lines the inside is scraped off, pressed, and made into a small ball which is afterward placed in the center of the cavity of one of the halves of the tube. This latter half is then fixed to the ground in such a way that the cavity and ball face downward. The operator next fashions the other half of the tube into a straight cutting instrument like a knife-blade, which he applies transversely to the fixed half and gives an alternating motion so as to produce a sort of sawing. After a certain length of time, a groove, and finally a hole, is produced. The cutting edge of the instrument is then so hot that it sets on fire the ball with which it has come in contact.

[Illustration: FIG. 3.--GAUCHO OBTAINING FIRE.]

Some peoples, the Fuegians especially, procure fire by striking together two flints. In the Aleutian Islands these latter, having been previously covered with sulphur, are struck against each other over a small saucer of dry moss dusted with sulphur. The Eskimos employ for this purpose pieces of quartz and iron pyrites.

In the Sandwich Islands recourse is had to a process that necessitates much skill. There is arranged in a large dry leaf, rolled into the shape of a funnel, a certain number of flints along with some easily combustible twigs. On attaching the leaf to the end of a rod, and revolving the latter rapidly, it is said that fire is produced.

Processes that are based upon the clashing of two flint stones must be much more inconvenient of application than we would be led to suppose. We are, in fact, accustomed to see the flint and steel used, but here the spark is a bit of iron raised to red heat through a mechanical action that has violently detached it from the mass under the form of a small sliver. In the case of two flint stones, the light that is perceived is of an entirely different nature, for it is a phosphorescence which is produced, even by a very slight friction, not only between two pieces of silex, but also between two pieces of quartz, porcelain, or sugar; and that the heat developed is but slight is proved by the fact that the phenomenon may occur under water. Of course, fragments of stones may be raised to a red heat through percussion; but this does not often occur, so for this reason the Fuegians keep up with the greatest care the fires that they have lighted, and it is this very peculiarity that has given their country a characteristic aspect and caused it to be named Terra del Fuego (land of fire). When they change their residence they always carry with them a few lighted embers which rest in their canoes upon a bed of pebbles or ashes.

The same thing occurs, moreover, among the Australians and Tasmanians, who employ, as we have just seen, the rotary process. There are women among these peoples whose special mission it is to carry day and night lighted torches or cones made of a substance that burns slowly like punk. When, through accident, the fire happens to get extinguished in a tribe, these people often prefer to undertake a long voyage in order to obtain another light from a neighboring tribe rather than have recourse to a direct production of it.

We can understand from what is still taking place in these distant countries why the worship of fire should have existed among our ancestors, and why sacerdotal associations, such as the Brahmins of India, the Guebers of Persia, the Vestals of Rome, the priests of Baal in Chaldea and Phenicia should have been specially instituted for producing and preserving it.

Plutarch narrates (Numa, chap. ii.) that when the sacred fire happened to go out, there was employed for relighting it a brass mirror that had the form of a cone generated by the hypothenuse of an isosceles rectangular triangle revolving around one of the sides of the right angle.

[Illustration: FIG. 4.--NATIVE OF OCEANICA OBTAINING FIRE BY FRICTION.]

In a poem upon stones attributed to Orpheus, it is said that the sacred fire was also lighted by a bit of crystal which concentrated the rays of the sun upon the material to be inflamed. This process must have been the one that was most usually employed before fire became common. In fact, a plano-convex crystal lens has been found among the ruins of Nineveh. Aristophanes, in the _Clouds_, puts on the stage a coarse personage named Strepsiades, who points out to Socrates how he must manage so as not to pay his debts:

"Streps.--Hast thou seen among druggists that beautiful transparent stone that they employ for lighting a fire?

"Socr.--Thou meanest glass.

"Streps.--Yes.

"Socr.--Well! what wouldst thou do with it?

"Streps.--When the registrar shall have made out his summons against me, I will take the glass, and, placing myself thus in the sun, will cause his writing to melt."

As well known, writing was then traced on waxen tablets. Servius (in _˘n_., xii., 200) affirms that men of ancient times, instead of lighting fire upon the altar themselves, in their sacrifices, caused it to descend from heaven. He adds, according to Pliny, Titus Livius, and several old Latin historians, that Numa, who was initiated into all the wisdom of Etruria, practiced this art with success, but that Tullius Hostilius, having desired to repeat the evocation, guided only by the books of Numa, did not accomplish all the formalities prescribed by the rite and was struck dead by lightning.

Is it not curious that twenty-four centuries afterward, in 1753, the physicist Reichman was killed by lightning in trying to repeat Franklin's experiment? This coincidence, however, is not the only one. Pliny (ii., 53) recounts that lightning was evoked by King Porsenna at the time when a monster named _Volta_, who was ravaging the country, was directing himself toward the capital, Volsinies.

If we return to the Vedas, who had the habit of personifying all phenomena, we shall find that the fire Agni was the son of the carpenter who had manufactured the instrument by which it was produced, and of _Maya_ (magic). He took the name of Akta (anointed, [Greek: christos]) when, nourished by libations of butter, he had acquired his full development. The Persians attributed likewise to Zoroaster the power of causing fire to descend from heaven through magic. Saint Clement of Alexandria (_Recog_., lib. iv.) and Gregory of Tours (_Hist. de Fr._, i., 5) speak of this. However this may be, the marvelous art was lost at an early date, for it was at such a date that priests began to have recourse to tricks that were more or less ingenious for lighting their sacred fireplaces in an apparently supernatural manner.--_A. De Rochas, in La Nature_.

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ST. BLAISE, THE WINNER OF THE DERBY.

St. Blaise, the property of Sir Frederick Johnstone, was bred by Lord Alington, and is by Hermit from Fusee. This is an unexceptionable pedigree, for Hermit is now as successful and fashionable a sire as was even Stockwell in his palmiest days, while Fusee was far more than an average performer on the turf, and won several Queen's Plates and other races over a distance of ground. St. Blaise is by no means a big colt, standing considerably under sixteen hands. His color is about his worst point, as he is a light, washy chestnut, with a bald face and three white heels. He has a good head and neck, and very powerful back and muscular quarters, added to which his legs and feet are well shaped and thoroughly sound. His first appearance was made in the Twenty-fourth Stockbridge Biennial at the Bibury Club Meeting, when he won easily enough; but there were only four moderate animals behind him. A walk-over for the Troy Stakes followed, and then Macheath beat him easily enough for the Hurstbourne Stakes, though he finished in front of Adriana and Tyndrum. For the Molecomb Stakes at Goodwood, he ran a dead-heat with Elzevir, to whom he was giving 7 lb.; and Bonny Jean, in receipt of 10 lb., was unplaced. A 7 lb. penalty seemed to put him completely out of the Dewhurst Plate; but he must then have been out of form, as, on the following day, it took him all his time to defeat Pebble by a neck in the Troy Stakes. This season he has only run twice. His fourth in the Two Thousand was by no means a bad performance, considering that he was palpably backward; and his victory of last week is too recent to need further allusion. Porter, his trainer, can boast of several other successes in the great race at Epsom; but Charles Wood had never previously ridden a Derby winner. St. Blaise was unfortunately omitted from the entries for the St. Leger, but has several valuable engagements at Ascot next week, and appears to have the Grand Prize of Paris, on Sunday, at his mercy.--_Illustrated London News_.

[Illustration: ST. BLAISE, THE WINNER OF THE DERBY.]

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[NATURE.]

SCIENTIFIC PROGRESS IN CHINA AND JAPAN.

Various steps in the progress of China, and Japan in the adoption of Western science and educational methods have from time to time been noticed in these columns. To the popular mind the names of the two countries are synonymous with rigid, unreasoning conservatism and with rapid change, respectively. The grave, dignified Chinese, who maintains his own dress and habits even when isolated among strangers, and whose motto appears to be, _Stare super mas antiquas_, is popularly believed to be animated by a sullen, obstinate hostility toward any introduction from the West, however plain its value may be; while his gayer and more mercurial neighbor, the Japanese, is regarded as the true child of the old age of the West, following assiduously in its parent's footsteps, and pursuing obediently the path marked out by European experience. There is considerable misconception in this, as indeed there is at all times in the English popular mind with regard to strange peoples. Broadly speaking, it is no doubt correct to say that, Japan has adopted Western inventions and scientific appliances with avidity; that she has shown a desire for change which is abnormal, and a disposition to destroy her charts and sail away into unsurveyed seas, while China remains pretty much where she always was. She is now, with some exceptions, what she was twenty, two hundred, perhaps two thousand years ago, while a new Japan has been created in fifteen years. All this, we say, is true, but it is not the whole truth. China also has had her changes; not indeed so marked or rapid, not so much in the nature of a _volte-face_ on all her past as those of her neighbor.

The radical difference between the two countries in this respect we take to be this: that while Japan loves change for the sake of change, China dislikes it, and will only adopt it when it is clearly demonstrated to her that change is absolutely necessary. To the Japanese change appears to be a delightful excitement, to the Chinese a distasteful necessity; to the former whatever is must be wrong, to the latter whatever is is right. As a consequence of this difference between the two peoples, when China once makes a step forward it is generally after much deliberation, and is never retraced. Japan is constantly undertaking new schemes with little care or thought for the morrow, but with the applause of injudicious foreign friends. In a short time she discovers that she has underrated the expense or exaggerated the results, and her projects are straightway abandoned as rapidly and thoughtlessly as they were commenced. Swift suggested as a suitable subject for a philosophical writer a history of human projects which were never carried out; the historian of modern Japan finds these at every turn. Where, for example, are the results of the great surveys, trigonometrical and others, which were commenced in Yezo and the main island about ten years ago? A large, expensive, but highly competent foreign staff was engaged, and worked for a few years; but suddenly the whole survey department was swept away, and the valuable instruments are, or were recently, lying rusting in a warehouse in Tokio. The same story may be told of scores of other scientific or educational undertakings in Japan. An able and careful writer, Col. H.S. Palmer, R.E., who has recently, with a friendly and sympathetic eye, examined the whole field of recent Japanese progress, in the _British_ _Quarterly Review_ is forced to acknowledge this. "Once having recognized," says this officer, "that progress is essential to welfare, and having resolved, first among the nations of the East, to throw off past traditions and mould their civilization after that of Western countries, it was not in the nature of the lively and impulsive Japanese to advance along the path of reform with the calmness and circumspection that might have been possible to a people of less active temperament. Without doubt many foreign institutions were at first adopted rather too hastily, and the passing difficulties which now beset Japan are to some extent the inevitable result." It would be blindness to deny that the net result of the Japanese efforts is progress of a very remarkable kind, but it is a progress which in many respects lacks the firm and abiding characteristics of Chinese movements.

The proverb, _Chi va piano va sano_, which was recommended ten years ago to Japanese attention by an eminent English official, and apparently disregarded by them, has been adopted by their continental neighbors. To the blandishments of pushing diplomatists or acute promoters, the Chinese are deaf. However we may felicitate ourselves on our inventions, scientific appliances, "the railway and the steamship and the thoughts that shake mankind," our progress, the newspapers, the penny post, and what not, China will not adopt them simply because _we_ have found their value and are proud of them. But if, within the range of her own experience, she finds the advantage of these things, she will employ them with a rapidity and decision surpassing those of the Japanese. A conspicuous instance of this will be found in her recent action with respect to telegraphs. For years the Chinese steadily refused to have anything to do with them; the small land line which connected the foreign community of Shanghai with the outer world, was maintained against the violent protests of the local authorities, and the cable companies experienced some difficulty in getting permission to land their cables. But during the winter of 1870-80, when war with Russia was threatened, the value of telegraphs was demonstrated to the Peking government. The Peiho at Tientsin was closed by ice against steamers, and news could only be carried to the capital by overland couriers from Shanghai. Before a year elapsed a land line of telegraph was being constructed between this port and Tientsin; in a few months the line was in working order, and the Chinese metropolis is now in telegraphic communication with every capital in Europe.

This conservatism, respect for antiquity, conceit, prejudice, call it what we will, has something in it that extorts our respect. Let us imagine a dignified and cultivated Chinese official conversing with a pushing Manchester or Birmingham manufacturer, who descants on the benefits of our modern inventions. He would probably commune with himself in this wise, whatever reply Oriental politeness would dictate to his interviewer: "China has got on very well for some tens of centuries without the curious things of which this foreigner speaks; she has produced in this time statesmen, poets, philosophers, soldiers; her people appear to have had their share of affliction, but not more than those of Europe; why should we now turn round at the bidding of a handful of strangers who know little of us or our country, and make violent changes in our life and habits? A railway in a province will throw thousands of coolies and boatmen out of employment and bring on them misery and starvation. This foreigner says that railways and telegraphs have been found beneficial in his country; good, let his countrymen have them if they please, but let us rest as we are for the present. Moreover, past events have not given us such faith in Europeans that we should take all they say for wisdom and justice." A day will undoubtedly come when China also will have her great mechanical and scientific enterprises; but what we contend for here is that nothing we can say or do will bring that time an hour nearer. European public opinion is to China a dead letter; she refuses to plead before that tribunal. Each step of her advance along our path must be the result of her own reflection and experience; and our wisest policy would be to leave her to herself to advance on it as she deems best. SINENSIS.

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THE DIAMOND FIELDS OF SOUTH AFRICA.

At a recent meeting of the Institution of Civil Engineers, the paper read was "On the Diamond Fields and Mines of South Africa," by Mr. James N. Paxman, Asoc. M. Inst. C.E.

The author commenced by stating that Kimberley was situated in Griqualand West, above 700 miles northeast from Table Bay, and 450 miles inland from Port Elizabeth and Natal on the east coast. Lines of railway were in course of construction from Table Bay and Port Elizabeth to Kimberley, and were about half completed. In Griqualand there were several diamond mines, the principal of which were Kimberley, De Beer's, Du Toit's Pan, and Bultfontein.

In the Orange Free States there were also two mines, viz., Jagersfontein and Koffeyfontein, the first of which produced fine white stones. The mines were all divided into claims, the greatest number of which were to be found in the Du Toit's Pan mine. Bultfontein came next.

The deepest and most regularly worked was the Kimberley mine. The next deepest was De Beer's, which, however, was very unevenly worked. Then followed Du Toit's Pan and Bultfontein. The Du Toit's Pan mine ranked next in importance to Kimberley mine. Diamonds were first discovered in 1867 by Mr. O'Reilley, a trader and hunter, who visited a colonist named van Niekirk, residing in Griqua. The first diamond, on being sent to the authorities, was valued at 500_l_. Considerable excitement was caused throughout the colony, and the natives commenced to look for diamonds, and many were found, among which was one of eighty-three and a half carats, valued at 15,000_l_. In 1868 many enterprising colonists made their way up the Vaal River, and were successful in finding a good number of diamonds. The center of the river diggings on the Transvaal side was Klipdrift, and on the opposite side Pniel. In all there were fourteen river diggings. Du Toit's Pan and Bultfontein mines were discovered in 1870 at a distance of twenty-four miles from the river diggings. The diggers took possession of these places. Licenses were granted giving the first diggers a right to work. In 1871 De Beer's and Kimberley mines were discovered, and in 1872, Mr. Spalding's great diamond of 282‰ carats was found at the river diggings.

The mines were of irregular shape, and were surrounded by reef. The top reef was a loose shale, and had given great trouble from the frequent slips. Below this were strata of trachitic breccia and augite; the formation was then seamy to an unknown depth.

Within the reef, the surface soil was red, and of a sandy nature. The next stratum was of a loose, yellow, gravelly lime, and the third blue, of a hard, slaty nature. This last was the real diamantiferous soil.

Large stones had been found in the "yellow," but the working of this generally did not pay. Kimberley mine, however, had paid very well all through. The method of working in deep ground was determined by roadways running north and south. The soil was hauled up to these roadways, and taken to the sorting tables. The roadways decaying shortly after exposure to the atmosphere, a system of hand windlass was adopted, which worked very well for a time until horsewhims were adopted in 1873. The depths of the mines increasing, horsewhims had to give way to steam-engines in 1876.

The first diggers treated on an average ten loads per day each party. At the present time the least taken out by any engine, when fully employed, was 250 loads per day. The cost of working, with present appliances, the first one hundred feet in depth, was 3s. 6d. per load; the second one hundred feet (mostly blue) 5s.; the third one hundred feet 8s.; and the fourth one hundred feet 11s. Through scarcity of water a system of dry-sorting had to be resorted to for several years; but it was superseded by the introduction of washing machinery, which was now generally employed.

At the commencement, through inexperience, many serious mistakes were made. When the first diggers reached the bottom of the red sand, they thought no diamonds would be found in the next stratum. When, however, diamonds were found in the second stratum, the diggers had again to remove the debris, and so also when the "blue" was reached. Some of the claims in the Du Toit’s Pan and Bultfontein mines were irregular in shape. The other mines, however, had been properly and regularly laid out. One or two shafts had been connected with the mines by underground galleries. These galleries were convenient in the case of falls of reef. Labor, at first, was cheap; but from 20s. per month, wages rose to 30s. per week, and food. The yellow soil offered no difficulty in working, being loose and broken, but the blue soil required blasting.

Several methods were adopted for extracting the soil and carrying it from the mine before steam was introduced. The cost of wood for heating purposes was a serious item, but good coal had now been found at 160 miles from Kimberley, costing 13l. per ton; another serious item of expense was the transport over natural roads only, costing from 18_l_. to 30_l_. per ton.

The machinery designed by the author for this industry was described. A sixteen horse-power direct-acting winding engine was introduced for hauling up loads at the rate of about one thousand feet per minute, and a twenty-five horse-power geared engine, for hauling up heavier loads at the rate of from six hundred feet to seven hundred feet per minute.

Water was dear, and water-heaters were fitted to each engine, by which thirty-three per cent. of the water was again used, thus saving one third. The boilers were of the locomotive type, mostly of steel, to save weight, and thus reduce the cost of transit. The fire-boxes were also made of steel of very soft and ductile quality. A semi-portable engine was made for driving the wash mill. The engine was so arranged that it might be removed from the boiler and placed separately. The boiler was made to work at a pressure of 140 pounds per square inch. Automatic cut off gear was fixed to each engine, and the governors were provided with a spiral spring for adjusting the speed. A screen, or cylinder wash mill and elevator, were used for dealing with the diamantiferous soil, and were described. Standing wires were fixed at the back of the machinery, and passed over a frame fixed at the top of the mine, the end of the mine being secured to strong wooden posts. After the blue soil had been blasted and collected into trucks, it was placed in tubs, which ascended the standing wires. It was then emptied into the depositing box. The yellow soil might be put into the wash mill direct, also that portion of the blue which had passed through the screen fixed over the depositing box. The remainder of the blue, which was spread out to a thickness of four inches or six inches on the depositing ground, some distance from the mine to dry, was delivered into the upper part of the screen. The return water from the elevator, with a portion of fresh water, was also discharged at this point, and operations were thus greatly facilitated, the soil becoming thoroughly saturated, and passing more easily down the shoots. The large pieces which would not drop through the meshes of the screen were discharged into trucks at the lower end and carried away. The smaller pieces with water, in the form of sludge, fell through into a shoot, and thus were conveyed into the wash mill pan, and there kept in constant rotating motion by agitators. The diamonds and other pieces of high specific gravity sank to the deepest part of the pan, and the remainder of the sludge was forced over the inner ledge to the elevator. The sludge was then lifted and thrown upon an inclined screen and down the shoot over the side of the bank. The residue left in the pan at the end of the day's work was passed through a pulsator, in which, by the force of water, the mud and lighter particles were carried away, leaving behind the diamonds, agates, garnets, and other heavy stones. It was the practice occasionally to put a few inferior stones in the soil, to test the efficiency of the machinery.

In 1881 the author paid a visit to Kimberley, and found the industry a large one. The Post Office return showed the value of diamonds passed through the office in one year to be 3,685,000_l_. Illicit diamond traffic had hitherto been a source of great trouble at the fields. It was a question whether this industry would ever cease; in any case there was no doubt but that it would last for over a century. It was believed that the main bed of diamonds had not yet been reached, and that the mines in operation were merely shafts leading to it. Now that the water works were finished, with a bountiful supply of water, coupled with the great boon of railways to the Fields, and the advantage of a law recently passed for the prevention of illicit buying, a great and prosperous future was in store for the Diamond Fields.

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SPONGES AT THE BAHAMAS.

Within the last few decades the sponge industry of the Bahama Islands has increased at such a rate that to-day it is the second in importance on the island. Although the product is not of such excellent quality as that from the Mediterranean, it sells well and is in demand both in England and in America.

For sponge fishing little boats of ten tons burden are employed and manned by from six to twelve men. The sponges that are washed upon the rocks and reefs are taken with iron rakes fastened to long poles, or are brought to the surface by divers and spread out on the deck of the vessel. This kills their soft, slimy organisms, which are black as tar. The sponges are then repeatedly beaten with sticks to remove this black slime, and afterward well washed.

The sponges are then sorted and softened for several hours in lime water, dried in the sun, and bleached. They are finally pressed by machinery into 100 lb. balls and then packed for shipping.

A rich and very extensive "sponge field" was recently discovered near Eleuthera, but as the water there has a considerable depth, five or six fathoms, fishing is attended with difficulty. In fact, it is rendered impossible wherever the "segler" or sailor fish are found, for the mud which these tiny creatures stir up completely veils the sponges from the eye of the fisherman.

In 1881 the export amounted to $150,000, of which three-fourths came to America.--_Chem. Zeit_.

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TESTING FISH OVA FOR IMPREGNATION.

The development of the eyes of game fishes (salmonoids), as is well known, is relatively far advanced before the fish culturist is positively assured that embryos are developing normally in the egg. A method, therefore, which would enable us to shorten this period of probation would not only be desirable, but be also of value under certain circumstances, since it is certainly annoying after having had them in water for four or five weeks, spending time and care over them, to eventually find, when the "eye spots" do not develop, that all our trouble was wasted and that no development at all took place.

It is true one may, with proper preparations and with the help of the pocket lens or microscope, follow the development while there may be no external signs of the process evident. This method of making the test is, however, not adapted to the purposes of the practical fish culturist, who will have better success by the following method:

If fertilized fish ova are placed in a 50 per cent. solution of wine vinegar [any ordinary vinegar will probably be found to answer just as well--_Tr_.] the embryo, even during the very first stages of development, will become apparent to the eye lying on the transparent yelk. The acetic acid contained in the mixture, one part water to one part wine vinegar, causes the material of the embryo proper to coagulate, while the yelk remains clear.

A short time after the ova are laid in this mixture, and during the first week after impregnation, a white circle at one pole of the egg should become apparent, and in the course of the second week a cylindrical white streak running from the edge of the circle toward its center should be evident. If these features are not developed by the test, the eggs have not been fertilized, and are, therefore, worthless.

We will not complicate the application of the method by describing other details of the development, but would merely suggest that when a lot of ova are fertilized a small portion should be left unimpregnated. These could then be tested in comparison with the fertilized ova from day to day, using say three eggs at a time of each lot. The observant culturist could by this means construct for himself a scale of development covering the period embraced by his experiments. At a lower temperature the development is slower than at a higher one. The difference of appearance between fertilized and unfertilized ova treated by the method will demonstrate its utility. Whoever does not trust to the method for the evidence of death of the eggs until after five weeks subsequent to impregnation, must of course wait.

Director Tiefenthaler, of Kötzen, has had the kindness to test the method practically, and finds it useful to fish culturists.--_Prof. Nussbaum_.

[A very little practice, it seems to the translator, would serve to enable any person of ordinary intelligence to apply this method, or several others which might be suggested. Other substances which would answer the same purpose would be dilute solutions of picric or chromic acid, of not more than one to one-half per cent., or one part to two hundred of water. Vinegar or acetic acid of the shops may also be used; the last to be diluted in the proportions of about one part in ten of water. The acids cited will coagulate and cause the germ disk to turn white or yellow in a few hours. Chromic is better than picric acid, as it coagulates the yelk also, but turns the latter much darker than the embryo or embryonic disk.--_Tr_.]

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