SCIENTIFIC AMERICAN SUPPLEMENT. No 1501

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1904, by Munn & Co.

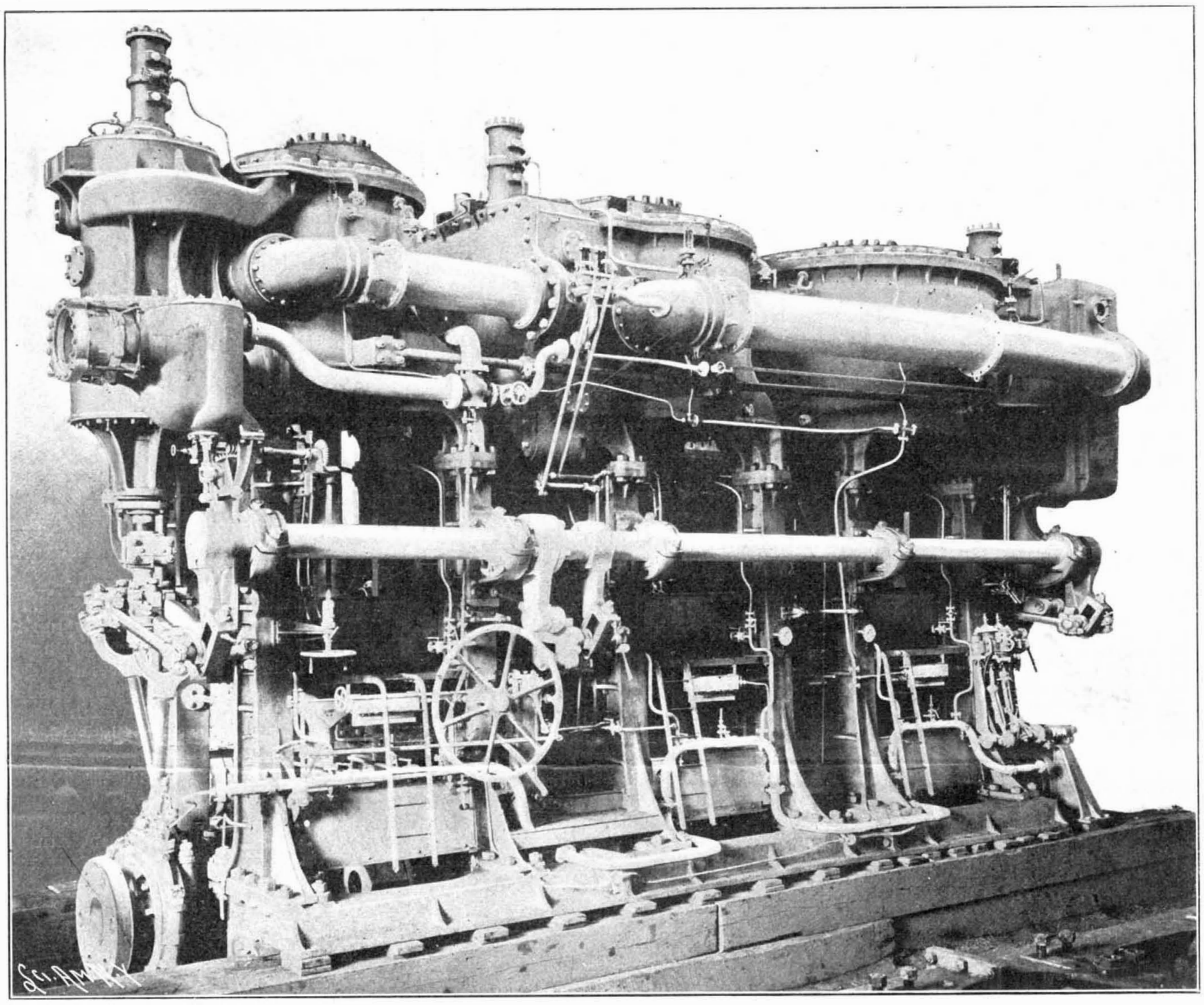
Scientific American, established 1845.
Scientific American Supplement, Vol. LVIII., No. 1501.

NEW YORK, OCTOBER 8, 1904.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

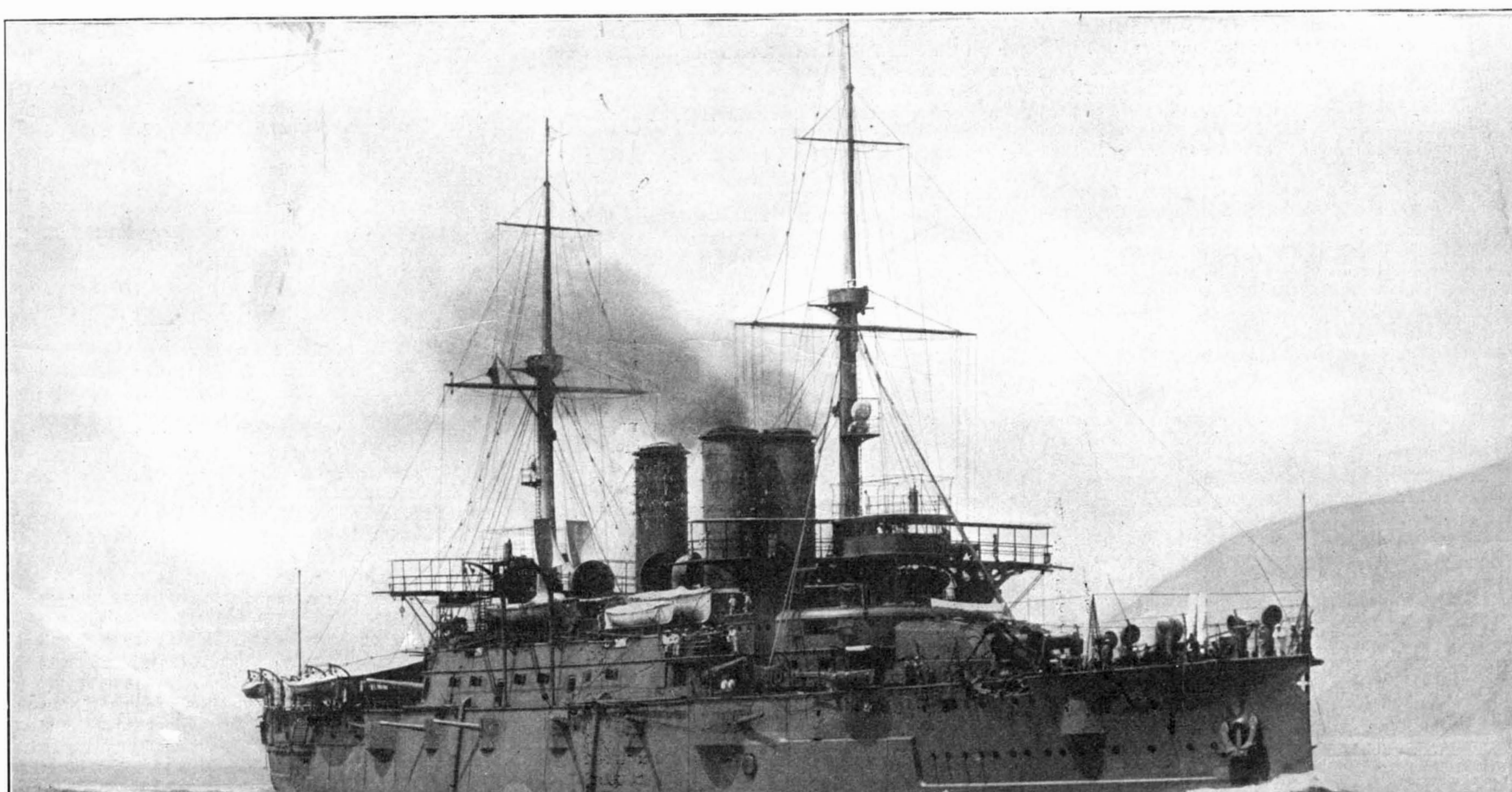
ITALIAN FIRST-CLASS BATTLESHIP "REGINA MARGHERITA."

THE accompanying handsome illustration is from a photograph of one of the latest of the Italian battleships the "Regina Margherita." This vessel is 427 feet long, 78 feet in beam, and 27 feet in draft. She was built at the royal dockyard of Spezia. Her machinery was constructed by the firm of Gio. Ansaldo, Armstrong & Co., of Genoa, to whom we are indebted for our illustrations. On her mean draft, the ship has a displacement of 13,427 tons. Her armament consists of four 12-inch guns carried in two turrets, protected by 8 inches of steel; four 8-inch guns, one at each corner of the superstructure, protected by 6-inch casemates; twelve 6-inch guns mounted in broadside behind 6 inches of armor, the last named guns being on the main deck; sixteen 3-inch guns, and a dozen smaller rapid-fire guns. The armor belt is continuous, 6 inches thick amidships and tapering to 2 inches at the ends. There are two armored decks, the protective deck proper having a thickness of 3 inches on the slopes, while the main deck is protected by 1 2-3 inches of steel. This, associated with the coal bunkers, gives an excellent safeguard against projectiles entering the vitals of the ship. The "Regina Margherita" carries four submerged torpedo tubes, and on her trial, when indicating a mean collective horsepower of 20,664, she achieved a speed of 20.3 knots with a coal consumption of 1.98 pounds of coal per horsepower per hour.



Four-cylinder, triple-expansion type. Horse-power, 20,664; revolutions, 121 per minute.

ONE OF THE TWIN ENGINES OF THE BATTLESHIP "REGINA MARGHERITA."



Displacement, 13,427 tons. **Speed,** 20 3 knots. **Armor:** Belt, 6 inches; turrets, 8 inches; casemates, 6 inches. Decks: Lower, 3 inches; upper, 1⅔ inches. **Armament:** Four 12-inch, four 8-inch, twelve 6-inch, sixteen 3-inch, 12 small guns. **Torpedo tubes:** 4 submerged.

ITALIAN BATTLESHIP "REGINA MARGHERITA."

We also present an illustration of one of the twin engines, the machinery consisting of two main engines fitted with all the necessary auxiliary engines, steam being supplied by twenty-eight Niclausse water-tube boilers. The working pressure is 300 pounds, being reduced to 250 pounds at the engine rooms. The main engines are of the four-cylinder triple-expansion type, the diameter of the cylinders being 37 inches for the high-pressure, 60¼ inches for the intermediate, and 69¼ inches for the two low-pressure cylinders; the stroke is 47¼ inches. The engines are balanced on the Schlick system, the two low-pressure cylinders being in the center and the high and intermediate cylinders at the ends, and here it may be said that the balancing proved most effective. Stephenson link-motion is adopted for working the valves, which are piston type on the high and intermediate pressure cylinders, and of the double-ported flat design on the low-pressure cylinders. The screws are inward-turning, and the starting platforms are in the center of the ship. Each cylinder is supported by two cast-steel columns in the front side and by one cast-steel diaframe at the back. The bedplates are of cast steel.

The pistons, cylinders, and steam-chest door are of cast steel. The piston rods and connecting rods are of Siemens-Martin steel; the connecting-rod body of the low-pressure cylinders is hollow for balancing purposes. White metal is fitted in the bearings of the connecting-rod gudgeons and crankpins, and it was very successfully tried. Each cylinder is fitted with a cast-steel slipper lined with white metal on rubbing surfaces; the guide bars are of cast iron, bolted on the back standards.

The crankshafts are hollow, and each consists of four interchangeable pieces, 18 5-16 inches in external diameter, both at journals and at the crankpins. Each crankpin is 20⅞ inches long; each engine has eight main bearings, with a collective length of 13 feet 8 inches. The thrust shafts have external diameter of 18 5-16 inches; the thrust blocks are of the horseshoe type, with a collective surface of 15 square feet. The propeller shafts are 18 5-16 inches in external diameter. All crank, thrust, and propeller shafts are of best mild steel.

The propellers are three-bladed; they have a diameter of 18 feet 8½ inches, and pitch of 19 feet 8¾ inches. The bosses are of gun metal, and the blades are of manganese bronze.

As already stated, the boilers are of the Niclausse water-tube type. There are twenty-eight Niclausse boilers; each boiler has 15 headers with 18 tubes, and there are collectively 420 headers with 7,560 tubes. The tubes have the outside diameter of 3¼ inches, and the length of 7 feet 10½ inches; the headers are of malleable cast iron; the tubes are of steel solid drawn. Each boiler has one firebox and three firedoors. The aggregate heating surface of the twenty-eight boilers is 50,2,0 square feet, and the total grate area is 1,555 square feet. There are three smokepipes of the height of 92 feet from the grate bars. The boiler rooms are arranged for the assisted draft in closed stokehold but non-airtight; the maximum air pressure admitted is of ⅜ inch. The air pressure is furnished by twelve electric fans. The total weight of machinery complete, including water in the boilers, is 1,550 tons.

UTILIZATION OF PETROLEUM WAX.

THE solid hydrocarbons, other than paraffine, contained in the residual products of the distillation of petroleum, have not been well studied, and are but little employed. Still, we should endeavor to find an employment for them, in order to reduce, as far as possible, the loss occasioned by the refining of crude oils.

Petroleum wax is a substance whose composition is slightly variable. It has a certain consistency when cold, and commences to soften between 30 deg. and 35 deg. C. It is strongly adhesive, does not possess any of the properties of fats, and is not suitable for the lubrication of machinery. Dr. Berthier has, however, discovered a use which, if generalized, will make of it an industrial product of the first order.

It is well known that the cracks of floors are nests for microbes, for the dust which collects there is difficult of removal. Convinced of these facts, hygienists and architects have long endeavored to fill these cracks efficiently, but they have never obtained good results. Boiled linseed oil, carbo-lineum, coal tars, and even paraffine, in time lose their adhering quality. Cements and varnishes crack, and lack elasticity. Dr. Berthier has succeeded in solving the problem by an application of a hot mixture of 70 grammes of petroleum wax, 30 grammes of Carnauba wax, and 20 grammes hydraulic lime heated to 85 deg. C.

We will not dwell on the operative method, for it is very simple. After perfectly cleaning the floor, the hot liquid is poured into the cracks, allowed to solidify, and the surplus is removed to the level of the floor by means of a glazier's knife, previously held in the flame of an alcohol lamp.

Petroleum wax is cheap, being valued at from 10 to 12 francs per 100 kilogrammes; Carnauba wax costs nearly 3 francs per kilogramme.

Under the play of the wood, petroleum wax does not break; it is both adherent and elastic. Tests made at the military hospital of Amélie-des-Bains have given perfect results; the cracks did not reopen for four years.

Hygienic progress often constrains us to renounce our old habits, and to submit to new precautions which are annoying. One of the most difficult changes to secure in domestic arrangements is the abandonment of the dry broom. Some housewives cannot make up their minds to dampen their floors. When one speaks of the danger incurred by the raising of the dust, they answer that in well-kept-houses the floors are waxed, and that if they are cleaned with wet cloths, the wax must be renewed every day. The employment of a mineral wax, composed according to Dr. Berthier's formula (petroleum wax, 20 grammes; paraffine, 100 grammes), will overthrow all the objections which can be raised against this sanitary measure.

The mixture is applied solid, like beeswax; the floor is rubbed, brushed, and a woolen rag passed over it. The adherence is greater when a small proportion of beeswax is made use of. It is sufficient to wax the floors once a month; they may be washed at any time, and on drying they will resume their brilliancy. The tint of the waxed wood is very fine, but in our opinion when a perfect imitation of encaustic is to be obtained, the proportion of paraffine should be somewhat diminished, and that of wax increased, according to the following formula: Petroleum wax, 1 part by weight; paraffine, 3 parts.

Dr. Berthier gives the composition of cheap paints having a base of petroleum wax.

These paints, thickened, would serve for sub-basements and replace the application of coal tar, which has a dark, gloomy appearance. The formulas are special for each layer.

Composition for first layer: Petroleum wax, 125 grammes; coal tar, 120 cubic centimeters; red ocher, 35 grammes. Second coat: Petroleum wax, 250 grammes; coal oil, 150 cubic centimeters; red ocher, 100 grammes; lampblack, 5 to 10 grammes. Coal oil is a solvent of petroleum wax.

It is to be regretted that these paints do not contain paraffine, for this body has a marvelous power in rendering wood and walls water-proof; it has no antiseptic property, but it prevents access of the air, and is sufficient to arrest all processes of fermentation.—Translated from Le Journal du Petrole.

NON-POISONOUS TEXTILE AND EGG DYES FOR HOUSEHOLD USE.

THE preparation of non-poisonous colors for dyeing fabrics and eggs at home constitutes a separate department in the manufacture of dyestuffs.

Certain classes of the aniline dyes may be properly said to form the materials. The essence of this color preparation consists chiefly in diluting or weakening the coal-tar dyes, made in the aniline factories, and bringing them down to a certain desired shade by the addition of certain chemicals suited to their varying characteristics, which, though weakening the color, act at the same time as the so-called mordants.

The original and chief seat of this peculiar and apparently very profitable branch of manufacture is, since the beginning of the eighties, the town of Quedlinburg.

The sale of these convenient little packages of dyeing materials, which are put up for the price of 25 pfennige (6 cents), 10 pfennige (2½ cents), and even 5 pfennige (1¼ cent), has reached enormous dimensions; they are found in fact in all quarters of the globe.

It is by no means rare, so say the jobbing and export houses in Hamburg and Lubeck, that single shipments of these household dyes amounting to one hundred thousand cans are sent to Finland, Russia, Sweden, Norway, Holland, the Orient, etc. Particularly during the Easter festival do these non-poisonous dyes find a ready and extensive sale both at home and abroad. In all Christian countries the dyeing of eggs is one of the accompanying features of Passion Week. Without it the smaller children would hardly realize that the season was at hand. Finland and Russia, where this custom may be said to be universal, consume these colors in enormous quantities during this time of the year.

The making of these non-poisonous dyeing mixtures is carried out according to the peculiar and individual properties of the coal-tar dyestuffs.

In color technics, it is well known that the anilines are divided with reference to their characteristic reactions into groups of basic, acid, moderately acid, as well as dyes that are insoluble in water.

As a natural consequence, in any cases where combinations of one or more colors are needed, only dyes of similar reaction could be combined, that is, basic with basic, and acid with acid.

For the purpose of reducing the original intensity of the colors, and also as mordants, dextrine, Glauber's salt, alum, or aluminium sulphate is pressed into service. Where Glauber's salt is used, the neutral salt is exclusively employed, which can be had cheaply and in immense quantities in the chemical industry. Since it is customary to pack the color mixtures in two paper boxes, one stuck into the other, and moreover since certain coal-tar dyes are only used in large crystals, it is only reasonable that the mordants should be calcined and not put up in the shape of crystallized salts, particularly since these latter are prone to absorb the moisture from the air, and when thus wet likely to form a compact mass very difficult to dissolve. This inconvenience often occurs with the large crystals of fuchsine and methyl-violet. Because these two colors are mostly used in combination with dextrine to color eggs, and since dextrine is also very hygroscopic, it is better in these individual cases to employ calcined Glauber's salt. In the manufacture of egg colors the alkaline coloring coal-tar dyes are mostly used, and they are to be found in a great variety of shades.

Of the non-poisonous egg dyes, there are some ten or a dozen numbers, new red, carmine, scarlet, pink, violet, blue, yellow, orange, green, brown, black, heliotrope, etc., which when mixed will enable the operator to form shades almost without number.

The manufacture of the egg dyes as carried on in the factory consists in nothing more than a mechanical mixing of basic coal-tar dyestuffs, also some direct coloring benzidine dyestuffs, with dextrine in the ratio of about 1 part of aniline dye to 8 parts of dextrine; under certain circumstances, according to the concentrated state of the dyes, the reducing quantity of the dextrine may be greatly increased. As reducing agents for these colors insoluble substances may also be employed. As we have already mentioned above, a part also of the egg dyes are treated with the neutral sulphate; for instance, light brilliant green, because of its rubbing off, is made with dextrine and Glauber's salt in the proportion of 1:3:3.

It is scarcely possible to conceive of anything simpler than the making of these colors, especially when the mixing process may be repeatedly tested upon the eggshells.

Where the work is conscientiously carried out, and with the facilities offered by the coal-tar factories in their myriads of shades, no one need be overcome by difficulties.

With this as with other branches of manufacture, outside of the quality of the colors, much depends upon the get-up or appearance of the packages.

A pleasing exterior for the packing boxes, and where possible a nicely fitted up showcase, in which the colors are tastefully arranged, displaying their brilliant contrasts, will greatly facilitate the sale of the goods.

When we turn our attention to the dyes prepared for coloring textile fabrics, of wool or cotton, we meet with an almost endless variety of shades, compared to those used for the dyeing of eggs. More than fifty colors are in constant demand. In the beginning these colors were put up separate from their mordants, possibly because at that time it was the accepted opinion that when mixed they underwent a change, which was disadvantageous to their subsequent employment, or perhaps it may have been because only dyes were then at command which required the fabrics to be mordanted in advance. Where specially desired, these styles of packages may yet be had; they contain the coloring matter in one box and the alum and Glauber's salt in the other. To-day, for example, we find a most beautiful black put up in this way. It is made by a most thorough mixing of ground substances as follows: 1. 50 parts of hematine, 4.8 parts of blue vitriol, and 9 to 10 parts of Glauber's salt as a mordant. 2. 17 to 18 parts of potassium dichromate and 10 to 12 parts of Glauber's salt. By mixing these direct with Glauber's salt and aluminium sulphate, in the ratio of 1:3:5, most beautiful effects are accomplished.

A beautiful marine blue is attained by mixing 0.5 part of brilliant green with 0.5 part of methyl violet and 3 parts of Glauber's salt and 3 parts of alum. It is understood of course that these last two colors or dyes, black and marine blue, belong to the group of dyes wherein the color and mordant are mixed, and this method of packing them is now almost exclusively followed in the trade.

Shirt-waist dyes in packages for 10 pfennige (2½ cents) are very popular. Since the shirt-waist is commonly made of cotton or silk for the summer, the benzidine dyestuffs are best adapted for dyeing them. The usual ratio for mixing these is 1 part of dye, 3 parts of Glauber's salt, and 3 to 4 parts of alum or its corresponding aluminium sulphate. Cream color is very much in demand for giving the *ecru* effect to curtains, etc. For this purpose chrysophonine, at times also called Mikado yellow, is used. These are reduced with Glauber's salt, and the last dye effected with common table salt.

The colors and mordants may be easily ground in a mortar with a pestle, or in a mill in which the stones are somewhat inclined to the floor. These oblique mills seem to have the preference over horizontal mills in the aniline factories.—Farben Zeitung.

LUTES.*

By SAMUEL S. SADTLER.

THE subject of plastic cements used to secure joints in vessels and connections (generally for temporary purposes), has been rather neglected in the chemical literature.

The success or failure of processes has very seldom depended upon the choice of satisfactory lutes, but great annoyance has been experienced in chemical works and manufacturing places where only unsuitable compounds have been found to seal apertures in nitric acid, chlorine, hydrogen-sulphide, and illuminating-gas apparatus, and frequently considerable damage to property and loss of life has resulted.

I have, therefore, thought it advisable to bring together under the one title such formulæ as I know to be reliable, or have reasonable grounds for believing so, and hope they may be useful to others for laboratory or works' use.

The majority of these cements are useful for purposes of preventing the escape of inert gases, and others are suitable for more or less special purposes, where corrosive gases, etc., come in contact with them. Many of them had to be put down from memory, and therefore the product obtained in their use may be a little too stiff or too thin, but such deficiencies could be easily regulated.

Lutes always consist of a menstruum and dissolved

* Read before the Franklin Institute and reprinted from its Journal.

or suspended solids, and they must not be attacked by the gases and liquids coming in contact with them. In some cases the constituents of the lute react to form a more strongly adhering mass.

The conditions of application are, in brief:

(a) Heating the composition to make it plastic until firmly fixed in place.

(b) Heating the surfaces.

(c) Applying the lute with water or a volatile solvent, which is allowed to volatilize.

(d) Moistening the surfaces with water, oil, etc. (the menstruum of the lute itself).

(e) Applying the lute in workable condition and the setting taking place by chemical reactions.

(f) Setting by hydration.

(g) Setting by oxidation.

These principles will be found to cover nearly all cases.

Joints should not be ill fitting, depending upon the lute to do what the pipes or other parts of the apparatus should do. In most cases one part of the fitting should overlap the other so as to make a small amount of the lute effective and to keep the parts of the apparatus rigid, as a luted joint is not supposed to be a particularly strong one, but rather one quickly applied, effective while in place and easily removed.

Very moderate amounts of the lute should be used, as large amounts are likely to develop cracks, be rubbed off, etc.

A classification may be given as follows:

(1) Plaster of Paris.
(2) Hydraulic cement.
(3) Clay.
(4) Lime.
(5) Asphalt and pitch.
(6) Resin.
(7) Rubber.
(8) Linseed oil.
(9) Casein and albumen.
(10) Silicates of soda and oxychloride cements.
(11) Flour and starch.
(12) Miscellaneous, including core compounds.

I. PLASTER OF PARIS

is, of course, often used alone as a paste, which quickly solidifies, for gas and wood distillation retorts, etc., and similar places where quickness of setting is requisite. It is more often, however, used with some fibrous material to give it greater strength. Asbestos is the most commonly used material of these, as it will stand a high temperature. When that is not so important, straw, plush trimmings, hair, etc., are used as binders, while broken stone, glass and various mineral substances are used as fillers, but they do not add anything to the strength. These lutes seem to be particularly suitable for oil vapors and hydrocarbon gases.

Formulæ: (1) Plaster and water.
(2) Plaster (wet) and asbestos.
(3) Plaster (wet) and straw.
(4) Plaster (wet) and plush trimmings.
(5) Plaster (wet) and hair.
(6) Plaster (wet) and broken stone, etc.

II. HYDRAULIC CEMENT.

Cement is used either alone or with sand, asbestos, etc., and I have been informed that these lutes are suitable for nitric acid. When used with substances such as resin or sulphur, it is probably employed because it is in such a fine state of division and used as a filler and not because of any powers of setting by hydration.

Formulæ: (1) Cement—neat.
(2) Cement and asbestos.
(3) Cement and sand.

III. CLAY.

This most frequently enters into the composition of lutes as a filler, but even then the very finely divided condition of certain grades renders it valuable, as it gives body to a liquid, such as linseed oil, which, unless stiffened, would be pervious to a gas, the clay in all cases being neutral. Thus, for luting pipes carrying chlorine, a stiff paste of clay and molasses has been suggested by Theo. Köller in Die Surrogate, but I cannot recommend it, as it soon gives way.

Formulæ: (1) Clay and linseed oil.
(2) Same using fire-clay.
(3) Clay and molasses.
(1) Is suitable for steam, etc.
(2) For chlorine and
(3) For oil-vapors.

IV. LIME

is used in the old lute known as putty, which consists of caustic lime and linseed oil. Frequently the lime is replaced by chalk and china clay, but the lime should be, in part at least, caustic, so as to form a certain amount of lime soap. Lime is also used in silicate and casein compositions, which are very strong and useful, but will be described elsewhere.

Formulæ: (1) Lime and boiled oil to stiff mass.
(2) Clay, etc., boiled oil to stiff mass.

V. ASPHALT AND PITCH.

These substances are used in lutes somewhat interchangeably. As a rule, pitch makes the stronger lutes. Tar is sometimes used, but, because of the light oils and, frequently, water contained, it is not as good as either of the others.

Asphalt dissolved in benzol is very useful for uniting glass for photographic, microscopical and other uses. Also for coating wood, concrete, etc., where the melted asphalt would be too thick to cover well. Benzol is the cheapest solvent that is satisfactory for this purpose, as the only one that is cheaper would be a petroleum naphtha, and it does not dissolve all the constituents of the asphalt. For water-proofing wood, brick, concrete, etc., melted asphalt alone is much used, but when a little paraffin is added it improves its water-proofing qualities, and in particular cases boiled oil is also added to advantage.

Formulæ: (1) Refined lake asphalt.
(2) Asphalt .... 4 parts
Paraffin .... 1 part
(3) Asphalt .... 10 parts
Paraffin .... 2 parts
Boiled oil .... 1 part

Any of these may be thinned with hot benzol or toluol. Toluol is less volatile than benzol and about as cheap, if not cheaper, the straw-colored grades being about 24 cents per gallon.

Examples of so-called "stone cement" are:

(4) Pitch .... 8 parts
Resin .... 6 parts
Wax .... 1 part
Plaster .... ¼ to ½ part
(5) Pitch .... 8 parts
Resin .... 7 parts
Sulphur .... 2 parts
Stone powder .... 1 part

These compositions are used to unite slate slabs and stoneware for domestic, engineering, and chemical purposes. Various resin and pitch mixtures are used for these purposes and the proportions of these two ingredients are determined by the consistency desired. Sulphur and stone powder are added to prevent the formation of cracks, sulphur acting chemically and stone powder mechanically. Where the lute would come in contact with acid or vapors of the same, limestone should not be the powder used, otherwise it is about the best. Wax is a useful ingredient to keep the composition from getting brittle with age.

A class of lutes under this general grouping that are much used are so-called "marine glues." They must be tough and elastic. When used for calking on a vessel they must expand and contract with the temperature and not crack or come loose.

Formulæ:

(6) Pitch .... 3 parts
Shellac .... 2 parts
Pure crude rubber .... 1 part
(7) Pitch .... 1 part
Shellac .... 1 part
Rubber substitute .... 1 part

These are used by melting over a burner.

VI. RESIN, SHELLAC AND WAX.

A strong cement used as a stone cement is:

(1) Resin .... 8 parts
Wax .... 1 part
Turpentine .... 1 part

It has little or no body and is used in thin layers.

For nitric and hydrochloric acid vapors:

(2) Resin .... 1 part
Sulphur .... 1 part
Fire clay .... 2 parts

Sulphur gives great hardness and permanency to resin lutes, but this composition is somewhat brittle.

Good water-proof lutes of this class are:

(3) Resin .... 1 part
Wax .... 1 part
Powdered stone .... 2 parts
(4) Shellac .... 5 parts
Wax .... 1 part
Turpentine .... 1 part
Chalk, etc. .... 8 to 10 parts

For a soft air-tight paste for ground-glass surfaces:

(5) Wax .... 1 part
Vaseline .... 1 part

(6) A strong cement, without body, for metals (other than copper or alloys of same), porcelain, and glass is made by letting 1 part of finely powdered shellac stand with 10 parts of ammonia water until solution is effected.

VII. RUBBER.

Because of its toughness, elasticity, and resistance to alterative influences, rubber is a very useful constituent in lutes, but its price makes its use very limited.

Leather cement:

(1) Asphalt .... 1 part
Resin .... 1 part
Gutta percha .... 4 parts
Carbon disulphide .... 20 parts

To stand acid vapors:

(2) Rubber .... 1 part
Linseed oil .... 2 parts
Fire clay .... 3 parts

(3) Plain Rubber Cement.—Cut the crude rubber in small pieces and then add the solvent. Carbon disulphide is the best, benzol good and much cheaper, but gasoline is probably most extensively used because of its cheapness.

(4) To make corks and wood impervious to steam and water, soak them in a rubber solution as above; if it is desired to protect them from oil vapors, use glue composition. (See Section IX.)

VIII. LINSEED OIL.

This is one of the most generally useful substances we have for luting purposes, if absorbed by a porous substance that is inert.

Formulæ:

(1) China clay of general utility for aqueous vapors.
Linseed oil of general utility for aqueous vapors.
(2) Lime forming the well-known putty.
Linseed oil forming the well-known putty.
(3) Red or white lead and linseed oil.

These mixtures become very strong when set and are best diluted with powdered glass, clay or graphite. There are almost an endless number of lutes using metallic oxides and linseed oil. A very good one, not getting as hard as those containing lead, is:

(4) Oxide of iron and linseed oil.

IX. CASEIN, ALBUMEN AND GLUE.

These, if properly made, become very tough and tenacious; they stand moderate heat and oil vapors, but not acid vapors.

(1) Finely powdered casein .... 12 parts
Slaked lime (fresh) .... 50 parts
Fine sand .... 50 parts
Water to thick mush.

A very strong cement for ground unions, stands moderate heat, as follows:

(2) Casein in very fine powder .... 1 part
Rubbed up with silicate of soda .... 3 parts

A strong lute for general purposes, which must be used promptly when made:

(3) White of egg made into a paste with slaked lime.

A composition for soaking corks, wood, packing, etc., to render them impervious to oil vapors, is:

Gelatin or good glue .... 2 parts
Glycerin .... ½ to 1 part
Water .... 6 parts
Oil of wintergreen, etc., to keep from spoiling.

X. SILICATE AND OXY-CHLORIDE CEMENTS.

For oil vapors, standing the highest heat:

(1) A stiff paste of silicate of soda and asbestos.

Gaskets for superheated steam, retorts, furnaces, etc.:

(2) Silicate of soda and powdered glass, dry the mixture and heat.

Not as strong, however, as the following:

(3) Silicate of soda .... 50 parts
Asbestos .... 15 parts
Slaked lime .... 10 parts

Metal cement:

(4) Silicate of soda .... 1 part
Oxides of metal, such as zinc oxide; litharge, iron oxide, singly or mixed 1 part

Very hard and extra strong compositions:

(5) Zinc oxide .... 2 parts
Zinc chloride .... 1 part
Water to make a paste.
(6) Magnesium oxide .... 2 parts
Magnesium chloride .... 1 part
Water to make a paste.

XI. FLOUR AND STARCH COMPOSITIONS.

(1) The well-known flaxseed poultice sets very tough, but does not stand water or condensed steam.

(3) Flour and molasses, made by making a stiff composition of the two. This is an excellent lute to have at hand at all times for emergency use, etc.

(3) Stiff paste of flour and strong zinc chloride solution forms a more impervious lute, and is more permanent as a cement. This is good for most purposes, at ordinary temperature, where it would not be in contact with nitric acid vapors or condensing steam.

(4) A mixture of dextrin and fine sand makes a good composition, mainly used as core compound.

XII. MISCELLANEOUS.

(1) Litharge.
Glycerin.

Mixed to form a stiff paste, sets and becomes very hard and strong, and is very useful for inserting glass tubes, etc., in iron or brass.

For a high heat:

(2) Alumina .... 1 part
Sand .... 4 parts
Slaked lime .... 1 part
Borax .... ½ part
Water sufficient.

Of course, there are an almost infinite number of lutes or cements, but, classified as these are, they represent the largest number of them. The formulas that are not original, or were kindly given by friends, have been seen in the literature one here and one there, and laid aside for a year or more, so I can hardly give the credit for them that I would like to.

A class of mixtures that can only be classified according to their intended use are core compounds.

(1) Dextrin, about .... 1 part
Sand, about .... 10 parts
With enough water to form a paste.
(2) Powdered anthracite coal, with enough molasses to form a stiff paste.
(3) Resin, partly saponified by soda lye.. 1 part
Flour .... 2 parts
Sand (with sufficient water) .... 4 parts

(These proportions are approximate and the amount of sand can be increased for some purposes.)

(4) Glue, powdered .... 1 part
Flour .... 4 parts
Sand (with sufficient water) .... 6 parts

For some purposes, the exact uses of which I am not familiar, the following mixture is used. It does not seem to be a gasket or a core compound:

(5) Oats (or wheat) ground .... 25 parts
Glue, powdered .... 6 parts
Sal ammoniac .... 1 part

I would say in conclusion that in any works or laboratory it is very good to have some such compositions made up ready to use without delay when wanted. Just which one, depends on the nature of the manufacturing or other work done.

I hope that some of the material contained in this paper may prove of benefit to some here present.

MERCADIER'S SYSTEM OF ATTUNED TELEGRAPHY.

The efforts being unremittingly put forth in telegraphy, at the present time, to free itself from the trammels of the wire conductors, and by means of multiple and accelerating systems to expedite the immense and constantly increasing mass of traffic between the great central points over fewer wires and with the aid of fewer assistants, have achieved results worthy of consideration through the final perfection of the tuning fork system of Prof. Mercadier, director of the High School for Post and Telegraph in Paris, which is now ready for practical installation.

In his invention for manifold telegraphy Prof. Mercadier started with the idea that the waves of electrical impulse, as applied in telegraphy, must continue their journey through the wire without disturbing each other, in the same manner as the sound waves caused by various noises do through the air. The human ear is capable of distinguishing the greatest variety of sounds and tones coming to it at the same time; this then is a proof that the various sound waves do not interfere the one with the other, but travel along side by side or one over the other in the same medium, each one pursuing its own well-defined course. The same is true of the electric waves.

Bearing the fact in mind, Prof. Mercadier makes use of alternating currents, which, by the application of tuning fork interrupters, are taken from direct-current sources, for the transmission of the telegraphic signals, in his multiplex system.

At the sending station, and by means of a series of tuning forks, a variety of perfect musical tones are generated. The vibrations corresponding to these tones are transferred electrically to the conductor; every vibration transmits a short electrical impulse or current to the conductor.

If, for example, a fork be tuned to the note *b*, it will send into the wire 240 short electric impulses, which will continue on, as electric waves, to the receiving station.

The current waves formed by other and differently tuned forks may pass over the same wire at the same time; they work their way side by side, and independently of each other.

At the receiving station each wave current finds its way to its correspondingly tuned receiver; leaving those not tuned in harmony with it quite undisturbed. These receivers are called monotelephones. They possess the characteristic of giving expression to the alternating currents passing through them, only in so far as they reproduce the tone peculiar to their membrane. Accordingly, when several of these differently-tuned transmitters and receivers are cut into a circuit, each telephone will reproduce essentially only the tones emanating from its correspondingly attuned companion at the other end.

In Fig. 1 we exemplify the principles of the Mercadier system. Between the tongues of the tuning fork *S* lies the electro-magnet *E*, in the circuit of the galvanic battery *Bm*.

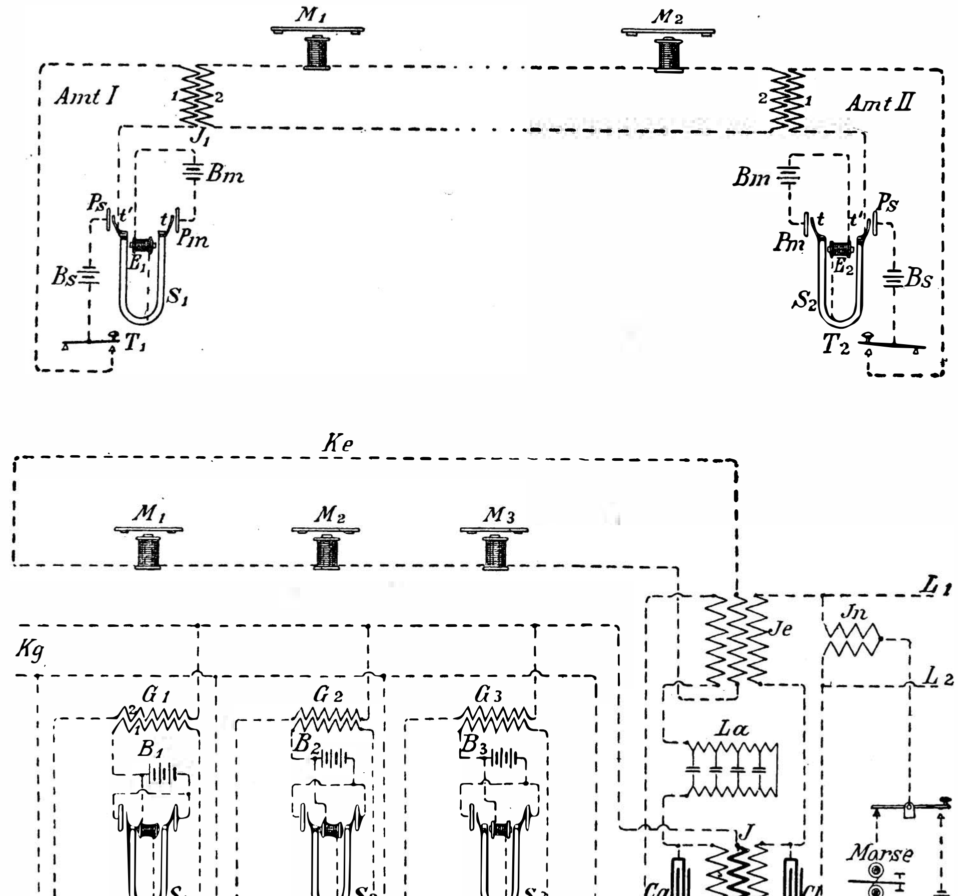


Fig. 1.—CIRCUITS OF THE MERCADIER SYSTEM OF WIRELESS TELEGRAPHY.

Now, if the circuit be closed by the contact of the steel point *t*, situated upon one tongue of the fork, with the platinum plate *Pm*, the magnet *E* attracts both tongues of the fork, and thereby breaks the circuit again, whereupon the tongues swing back again. Thus the current will be closed again and the play repeats itself. In this manner the fork will be set vibrating, and be maintained in this condition by the galvanic battery, making in every second of time a number of vibrations corresponding to its proper tone.

The insulated steel point *t'*, placed upon the other tine of the fork, makes the same motions as *t* and closes, with every vibration, the circuit of the transmitting battery *Bs*, but only when the key *T* is depressed.

In this case the current impulses generated at Office No. 1 reach the winding *I* of the induction transmitter *J'*, and are thence sent into the main line. They

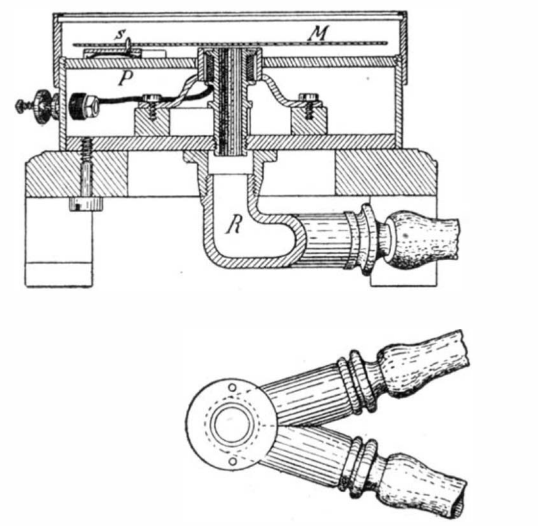


Fig. 2.—DIFFERENTIAL DUPLEX SWITCH.

pass through both monotelephones M^1 and M^2, but are intelligible only at M^2, which is tuned to the same pitch as the fork S^1. Now, if the fork S^2 in Office No. 2 emits a tone differing from that of S^1, and provided that the receiver M^1 is attuned to the same pitch as fork S^2, then Office No. 2 may send messages through the line at the same time as Office No. 1, though in the opposite direction, which will pass through M_2 also, but be intelligible only to the operator at M^1.

Thus we perceive that currents of varying periodic wave lengths may be simultaneously sent through the same conductor without interfering with one another.

No obstacle or objection exists to the connection with the ends of the induction coil *I* of several, or in fact any number of transmitting current circuits emanating from forks of different pitch established in either or several offices, provided always the monotelephones of corresponding pitch are installed at the other or receiving stations. From every transmitter messages in Morse letters may be simultaneously sent into the line, and read off at the corresponding receivers in the form of audible long and short tones emitted by the vibrating fork.

As above described, these connections are theoretically correct, yet in practice they demand further additions, because monotelephones which respond to a single tone only are not of possible construction. These receivers emit other than their fundamental tones, though very much feebler, the proper tone being from 50 to 100 times as strong as the others. Such a predominance in strength is indeed sufficient to enable the operator to select the correct tone from the arriving tones, which, though greatly weakened, are, among themselves, of about the same general strength.

However, the much more forcible departing currents would affect the receivers in the same office, and produce a noise similar to the boiling of water, which would materially hinder the easy perception of the correct sign.

To protect the receivers from the effects of the departing currents, Mercadier makes use of a differential duplex switch, which we show in Fig. 1 arranged for an office.

The differential transformers *J* and *Je*, each having three separate windings of wire, are the devices employed for rendering the departing currents ineffective upon the receiving circuit. Let us now trace the path of the arriving current waves. Coming in from the line at L^1, they pass through the windings on the right of the differential transformers, *Je* and *J* back to the conductor L^2.

In the middle windings of the transformer *Je* the arriving current waves induce alternating currents, which pass through all the monotelephones on the receiving circuit *Ke*. Each monotelephone responds only to that alternating current the periodic number of which agrees exactly with vibratory pitch of the telephone membrane. To the sending circuit *Kg* the various transmitters G^1, G^2, and G^3 are connected. Each fork sends uninterruptedly a number of current impulses into the primary winding of the induction coil, corresponding to its vibratory pitch. As often and as long as the circuit of the secondary winding of the induction coil is closed by the depression of the key *T*, there are induced in the coil alternating currents, the wave lengths of which correspond exactly with the vibrations of the fork. Of course it is apparent that with such a connection for each fork, only one battery, *B*, is needful. In this simplified arrangement the steel point on the left tine of the fork is not insulated; consequently, the battery sends its current through both the electro-magnet and the wire 1 (Fig. 1) or primary winding, of the induction coil.

The sending circuit *Kg* is closed by the primary winding of the differential transformer *J* (Fig. 1). By means of the secondary winding of the transformer *J*, situated on the right side, the current impulses from the transmitter are carried over to the conductor, which is connected with the secondary coil of the transformer *Je*.

Any inductive effect of this latter upon the central coil will be counterbalanced by the opposing induction proceeding from the equalizing circuit formed by the artificial circuit *La* and the winding on the left side of the transformers *J* and *Je*.

Thus, through the differential transformers, the departing currents will be sent out upon both the equalizing circuit and the main line; the currents of both circuits being of equal strength and acting, though in a contrary sense, upon the primary winding of the transformer *Je*, will neither affect it nor the receiver current *Ke* so closely connected with it.

The condensers *Ca* and *Cl* serve chiefly to equalize the two current circuits in such a manner that the current waves in both the main line and the equalizing circuit shall at all times be equal to the phase of oscillation. The artificial conductor or circuit *La* consists of a combination of wire resisters and condensers.

The monotelephone, which we show in Fig. 2, contains within a cylindrical case with a glass cover a powerful magnet, upon the hollow core of which is mounted a magnetizing coil. The membrane *M* is about 2 millimeters thick, and instead of being clamped all around by the rim, it is pierced at three points and supported upon points *s*, which move in slots radially cut in the plate *P*. Every membrane or diaphragm is thus adapted to be tuned to any desired tone corresponding to its diameter. It transmits vigorously when a series of alternating currents, having the same number of vibrations as its fundamental tone, pass through it, but remains quite unaffected when the number of vibrations varies by at least a half-tone. The sound waves generated by the diaphragm pass through the hollow magnet into the tube *R*, and through the hollow flexible tubing arranged singly or double to the ear or ears of the operator. The distance between the diaphragm and the pole of the magnet is adjusted by turning the plate *P*, which is carried on a screw thread inside the case. Once adjusted, there is no need of a change, for the tone pitch remains constant.

The Mercadier system as arranged by himself provides for an even dozen of senders and receivers in each station, so that 24 messages could be sent simultaneously over the same line of a single wire. The tuning forks of the sending instruments of one office are tuned in unison with the receiving instruments, monotelephones of a distant office, each one giving forth one of the twelve musical tones, *b*, *c*, *c* sharp, *d*, *d* sharp, up to and including *b* flat. These tones succeeding each other according to the chromatic scale, half a tone apart, are produced by vibrations per second varying from 240 up to 455. Now, if, for example, in Office No. 1 the key belonging to the *c* fork be pressed, there arise immediately in the sending circuit *Kg* alternating currents of a frequency equal to the vibrations due to the tone *c*, and by means of the differential transformer *J* they are borne out upon both the main and equalizing circuits, while their transmission to the receiving circuits of the same office will be prevented by the differential transformer *Je*. The alternating currents arriving at Office No. 2 produce their effect only in the differential transformer *Je*, by the aid of which they are transferred to the receiving circuit *Ke*, in which they cause a response only in the monotelephone tuned to *c*.

Without in the least disturbing this process, any or all of the other keys in either or both the offices No. 1 and No. 2 may be worked at the same time.

The current waves of different frequency spread themselves out, and work side by side without interference and quite independently. Besides the tuning fork system of telegraphy, still another system, the ordinary Morse system, for example, driven by a direct current, may be cut in on the same line; both currents will traverse the same medium without interfering with one another.

In practice, a complete apparatus consists of both a sender and a receiver, so that the operator may both send and receive messages.

The ear tubes are fastened to the head, so that both hands remain free. So as not to disturb the operator, the tuning fork circuit interrupter may be set up at some distance from the key, either in a room by itself or within a small felt-lined case under glass. To start the interrupter, screw the disk *Pm* (Fig. 1) forward until it touches the point *t*, and fix it there by means of the jam nut; the fork will continue to vibrate then quite of itself, as long as the battery produces sufficient power. Now screw the plate *Ps* (Fig. 1) forward until sparks appear between it and the point t^1. Sparks, small but clear, must be plainly visible at both contact points; it is advisable to alter the points of contact every day by slightly turning the plates. Dry elements or cells will serve for the battery; two to three large French Bloc cells are sufficient for each fork interrupter, even for a long line. In connecting in the cells, care must be taken that the positive current pass from the point *t* to the plate *Pm*, because with that arrangement the points suffer less wear, and the contact remains cleaner.

In setting up the instruments, the induction coils must be so far removed from the tuning forks as to be beyond the reach of any magnetic influence emanating from them.

The condensers *Cl* and *Ca*, which possess a value divided into tenths and twentieths of a microfarad, are so regulated that from an outlying station any sending current may be employed, and as many stops be inserted in the condensers until the current cannot be heard in the monotelephones of other periodicity. The equalization is then correct for the currents of the other sending stations.

The operation of the Mercadier telegraph, according to the connections shown in Fig. 1, demands a double conductor; this is the customary form of installation. If, however, a double conductor is not available, a newly-invented system of connections may be employed for a single conductor, in which an apparatus consisting of contact disks is substituted in the place of the tuning fork interrupter, said disks being given a certain speed of revolution by means of an electric motor.

For the single disks the number of contacts is estimated in such a way that with a predetermined rate of speed, and from a direct-current source through the intermediation of the differential transformers, they send into the system alternating currents, the frequency of which correspond exactly with the fundamental vibrations of their respective monotelephones.

Successful trials of the Mercadier telegraph system have been carried out in France on the line between Paris and Dijon, as well as between Toulouse and Bordeaux, while in Germany the line between Berlin and Frankfort-on-the-Main operated to the satisfaction of the experimenters. Its application is not confined to the connection of merely two end stations; intermediate stations may be cut in without detriment to the system.

If it be proposed to unite twelve outlying stations with the central office, then the latter must be provided with twelve complete sets of apparatus, one of each of which is to be connected with one of a corresponding tone situated in outlying stations, the whole connected one after the other; thus connected the sub-stations cannot communicate one with the other. Should it be desirable that the intermediate stations may communicate with each other as well as with the central office, then five offices are the most that can be accommodated by the system of twelve tones, each station to receive four. The calling of any desired station follows then by the aid of a resonator, which so increases the timbre of the monotelephone that it can be heard at some distance away.

During the trials it developed that the wave currents of the tuning fork system disturbed the traffic on neighboring telephone lines by induction; that technicians will discover ways and means of overcoming this difficulty is to be expected. At all events, the Mercadier telegraph is one of the most ingenious inventions of the last decade in the field of wire telegraphy, and we trust that the inventor will experience the complete fulfillment of his most sanguine hopes.—Translated from Prometheus.

A QUARTZ-THREAD VERTICAL FORCE MAGNETOGRAPH.

By W. Watson, A.R.C.S., D.Sc., F.R.S., Assistant Professor of Physics at the Royal College of Science, London.

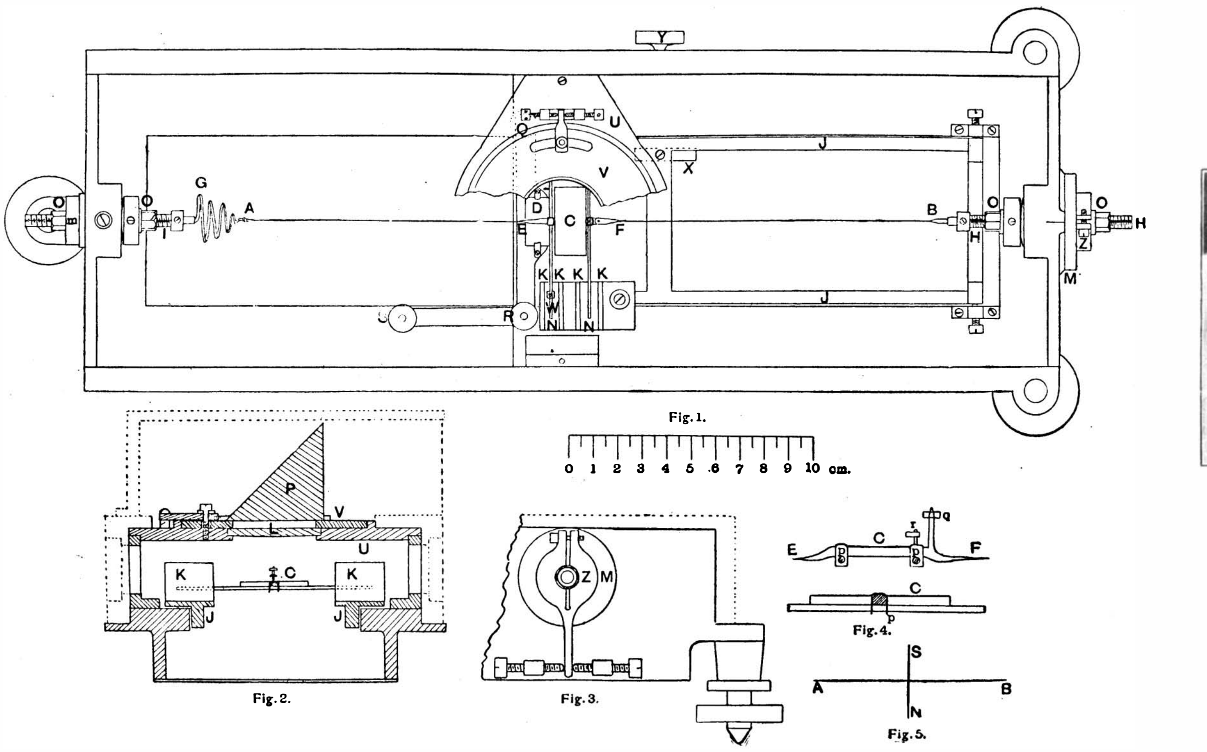
The late Dr. Eschenhagen was the first to show that when the moment of inertia of the suspended system in a horizontal-force magnetograph is made very much smaller than that employed in the ordinary form, it is possible to detect variations in the earth's field of quick period. Since the study of these short-period variations promises to be of considerable interest, the design of self-recording instruments capable of giving satisfactory records becomes of importance. Both Dr. Eschenhagen* and the author† have described forms of apparatus suitable for recording the variations of the declination and horizontal component. The design of a satisfactory form of instrument to record the rapid variations of the vertical component presents, however, some very considerable difficulties. Thus, if the attempt is made to reduce to any great extent the moment of inertia, and hence the mass, of the balanced magnet in the ordinary form of Lloyd's balance, it is found that irregularities are immediately introduced owing to imperfections or dirt interfering with the free movement of the knife-edge. Further, the slight tremors to which the base of the instrument is almost always subject cause the knife-edge to slip about on the plane, and thus the azimuth of the magnet varies, and there is difficulty in obtaining a satisfactory record.

The above considerations led the writer, about two years ago, to try various other forms of Lloyd's balance; and the following paper contains a description of the instrument finally arrived at, and which has been actually run for some considerable time.

In principle the instrument resembles the quartz-thread gravity-balance designed by Prof. Threlfall.‡ In addition to the advantages to be expected from this form of balance due to the suppression of the knife-edge, it promised to allow of a very simple method of compensating for the effects of changes of temperature. This is of considerable importance, for many vertical-force magnetographs might almost be used more efficiently as thermographs than as instruments for recording changes in the vertical component.

The principle of the instrument it to have a magnet *NS* (Fig. 5) suspended on a horizontal quartz fiber *AB*, the fiber being kept stretched by means of a spring. The center of gravity of the magnet and the torsion of the fiber are so adjusted that the axis of the magnet is horizontal. In order to see how the temperature compensation can be effected, let us suppose that the axis of the supporting fiber passes through the center of gravity of the magnet, so that in the northern hemisphere the fiber has to be twisted, say by turning the end *B* in the anti-clockwise direction as seen when looking along the fiber from *B* toward *A*. If now the temperature rises two effects will be produced. In the first place, the magnetic moment of the magnet will decrease, and hence the couple acting on the magnet, due to the vertical component of the earth's magnetic field, will decrease. The result will be that the north end of the magnet will rise. Secondly, owing to the fact that the torsional rigidity of fused silica increases with rise of temperature, the couple due to the torsion of the fiber will increase. On this account also the north end of the magnet will rise. Next let us adjust the balance of the magnet so that the center of gravity lies on the same side of the axis of the fiber as the south pole, the displacement being such that to make the magnet lie with its axis horizontal, the fiber has to be twisted in the clockwise direction. In this case, when the temperature rises the north end of the magnet will tend to rise owing to the decrease in magnetic moment, but will tend to fall owing to the increase in the stiffness of the fiber. Thus, by suitably adjusting the horizontal displacement of the center of gravity of the magnet, that is the initial torsion of the fiber, we can so arrange matters that the decrease in the couple due to the one effect is exactly equal to the increase due to the other; and so changes of temperature do not affect the position of the magnet. In the instrument described, the horizontal displacement of the center of gravity is effected by moving a small weight along the magnet; and the possibility of obtaining complete compensation depends on the fact that the coefficient of increase of the rigidity of the fiber is much greater than the coefficient of linear expansion of steel.*

The construction of the instrument will be evident from Figs. 1, 2, 3, 4. The base of the instrument consists of a strong metal casting having uprights at the ends which carry the attachments for the ends of the fiber. Two uprights screwed to the middle of the base serve to support a circular plate *U*, which carries the plano-convex lens *L*, used to form an image of the slit on the recording-drum. The circular disk *V* can turn through a small angle, its position being determined by two adjusting screws, and it carries the right-angled reflecting prism *P*. One end of the quartz fiber is fused to a quartz spring *G*, while the other end is fused to a small rod of quartz which is soldered into a small metal rod, which is clamped by means of a screw to the screw *H*. Both the screws *H* and *I* have a key-way cut along them, so that by means of the nuts *O*, they can be moved parallel to their axis but without rotation. These screws pass through holes in the two collars *m* and *M*, which themselves fit in the uprights carried by the base. The collar *M* carries a divided head, and is fitted with a fine adjustment *Z*, shown in Fig. 3. Since only the portion *FB* of the quartz thread is twisted, the fine adjustment and divided head allow of the twist put into the thread being accurately adjusted and read off. A knowledge of the amount of twist is of assistance when adjusting the temperature compensation.



THE CONSTRUCTION OF THE MAGNETOGRAPH.

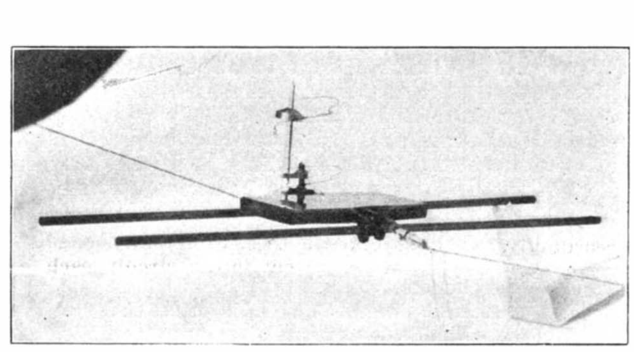


Fig. 6.

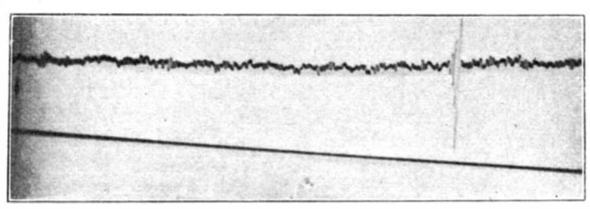


Fig. 7.

The fixed mirror *D* is supported on an L-shaped piece of brass, which is held in place by three studs fixed to the base which pass through loose-fitting holes. The L-shaped piece is held up by small spiral springs against three nuts *S*, *R*, *Q*, which screw on these studs. By adjusting these three nuts the position of the spot of light reflected from the fixed mirror can be adjusted.

The suspended system consists of two magnets 8 centimeters long and 1 millimeter in diameter attached by means of small platinum straps, *p* (Fig. 4), to two rods of fused silica which form part of the plate of fused silica *C* forming the mirror. These rods are bent as shown, and are fused to the ends *E* and *F* of the suspension fiber. There is also a small vertical rod of fused silica, which serves to carry a small weight *q* used when adjusting the sensitiveness. The reason why this gravity-bob is carried by a rod of fused silica is that, owing to the exceedingly small co-efficient of expansion of silica, the center of gravity,

* Terrestrial Magnetism. † Terrestrial Magnetism.
‡ Trans. Royal Society.

* The simple rigidity of fused silica in the form of fibers of moderate diameter increases by 0.00013 of its value for 1 deg. C., while coefficient of linear expansion of steel is 0.000011.

and hence the sensitiveness, is not appreciably altered by the changes of temperature. Since the weight q cannot be moved vertically, the sensitiveness is adjusted by filing the weight till the required sensitiveness is nearly attained. The final adjustment is made by means of a very small weight r which can be screwed up and down. The upper surface of the mirror is platinized.* It wil be noticed that the movable system consists of very few parts, while the mirror being attached to the fibers by fusion, we are in no way dependent on cements.

Since the tension put into the thread is such as to stretch the spring G through two or three millimeters, the variations in tension produced by changes in the length of the metal base are insignificant, and will certainly, over the comparatively small temperature-range likely to occur, be proportioned to the first power of the temperature, and hence can be eliminated when making the temperature adjustment. A photograph of one of the suspensions is shown in Fig. 6. The adjustment for temperature-compensation is made by means of a small weight W which is clamped on to one of the magnets. The weight of the moving system is about 3 grammes.

In order to damp the vibrations of the magnet four copper plates K are placed near the poles. These plates are attached to an arrester, J, which can be raised by a cam X worked by a handle Y. When the arrester is raised the right-hand magnet rests in two V's, while the left-hand magnet rests on a plane surface.

The instrument is closed in with a wooden case, and a thermometer passes through the upper surface of this case, the bulb being in the neighborhood of the magnets. A small drawer is fitted at the lower part of the base which serves to contain some desiccating agent when the instrument is used in a damp situation.

An instrument of the above pattern was, owing to the kindness of the Director (Dr. R. T. Glazebrook), tested at the National Physical Laboratory, and was found to work satisfactorily. Owing to disturbances produced by electrical railways it was impossible to make the temperature-compensation at South Kensington; and Mr. F. E. Smith, of the National Physical Laboratory, kindly undertook to perform the adjustment after the instrument was removed to Bushy House. He performed this adjustment with such skill, that with a change of temperature of 7 deg. C. he was unable to detect any vibration in the scale-reading (1 millimeter $= 1.6\gamma$) due to temperature change. When making these temperature adjustments, the trace obtained from a vertical-force magnetograph which was kept at a constant temperature was used to eliminate changes in V. I should like here to express my thanks to Mr. Smith for the trouble he took, and my appreciation of the skill with which he handled what is necessarily a very fragile and delicate instrument. In Fig. 7 is given a reproduction of a portion of a trace obtained with this instrument when at Bushy. In the original 1 centimeter corresponded to 3 minutes of time and 8γ† respectively. The recording-drum was at a distance of 170 centimeters from the instrument.

The following hints as to making and adjusting the movable system may be of assistance to any one attempting to make one of these instruments. A slab of fused silica is cut by means of a lapidaries' wheel, armed with diamond-dust, and roughly ground to size with carborundum on a metal plate.‡ Two small tags of silica are then attached to the sides of this slab by fusion with an oxyhydrogen flame. These tags serve to support the stirrups which carry the magnets, and to their ends the fibers will be fused afterward. The surfaces of the slab and of the tags are ground plane and approximately parallel, and then one surface is ground and polished optically plane. The platinum stirrups for the magnets having been fitted, the small silica upright for the inertia-bob is fused to one of the tags. The surface of the mirror having been platinized, the magnets are fitted in place, a small quantity of fused shellac being used to prevent the stirrups slipping.

To prepare the fibers, a rod of fused silica having a diameter of about 2 millimeters is taken and heated in a small oxyhydrogen flame, and then rapidly drawn out. Two stops must be arranged so as to limit the distance the hands can be separated, and hence the length of the fiber produced. With a little practice it is possible to obtain a fiber of a suitable length and diameter (0.008 to 0.010 centimeter). The two portions of the original rod must be cut off about a centimeter from the end of the fiber. One of these ends is fused to one of the tags attached to the mirror. The other end is in one case fused to the quartz spring, and in the other is soldered by the process described by Threlfall§ to a small brass rod which fits into the clamp attached to the screw H (Fig. 1).

To adjust the center of gravity, the movable system is mounted between two uprights on a wooden board, while a small U-shaped piece of brass, with slots to take the tags attached to the mirror, supports the mirror and magnets. The rods of quartz between the fiber and the mirror are then softened by heating in a very small oxyhydrogen flame, and bent so that the center of gravity lies a little below the line of support. During this operation the uprights of the U protect the magnets and mirror from the heat of the flame. The operation is one requiring some delicacy of touch, but is really not as difficult as one would suppose.

With reference to the adjustment for temperature compensation, the side on which the weight will have to be placed depends on which side of the suspension-line the center of gravity is situated, since it is almost impossible to get it exactly vertically below this line when adjusting the system. By, however, running the instrument in a situation where the changes of temperature are considerable, it will soon be seen whether it is over- or under-compensated. By making two sets of observations with the weight in two widely different positions, and noting the amount of twist put into the fiber, the position for compensation can be calculated. In this connection the easiest way is to calculate the correct amount of twist for the fiber, put in this amount of twist, and then adjust the weight till the magnet is horizontal.

The advantages claimed for this form of vertical-force magnetograph are:

1. The elimination of the knife-edge, and hence the absence of irregularities introduced by the presence of dust, etc., on the supporting plane. Also the needle does not move in azimuth owing to tremors of the supports.

2. The number of materials and separate parts entering into the composition of the movable system is small, and, with the exception of the steel of the magnets, they are unoxidizable and unaffected by impurities in the air.

3. The method of compensating for temperature is simple, and does not involve complicated counterpoise likely to get displaced.

4. The moment of inertia of the movable system is small although the magnetic moment is considerable.

5. The mirror cannot be distorted by its mounting, nor is there any likelihood of the position of the mirror with reference to the magnets being variable with temperature.

A second instrument has been constructed according to this design, the cost being defrayed by the Government Grant Committee of the Royal Society; and it is proposed to set up this instrument in the new Magnetic Observatory belonging to the National Physical Laboratory.

* Watson, Phil. Mag. July, 1903, p. 191; Proc. Phys. Soc. of Lond. xviii. (1903).

† $1\gamma = 0.00001$ C.G.S. unit.

‡ The methods of working such quartz mirrors and producing the platinum reflecting surface are described in the paper referred to previously.

§ "Laboratory Arts," p. 226 (Macmillan & Co.)

[Concluded from SUPPLEMENT No. 1500, page 24039.]

THE WORK OF A GREAT ETHNOLOGIST.*

By HENRY A. BALFOUR, M.A.

It is difficult to account at all for the existence of many of the forms such as I have briefly described, except on the supposition that they are survivals from more or less early stages in a series of progressive evolution; and, for myself, I do not believe that so inefficient and yet so elaborate an instrument as, to take an example, the harp of ancient Egypt, Assyria, and India could have come into being by any sudden inventive process, by "spontaneous generation," as it were, to use a biological term; whereas, the innate conservatism of the human species, which is most manifest among the lower and more primitive races (I use the term conservatism, I need hardly say, in a non-political sense) amply accounts for such forms having been arrived at, since the rigid adherence to traditional types is a prevailing characteristic of human culture, and only admits of improvement by very slight and gradual variations upon existing forms. The difficulty experienced by man in a primitive condition of culture of emancipating himself from the ideas which have been handed down to him, except by a very gradual and lengthy process, causes him to exert somewhat blindly his efforts in the direction of progress and often prevents his seeing very obvious improvements, even when they are seemingly forced upon his notice. For instance, the early Egyptian, Assyrian, and Greek harps, as I have already stated, were destitute of a fore-pillar, and this remained the case for centuries, in spite of their actually existing in an environment of other instruments, such as the lyre and trigonon, which in their rigid, unyielding frames possessed and even paraded the very feature which was so essential to the harp, to enable it to become a really efficient instrument. The same juxtaposition of similar types, without mutual influence, may be seen in modern Africa among ruder forms of these instruments.

And yet, in spite of instances such as this—where a valuable feature suggested by one instrument has not been adopted for the improvement of another even though the two forms are in constant use side by side—we must recognize that progress in the main is effected by a process of bringing the experience gained in one direction to bear upon the result arrived at in another. This process of grafting one idea upon another, or, as we may call it, the hybridization of ideas and experiences, is a factor in the advancement of culture whose influence cannot be overestimated. It is, in fact, the main secret of progress. In the animal world hybridization is liable to produce sterile offspring; in the world of ideas its results are usually far different. A fresh stimulus is imparted, which may last through generations of fruitful descendants. The rate at which progress is effected increases steadily with the growth of experience, whereby the number of ideas which may act and react upon one another is augmented.

It follows, as a corollary, that he who would trace out the phylogenetic history of any product of human industry will speedily discover that, if he aims at doing so in detail, be must be prepared for disappointments. The tangle is too involved to be completely unraveled. The sequence, strictly speaking, is not in the form of a simple chain, but rather in that of a highly complex system of chains. The time-honored simile afforded by a river perhaps supplies the truest comparison. The course of the main stream of our evolution series may be fairly clear to us, even as far as to its principal source; we may even explore and study the general effect produced by the more important tributaries; but to investigate in detail the contributions afforded in present and past of the innumerable smaller streams, brooks, and runlets is clearly beyond any one's power, even supposing that the greater number had not changed their course at times, and even, in many cases, run dry. While we readily admit that important effects have been produced by these numberless tributary influences, both on the course and on the volume of the river, it is clear that we must in general be content to follow the main stream. A careful study of the series of musical instruments, of which I gave but a scanty outline, reveals very clearly that numberless ideas borrowed from outside sources have been requisitioned and have affected the course of development. In some cases one can see fairly clearly whence these ideas were derived, and even trace back in part their own phylogenetic history; but a complete analysis must of necessity remain beyond our powers and even our hopes.

It will have been observed that, in the example of a sequence series which I have given, the early developmental stages are illustrated entirely by instruments belonging to modern savage races. It was a fundamental principle in the general theory of Col. Lane Fox that in the arts and customs of the still living savage and barbaric peoples there are reflected to a considerable extent the various strata of human culture in the past, and that it is possible to reconstruct in some degree the life and industries of man in prehistoric times by a study of existing races in corresponding stages of civilization. His insistence upon the importance of bringing together and comparing the archæological and ethnological material, in order that each might serve to throw light upon the other, has proved of value to both sciences. Himself a brilliant and far-seeing archæologist as well as ethnologist, he was eminently capable of forming a conclusion upon this point, and he urged this view very strongly.

The earth, as we know, is peopled with races of the most heterogeneous description, races in all stages of culture. Col. Lane Fox argued that, making due allowance for possible instances of degradation from a higher condition, this heterogeneity could readily be explained by assuming that, while the progress of some races has received relatively little check, the culture development of other races has been retarded to a greater or less extent, and that we may see represented conditions of at least partially arrested development. In other words, he considered that in the various manifestations of culture among the less civilized peoples were to be seen more or less direct survivals from the earlier stages or strata of human evolution—vestiges of ancient conditions which have fallen out at different points and have been left behind in the general march of progress.

Taken together, the various living races of man seem almost to form a kind of living genealogical tree, as it were, and it is as an epiphyte upon this tree that the comparative ethnologist largely thrives; while to the archæologist it may also prove a tree of knowledge the fruit of which may be eaten with benefit rather than risk.

This certainly seems to be a legitimate assumption in a general way; but there are numerous factors which should be borne in mind when we endeavor to elucidate the past by means of the present. If the various gradations of culture exhibited by the condition of living races—the savage, semi-civilized or barbaric, and the civilized races—could be regarded as accurately typifying the successive stages through which the higher forms of culture have been evolved in the course of the ages; if, in fact, the different modern races of mankind might be accepted as so many sections of the human race whose intellectual development has been arrested or retarded at various definite stages in the general progression, then we should have, to all intents and purposes, our genealogical tree in a very perfect state, and by its means we could reconstruct the past and study with ease the steady growth of culture and handicrafts from the earliest simple germs, reflecting the mental condition of primæval man up to the highest manifestations of the most cultured races.

These ideal conditions are, however, far from being realized. Intellectual progress has not advanced along a single line, but, in its development, it has branched off in various directions, in accordance with varying environments; and the tracing of lines of connection between different forms of culture, as is the case with the physical variations, is a matter of intricate complexity. Migrations with the attendant climatic changes, change of food, and, in fact, of general environment, to say nothing of the crossing of different stocks, transmission of ideas from one people to another, and other factors, all tend to increase the tangle.

Although in certain instances savage tribes or races show obvious signs of having degenerated to some ex-

* Address before Anthropological Section of British Association for the Advancement of Science.

tent from conditions of a higher culturedom, this cannot be regarded as the general rule, and we must always bear in mind the seemingly paradoxical truth that degradation in the culture of the lower races is often, if not usually, the direct result of contact with peoples in a far higher state of civilization.

There can, I think, be little doubt that Col. Lane Fox was well justified in urging the view that most savage races are in large measure strictly primitive, survivals from early conditions, the development of their ideas having from various causes remained practically stationary during a very considerable period of time. In the lower, though not degenerate, races signs of this are not wanting, and while few, possibly none, can be said to be absolutely in a condition of arrested development, their normal progress is at a slow, in most cases at a very slow, rate.

Perhaps the best example of a truly primitive race existing in recent times, of which we have any knowledge, was afforded by the native inhabitants of Tasmania. This race was still existing fifty years ago, and a few pure-blooded survivors remained as late as about the year 1870, when the race became extinct, the benign civilizing influence of enlightened Europeans having wiped this extremely interesting people off the face of the earth. The Australians, whom Col. Lane Fox referred to as being "the lowest among the existing races of the world of whom we have any accurate knowledge," are very far in advance of the Tasmanians, whose lowly state of culture conformed thoroughly with the characteristics of a truly primitive race, a survival not only from the Stone Age in general, but from almost the earliest beginnings of the Stone Age. The difference between the culture of the Tasmanians and that of the Australians was far greater than that which exists between man of the "River Drift" period and his Neolithic successors. The objects of every-day use were but slight modifications of forms suggested by nature, involving the exercise of merely the simplest mental processes. The stone implements were of the rudest manufacture, far inferior in workmanship to those made by Palæolithic man; they were never ground or polished, never even fitted with handles, but were merely grasped in the hand. The varieties of implements were very few in number, each, no doubt, serving a number of purposes, the function varying with the requirements of the moment. They had no bows or other appliances for accelerating the flight of missiles, no pottery, no permanent dwellings; nor is there any evidence of a previous knowledge of such products of higher culture. They seem to represent a race which was isolated very early from contact with higher races, in fact, before they had developed more than the merest rudiments of culture—a race continuing to live under the most primitive conditions, from which they were never destined to emerge.

Between the Tasmanians, representing in their very low culture the one extreme, and the most civilized peoples at the other extreme, lie races exhibiting in a general way intermediate conditions of advancement or retardation. If we are justified, as I think we are, in regarding the various grades of culture observable among the more lowly of the still existing races of man as representing to a considerable extent those vanished cultures which in their succession formed the different stages by which civilization emerged from a low state, it surely becomes a very important duty for us to study with energy these living illustrations of early human history in order that the archæological record may be supplemented and rendered more complete. The material for this study is vanishing so fast with the spread of civilization that opportunities lost now will never be regained, and already even it is practically impossible to find native tribes which are wholly uncontaminated with the products, good or bad, of higher cultures.

The arts of living races help to elucidate what is obscure in those of prehistoric times by the process of reasoning from the known to the unknown. It is the work of the zoologist which enables the palæontologist to reconstruct the forms of extinct animals from such fragmentary remains as have been preserved, and it is largely from the results of a comparative study of living forms and their habitats that he is able, in his descriptions, to equip the reconstructed types of a past fauna with environments suited to their structure, and to render more complete the picture of their mode of life.

In like manner, the work of the ethnologist can throw light upon the researches of the archæologist; through it broken sequences may be repaired, at least suggestively, and the interpretation of the true nature and use of objects of antiquity may frequently be rendered more sure. Col. Lane Fox strongly advocated the application of the reasoning methods of biology to the study of the origin, phylogeny, and etionomics of the arts of mankind, and his own collection demonstrated that the products of human intelligence can conveniently be classified into families, genera, species, and varieties, and must be so grouped if their affinities and development are to be investigated.

It must not be supposed—although some people, through misapprehension of his methods, jumped at this erroneous conclusion—that he was unaware of the danger of possibly mistaking mere accidental resemblances for morphological affinities, and that he assumed that because two objects, perhaps from widely separated regions, appeared more or less identical in form, and possibly in use, they were necessarily to be considered as members of one phylogenetic group. On the contrary, in the grouping of his specimens according to their form and function, he was anxious to assist as far as possible in throwing light upon the question of the monogenesis or polygenesis of certain arts and appliances, and to discover whether they are exotic or indigenous in the regions in which they are now found, and, in fact, to distinguish between mere analogies and true homologies. If we accept the theory of the monogenesis of the human race, as most of us undoubtedly do, we must be prepared to admit that there prevails a condition of unity in the tendencies of the human mind to respond in a similar manner to similar stimuli. Like conditions beget like results; and thus instances of independent invention of similar objects are liable to arise. For this very reason, however, the arts and customs belonging to even widely separated peoples may, though apparently unrelated, help to elucidate some of the points in each other's history which remain obscure through lack of the evidence required to establish local continuity.

I think, moreover, that it will generally be allowed that cases of "independent invention" of similar forms should be considered to have established their claim to be regarded as such only after exhaustive inquiry has been made into the possibilities of the resemblances being due to actual relationship. There is the alternative method of assuming that, because two like objects are widely separated geographically, and because a line of connection is not immediately obvious, therefore the resemblance existing between them is fortuitous, or merely the natural result of similar forms having been produced to meet similar needs. Premature conclusions in matters of this kind, though temptingly easy to form, are not in the true scientific spirit, and act as a check upon careful research, which, by investigating the case in its various possible aspects, is able either to prove or disprove what otherwise would be merely a hasty assumption. The association of similar forms into the same series has therefore a double significance. On the one hand, the sequence of related forms is brought out, and their geographical distribution illustrated, throwing light, not only upon the evolution of types, but also upon the interchange of ideas by transference from one people to another, and even upon the migration of races. On the other hand, instances in which two or more peoples have arrived independently at similar results are brought prominently forward, not merely as interesting coincidences, but also as evidence pointing to the phylogenetic unity of the human species, as exemplified by the tendency of human intelligence to evolve independently identical ideas where the conditions are themselves identical. Polygenesis in his inventions may probably be regarded as testimony in favor of the monogenesis of man.

I have endeavored in this address to dwell upon some of the main principles laid down by Col. Lane Fox as a result of his special researches in the field of ethnology, and my object has been twofold. First, to bear witness to the very great importance of his contribution to the scientific study of the arts of mankind and the development of culture in general, and to remind students of anthropology of the debt which we owe to him, not only for the results of his very able investigations, but also for the stimulus which he imparted to research in some of the branches of this comprehensive science. Secondly, my object has been to reply to some criticisms offered in regard to points in the system of classification adopted in arranging his ethnographical collection. And, since such criticisms as have reached me have appeared to me to be founded mainly upon misinterpretation of this system, I have thought that I could meet them best by some sort of restatement of the principles involved.

It would be unreasonable to expect that his work should hold good in all details. The early illustrations of his theories were to be regarded as tentative rather than dogmatic, and in later life he recognized that many modifications in matters of detail were rendered necessary by new facts which had since come to light. The crystallization of solid facts out of a matrix which is necessarily partially volatile is a process requiring time. These minor errors and the fact of our not agreeing with all his details in no way invalidate the general principles which he urged, and we need but cast a cursory glance over recent ethnological literature to see how widely accepted these general principles are, and how they have formed the basis of, and furnished the inspiration for, a vast mass of research by ethnologists of all nations.

It appears more than probable that Cambridge will be much involved in the future advancement of anthropological studies in Great Britain, if we may judge from the evident signs of growing interest in the science, not the least of which is the recent establishment of a board of anthropological studies, an important development upon which we may well congratulate the university. Within my own experience there have been many proofs of the existence in Cambridge of a keen sympathy with the principles of ethnological inquiry developed by Col. Lane Fox, and I feel that, as regards my choice of a theme for the main topic of my address, no apology is needed. For my handling of this theme, on the other hand, I fear it must be otherwise. I would gladly have done fuller justice to the work of Col. Lane Fox, but, while I claim to be among the keenest of his disciples, I must confess to being but an indifferent apostle.

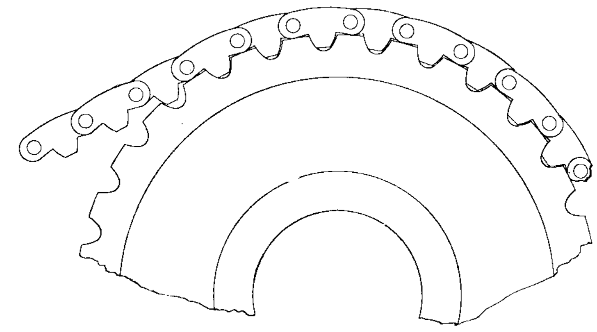
I have been obliged, moreover, to pass over many interesting features in the work of this ingenious and versatile scientist. I have made no attempt to touch upon his archæological researches, since it has been necessary for me to restrict myself to a portion only of his scientific work. In this field, as in his ethnological work, his keen insight, ingenuity, and versatility were manifested, while the close attention which he bestowed upon matters of minute detail have rendered classical his work as a field archæologist. While the greater part of his ethnological work is associated with the name Lane Fox, by which he was well known until 1880, most of his researches into the remains of prehistoric times were conducted after he had in that year assumed the name of Pitt Rivers, on inheriting an important estate, which, by the happiest of coincidences, included within its boundaries a considerable number of prehistoric sites of the highest importance. That he made full use of his opportunities is amply manifested in his published works. In his archæological work are repeated the characteristics of his ethnological researches, and one may with confidence say of his contributions to both fields of inquiry that, if he advanced science greatly through his results he furthered its progress even more through his methods. By his actual achievements as a researcher he pushed forward the base of operations; by his carefully-thought-out systems for directing research he developed a sound strategical policy upon which to base further organized attacks upon the unknown.

A SILENT DRIVE CHAIN.

THIS chain is the outcome of the efforts of the inventor, Mr. Carl G. A. Schmidt, Jr., of Columbus, Ohio, to produce a powerful drive chain and at the same time a simple, light, durable, and practically non-stretchable chain. It is of the multiple steel link type, and is intended for any kind of driving of machinery, and an improvement over existing chains and over leather or similar belting.

The chain eliminates the exact and fixed centers necessitated when gearing is used, and it eliminates the slipping, stretching, and lacing experienced in the use of leather or similar belting.

The link tooth and sprocket tooth are so constructed as to permit the use of any number of teeth on the sprockets, of course within rational limits, but due



A SILENT DRIVE CHAIN.

to this fact, practically, almost any speed ratio can be obtained.

Connecting the pin centers of a link, it will be seen that the line of pull or stress in the link is through solid metal, and as a straight line is the shortest distance between two points, this line is the shortest path for the pull to exert itself. Consequently, there will be no tendency for the link to straighten out, and thus lengthen and change its stretch, as would be the case if the link were somewhat U shaped. Due to this fact, the chain can be rated at a higher working strain, and will not stretch until the load exceeds the elastic limit of the metal used in its construction.

Of course, the chain is rated, taking the bearing value of the pin into consideration; proportionately large pins are used to obtain good bearing and strength. Consequently, for the same pitch and width, this chain can be lighter; or for a given load, this chain can be smaller in width; or for the same width, the pitch can be smaller; hence, it may run at higher speeds than a heavier chain.

The shape of the link tooth and sprocket tooth lessens the tendency of the chain to climb, or, in case of a loose chain, to slip over the sprocket teeth.

A feature of the chain is the oblique faces under the pins. These are used to produce a chain of the minimum height and also to give the chain a closer and firmer grip on the sprocket teeth. Because of these oblique faces, the link rests on the top of a sprocket tooth, and not on the corners; the latter would convert the link into a beam with ends overhanging and loaded. This would produce bending moments in the link, which are very undesirable, as they would tend to distort it.

Again, the faces of the link tooth and sprocket teeth have been so designed that when the link tooth disengages the sprocket tooth, it immediately swings clear of the same, and does not rub along its full length. In engaging, the action is the same, only reversed, and consequently there is no power lost in friction, as the faces do not touch until the link has swung into its final position on the sprocket. This action and construction eliminate wear along the tooth faces, which is an important factor in keeping the pitch constant and making the chain durable.

IN a recent number of the Comptes Rendus M. Gutton describes how he proved the magnetic effect of electric convection by means of Rowland's arrangement and a luminescent screen. M. Bichat proves that the "conduction" of N-rays takes place by their successive reflection at the inner surface of the wire.

CHINESE PAVILION AT THE ST. LOUIS FAIR.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

THE Chinese pavilion at the St. Louis Fair is not a government building, in the sense of being the headquarters of the Commission. It is merely intended as an exhibit of typical Chinese domestic architecture of the higher class. It is a faithful reproduction, in its main features, of Prince Pu Lun's reception hall and summer home in Peking. The entrance gate is known as the Pilow, and forms the most conspicuous object as one approaches the group of buildings. To the left in the outer gardens is an arbor, for summer use, and then entrance is had to the main group of buildings through a doorway of unpretentious appearance. Inside the court we find to the right the ladies' and to the left the gentlemen's waiting room, while directly in front is the main reception hall, whose chief object of interest is a set of furniture which is an exact copy of the royal furniture at Peking. Back of the seat of honor is hung some characteristic symbolical Chinese embroidery. The center figure, which is worked in red, is symbolical of long life; the figure to the right, worked in yellow, signifies prosperity; while the third figure, worked in green, signifies happiness and peace. The furniture is a fine example of Chinese wood carving and inlaid and fretwork.

THE CHINESE PAVILION AT THE ST. LOUIS FAIR

The main Chinese exhibit, however, is to be found in the Palace of Liberal Arts, where it occupies a considerable amount of space. It is certainly one of the most curious and novel displays to be found in the whole Exposition grounds. It includes a little of everything China produces or manufactures, something from every part of the empire, from the provinces of the north, where the climate is as cold as Minnesota, to those at the far south, where the climate is similar to that of Cuba. As the result of the personal interest taken by the Chinese government in this exhibit, and the rare character of the treasures that have been gathered together, a visitor to the Chinese section can see more of the choice and artistic things of China than he could if he spent many years traveling through the empire itself.

The customs department, which took charge of the collection of material, made a sweeping canvass of the eighteen provinces of the empire, and was careful to select such matter as would be thoroughly representative of the empire's varied industries and peoples. Outside of the Government collection, the Chinese officials of the seven most important provinces have loaned lavishly from their private collections of curiosities and family treasures, and among these curios are many objects of beauty that no foreigner has ever seen, including one vase that was recently sold in Peking for $10,000. There is much ancient carved ivory, jade, and silver and other ornaments. That these objects of art have been personally contributed by the viceroys of the provinces, may be fairly taken as an indication of China's growing interest and friendship for the United States.

The exhibit contains a very rich collection of silks, satins, and velvets from the imperial looms. There are over one hundred and ten varieties of native boats, shown in miniature models. The story of much of the agricultural and engineering work and the domestic life of the country is told by means of models, a typical group of which is shown in one of our illustrations. There are models of famous temples, complete even to the minutest details; of types of bridges, of public buildings, of examination halls, of famous idols, and of monumental arches. Things characteristic of each treaty port are represented. There are figures attired in embroidered silks and satins, to show the dress of the upper classes, and other figures costumed after the manner of the plain people. Altogether, it is safe to say that there is no given space at the fair that can hold the interest of the visitor uninterruptedly for such a length of time as this exhibit of the Celestial Empire.

ATLANTIC CATTLE-CARRYING.

"STIFF-CATCHERS" AND THEIR VICTIMS.

By WALTER WOOD.

THE strong and abiding prejudice of the Englishman against either frozen or chilled meat, or imported meat of any sort if he knows it to be imported, can be overcome only in one way. Instead of carcasses chilled or frozen being brought, the live cattle are conveyed to an English port and at once taken ashore and slaughtered within a period not exceeding ten days. Often enough, if the market is short of meat, the killing is done within twenty-four hours or less. The beef is in excellent condition, and even an expert would find it hard to tell the difference between this and the home-grown product.

Live-cattle-carrying across the Atlantic has been a recognized trade for many years. In the past the business has been the cause of much misery and loss, due to inadequate provision for carrying and inefficient attention, apart from the ravages of bad weather. Mr. Plimsoll's soul was so much disturbed by the deplorable state of things existing in his time that he put forth all his great energy to effect reforms, and the large and thoroughly equipped steamships which now bring cattle from America to England are due in great measure to his influence. There is quite a fleet of these steamers, the principal owners of cattle-ships being the Atlantic Transport Company and other sections of the Morgan Combine, and Messrs. Thomas Wilson & Sons, Limited, of Hull. Contrary to general belief, the Cunard Steamship Company, Limited, carry cattle by two or three of their American boats, prominent among them being the "Ultonia," which runs between Liverpool and Boston, and is chiefly remarkable as being the first passenger-ship crossing the Atlantic to carry third-class passengers exclusively.

A typical Atlantic cattle-boat is the "Toronto," of the Wilson Line. She, like her sister ship, the "Consuelo," is a new twin-screw vessel of, in round figures, six thousand tons and six thousand horse-power. The six thousand horse-power is, however, really a paper strength only, for the engines will not develop anything like that energy, and even in the fairest and most favorable weather the ships do not go beyond about a dozen knots. They can be run up to fourteen if coal enough is burnt, but fuel is costly, and adequate profits are obtainable only from low speed. They carry a few first-class passengers, and are slow but sure boats. Twelve days make an average run between New York and Hull, a day less being taken for carrying cattle to the Thames. In heavy weather the run may extend to sixteen days.

The "Toronto" will carry comfortably a thousand head of cattle. They are mostly accommodated on the main deck, which is remarkably well ventilated and equipped for its peculiar purposes. In fine weather the hatches are left off, and the cattle-doors in the ship's side are opened, and trips have been made repeatedly at the end of which the main deck, or cattle deck, as it is called, has smelled as fresh as at the beginning of the voyage. In bad weather, of course, the state of things is much worse, and the cattle, like human beings, are put to great discomfort. No pen, indeed, could exaggerate the horrors of the North Atlantic passage in winter, so far as cattle and sheep are concerned. Cattle on deck often have the sea-water which comes on board frozen on their backs, and heavy rolls and pitches cause many broken legs and other serious or fatal injuries. Out of a cargo of five hundred sheep which one Atlantic steamer conveyed to Hull not long ago, only two hundred were landed at that port. The rest had perished. In one morning alone fifty carcasses were thrown overboard, that number of sheep having been suffocated by being battened down—a proceeding made imperative by the severity of the weather.

The whole of the main deck of a ship like the 'Toronto," from stem to stern, is open, to allow of the freest possible circulation of air, and a walk round is a striking spectacle as well as a revelation into Atlantic cattle-carrying. The beasts, which are all steers, are in pens or stalls, three or four to each stall. The stalls are formed by placing boards into iron stanchions, a simple, elastic, and convenient arrangement. These divisions, of course, prevent the cattle from getting too close together, and keep them from being unduly distressed or injured by the motion of the ship. Every ingenious contrivance for clearing the deck of refuse is present, and the genuine cattlemen and their strange assistants the "stiffs" see to it that the animals do not lack attention. Too much water must not be given in hot weather, as this induces illness, and illness very soon means loss, seeing that each beast has a value of about fifteen or twenty pounds. Coming through the Gulf Stream in the heat of summer, for example, when everybody on board is gasping for air and even a sheet in one's bunk is a burden, the cattle have an unhappy time, and it is distressing to hear their low moans of complaint. They are marvelously patient with it all, and stand quietly or lie day after day in apparent

Copyright 1904 by Louisiana Purchase Exposition Company.

ONE CORNER OF THE CHINESE EXHIBIT AT THE ST. LOUIS FAIR, SHOWING A CHARACTERISTIC GROUP OF MODELS.

perfect content, less the disadvantages which have been indicated. In spite of their good eating at sea, they lose bulk and shrink in a very noticeable manner. This shrinkage, however, speedily disappears under the reviving influence of green pastures ashore. In some cases the animals fatten while at sea. Much depends on the quality of the fodder. If the compressed hay is good, the cattle will eat it; it not, they will reject it, just as a human being will refuse to eat bad food. The cattle are watered in the morning, between four and six o'clock, and that usually lasts for the day.

The cattle are collected from various parts of the West, so that when they are put on board in New York or other eastern ports they may have had a week's railway journey. They are brought alongside the ship, as she lies at her pier, in cattle-lighters, which are huge structures with two stories for their accommodation. On the lower deck is an opening for the removal of the cattle, which pass from the lighter to the main deck of the steamer through the cattle-doors, and on the upper deck is a similar mode of egress on to the deck proper, or shelter-deck, of the vessel, where movable pens are placed. The lighter is towed by a tug which is made fast alongside, and is handled with astonishing dexterity and expedition—far more quickly, it must be confessed, than similar work is done in England.

As soon as the gangways are in position the cattlemen drive their charges from the lighter to the ship. With luck, this will be a simple and easy matter, for the cattle will come quietly from one craft to another. From one lighter in New York, for example, I saw more than four hundred head come on board the "Toronto" in rather more than an hour. But sometimes a strange panic seizes the brutes, and they refuse to be driven or pushed or cajoled on board. In that case—there is no help for it—they must be slung into the ship, and accordingly they are hoisted on board by derricks, of which the "Toronto" is provided with no fewer than twenty-six, giving her when they are in use the appearance of a little forest. Strange shouts by the cattlemen (as far as I could interpret it, the chief one was "Out, boy!") and more or less gentle whacks with sticks are enough to induce the most reflective steer to go on board the ship. He runs clumsily to his stall, and is secured at once with a short, stout rope which is round his neck when he comes from the lighter. Occasionally a fine young fellow will have a ring through his nose and a malicious gleam in his eye; and sometimes there will be an animal which is either blind, or going blind, and very pathetic, too, such creatures look as they stand so patiently from day to day.

The cattle are, of course, attended to by a staff of men who are entirely separate from the crew. This staff consists of the cattlemen proper and another band known as "stiffs." The genuine cattleman is a remarkable and picturesque person. I saw one on board the "Toronto" who would have gladdened the heart of a sculptor. He was a tall man, of magnificent physique, with a soft, brigand-sort of hat, flashing blue eyes, brown face, long brown mustache, and crisp, curly brown hair. He had a splendid pose and a strange dignity, despite his tattered boots and trousers and braces over shirt. He wore a belt, and stuck in the back of it was the hatchet which every genuine cattleman carries—a weapon which is a combination of ax and hammer, and is of use on a hundred and one occasions when he is hammering boards up to imprison the cattle and cutting the wire bands which secure the compressed hay.

The stiffs are a body apart. They live separately from the cattlemen, who despise them because they are what they are and not the genuine article. A stiff is a man who is working his passage, and he is furnished by the human sharks and harpies who infest New York, and are known as "stiff-catchers;" they are mostly foreigners, and literally traffickers in human flesh and blood. Generally speaking, the stiffs also are foreigners who have been some time in America and have made a little money, say twenty, fifty, or one hundred pounds. They are going home to Russia, Germany, Sweden, or elsewhere, and are traveling on the cheap. For seven or eight dollars they can be put on board a cattle boat, and this is done regularly. The Jew harpy gets the dollars and the ship gets the man, who sometimes is about as intelligent as the cattle which it is his duty to tend. He gets no pay, of course, except the nominal shilling, and in fine weather has not overmuch work to do. He will either snore in the stiffs' quarters forward, where a dozen or more such men are accommodated, or sleep in an empty cattle pen or on the trusses of hay, or squat about and play cards. On my "Toronto" trip we brought ten stiffs from New York to London, and there were as many genuine cattlemen. Some stiffs, however, are able and willing workers, and are made use of in the ship's vitals as trimmers or firemen. On the "Toronto" three were employed in the bunkers, and one who was an English sailor was at work generally in the ship. All did their duty admirably. The sailor, of course, could have easily enough have arranged to work his passage without paying the stiff-catcher his outrageous fee.

The first officer had in his care no less a sum than three hundred pounds, which had been deposited with him by the ten stiffs—an average of thirty pounds per stiff. Among these stiffs are some strange characters, victims of life's little ironies and fortune's strange freaks. Broken gentlemen occasionally embark as stiffs and land penniless in England; or some dangerously ill man will get on board in the hope of reaching home before he dies. "Only those who brave its dangers comprehend its mysteries," sang the poet of the ocean; and only those who travel as stiffs or mingle with them know how many wrecks and tragedies of life they represent.

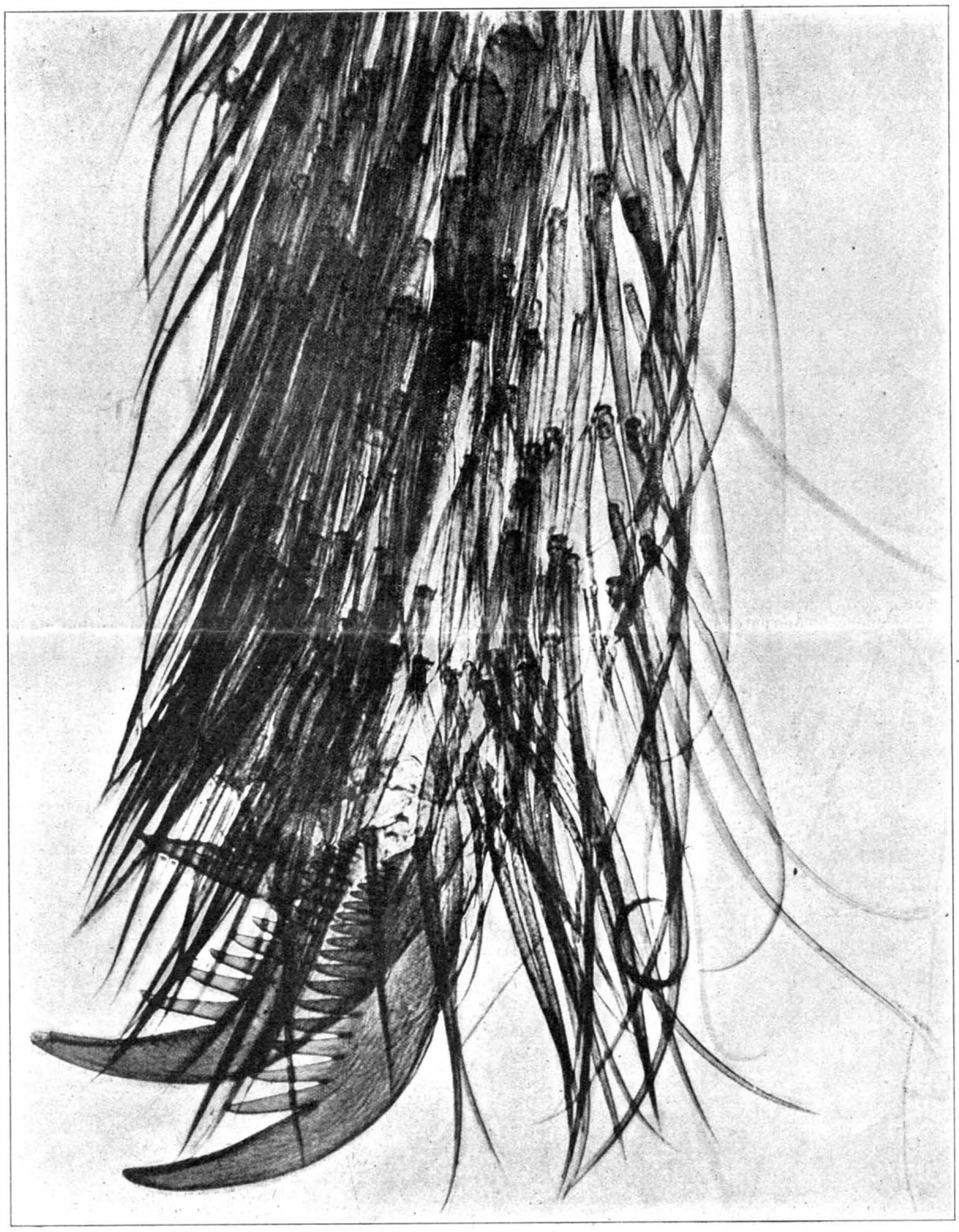
On a British cattle boat not long ago a man was discovered among the hay when the ship was three days out of Boston. The stowaway was terribly ill; he was starving, and was obviously in the last stage of sickness. The captain and the doctor did all that was possible, and the passengers helped with clothing and money; but the man died and was buried at sea. By the same steamer, but on another voyage, a young American millionaire, who meant to start ranching and wished to learn all he could about his work, traveled as a cattleman and stuck pluckily to his work from first to last. By her also voyaged two or three young Harvard students who wished to visit England as economically as possible. These university men also kept to their bargain, and worked as well as the best cattlemen on board.

There are many things which are peculiar to North Atlantic cattle boats. One is that the white paint becomes curiously discolored because of the presence of the animals, the sailors' theory being that they have some chemical action on the paint. Again, cattle have the power of making a ship roll or adding to the length of her roll. In harbor, when coming on board, occasionally they make the vessel roll quite heavily; while at sea in bad weather, when they are thrown helplessly about, their heavy weight, being near the top of the ship, adds greatly to the motion. Such, at any rate, is an officer's statement. Another strange thing about cattle is their power of scenting land. Sometimes they will set up a united bellow when thirty or forty hours from shore, or they may not show signs of recognizing land until it has been sighted. Occasionally, again, they will exhibit no excitement of any sort, but that is when the voyage across the Atlantic has been exceptionally smooth and comfortable, and the animals are in no hurry to leave the ship.—Chambers's Journal.

On the Bavarian state railways the passenger carriages are regularly disinfected with formaldehyde. The method adopted is to close the windows and doors tightly, and on the floor of the car is placed a pan which contains metal weights heated to a dull red color. A 20 per cent solution of formaldehyde is then poured into the pan. After having been left for about seven hours the carriage is then thoroughly ventilated.

THE LEG AND FOOT OF A SPIDER.

AT a recent conversazione of the Royal Society this photomicrograph was shown, with many others. The aim of the exhibitors, Messrs. Arthur E. Smith and Richard Kerr, was to point out the value of direct photography on a 12 by 10 inch plate and to show its advantages over enlargements made from smaller negatives. The details obtained at once by combining an unusually large camera with a monocular microscope are greater than those secured by ordinary amplifying methods. This illustration represents an enlargement of 260 diameters and has been obtained by a one-inch objective and a focal length of 37 inches approximately. The negative has received no touching up whatever.—Knowledge.



This reproduction was procured without the use of an ordinary microscope by direct photographic enlargement.

THE LEG AND FOOT OF A SPIDER.

THE "WOLVIN'S" REMARKABLE UNLOADING RECORD.

WHATEVER may be the earning record of individual vessels on the Great Lakes during the present season, that of the "Augustus B. Wolvin" will undoubtedly be fair notwithstanding the low rates prevailing. The career of the "Wolvin" up to date is certainly that of the ideal tramp, for her movements have been more variable than those of the ordinary steamer. When she was launched at Lorain she took on 9,904 tons of soft coal for Duluth. Then she went to Two Harbors and took 9,727 gross tons of ore to Buffalo. From there she proceeded to Milwaukee with 10,569 tons of hard coal and then went light to Escanaba. At Escanaba she loaded 10,973 gross tons of ore for South Chicago and then went to Duluth light. Then she loaded 9,945 gross tons of ore for Conneaut. With this latter cargo she was drawing when she left Duluth 18 feet 10 inches forward and 19 feet 3 inches aft. Of course, she was drawing something less than this when she reached the rivers owing to her consumption of fuel. She drew 20 feet in her record cargo of 10,973 gross tons of ore from Escanaba to South Chicago. Her cargo record to date is therefore as follows:

9,904 net tons, 1,800 pounds soft coal Lorain to Duluth.

9,727 gross tons iron ore Two Harbors to Buffalo.

10,569 net tons hard coal Buffalo to Milwaukee.

10,973 gross tons iron ore Escanaba to South Chicago.

9.945 gross tons iron ore Duluth to Conneaut.

The "Wolvin" in her last trip to Conneaut established what is likely to be the unloading record for ore for some time. Her cargo of 9,945 gross tons was unloaded in precisely 4 hours and 30 minutes by four Hulett clam-shell machines and four Brown electrical machines working together. The "Wolvin" had been at Conneaut since Friday night, but was compelled to wait her turn until Monday morning. At 7:20 o'clock Monday morning the eight buckets began working upon her and at just 11:52 o'clock the last bucket was hoisted from the hold and the whistle of the big steamer signaled for a tug. She had been completely unloaded without any hand labor whatever. No such work has ever been done before on the Great Lakes. The nearest approach to it is the record of the "James H. Hoyt," when 5,200 tons of ore were taken from that steamer by the four Hulett machines in 3 hours and 52 minutes. The "Hoyt," like the "Wolvin," has her hatches spaced 12-foot centers.—Marine Review.

THE MODERN STEAM LOCOMOTIVE.*

By Prof. W. F. M. Goss.

In the early development of American railroad systems, locomotives were used which, with few exceptions, were of a single type. As the extent of track increased, it was equipped with locomotives of the "American type." It made no difference whether the service was freight or passenger, or whether the locomotives were for use on heavy grades or level track, the fitness of the type was rarely questioned. The extent to which the design was duplicated is disclosed by the fact that in the early eighties a single establishment supplying many different railroad companies, and building in one year 600 locomotives, employed but a single man as draftsman.

As a response to early conditions, the type was almost perfect. By the exclusion of other types the problems of the builder were simplified, and the cost of manufacture was kept down; and when track mileage was increasing at enormous bounds this was important. As the same patterns were used over and over again every detail was proven in service upon hundreds of locomotives, hence cost of maintenance was low. The design was well adapted to the rough track common in pioneer work and considering the character of the service rendered the type was and still is remarkably efficient as a power plant. But while the type still has an important place in service, few locomotives of its kind are now being built. Its decline is due to the fact that as a type it cannot take on proportions which the modern locomotives must possess. One reason for this is to be found in the fact that it will not admit a grate of sufficient size for present-day requirements, and another is in its limited tractive power. The grate of the locomotive lies very near the source of its power, and if restricted then the power of the locomotive cannot expand. Originally the firebox of the American type locomotive was limited in width by the space between the side frames and in length by the distance between the driving axles. In locomotives common in the eighties, the width of the grate was not more than 34 inches, and the length generally less than 72 inches. Various means have since been employed to increase its size. The spacing between the driving axles was increased in order that the firebox might be made longer; the boiler was raised to allow the firebox to rest on top of the frames, instead of between them, allowing the width of the two side frames to be added to the width of the grate, and in some cases the grate was inclined upward and allowed to extend back over the rear driving axle. By means such as these the American type locomotive of 1876 came to be the American type locomotive of 1893, greatly augmented in proportions and power; but nevertheless defining severe limitations to be met by the designer.

The second limitation affecting the American type concerns its tractive power. Assuming adhesion, or, better, the coefficient of friction between wheel and rail to be equal to one-fifth of the weight on drivers, the American type engine of the eighties, carrying from 14,000 pounds to 16,000 pounds upon each driver, was capable of exerting a tractive force of from 10,000 pounds to 12,000 pounds. Wheel loads have since so increased that the modern engine may be depended upon to develop a tractive force of 5,000 pounds per driver, or a maximum of 20,000 pounds for the American type locomotive.

Until harder materials can be had for rails and tires, it is not likely that wheel loads can be further increased, so that greater tractive power must involve more than four-coupled wheels, and therefore a departure from the American type. With these facts in mind it will be of interest to inspect a few modern types, and to note the manner in which they have been developed from the original.

Turning to the process which goes on within the firebox, it will be found that under favorable conditions, each pound of coal burned will sustain 1 indicated horse-power for a period of from 12 to 15 minutes. Within certain limits the power developed is nearly proportional to the amount of coal burned. In the development of the modern locomotive, grates have been enlarged and heating surface extended that larger amounts of fuel may be burned. In one direction only has the designer found the way blocked against his ingenuity. He has not been able materially to augment the strength of the fireman, and consequently, when running under constant conditions, the power of the modern engine has not increased in proportion to its dimensions. A laborer is working at a fair rate when, in unloading coal from a gondola car, merely dropping it over the side, he handles 6,000 pounds of coal per hour. At the limit, a locomotive fireman will handle an equal amount, standing on an unsteady platform, placing it upon some particular part of the grate, and usually closing the door after each scoopful. This rate will serve to develop approximately 1,200 indicated horse-power, and cannot be exceeded under sustained conditions of running, though for short intervals the rate of power may outrun the rate of firing. Because of the limitations upon the strength of the fireman it is probable that further growth in locomotives will probably await the coming of an automatic stoker which will serve to remove its operation from dependence upon the physical condition of a single man.

The amount that a locomotive will pull at the drawbar depends upon its speed. At slow speed, the maximum pull is limited by adhesion. After the point in the speed is reached for which the adhesion is sufficient to permit the development of the full power, the pull, assuming no loss of power between cylinder and drawbar, is inversely proportional to the speed. For a locomotive capable of developing 1,200 horse-power the pull at 25 miles is 22,500 pounds, while at 80 miles the pull is 7,000 pounds. The loss between the cylinder and drawbar, however, which in an actual locomotive must always occur, reduces the maximum actual pull at 80 miles to about 5,000 pounds.

The discussion of grate areas and fireboxes suggests the question as to whether there are not other forms of boilers than those commonly in service which would serve the locomotive better. The Vanderbilt boiler, having a cylindrical firebox, is one answer to this question. Again, the extensive adoption of water-tube boilers in stationary and in marine service leads naturally to speculation concerning the application of this type to locomotive practice. Indeed, designs of water-tube locomotive boilers are not wanting, but none are of great promise. Among several that have been proposed is that of Mr. Drummond, of the London and Southwestern, the important feature of which is a high flue of large diameter across which water-tubes extend. The boiler of Mr. Drummond, while technically a water-tube boiler, is practically a shell boiler representing an unusual arrangement of tubing. In considering the possible success of any water-tube boiler it will be well to remember that the present locomotive boiler is not much heavier than the best of the water-tube boilers of similar capacity, and the fact that the boiler shell is depended upon to serve as a part of the framework of a locomotive, makes it impracticable to abandon the present shell without greatly increasing the weight of the frames. The side frames are tied to the boiler at frequent intervals, and such important details as guide yokes are in many cases as much dependent upon the boilers for their support as upon the frames. All this increases the difficulty in applying a water-tube boiler to a locomotive.

Closely identified with problems of boiler design is that of front-end arrangement. The front end includes the extending shell of the boiler forming the smoke-box, and in general all mechanism therein contained, such as steam and exhaust pipes, nettings, diaphragms, draft pipes and also the stack. The office of the front end is to draw atmospheric air into the ashpan, thence through the grate and fire; to draw the furnace gases through the tubes of the boiler, thence under the diaphragm and into the stack, and to force them out into the atmosphere. In order that this movement may take place a pressure less than that of the atmosphere is maintained in the smokebox so that when the locomotive is working there is a constant flow from the atmosphere along the course named and back to the atmosphere again. The difference in pressure between the atmosphere and the smoke-box is spoken of as the draft, and under normal conditions of running is usually represented by from 4 inches to 6 inches of water. The draft thus expressed, however, is approximately three times greater than that to which the fire is actually subjected. Thus, a third of the total draft is required to overcome the resistance of the ashpan and grate, together with the fire thereon. Another third is required to overcome the resistance of the tubes, and another third to overcome the resistance of the diaphragm. These facts serve to explain several things which ordinarily are not well understood.

In the design of the front end, practice has wobbled badly. The front end was first short, surmounted by a diamond stack, containing the netting. It was then extended to constitute a cinder trap. It was afterward discovered that the front end as a cinder trap was unnecessary and undesirable, and it is now in the process of being shortened again that it may not hold cinders, but may become entirely self-cleaning. While this portion of the locomotive has been the subject of a considerable amount of patient study, and while great progress has been made, much yet remains to be done before the whole problem of the front end is completely solved.

Passing now from boiler to machinery, mention must be made of the recent and very general substitution of steel for iron in all cast parts. Such castings as wheel centers, axle boxes, and rocker boxes, which were formerly of iron, are now cast in steel, with the result that the engine machinery has been lightened, and weight thus saved has been added to the boiler. The form of each individual part of the machine has been carefully studied with reference to the service it is to perform. For example, in an attempt to diminish wear and to reduce the chance of failure in valve gear, the width of links and the length of rocker and saddle pins have been made to occupy the full width between the frames of the engine. Piston valves, with their superior balance, have largely superseded flat valves. By the use of wheels of larger diameter and reciprocating parts of better design, the problem of counterbalancing driver wheels has been so simplified that extremely bad work in counterbalancing is now rarely found, except, perchance, representing combinations which are patented. I am often asked why it is that so much difference exists in the valve gears of American and foreign locomotives. First of all, it is but proper to note that whenever a practice becomes settled there is somewhere a reason for it. The Stephenson link motion has generally been used in this country because it is a good device, and because it is easily worked into the general lines of the American locomotive. In English practice, where inside cylinders are common, that portion of the main axle which lies within the frame is largely occupied by the cranks. There is no room for four eccentrics, and consequently the Joy gear, which takes its motion from the connecting rod, is much used. This gear seems on the whole admirably adapted to the condition described, though English designers complain that by its use the motion of the valve is considerably disturbed by a low joint or other irregularity in the grade of the track. Other gears are used in England, though none, perhaps, to the same extent or with as good reason as the one referred to. The Germans make very general use of the Walschaert gear, which takes its motion from a single eccentric and the cross head of the engine, while the French designer may choose any of the types mentioned, or if occasion seems to demand, may produce an original gear. The choice of a gear is in most cases doubtless made from practical considerations rather than from theoretical. In working out the general lines of the design of a locomotive one or another form adapts itself to the purpose better than others. Of course, this is not true in all cases, but assuming the choice of gear to be controlled by proper limits, it might be so, for it is not a difficult thing to secure a distribution of steam within a locomotive cylinder which will give results approaching maximum performance. A chief requisite in any valve gear is a degree of stiffness and an absence of lost motion which will make the movement of the valve positive. These qualities are especially necessary in the gear of a locomotive, for in this type of engine the port opening at running cut-off is frequently not over ¼ inch or ⅜ inch, so that even a slight defect in any of the mechanism between eccentrics and valve produces large proportional effects upon the time and extent of the port opening. Ten years ago light and poorly designed gear were common defects in the American locomotive. Then it sometimes happened that the steam distribution depended quite as much upon the oilcan as upon the position of the reverse lever, and reports are current of an engine which would run well under a partially open throttle, but would stop if the throttle were fully opened, the mechanism being insufficient to move the valve when the pressure was heavy upon it. But the valve gear of the modern locomotive is not of this sort. With its heavy and direct connection, its double suspended link, and with the light weight of the valve to be moved, a marvelously good steam distribution is secured even at the highest speeds. Those who, seeing but one side of the really complicated problem, believe that locomotive valve gears ought to be revolutionized, should investigate carefully before they proceed. They should remember that the modern locomotive under ordinary conditions of running rarely requires more than 32 pounds of steam per indicated horse-power, while under favorable conditions it requires less than 25 pounds. Few simple stationary engines exhausting into the atmosphere, with their more complex forms of valve gears, are doing better than this, which is evidence of the narrowness of the margin limiting possible improvements in this direction.

With progress toward higher ideals in locomotive design, there has been a steady increase in steam pressure. During the past twenty years pressure has gone up from 130 pounds in 1880, to above 200 pounds in 1900, and this increase is responsible for many changes in the details of locomotives. Boilers have, of course, become heavier, and where power has not increased, cylinders have become smaller and lighter. In other words, by virtue of the higher steam pressure, the dimensions of the engines of the locomotive have not increased in proportion to their increase in power. The higher steam pressures are chiefly responsible for a very general adoption of the piston valve. The extent to which they have affected the economy of the engines cannot be definitely defined. From a purely thermo-dynamic point of view, each increment in pressure should bring its return in increased economy, but as the scale of pressure ascends, the economy increment diminishes while radiation and leakage losses increase. The range of pressure now common in locomotive service is so high as compared with that employed in other types of engines as to fairly raise the question as to whether economical limits have not already been reached or even exceeded. The practical question can best be defined somewhat as follows: An opportunity is presented whereby the boiler of a proposed locomotive may be 5,000 pounds heavier than that of an existing class. Should this additional weight be utilized in making a stronger boiler that a higher pressure may be carried, or should

* A paper read before the American Society of Mechanical Engineers.

it be utilized in making a larger boiler that the rate of evaporation may be reduced? Either course should result in increased economy in operation, but which course will prove most economical and where the limits lie, cannot be stated. It will, I am sure, be of interest if I add that the whole question of locomotive performance as affected by boiler pressure and extent of heating surface is one which is now being carefully studied in connection with the locomotive testing plant of Purdue University under the patronage of the Carnegie Institution.

With steam pressure upon simple engines approaching 200 pounds, the advisability of using compound cylinders began to be considered. In the early nineties the compound locomotive became a subject of much interest in this country. The advantage of compounds as an abstract proposition was not doubted. The problem was to build up a mechanism which, while meeting the requirement of correct theory, would at the same time be sufficiently strong and simple to justify its use under the severe conditions of locomotive service. At first, all efforts were directed to the development of a 2-cylinder type, the impression being that to succeed, a compound must have no more parts than a simple engine. But as time passed and all locomotives grew in size, the problem of the 2-cylinder compound became one of increasing difficulty, until now the clearance in tunnels and past station platforms is on many roads insufficient to allow passage of the large low-pressure cylinder. Meanwhile, the Vauclain 4-cylinder type has come into extensive use, and 4-cylinder tandem-compounds are being introduced, until now the tendency is strongly toward a 4-cylinder type. In all this there has necessarily been much experimentation, and experimentation sometimes leads to troubles and disappointments as well as to promise and success. In some cases the compound locomotive has proven expensive to maintain; in others, ill adapted to the service expected of it. Compounds should not often be used under conditions requiring frequent starting and stopping, or when changes in the grade of the track are such as to require frequent changes in the conditions of running. It is on the long, steady pulls that they will show their largest gains over the efficiency of the simple engine. Another fact of great importance in any discussion of the economic performance of the compound as compared with the simple, and yet one which is rarely taken into account, is that which concerns the proportion of the total coal used which is burned while the engine is advancing its train over the road. In the freight service of the average road not more than 80 per cent of the total coal burned is effective in the generation of steam for the cylinder of the engine. The other 20 per cent represents fuel used in firing up, in keeping the engine warm while standing, or remains in the firebox at the conclusion of the run. Obviously, no change in cylinder arrangement can reduce the amount of coal thus consumed. A compound locomotive, therefore, which upon test shows a fuel saving of 10 per cent over that required by a simple engine will, when put into regular freight service, have a chance to save but 1-10 of 80 per cent of the amount of coal which the simple engine uses. These are facts which should be fairly faced in any discussion of the compound problem. They in no wise discredit the usefulness of compounds, which without doubt are to have a large part in the future service upon American roads.

Having now seen that American practice in compounding is committed to the 4-cylinder type, it will be of interest to consider a design which theoretically at least must be regarded as the highest development of that type. I refer to the design of the De Glehn balanced compound which was first brought out in 1886, and which for several years has been the standard for all new passenger power on several of the larger roads of France. An examination of the drawing suggests great complication, but I shall attempt to show that the design embraces very little that is objectionable, and that it presents certain advantages which no other design has compassed. I can perhaps forestall criticism by saying that many American engineers, who have had an opportunity to observe its action, have expressed their admiration with enthusiasm. The fact, also, that the Pennsylvania Railroad is at great cost importing from France an engine of this type for experimental work on its lines; that the American Locomotive Company is building a large engine upon this general design, and that both of these will be tested upon the locomotive testing plant of the Pennsylvania Railroad Company at St. Louis this summer, should give additional interest to the De Glehn balanced compound.

In the De Glehn design, the two low-pressure cylinders of a 4-cylinder compound are placed side by side between the frames, and connect with inside cranks, which are set quartering on the forward driving axle. The details of these cylinders and surrounding parts are similar in every respect to those of all inside-connected engines. Thus placed, the low-pressure cylinders are well protected from radiation, and they connect with exhaust passages which are both short and direct. The high-pressure cylinders are placed outside the frame and connect with outside cranks in the wheels of the second driving axle. These cylinders are not in the same cross-section with the low-pressure cylinders, but are carried back on the frames a distance which is substantially equal to the spacing of the driving axles, so that the main rod of the outside cylinder connecting with the second driving axle is no longer than the main rod of the inside cylinder connecting with the first driving axle. The side frames between the high-pressure cylinders are strengthened in substantial cross-bracing in the form of a casting, not shown in the sketch, which, so far as the frames are concerned, serves the purpose of a false saddle at this point.

The two or more pairs of driving wheels are connected by coupling rods, the several cranks being so arranged that the pins for the coupling rods in the front drivers are set diametrically opposite the inside cranks of the axles carried by these wheels. When one of the outside pistons moves forward, an inside piston moves backward, the reciprocating parts of each high-pressure cylinder being balanced by the reciprocating parts of its neighboring low-pressure cylinder. If, under these conditions, each wheel is perfectly balanced for its revolving parts, and if the reciprocating parts of the high-pressure engine have the same weight with those of the low-pressure engine, the machine as a whole will be balanced, both horizontally and vertically. So far as the action upon the track is concerned the balance will be practically perfect.

It will be seen that the machinery of these engines, as compared with that of an American 2-cylinder engine, involves nearly double the number of parts. Thus, the French engine may have the same number of axles and wheels, but all other machine parts, such as pistons, cross heads, main rods, valve motions, and valves, are in duplicate. Each cylinder is treated as a complete unit, having its individual cross head and its individual main rod. There are four sets of cross heads instead of two, as in American practice, and four main rods instead of two. But these apparent disadvantages are more than compensated by the increased lightness of the parts involved, and by the possibility of a higher character of design. In American practice, the two main rods of a modern engine must be designed to transmit from 800 horse-power to 1,000 horse-power. That this may be accomplished rods have become enormously heavy, and crank pins have grown to be as large as axles were ten years ago. Moreover, the forces to be transmitted often exceed the ability of the fixed portions of the machine to withstand properly, hence parts strain, journals and brasses fit badly, and hot pins and boxes result. An American locomotive, if designed after the De Glehn type, would have four rods, each transmitting from 400 horse-power to 500 horse-power, and the rods themselves would be light. The pins, while comparatively small, would afford liberal bearing surface without exceeding a convenient limit in size, and concentrated stresses upon all fixed parts would be reduced. In such a case, who shall say that the duplication of parts, when offset by such obvious advantages, increases the chances of failure. Is it not conceivable that under the conditions which have been described a large number of parts may even involve fewer chances of failure?

Another objection often regarded as insurmountable by the American designer, is that the inside cylinders necessarily connect inside of the frames, and, hence, a crank axle is necessary. When this objection is analyzed, it is found to be based in part upon the extra cost of a crank axle, and in part upon experiences of long ago. Early American engines which were fitted with crank axles were very flexible, and were frequently run over exceedingly rough track. The record shows that in such engines there were numerous failures of axles. We, therefore, said, and for years have continued to say, that we will not use the crank axle. Our modern engine, however, is less flexible than the earlier one, and is less subject to strains through inequalities in the track. Our advantages in this respect are at least equal to those of other countries. If England and France can run crank axles, why may we not do the same? The fact that these countries do use them, and meet with few failures, would indicate that the American objection is largely historic.

But the French compound presents another side to the axle question, too important to be overlooked. The problem of transmitting 1,500 horse-power or 2,000 horse-power through a single locomotive axle has in American practice led to the adoption of axles of very large diameter. In spite of this fact, axle failures on heavy engines are by no means unknown. With steam pressures and cylinder diameter still tending upward, where is there sign of relief? Here, again, we can well afford to look with favor upon the French compound, for by its design the total power of the engine, instead of being transmitted through a single axle, as in American practice, is divided between two. The inside cylinders connect with the forward axle, and the outside cylinders with the rear axle. By the adoption of the De Glehn type, no single axle of our modern engines would be called upon to transmit as much as 1,000 horse-power, and present diameters could be materially reduced, and at the same time allow a wider margin of safety. The balanced-compound, therefore, instead of introducing axle troubles, may reasonably be expected to lead to a betterment in present conditions. The advantages of the French type may be summarized as follows: It solves completely the difficult problem of balancing drive wheels, it constitutes a satisfactory system of compound cylinders, it avoids the concentration stresses in frames, it divides the total work of the cylinders between two axles instead of concentrating it in one, and the dimensions of the details of its machinery are such as will permit them to be well designed. The work of the De Glehn has had a marked influence on locomotive design in many countries, as is to be seen in the building of balanced compounds in Germany, England, and in the United States, as well as in France.

Quite recently a rival of the compound has appeared. While Americans have been rigidly orthodox in their application of principles, contenting themselves with such progress as may appear in the better design of machine parts and in the choice of better materials from which to construct them, and while the French have been busying themselves with the problems of their balanced compounds, German designers, under the leadership of Herr Wilhelm Schmidt, have been experimenting with superheated steam. Encouraged by his success in stationary practice, Herr Schmidt has extended the application of his system to locomotives, with the result that there are now four or five locomotives of the Schmidt type running and still others building. These engines are in service on the State Railroads of Prussia, and it is claimed that their performance is 25 per cent better than that of similar engines using saturated steam. The Schmidt system involves no material changes in the exterior form of the locomotive boiler, but the tubing is modified and the smokebox design is so changed as to accommodate the superheater which is located therein. A flue 10 inches or 12 inches diameter extends from firebox to smokebox along the lower portion of the barrel of the boiler. This displaces from 20 to 30 of the small tubes which would otherwise have its place. Its purpose is to deliver to the smokebox a considerable volume of furnace gases at a high temperature, in the accomplishment of which purpose the tube serves well. To give room for the superheater, the diameter of the smokebox shell is somewhat greater than the barrel of the boiler.

The pipes of the superheater occupy a space lying between the outside shell of the smokebox and the interior partition sheet, a cross section of this space having the shape of a horseshoe, the toe calk of which may be assumed to be at the bottom of the boiler. The construction is such that the gases discharged from the small tubes are free to pass directly up the stack, having thus no contact with the superheater, all as in an engine of usual construction. The gases discharged from the large flue, however, pass into the space occupied by the superheater at a point near the bottom, and sweeping around on either side, are discharged into the smokebox space on either side at points near the base of the stack. The length of this annular space in the direction of the axis of the boiler is almost equal to the diameter of the boiler. It is filled with the pipes of the superheater. The pipes start from a header near the stack on one side, and pass around to a similar header near the other side, the extent of the superheating surface thus provided equaling 25 per cent of the direct heating surface of the boiler. The headers are so arranged that steam passing the throttle of the engine goes to one of the headers, thence by one-half of the whole number of pipes to the opposite header, thence by the remaining pipes back to the first header, from which it is conveyed to the cylinders. In this passage and re-passage of the pipes, the temperature of the steam is raised to 500 deg. and 600 deg. Fahr., which is from 125 deg. to 225 deg. above the temperature of the saturated steam at usual boiler pressures. This steam is conveyed directly to the cylinders. Published reports of the performance of the Schmidt locomotive show a gain in efficiency which is generally stated to be equal to 25 per cent, and the absence of all trouble in respect to cylinders or superheaters. These statements if true are full of significance.

Examining the design more in detail, we shall find in the Schmidt locomotive a condition more favorable to the use of a superheater than any which has ever been tried in this country. The installations with which we have hitherto dealt have served in stationary or marine practice. The superheater of these plants has either been a separate boiler-like device in which no water was carried, or has been so combined with the boiler as to be always in close communication with its furnace. Under these conditions, when the engine throttle is closed, the circulation of steam within the tubes of the superheater ceases and the metal of the tubes, together with the entrapped steam within them, remain exposed to the undiminished intensity of the furnace action. In this manner, the tubes are often heated to a very high temperature, a result which, when often repeated, leads necessarily to a failure of the superheater. Again, when after an interval of inactivity, the engine is started, the steam which has been held back within the superheater until it has been raised to an enormously high temperature, passes on to the engine, oftentimes retaining enough of its heat to burn the lubrication and sometimes the rod packings. But all difficulties of this class, which to a greater or less degree have appeared in the operation of every stationary plant using superheated steam, are doubtless avoided in the Schmidt locomotive. In this machine, as in other locomotives, the rate of combustion varies with the volume of steam used. When the throttle is open, the fire burns brightly; when it is closed, its activity is at once suppressed. When there is no steam passing within the tubes of the superheater, the gases circulating around the tubes are comparatively low in temperature, and when the conditions are so changed that the temperature of the gases becomes maximum, the volume of steam passing the tubes is greatest. Just as the draft responds to the varying demands which are made upon the boiler, so the volume of heat which is available for superheating varies with the quantity of steam which is to be superheated. The details of the design provide that when the glower is on, dampers are closed which prevent the circulation of gases in the superheater so that it is only when the throttle is open

that the superheater does work. This would seem to make impossible any overheating of the superheater. In view of the highly favorable character of all these conditions, it is likely that it will be found easier to maintain a superheater of the Schmidt design on a locomotive than in connection with any other type of engine, and, moreover, that the superheating in locomotive service may be a pronounced success, while in other classes of service its future is still problematical.

I would add that it is expected that two superheating locomotives of German manufacture are to be tested at St. Louis during the Fair by the Pennsylvania Railroad Company.

AQUATIC PRODUCTS AS FERTILIZERS.*

By CHARLES H. STEVENSON.

A FERTILIZER is any substance added to the soil for the purpose of producing a better growth of crops. The food required by plants is supplied in part from the atmosphere, but principally from the soil. If the supply of any one of the necessary ingredients be deficient, a small crop is the result; and the purpose of fertilizers is to supply the plant-foods lacking in the soil.

The general use of fertilizers is of comparatively recent origin, yet the preparation of these substances supports an extensive industry, employing a large amount of capital and many thousands of men. Compared with the immense quantities of barnyard materials, phosphate rocks, etc., the use of aquatic products for fertilizer is relatively small, yet it is by no means unimportant in the fishery industries.

Fish, seaweed, shells of mollusks and crustaceans, and various other aquatic products have long been known to possess rich fertilizing properties. All kinds of fish can be used for this purpose but, owing to the greater value of choice species as food, only the non-edible ones and the waste parts are utilized. The menhaden is the only fish taken in great quantities in this country especially for conversion into fertilizer. The output of this species is very large, amounting to 30 per cent of the total catch of fish in the United States, and its capture maintains one of the most extensive and vigorously prosecuted of the American fisheries. Compared with that from menhaden, the quantity of fertilizer made from other fish is small, and only such are used for this purpose as cannot be profitably employed in any other way.

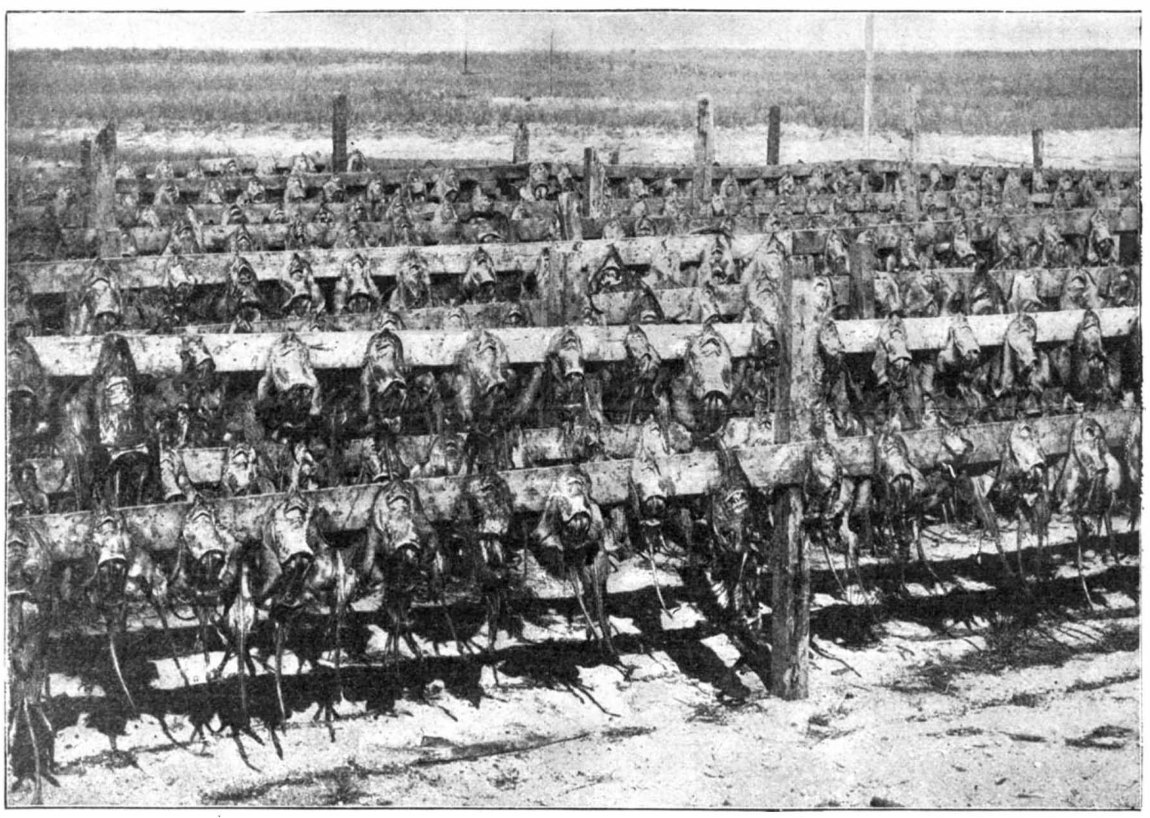
The original use of fish for fertilizing purposes was in a fresh or green state, and they were added to the soil directly after their capture, although, of course, no special effort was made to preserve their freshness. Before the advent of the colonists in America, the Indians were accustomed to manure their small crops of corn by placing one or more fish in each hill or by spreading them broadcast over the field, and this practice was followed by the early settlers. Owing to the original richness of the soil and the limited agricultural operations, the use of fertilizers was of comparatively small extent until the latter part of the eighteenth century. It appears that fish were then employed for this purpose all along the Atlantic seaboard from Maine to North Carolina wherever they were obtainable in sufficient quantities.

Fresh fish contain usually from 65 to 80 per cent of water and from 1 to 16 per cent of oil. Neither of these has any value as a fertilizer. On the contrary they decrease the portability and storage qualities of the constituents, and the presence of the oil is prejudicial to the decomposition of the fertilizer when applied to the soil.

Early in the nineteenth century the fishermen occasionally extracted the oil from the fish when the latter were unusually fat, thus removing an injurious ingredient, for which valuable uses were found. This resulted gradually in the establishment of factories for removing the oil, and likewise most of the water, so that the fertilizing substance might be in better condition for transportation. At present most of the fish used for fertilizer are treated in this manner, even the farmer-fishermen finding it more profitable to sell their catch at the factories and purchase the scrap; but large quantities of fish in a fresh state are yet used precisely as was the custom three hundred years ago.

Owing to its great abundance, combined with its non-edible qualities, the menhaden is the principal fish used for fertilizer in this country, and the quantity used annually is about 800,000,000 in number, or 240,000 tons round or live weight. Of these fully 99 per cent are handled at the factories, and the remainder are used in a fresh or green state. With the menhaden are taken some skates, sea-robins, bellows-fish, and other waste fish. Aside from a few that may be taken with the menhaden, and occasionally some river herring or alewives, no other fish are captured in the United States especially for fertilizer to any great extent.

Formerly nearly all waste produced in dressing fish for market was thrown away as useless; but in recent years, in the fisheries as in other industries, the utilization of waste material has been made a subject of careful investigation, and many substances formerly considered refuse are now found to contain elements of commercial value. The dressings at the fish markets and at the fishing centers, the refuse of canneries and boneless-fish factories, and even the carcasses of whales are turned to account in the production of fertilizer. In addition to these materials, the farmers use large quantities of seaweeds, horseshoe crabs, oyster shells, clam shells, etc.



DRYING SKATES FOR MANUFACTURE INTO FERTILIZER, OPPOSITE PROVINCETOWN, MASS.

The total annual product of menhaden fertilizer in the United States according to the latest returns amounted to 85,830 tons, for which the producers received $1,539,810. It is difficult to approximate the quantity of other fishery products used for fertilizer, but it is estimated that the waste fish of all kinds amount to about 20,000 tons, worth $200,000; horseshoe crabs, shells of shrimp, etc., 800 tons, worth $16,000; shells and agricultural lime, 60,000 tons, worth $150,000; and seaweeds, 250,000 tons, worth $312,500, making a total estimated output for this country per year of 416,630 tons, worth $2,118,310.

* From United States Fish Commission Report.

CONTEMPORARY ELECTRICAL SCIENCE.*

CHARGE OF AN ELECTRON.—J. S. Townsend compares the various values found for the charge of an electrolytic ion and an electron, and finds that the difference lies well within the limits of the probable experimental error. If E is the charge on a hydrogen ion or atom in a liquid electrolyte, N the number of molecules per cubic centimeter of a gas under normal conditions, then, since a known volume of hydrogen is evolved at the negative electrode when unit quantity of electricity passes through the liquid, the formula

$$N \times E = 1.22 \times 10^{10}$$

is established, E being measured in electrostatic units. In this formula the most probable value for N, according to Lord Kelvin, is 10^{20}, and 1.22×10^{-10} is not improbably an upper limit to the value of the charge in electrostatic units. Of the values determined from electrons liberated by Röntgen rays that of H. A. Wilson is probably the most reliable. By the method which he used he avoids the necessity of finding the number of drops in the cloud formed by the expansion of the conducting gas, and a very uncertain quantity is thus eliminated from his calculations. He concludes from his experiments that "it may be considered established that e lies between 2×10^{-10} and 4×10^{-10} electrostatic units." The lower limit is in fair agreement with the value 1.2×10^{-10} found for E by taking $N = 10^{20}$. Therefore, the value 2×10^{-10} does not differ by more than the factor 2 from the most probable values which can be obtained from the electrolytic and electron methods. —J. S. Townsend, Phil. Mag., March, 1904.

PHYSIOLOGICAL EFFECTS OF N-RAYS.—A. Charpentier has observed that N-rays exert a direct effect upon the human ear, and increase the sharpness of hearing while they act. On the other hand, the newly-discovered N′-rays diminish the sharpness of hearing, and generally have the opposite physiological effects to the N-rays. Some human tissues emit N′-rays, such as a muscle kept in a state of tension without actual contraction. It may be supposed that all physiological activities give rise to N-rays and N′-rays, and that in some of them one species predominates and in others the other species. This is the physiological analogy to the mixture of N-rays and N′-rays given out by a Nernst lamp. —A. Charpentier, Comptes Rendus, March 7, 1904.

PHYSIOLOGICAL ACTION OF N-RAYS AND CONDUCTED RAYS.—A. Charpentier has discovered two additional effects of N-rays. If a strong source of N-rays is placed about 4 centimeters behind the top of the skull, and a little above it, not only are faintly luminous objects perceived with greater brightness and detail, but in absolute obscurity a faint luminous cloud is perceived, evidently due to a slight excitement of the visual nerve center. The effect is distinctly shown when a copper wire is used to "conduct" the rays from the source to a small copper plate placed at the point indicated. The second new effect is objective, and consists in the enlargement of the pupil when the conducting plate is placed over the seventh cervical vertebra. The dilatation observed varies from ½ millimeter to 1 millimeter. The apparent increase of luminosity previously mentioned is, however, not due to this enlargement of the pupil, as it remains the same if the objects are viewed through pinholes.—A. Charpentier, Comptes Rendus, February 1, 1904.

AN OPTICAL ANALOGY TO HERTZ'S GRATING EXPERIMENT.—F. Braun has succeeded in producing with ordinary light waves the effect produced by Hertz with a grating of parallel wires, which was found to reflect electric waves vibrating in a plane parallel to the wires while it freely transmitted those waves which vibrated at right angles to the wires. An attempt to discover this effect in the optical sphere had already been made by Du Bois and Rubens, who found a certain amount of polarization, but a greater transmission of parallel than perpendicular waves. But this is due to the fact that the finest gratings at the disposal of those physicists consisted of wires 0.01 millimeter thick. The author has succeeded better with wires disintegrated on a glass plate by means of a powerful electrostatic discharge. The disintegrated wire, usually of silver, showed a clear central line where it had lain on the glass. On each side of that there was a narrow band of metal. Outside that again, there were fine metallic needles in the form of very pointed isosceles triangles. Outside those, there was a zone of finely-divided metallic dust. On the border between the needles and the dust, the author discovered portions where light vibrating across the plane of the needles was transmitted more freely than light vibrating parallel to the needles. The author hopes to render the phenomenon more amenable to quantitative measurement by destroying a set of thin plates of a complex organic compound of gold in such a manner that only the gold remains. That ought to give a very fine and regular grating, which might be studied by means of Siedentopf and Szigmondy's ultra-microscopic method.—F. Braun, Sitzungsber. Akad. Wiss., Berlin, January 21, 1904.

NEW KIND OF N-RAYS.—R. Blondlot has found that besides the kind of N-rays already described, there exists another kind which reduces the luminosity of a feebly luminous surface instead of increasing it. The new kind, which he designates by N′, is specially abundant in the least refrangible part of the N-ray spectrum. On re-examining that part by means of an aluminium prism having a refracting angle of 60 or even 90 deg., he found an alteration between the two different kinds of rays in the spectrum. The following is a table of refractive indices (for aluminium) and wave lengths:

	Index.	$\mu\mu$
N′	1.004	3.0
N	1.0064	4.8
N′	1.0096	5.6
N	1.011	6.7
N′	1.0125	7.4
N	1.029	8.3
N	1.041	8.1

On plotting these results in a diagram, it is found that the first five values lie close together on a simple curve. Certain sources appear to emit N′-rays only, or predominantly. Among these are wires of copper, silver and platinum. Bichat has found that ethyl ether, brought into a state of forced extension by Berthelot's process, emits N′-rays. When that state is ended, either by a slight shock or spontaneously, the emission of N′-rays ceases instantly. N′-rays, like N-rays, may be stored up. Thus, if a piece of quartz is brought near a stretched copper wire, it emits N′-rays for some time after.—R. Blondlot, Comptes Rendus, February 29, 1904.

* Compiled by E. E. Fournier d'Albe in the Electrician.

THE MECHANICS OF THE GYROSCOPE.

By DR. S. TOLVER PRESTON.

WHILE the gyroscope affords a notable illustration of the harmony among physical laws, the elementary exposition of the principles governing its action does not seem to have received the attention it deserves.

Prof. Perry's interesting work,* entitled "Spinning Tops," contains little more than rules for ascertaining what will happen under given conditions, together with striking experimental illustrations, and applications to cosmical phenomena, such as those connected with the rotation of the earth and other planets.

It is superfluous to dwell at length on the practical importance of the subject, since rotation is one of the most general motions produced in machinery. The most recent theories of molecular structure also involve the orbital motions of atoms and electrons; so that, from the atom to the solar system, we are continually confronted with problems dealing with rotations and revolutions. On the other hand, text-books afford no adequate elementary treatment of this subject. I have therefore been reduced to think out an elucidation for myself, which I venture to present here.

According to the Newtonian system of dynamics (a system which is now universally recognized and accepted), the velocity of a particle can only be increased in any given direction by the application of a force acting in that direction; conversely, its velocity in a given direction can only be diminished by the application of a force acting in an opposite direction. The magnitude of the applied force is proportional to the rate of increase or decrease of the velocity of the particle.

Let us suppose that a series of equal heavy particles are arranged around the circumference of the circle in Fig. 1. These particles may be supposed to be rigidly connected one with another, the whole being connected by massless spokes, with an axle passing through *C*, the center of the circle; this axle being at right angles to the plane of the paper. This arrangement constitutes an ideal flywheel, and may be considered typical of an ordinary gyroscope disk.

Let the flywheel be set in rotation in the direction indicated by the arrow. The problem before us is to determine the nature of the forces which must be applied to the rotating flywheel in order to deviate the axis of rotation. Let us suppose that the flywheel, while still rotating about its axle, is constrained in addition to turn about the line *A B*, at right angles to the axle. Looking in the direction *A B*, let the flywheel turn about that line in a clockwise direction, so that the side *L* moves downward through the plane of the paper, while the side *R* moves upward through the same plane. The particles at *e* and *p* being, at the given instant, on the axis of rotation *A B*, will possess no velocity of rotation about that axis. So far as concerns other particles, their velocities of rotation about *A B* will be proportional to their perpendicular distances from that line. Sixteen equidistant particles on the circumference of the circle have been indicated. The rotational velocities of these particles, about the line *A B*, will be proportional to the respective perpendiculars let fall on *A B*.

In a certain interval of time the disk will complete a revolution about its axle. In one-sixteenth of this interval of time, the particle *a* will move round the circle so as to attain the position previously occupied by the particle *b*. In doing so, the particle *a* will acquire the velocity previously possessed by the particle *b*, i. e., its velocity will be diminished, since *b* is nearer than *a* to the axis *A B*. The diminution of velocity will of course be proportional to *a D*, where *b D* is a line drawn from *b* perpendicular to *C a*. But since the velocity of the particle *a*, in a direction passing vertically downward through the plane of the paper, is diminished as the particle moves from *a* to *b*, this particle must have been acted upon by a force directed vertically upward through the plane of the paper, and proportional to *a D*. This force is indicated by a small circle containing a dot at its center. The dot indicates the pointed end of an arrow supposed to be directed vertically upward through the paper; while the diameter of the small circle is drawn proportional to *a D*, or to the magnitude of the force.

While the particle *a* moved to *b*, the particle *b* moved to *c*. In this time the velocity of the particle *b*, perpendicular to the plane of the paper, must have been diminished by an amount proportional to *b E*. A small circle containing a dot at its center, and of a diameter proportional to *b E*, indicates the magnitude and direction of the force which must have been applied to the particle as it moved from *b* to *c*.

The force which acted on the particle *c* as it moved to *d*, and that which acted on the particle *d* as it moved to *e*, are represented in a similar manner.

Owing to the rotation about the line *A B*, all particles on the right-hand side of the disk are moving upward through the plane of the paper; thus it follows that the particle *e*, in moving to the position *f*, must have acquired a velocity, directed vertically upward through the paper, proportional to *G f*. It must, therefore, have been acted upon by a force, proportional to *G f*, directed vertically upward through the paper. The forces acting on the particles *f*, *g*, *h*, can be determined in a similar manner.

It is obvious that the velocity of the particle *k*, directed upward through the plane of the paper, is diminished as that particle moves to the position previously occupied by the particle *l*. Consequently, it must have been acted upon by a force, of which the magnitude is determined in the manner previously explained, acting downward through the plane of the paper. A circle, of which the diameter is proportional to this force, while the cross at its center represents

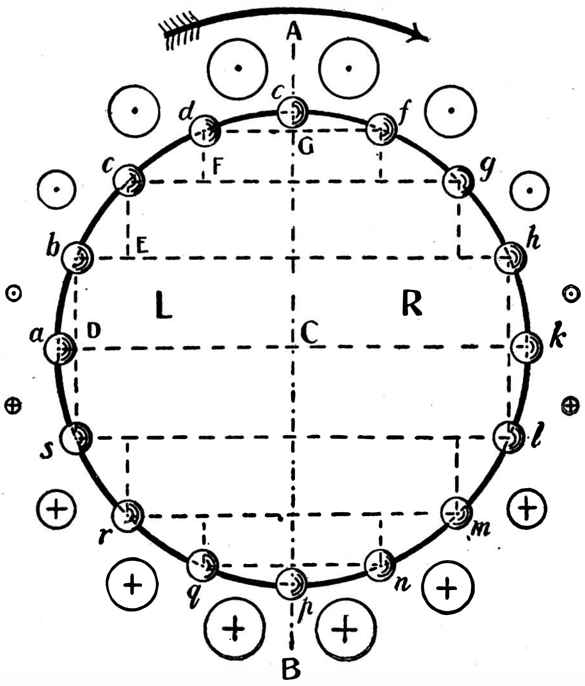


FIG. 1.

the feathered end of an arrow directed downward through the paper, indicates the magnitude and direction of the force acting on the particle *k* as it moved to *l*. The forces acting on the particles, *l*, *m*, *n*, *p*, *q*, *r*, *s*, are determined similarly, and represented by circles containing crosses, to indicate that the forces act downward through the plane of the paper.

A glance at Fig. 1 shows that all forces acting on the part of the flywheel above the line *a k*, are directed upward through the plane of the paper; while all forces acting on the part of the flywheel below the line *a k*, are directed downward through the plane of the paper. All the forces acting above the line *a k* might be replaced by a single resultant force, acting upward through the paper at some point on the line *C e*; while all the forces acting below the line *a k* might be replaced by a single resultant acting downward through the paper at some point in the line *C p*. These two resultant forces, acting parallel to each other, but in opposite directions, constitute a couple, and produce a torque or turning moment about the line *a k*. Thus, in order to turn the revolving flywheel about the diameter *e p*, we must apply a torque which, if it acted on the stationary flywheel, would turn it about the perpendicular diameter *a k*. Conversely, if we apply a torque tending to turn the flywheel about a diameter *a k*, it will turn, not about *a k* (as might have been expected), but about the perpendicular diameter *e p*.

The torque necessary to deflect the flywheel might be produced by forces acting directly upon it, as for instance, by blowing air on the upper half of the flywheel from the back, and on the lower half from the front. Generally, however, it is more convenient to act on the axle, the end above the plane of the paper

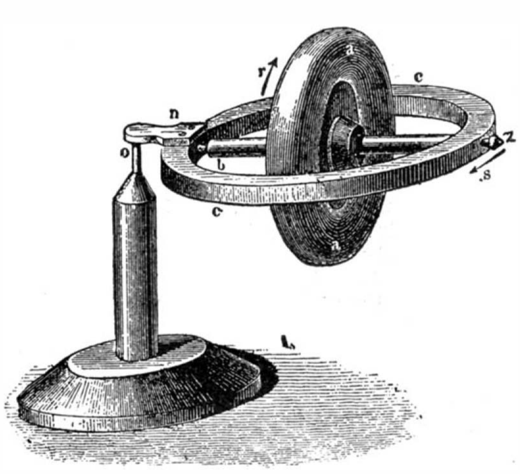


FIG. 2.

being urged in the direction *C B*, while the end below the plane of the paper is urged, by an equal force, in the direction *C A*.

Some further points should be noted. Any force acting to the right of the line *A B*, is equal, both in magnitude and direction, to a corresponding force acting to the left of the same line. Consequently, as the flywheel turns about the axis *A B*, no work will be performed by the forces producing this rotation. This follows from the circumstance that whereas one force acts in the direction of motion (so far as relates to rotation about the axis *A B*) the other equal force is opposed to that motion.

The actual behavior of a gyroscope can now be easily understood. The flywheel *a a* (Fig. 2) having been set in rapid rotation in the direction indicated by the arrow *r*, the frame carrying it is supported from a projection *n* at one end, on a pivot *o*. Instead of falling to the ground, as it would do if it were not rotating, the gyroscope remains with its axis *b z* horizontal; but the axis turns in a horizontal plane about the point of support *o*, in the direction indicated by the arrow *s*. The torque produced by the pull of gravity is easily seen to be that required to turn the flywheel *a a* about a vertical diameter in the direction mentioned. The fact that the flywheel, besides rotating about a vertical axis, also revolves in a circle about the point *o* as center, is merely due to the circumstance that, under the conditions of the experiment, the rotation cannot occur without the revolution.

It is instructive to consider the same problem from a somewhat different standpoint. We have already determined the nature of the applied forces required to turn the ideal rotating flywheel (Fig. 1) about the axis *A B*, in a clockwise direction when viewed from *A*. We found that a torque must be applied which tends to urge the end of the axle above the plane of the paper in the direction *C B*, and the opposite end of the axle in the direction *C A*. It will now be proved that the reaction of the rotating flywheel, when it turns as above, about the axis *A B*, produces a torque which tends to urge the end of the axle above the plane of the paper in the direction *C A*, and the other end of the axle in the direction *C B*.

Under the given conditions, the component velocities, downward through the plane of the paper, of the particles *a*, *b*, *c*, *d*, are all being diminished; and the consequent reactions tend to turn the axle in a clockwise direction, about the line *k a*, when viewed from the side *k*. The component velocities, upward through the plane of the paper, of the particles *e*, *f*, *g*, *h*, are all being increased, and the consequent reactions tend to turn the axle in the same direction. It is easily seen that the reactions due to the alterations in the velocities of the particles *k*, *l*, *m*, *n*, *p*, *q*, *r*, *s*, all tend to turn the axle of the flywheel in the same direction. Thus the torque due to the reaction of the rotating flywheel when turning about the axis *A B*, is of the character specified above.

The precise way in which the gyroscope (Fig. 2) acts can now be readily followed. When the frame carrying the rotating flywheel *a a* is first supported on the pivot *o*, the initial tendency is for the whole to descend toward the earth, under the action of gravity. But the pivot *o* prevents the end *b* of the axle from descending, so that an incipient rotation about a horizontal diameter commences. The reaction due to this rotation produces a torque which tends to turn the flywheel about a vertical diameter in the direction of the arrow *s*. As the flywheel is free to turn in this direction, it at once commences to do so, and in so doing generates a reacting torque opposing the incipient rotation produced by gravity. The action of gravity being opposed, the rate of (incipient) descent of the flywheel is diminished; but so long as descent continues, a torque acting in the direction of the arrow *s* will be produced, and this will increase the velocity of turning, thus increasing the torque which opposes the descent of the flywheel under the action of gravity. The flywheel, finally, acquires a rotational velocity in the direction of the arrow *s*, which produces a reacting torque just equal and opposite to that due to the pull of gravity. If friction were entirely absent, the flywheel would then cease to descend, and would continue to turn at a uniform rate in the direction of the arrow *s*. In this process, the work performed is that due to the incipient descent of the flywheel; this work is just sufficient to supply the kinetic energy due to the rotation of the flywheel and its supporting framework about the axis *o*. When the permanent condition outlined above has been attained, no further work is done in the absence of friction. If there is friction between the supporting lug *n*, and the pivot *o*, the gyroscope will slowly descend, at such a rate that the work performed by gravity is just equal to that needed to overcome the frictional drag.

In the absence of friction, it is obvious that the gyroscope turns about *o* as center merely by virtue of its own inertia, after the final state has been reached; in this respect the motion resembles that of a planet around the sun. The torque due to gravity, though necessary, only serves the purpose of neutralizing the reacting torque which the turning of the flywheel about a vertical diameter produces.

When the gyroscope (Fig. 2), instead of being capable of rotation in a horizontal plane about *o* as center, is hinged at *o*, so that it can move only in a vertical plane, it descends at once toward the earth, no difference being produced whether the flywheel is rotating or quiescent. In this case, since turning about a vertical axis is prevented, the gyroscope cannot generate a torque opposed to that due to the pull of gravity.

It is plain that when we attempt to turn a rotating flywheel about a diameter, no resistance is offered; but a torque is produced, tending to turn the flywheel about a perpendicular diameter; and unless this torque is neutralized by another of equal but opposite value, motion in a direction other than that required will occur.

Prof. Perry, in one experiment, inclosed a flywheel in a box, which served as a convenient means of supporting the ends of the axis of the flywheel, without risk of interfering with its rotational velocity. He remarks on the effects observed as follows:

"When I hold this box in my hands, I find that if I move it with a motion of mere translation in any direction, it feels just as it would do if its contents were at

* "Spinning Tops." By Prof. J. Perry, F.R.S, etc., 1901. (Society for Promoting Christian Knowledge, 43 Queen Victoria Street, E.C.)

This book is based on the "Operatives Lecture" delivered before the British Association in 1890. To my mind it appears that even a general audience of "operatives" would have been quite capable of grasping and appreciating far more of the elementary elucidation than was offered in connection with this fundamentally practical branch of mechanics. The field for the exercise of the powers of the scientific imagination becomes wider, in proportion as elementary methods of exposition are extended.

rest; but if I try to turn it in my hands, I find the most curious great resistance to such motion. The result is that when you hold this in your hands, its readiness to move so long as it is not turned round, and its great resistance to turning round, and its unexpected tendency to turn in a different way from that in which you try to turn it, give one the most uncanny sensations. It seems almost as if an invisible being had hold of the box and exercised forces capriciously. And, indeed, there is a spiritual being inside, what the algebraic people call an impossible quantity, what other mathematicians call 'an operator.'" (Spinning Tops, pp. 21-23.)

I shall not presume to criticise the last sentence; but the mention of "great resistance to turning round" appears capable of an ambiguous interpretation. It has already been pointed out that if a torque tends to rotate the flywheel about a diameter as axis, then the flywheel will actually turn about a perpendicular diameter as axis. It has also been proved that the forces acting on the flywheel do not work; it therefore follows that no true resistance is encountered, for motion against a resistance would entail a loss of energy. A given torque produces rotation in a direction that would not be anticipated from experience with non-rotating bodies; but the actual motion produced is exactly that to be predicted from a consideration of the problem from the standpoint of Newton's laws of motion. Thus the gyroscope, while apparently defying gravity, is really acting in accordance with accepted mechanical principles.

The movement of the axis of a revolving gyroscope-disk, at right angles to the disturbing force, is a fact familiar to experimenters. That this movement, at right angles to the direction of the force, is a consequence independently and directly deducible from the accepted law of the conservation of energy, is not so generally recognized.

Let us consider the very simplest instance of a gyroscope-disk, which, of course, is nothing more than a revolving flywheel inclosed in a case or box, as one sees in some familiar experimental illustrations depicted in text-books. The case or box then serves merely the purpose of a convenient frame to support the ends of the axis of the flywheel.

Now, we know that when the case is rotated by hand, so as to deflect the axis of the flywheel, a curious sensation of resistance is felt, when the flywheel at the same time revolves on its own axis.

Imagine there to be no friction, so that in our experimental illustration the velocity of the flywheel remains uniform. Suppose, further, the case or box to be connected with some convenient mechanism which produces the required rotation, thus deviating the axis of revolution of the inclosed flywheel, or producing more complicated movements if required, this mechanism being driven by any convenient motor. The inclosed flywheel can, of course, run independently on its own axis.

Friction in the mechanism is to be neglected; it can, if necessary, be taken into account or allowed for afterward. Ideal conceptions, such as where friction is neglected, are recognized as useful for the illustration of truths, and are quite legitimate, provided the essential conclusions are afterward slightly modified so as to fit exactly with the facts existing in Nature. The "perfect gas," for instance, constitutes a familiar theoretical ideal for deducing the essential truths about actual gases.

Provided that the flywheel is not revolving on its axis, and neglecting friction, everyone will concede that no work will be performed by the motor in rotating the box. This is tolerably self-evident. But it may not, possibly, be admitted as equally obvious, that no work will be performed by the motor in effecting deviations of the axis of the revolving flywheel.

Yet it appears that the theoretical conclusion as to the absence of work in this process, together with the correlated inference that special stresses, generated during the effected deviations of the axis of the revolving flywheel, are never in the resultant opposed to the applied forces which produce the deflections of the axis—are both independently deducible, as a simple consequence of the law of the conservation of energy.

(1) When the flywheel does not revolve, and the motor, deviating the axis in diverse directions, is started, we have a flywheel possessing unchanged rotational velocity (velocity equal to zero, that is) before and after the experiment, with nothing to show in the shape of work performed by the impelling motor—neglecting, of course, friction, as agreed. And clearly, under these conditions, no work is really done by the motor.

(2) When the flywheel does revolve on its own axis, and the motor (variously deviating the axis of the rotating flywheel) is put in action, we still have unchanged conditions before and after the experiment, in that the flywheel possesses unchanged rotational velocity.

For it is an accepted fact that no mere deviation of the axis of a revolving flywheel can alter its velocity of revolution on its own axis. To recognize this fact without difficulty, we have only to imagine the axis to be indefinitely thin, or, if we like, a mathematical straight line; in which case no torque or "couple" could act on such an axis in order to accelerate or retard the connected flywheel, since a couple or torque cannot possibly act without a radius of action. And the theory of the gyroscope or revolving flywheel is, as an accepted fact, independent of the thickness of the axis of revolution.

Accordingly we have, before and after our two experiments, a flywheel revolving on its axis with unchanged velocity. The conditions prevailing before the experiments have remained unaltered, while no more work is demanded in order merely to deviate the axis than would be demanded if the flywheel were not revolving; accordingly the inference is, that no work is performed either in experiment (1) or in experiment (2); that is, whether the flywheel revolves or not during the deviation of its axis.

How, then, can we account for the "curious resistance," apparently encountered when the axis of a revolving flywheel or gyroscope disk is deviated by hand?

Here a brief excursion into simple elements of physiology may be apt for our purpose. We may observe that, in the particular instance of the human body, a force cannot be sustained, even in the absence of accompanying motion, without the performance of work within the body. Holding out a weight at arm's length gives the appearance of external work performed, especially if (in addition) one revolve on one's own axis, without raising the weight higher. To try to burst open a closed door by merely pressing against it, may demand much work inside the human frame; but, of course, none is accomplished outside. For it may be superfluous to draw attention to the fact, that in order to perform work outside one's self, there must be not only a force, but there must be motion against this force. Motion at right angles to a force does not constitute work; since the motion is not opposed in that instance.

If we imagine a small satellite, or even meteorite, to be guided round a circular orbit by human agency alone, this would demand internal bodily work, possibly very great. But it is known that in this instance no work whatever is really achieved outside the human body. For it is a recognized principle that merely to change the path or direction of motion of a moving particle (or collection of particles) without acceleration, demands no expenditure of work or energy whatever. The same argument obviously applies to the revolving gyroscope disk or flywheel; no expenditure of work or energy is required in order to deviate its axis or plane of revolution, provided the flywheel be not accelerated in respect to its rotational velocity about its axis.

When the deviations of the axis of a revolving flywheel are effected by hand, the curious resistance experienced is clearly referable to the transverse stress which arises in the act of deflecting the axis of a revolving body. This stress being transverse (or laterally directed), cannot oppose the deflection; but it is experienced all the same by the hands of the operator, and he may assume he has done work, in the absence of due precautions; in other words, this stress may readily convey a deceptive appearance of work accomplished outside one's self.

Owing to the physiological innervation and shortening of muscles, with attendant oxidation, in merely sustaining a stress or force even without movement against it, an expenditure of work or energy inside the human frame is entailed, which may, to the sensations, seem like outside work performed.

Hence (as a brief summary) it appears to be independently inferable from the law of conservation of energy alone, that, in the resultant, all stresses observed or experienced in deviating the planes of revolution (or the axes) of flywheels, turbines, or other rotating machinery (as occurs on board a pitching or rolling ship, or elsewhere) are stresses which entail no work or waste of power on the part of the machinery concerned.

In his appreciated work on "Spinning Tops," Prof. Perry makes the following remarks (p. 24):

"When the flywheels of steam engines and dynamo machines and other quick-speed machines are rotating on board ship, you may be quite sure that they offer a greater resistance to the pitching or rolling or turning of the ship, or any other motion which tends to turn their axes in direction, than when they are not rotating."

The foregoing reasoning shows that, far from our being "quite sure" of the resistance to pitching or rolling offered by the revolving flywheels, we are led to anticipate that, in ordinary circumstances, such resistance is non-existent or negligible. As, however, Prof. Perry's statement embodies a not uncommon error, it may be well to devote a few lines to a careful consideration of what occurs. Let us suppose that the axis of a revolving flywheel lies in the direction from stem to stern of a ship. Then, if we exclude the action of friction at the bearings, rolling of the ship from side to side will produce no effect on the flywheel, and the flywheel will therefore offer no resistance.

Turning the ship will turn the flywheel about a vertical axis. The reaction of the flywheel will tend to slightly raise the bows and depress the stern of the ship, or *vice versa*. This "tilting" of the ship will be of but small extent, and will reach its maximum when the torque producing it is neutralized by the action of gravity tending to reduce the ship to its normal level. While the tilting is increasing (e. g., while the bows are ascending and the stern descending) the reaction of the flywheel will produce a very small torque opposing the turning of the ship; but so soon as the maximum tilt has been produced (which will occur almost instantaneously) all resistance to the turning of the ship vanishes. For a constant resisting torque to be produced, the ship would have to continually rotate in a vertical plane.

When the ship pitches, the flywheel rotates about a horizontal diameter perpendicular to the axis of revolution. This rotation will produce a torque tending to deflect the flywheel about a vertical axis, and, therefore, to turn the ship to one side or the other. If no turning is produced, there can be no torque to resist the rotation due to the pitching of the ship. This case is strictly analogous to that of the gyroscope, hinged so as to be capable of rotation only in a vertical plane. If the ship actually does turn under the action of the flywheel, a torque will be produced opposing the motion due to the pitching of the vessel; compare the slow descent of the gyroscope (Fig. 2) when friction at the pivot *o* prevents it from turning freely. In this case, some opposition would be offered to the pitching of the ship; but fairly rapid turning would be needful in order to make the opposition appreciable. In actual practice, it appears clear that revolving flywheels, etc., on board ship offer no appreciable resistance either to pitching, rolling, or turning.—Technics.

ROMANCE OF THE POTATO.

IN the spring of 1903 not a little surprise was felt when it became known that a novel variety of potato was being eagerly bought up for planting at twenty shillings a pound, the usual price of seed potatoes being from two pounds to four pounds a ton. A still greater surprise was awaiting at the end of the year when tubers of another variety—El Dorado—were sold at prices ranging from one hundred pounds to two hundred pounds per pound avoirdupois. As numbers of potatoes average two to the pound, the altogether remarkable sum of one hundred pounds must have been paid for many of the single tubers. It must be a puzzle to the general reader whose knowledge of this humble esculent does not perhaps extend beyond a daily renewal of acquaintanceship with the cooked article, and to whom all potatoes are alike, to understand how such things can be. It will partly explain matters if we say that during the last thirty years potato-growers have been continually on the lookout for improved varieties of the potato—varieties producing larger crops and unsusceptible, or slightly so, to potato disease. So remarkable has been the success of potato specialists, whose business it is to produce from the potato-apple new varieties, that whereas formerly six tons of tubers to the acre was considered a fair crop, in 1903 the sort called Evergood produced from fourteen to eighteen tons, and in a year when disease was more than usually prevalent the crop of that sort was quite clean. Evergood had of course made its name previous to 1903; but when the specialist who produced this variety declared that he had succeeded in obtaining a superior variety to that, which on trial produced such enormous crops as, roughly, one to one and a half hundredweight from a pound of "seed," with fifty to ninety tubers to a single plant, the desire to secure such an extraordinarily prolific potato can easily be understood. What is said to be an even superior variety came into notice during 1903. It was to be sold to the public in 1905; but a few pounds grown in England got upon the market and sold at the prices already noted. Orders are being solicited for the autumn of 1904 at the reasonable price of five guineas a pound, or for a ton the alluring figure of eleven thousand seven hundred and sixty pounds. The present value at two hundred pounds a pound avoirdupois is the startling one of four hundred and forty-eight thousand pounds per ton, and what a field of a few acres in extent planted at these prices would be worth is too stimulating to contemplate.

No doubt it will occur to those of an inquiring turn of mind to ask how potatoes costing two hundred pounds a pound for planting can be made to produce a paying crop at five guineas. The cost of production need hardly be considered, as the prices are so abnormally large as to be unaffected by rent or wages. It is clear that if only one hundredweight is secured from each pound planted the crop at five guineas a pound will amount to five hundred and fifty-eight pounds, yielding a not unhandsome profit. But astute potato-cultivators have reverted to a method tried some sixty years ago, whereby the seed-potato is made to provide a largely increased number of sets. Usually the potato-tuber is prepared for planting by cutting it in pieces each provided with one or more growing "eyes," which become the potato plant. By starting these "eyes" or shoots into growth by means of artificial heat, they may be removed when large euough and rooted in flower pots; and when these have grown somewhat the tops of the shoots may be cut off and also rooted in the same way; and so on till the advancing season renders it impossible to proceed with profit. Meanwhile the tuber produces more shoots, which in turn are treated as above; and once this method of propagation comes to an end the tubers themselves are utilized for planting. By these methods the producing power of a tuber is increased according to the number of times each shoot is increased; hence it is apparent that by a comparatively small outlay the value of the crop can be increased to an enormous extent.

No potato has even gained so much notoriety as El Dorado, raised by the famous Scottish grower, Mr. A. Findlay, of Markinch. There was considerable excitement in Peterborough market over the sale of a specimen of the famous El Dorado potato. The tuber weighed a little under half a pound, and was disposed of at the record price of eighty pounds. "The story of this potato," says the Gardeners' Magazine, "is quite romantic; the very name was a stroke of genius. The promise fulfilled by Northern Star assured for El Dorado a hearty reception; but the output of seed was so small and the competition for tubers wherewith to raise stock was so great that prices bounded up. Mr. George Massey, of Spalding, was one of the very first

to obtain stock, and from him Mr. Zech. Gray, a well-known grower at Everton, Sandy, purchased a stone-weight for twenty pounds. This set the ball rolling, and as Mr. Findlay resolved not to further distribute El Dorado until the autumn of 1904, the demand for the small stocks available was doubled and trebled, and so the prices rose. Messrs. Dennis, the Covent Garden salesmen, and Messrs. I. Pond & Sons, of York, possessed supplies, and the latter firm found a purchaser of four pounds at a hundred and fifty pounds per pound. This determined them to obtain further stock, and so, at the Smithfield Club Show, a member of this firm, finding that Mr. Massey had a limited stock for disposal, made him an offer of a thousand pounds for a stone; Mr. Massey refused, as he wanted fifteen hundred pounds, but eventually the bargain was struck at fourteen hundred pounds. Subsequently Mr. Massey sold a relatively small quantity for two thousand pounds, so that his original transaction brought him a very handsome return."

Some people are inquiring how so many potatoes can be used when at present the crops in a favorable season produce a glut in the markets, and prices are so low that the margin of profit to the grower comes perilously near the vanishing point. As in many other cases, it would appear that also in this an outlet is waiting for any increase in crop that may occur. Potatoes are already being used in the production of petrol, at least one large factory being in course of erection for the transformation of the tuber into oil. As to whether these abnormal prices are likely to be maintained no one can say; possibly they may for a year or two, but it can hardly be for long.—Chambers's Journal.

ELECTRICAL NOTES.

A correspondent to the Times suggests that, in view of the number of accidents recently reported, owing to contact with live rails, it would be advisable that some protective marking should be adopted whenever such rails or fittings are exposed to the public. The marking should be compulsory and uniform throughout the kingdom, and should act as a warning or indication of danger by day or night. He proposes that a black and white chequer or stripe should be used for this purpose and painted on the rails or fittings, universally indicating danger.

The single-phase system of electric traction is to be used on the Fort Wayne, Springfield and Decatur line, about 110 miles long, and on the Indianapolis and Connersville line, which is at present 53 miles long, but is to be extended to Hamilton, giving it a length of 93 miles. The generators for the latter, which, according to the Iron Age, were ordered before it was decided to use the new system, will develop electricity at 2,300 volts. This will be stepped up to 16,500 volts for two-phase transmission to static transformer sub-stations situated about 10 miles apart. There will be ten stations, half to be connected to one phase and half on the other, the current will be reduced to a pressure of 3,300 volts in the trolley wire, and further reduced by transformers on the cars to a working pressure.

F. Paschen has succeeded in showing that the so-called γ-rays or non-deflected radium rays are simply an extremely rapid species of the β-rays or cathode rays, that they carry a negative electric charge, and only differ by their very much greater velocity. He employed a powerful electromagnet giving fields of more than 12,000 units. On gradually bringing up the field to that amount, the less rapid rays were eliminated one by one. Thus the Lenard rays went at 500 units, and Kaufmann's β rays between 3,000 and 5,000 units. At 10,000 units and over only the γ-rays were left. These seem to move with a constant limiting velocity which may closely approach that of light.

In an article in the Electrical Review of New York it is stated that some $25,000,000 was spent by the early French engineering companies in purchasing machinery and supplying equipments for excavating the Panama Canal, and a good part of this was finally left to rot and decay in the tropical climate of the isthmus; but there was sccarcely any money spent for electrical machinery or implements of any kind. Even electric lighting along the route of the canal was not resorted to, and the shops and repair plants were constructed without thought of any electrical equipment. In the work of finishing the Panama Canal the latest machinery and methods will be employed. It has been variously estimated that it will require from six to ten years to complete the canal even under modern engineering conditions, and from one to two years of preparation will be required. There will hardly be a machine, repair shop, or operating plant that will not have electric power in some portion of it. In this respect the new machinery for the Panama Canal will differ radically from that shipped to the isthmus by De Lesseps and his engineers. Within six months the designs and specifications of some of this machinery will be finished, and the first shipments will probably be made within the current year, or the early part of the new. Electrically-driven conveyors, cranes and drills will be very much in evidence, and it is proposed to light up the route of the canal by electricity, so that work can be carried on in shifts night and day. The question of motive power on the isthmus is partly dependent upon the fuel problem. Coal is scarce and high priced in Panama; wood is not to be depended upon as an exclusive fuel for power production, and the question of harnessing the tides and currents of the mountain streams and Chagres River is difficult. While some attempt may be made to utilize the power of the river's flow for generating electricity, and coal and wood will be used for fuel purposes, it is possible that Texas oil may be used more than anything else. The cost of shipping this to the isthmus is less than that of transporting coal or wood. By running oil-tank steamers to the isthmus, it is estimated that the cost would be considerably under a dollar a barrel. There is good reason to believe that many of the portable electric power and lighting plants will burn liquid fuel entirely, while many of the steam shovels and dredges will use both oil and coal. The modern convertible type of grate, which permits of either coal or oil being used, appeals with the greatest force to those interested in work in the tropics where the fuel must be carried long distances.

ENGINEERING NOTES.

In a very interesting article in the Street Railway Journal of June 25, Mr. H. F. Schmidt gives an analysis of the various losses occurring in steam turbines. From tests on a 500-kilowatt Curtis turbine at Newport station, it appears that the losses were distributed as follows: Work available at shaft, 56 per cent; loss in final velocity of steam, 14 per cent; friction of wheels in chambers, 6.20 per cent; nozzle losses, 6 per cent; losses in buckets and spreading and leakage, 14.80 per cent; radiation, 3 per cent; total, 100 per cent. For a 1,250-kilowatt Westinghouse-Parsons turbine, used in connection with the lighting of the New York subway, the corresponding figures were approximately as follows: Energy available at turbine shaft, 62.80 per cent; friction of drum and buckets, 6.30 per cent; radiation, 7 per cent; loss by final velocity of steam (assumed), 12 per cent; losses in buckets and guides, friction, and leakage, 11.90 per cent; total, 100 per cent. The reason that the loss by final velocity of the steam is marked "assumed" is that in the Parsons type of turbine this loss cannot be even approximately calculated; and as it cannot be easily determined by experiment, it was necessary to assume it. Consequently, whatever error has been made in this assumption will also be present in the bucket loss which is obtained by subtraction. It is probable, however, Mr. Schmidt continues, that this figure is not far from correct.

An electric cableway is used over the Zambesi River for conveying materials from one bank of the river to the other during the construction of the Cape to Cairo Railway, which has now reached a point just below the Falls. At the point where the transport is to be effected, the banks are 650 feet apart and 400 feet above the water-level; 40,000 tons of railway material will have to be carried over to be used in the construction of the steel bridge of 500 feet span, which is to be built out simultaneously from each side. The steel cable, 8½ inches in circumference, is fixed on one side of the river to the top of a rigid tower of steel construction, and on the other to A-shaped sheer legs inclined away from the river at an angle of about 45 deg., hinged at the feet, which rest on concrete foundations, and loaded with a weight of about 60 tons suspended from the top. Thus when the conveyor travels along the cable toward the center of the span, the cable sags and the sheer legs assume a steeper angle, the extent of their movement being limited by an anchoring guy rope, returning to their original position through the action of the balance weight as the conveyor nears the opposite bank. At the same time the counterweight helps the motor as the load advances up the incline. The conveyor itself is suspended from two traveler wheels, a frame hanging from which carries the electric motor and gearing, etc., a chair for the driver, with the necessary levers to actuate the hoisting and traveling gear. The conveyor is capable of lifting and carrying a maximum load of 10 tons, and will, it is estimated, be able to transport 800 tons of material across the river in one day. The current, which is conveyed to the conveyor by a bare copper wire stretched across the river, is generated by a portable engine and dynamo on the river bank.

Water filtration at Pittsburg received the indorsement of the voters of that city on July 12, when they authorized the issue of $5,000,000 of bonds for the necessary works and for the introduction of meters. The ballot read: "Shall the city of Pittsburg increase its indebtedness to an amount not exceeding $5,000,000 for the purpose of water supply and distribution; the construction and establishment of a sand filtration plant for the filtration of said water supply and to provide for meters to be used in connection therewith?" It is generally understood that this vote means that $5,000,000 bonds can be issued in addition to the $2,500,000 previously authorized, although the wording of the ballot hardly bears out this interpretation. The contract plans, on which work is being rapidly pushed, provide for a total of 56 covered filters, each with a net area of one acre, but only 46 of these are to be constructed at present. A pumping plant will be installed to raise the water from the Allegheny River near Aspinwall to two sedimentation basins, the maximum lift being about 50 feet. From the sedimentation basins the water will flow by gravity through the filters to a covered filtered water reservoir, and thence under the river to the present Brilliant pumping station, from which it will be delivered to the distributing reservoirs. It is also proposed to install additional pumps at Brilliant, and to lay a pipe line for filtered water from Highland Reservoir No. 2 to the part of the city south of the Monongahela River not supplied at present by the city works. While there is some talk of contesting the vote on account of the small majority by which it was carried, doubtless due to the meter portion of the ballot, it does not seem likely that anything will come of such an attempt. The city is so manifestly in need of better water that it is difficult to understand the mental make-up of those who oppose the construction of purification works.—Engineering Record.

TRADE NOTES AND RECIPES.

Substitute for Benzine as a Cleaning Agent.—The following is recommended as a less inflammable mixture for cleaning purposes:

Chloroform	7.5 parts
Ether	7.5 parts
Alcohol	60.0 parts
Decoction of quillaya bark of 30.0	2250.0 parts

Hardly any dearer, but at least as effective and more convenient in its application, would be a mixture of the following chemically pure ingredients:

Acetic ether	10 p. c.
Amyl acetate	10 p. c.
Liquid ammonia	10 p. c.
Spirit of wine, dilute	70 p. c.

Another good non-inflammable spot remover consists of equal parts of acetone, spirit of sal-ammoniac, and diluted spirit. For use in large quantities we would call attention to carbon tetrachloride.—Pharmaceutische Zeitung.

How to Make a Non-Caustic Soap That Evolves Active Oxygen.—Till now it has not been possible to produce a soap that, without being harmful, possessed, besides the quality of loosening dirt, also bleaching and antiseptic characteristics, so that cleansing and bleaching might be combined in one operation. According to the patent issued to Prof. H. Gieszler and Dr. H. Bauer, of Stuttgart, this end may be attained by incorporating with ordinary stock soap an ammonium perborate or sodium percarbonate ether in a powdered form or mixed with fatty bodies free from glycerine, such as lanoline, spermaceti solutions, vaseline, or paraffine.

Ten to twenty per cent sodium or ammonium perborate is employed; for example, $NaBO_3$ or $Na_2B_4O_8$ or NH_4BO_3 or sodium percarbonate, Na_2CO_4, three entirely stable salts rich in oxygen, for the manufacture of which on a large scale serviceable methods already exist. These salts are not decomposed even in soap which contains 20 per cent of water. The oxygen is evolved at a temperature above 40 deg. C. slowly and steadily, but only when dissolved in large quantities of water, in other words, when in use, as in washing.

Such a soap will easily remove from linen or cotton goods stains of red wine, whortle berries, cocoa, and the like.—Neueste Erfindungen und Ehrfahrungen.

Perfumery Receipts.—

	Parts by weight.
Bouquet Courtain.	
Spirit	500
Palmarosa pomade extract	1,000
Jasmine pomade extract	500
Rose pomade extract	300
Violet pomade extract	1,000
Oil of bergamot	100
Oil of neroli	20
Tincture of iris	500
Tincture of musk	30
Bouquet de Fleurs.	
Rose pomade extract	1,500
Violet pomade extract	1,500
Tuberose pomade extract	1,500
Oil of bergamot	65
Oil of lemon	50
Oil of orange peel	50
Essence of benjamin	150
Bouquet de l'Imperatrice.	
Rose pomade extract	1,000
Violet pomade extract	600
Tuberose pomade extract	600
Orange blossom extract	250
Cassia pomade extract	250
Oil of bergamot	30
Orange flower water	500

—Wiener Seifensieder Zeitung.

Dead-gilding of an Alloy of Copper and Zinc.—The parts which are to be deadened must be isolated from those which are to be polished afterward, and also, and more particularly, from those which are to be kept out of sight and which are therefore not to be gilded. For this purpose they are coated with a paste made of Spanish white mixed with water. The articles prepared in this manner are then attached by means of iron wire to an iron rod and suspended in a furnace constructed for this process. The floor of this furnace is covered on four sides with plates of enameled earthenware for receiving the portions spattered about of the salt mixture given off later.

In the middle is an oven constructed like a cooking-stove, on which is an iron tripod for carrying the deadening-pan; this latter is cemented into a second pan of cast-iron, the intervening space being filled up with stove cement. In the middle of the pan is the bottom or sill provided with a thick cast-iron plate, forming the hearth. On all four sides of the latter are low brick walls, connecting with the floor of the furnace, and the whole is covered with thick sheet metal. On the side of the furnace opposite the side arranged for carrying the pans, is a boiler in which boiling water is kept. On the same side of the furnace, but outside it, is a large oval tub of a capacity of about 700 or 800 liters, which is kept filled with water. The upper portions of the staves of this tub are covered

with linen to absorb all parts that are spattered about. —Der Metallarbeiter.

SELECTED FORMULÆ.

Varnish for Tin Boxes.—In 75 parts of alcohol dissolve 15 parts of shellac, 2 parts of Venice turpentine, and 8 of sandarac.

Bookbinders' Varnish.—In 90 parts by weight of alcohol dissolve 12 parts of Venice turpentine and 30 parts, also by weight, of shellac of light yellowish shade.

To Exterminate Mites.—Mix together 10 parts of naphthalene, 10 of phenic acid, 5 of camphor, 5 of lemon oil, 2 of thyme oil, 2 of oil of lavender, and 2 of the oil of juniper, in 500 parts of pure alcohol.

A Paste for Cleaning Gloves.—Take 4 parts of water and dissolve in it 3 parts of soft soap to which add 1-16 of a part of oil of lemon, and make a paste of desired consistency by adding a sufficient quantity of prepared chalk. This paste is particularly suitable to kid gloves.

Blue Ink for Writing Upon Glass.—In 150 parts of alcohol dissolve 20 parts of rosin, and add to this drop by drop, stirring continuously, a solution of 35 parts of borax in 250 parts of water. This being accomplished, dissolve in the solution sufficient methylene blue to give it the desired tint.

Ironing Preparations.—Ironing wax: Melt carefully together Japan wax 200, paraffine 200, stearic acid 100, and pour into mold, pass the hot flat iron over this mass, which causes the iron to slide better and the laundered work to become glossy.

Laundry gloss: Heat potassium carbonate 15, spirit 100, stearic acid 15, and water 200, until the mass is uniform, thin with hot water 650, and stir until cool. Scent with oil of lavender as desired.—Deutsche Wascherei Zeitung.

Removing Oil Spots from Leather.—To remove oil stains from leather, dab the spot carefully with spirits of sal-ammoniac, and after allowing it to act for awhile, wash with clean water. This treatment may have to be repeated a few times, taking care, however, not to injure the color of the leather.

Sometimes the spot may be removed very simply by spreading the place rather thickly with butter, letting this act for a few hours. Next scrape off the butter with the point of a knife, and rinse the stain with soap and lukewarm water.—Gewerbeblatt.

New Preservatives.—These are salts for the preservation of meats by putting them in brine, and are a few of the formulæ given in the Zeitschrift für offentliche Chemie:

No. 1.—70 parts of potassium nitrate, 15 of sodium bicarbonate, and as much sodium chloride. Mix well together before using.

No. 2.—This is more exactly speaking a pickle; it is composed of a mixture of 50 parts of sodium nitrate, 5 of salicylic acid, and 45 of boracic acid. We cannot refrain from remarking that to our mind these two acids are far from being without danger to digestion.

No. 3.—Another pickle; 50 parts of sodium nitrate, 20 of sodium chloride, 20 of boracic acid, and 10 of sugar.

Receipts for Mouth Waters and Tooth Pastes.—

Mouth Washes.

1. Sandal wood	250.0
Guaiacum wood	250.0
Myrrh	150.0
Cloves	150.0
Cinnamon bark	100.0
Cochineal	100.0
Potash	1.0
Alumina	1.0
Oil of peppermint	20.0
Oil of cloves	20.0
Rose water	5,000.0
Spirit 90 per cent	15,000.0

Macerate for eight days and filter.

2. Star aniseseed	25.0
Cinnamon bark	25.0
Cinchona bark	25.0
Ratanhia	25.0
Cloves	25.0
Cochineal	5.0
Oil of aniseseed	5.0
Oil of peppermint	10.0
Dilute spirit	2,000.0

Macerate for eight days and filter.

Tooth Pastes.

1. Precipitated carbonate of lime	90.0
Soap powder	30.0
Ossa sepia, powdered	15.0
Tincture of cocaine	45.0
Oil of peppermint	0.6
Oil of ylang-ylang	0.3
Glycerine	30.0

Rose water to cause liquefaction.
Carmine solution to color.

2. Precipitated carbonate of lime	150.0
Soap powder	45.0
Arrowroot	45.0
Oil of eucalyptus	2.0
Oil of peppermint	1.0
Oil of geranium	1.0
Oil of cloves	0.25
Oil of aniseseed	0.25
Glycerine	45.0

Chloroform water to cause liquefaction.
Carmine solution to color.

—Neueste Erfindungen und Erfahrungen.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.