

# **Scientific American Supplement, No. 810, July 11, 1891 eBook**

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\* \* \* \* \*

## MINE TIMBERING.

The square system of timbering, in use in most of our large mines on the Pacific coast, was first introduced in Australia by Mr. W.H. Patton, who adopted it in the Broken Hill Proprietary mines, although it does not seem to be so satisfactory to the people there as to our miners, who are more familiar with it. The accompanying description and plans were furnished by Mr. Patton to the report of the Secretary of Mines for Victoria:

“The idea is supposed to have originated in the German mines, but in a crude form. It was introduced among the mines of the Pacific coast of America some 20 years ago, by a gentleman named Diedesheimer. Its use there is universal, and experience has evolved it from the embryo state to its present perfection. The old system and its accompanying disadvantages are well known. A drive would be put in for a certain distance, when it had to be abandoned until it could be filled up with waste material and made secure. This process entailed much expense. The stuff had first to be broken on the surface, then sent below, trucked along the drives, and finally shoveled into place. Ventilation was impaired and the drives were filled with dust. The men worked in discomfort, and were not in a condition to perform a full measure of labor. Under the system as adopted in the Proprietary mine, these disadvantages disappear. The cost is one-third less, ventilation is perfect, and every portion of the faces are accessible at all times. Sawn timber is used throughout; the upright and cross pieces are 10 inches by



10 inches, and stand 4 feet 6 inches apart; along the course of the drive, the cross pieces are five feet in length, and the height of the main drives and sill floor sets are 7 feet 2 inches in the clear. In blocking out the stopes, the uprights are 6 feet 2 inches, just one foot shorter than those in the main drives. The caps and struts are of the same dimensions and timber as the sill

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floor. The planks used as staging are 9 inches by 21/2 inches; they are moved from place to place as required, and upon them the men stand when working in the stopes and in the faces. A stope resembles a huge chamber fitted with scaffolding from floor to roof. The atmosphere is cool and pure, and there is no dust. Stage is added to stage, according as the stoping requires it, and ladders lead from one floor to the other; the accessibility to all the faces is a great advantage. If, while driving, a patch of low grade ore is met with, it can be enriched by taking a higher class from another face, and so on. Any grade can be produced by means of this power of selection. Opinions have been expressed that this system of timbering is not secure, and that pressure from above would bring the whole structure down in ruins. But an opinion such as this is due to miscomprehension of the facts. If signs of weakening in the timbers become apparent, the remedy is very simple. Four or more of the uprights are lined with planks, and waste material is shot in from above, and a strong support is at once formed, or if signs of crushing are noticed, it is possible to go into the stope, break down ore, and at once relieve the weight."

[Illustration: *The square system of timbering in mines.*]

\* \* \* \* \*

## TRANSIT IN LONDON, RAPID AND OTHERWISE.[1]

[Footnote 1: Abstract from a paper read before the Boston Society of Engineers, in April, 1890.]

By *James A. Tilden.*

The methods of handling the travel and traffic in the city of London form a very interesting subject for the study of the engineer. The problem of rapid transit and transportation for a city of five millions of inhabitants is naturally very complicated, and a very difficult one to solve satisfactorily.

The subject may be discussed under two divisions: first, how the suburban travel is accommodated, that is, the great mass of people who come into the business section of the city every morning and leave at night; second, how the strictly local traffic from one point to another is provided for. Under the first division it will be noted in advance that London is well provided with suburban railroad accommodation upon through lines radiating in every direction from the center of the city, but the terminal stations of these roads, as a rule, do not penetrate far enough into the heart of the city to provide for the suburban travel without some additional methods of conveyance.



The underground railroad system is intended to relieve the traffic upon the main thoroughfares, affording a rapid method of transportation between the residential and business portions, and in addition to form a communicating link between the terminals of the roads referred to. These terminal stations are arranged in the form of an irregular ellipse and are eleven in number.



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One of the most noticeable features of the underground system in London is that it connects these stations by means of a continuous circuit, or "circle," as it is there called. The line connecting the terminal stations is called the "inner circle." There is also an extension at one end of this elliptical shaped circle which also makes a complete circuit, and which is called the "middle circle," and a very much larger circle reaching the northern portions of the city, which is called the "outer circle." The eastern ends of these three circles run for a considerable distance on the same track. In addition to this the road branches off in a number of directions, reaching those parts of the city which were not before accommodated by the surface roads, or more properly the elevated or depressed roads, as there are no grade crossings.

With regard to the accommodation afforded by this system: it is a convenience for the residents of the western and southern parts of London, especially where they arrive in the city at any of the terminal stations on the line of the "circle," as they can change to the underground. They can reach the eastern end of the "circle," at which place is located the bank and the financial section of London, in a comparatively short time. For example, passengers arriving at Charing Cross, Victoria or Paddington stations, can change to the underground, and in ten, fifteen and thirty minutes respectively, reach the Mansion House or Cannon street stations, which are the nearest to the Bank of England. In a similar manner those arriving at Euston, St. Pancras or King's Cross on the northern side of the "circle," can reach Broad Street station in ten or fifteen minutes, which station is nearest the bank on that side of the "circle."

In a number of cases the underground station is in the same building or directly connected by passages with the terminal stations of the roads leading into the city. Examples of this kind would be such stations as Cannon Street, Victoria or Paddington. They are not, however, sufficiently convenient to allow the transference of baggage so as to accommodate through passengers desiring to make connection from one station to another across the city. Hand baggage only is carried, about the same as it is on the elevated road in New York. The method of cross town transfer, passengers and baggage, is invariably done by small omnibuses, which all the railroads maintain on hand for that special purpose. A very large proportion of the travel, however, if not the largest, is obtained by direct communication by means of the "circle" on branch lines with the various residential portions of north, west and south London.

Approximately on the underground railroad the fare is one cent per mile for third class, one cent and a half for second class, and two cents for first class, but no fare is less than a penny, or two cents. Omnibus fares in some instances are as low as a penny for two miles. This is not by any means the rule, and is only to be found on competing lines. The average fare would be a penny a mile or more.

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The fares on the main lines which accommodate the suburban traffic are somewhat higher than on the underground, perhaps 50 per cent. more. In every case, on omnibus, tram cars or railroads, the rates are charged according to distance. The system such as in use on our electric, cable and horse cars and on the elevated road in New York, of charging a fixed fare, is not in use anywhere.

The ticket offices of the underground roads are generally on a level with the street. In some instances both the uptown and downtown trains are approached from one entrance, but generally there is an entrance at either side of the railroad, similar to the elevated railroad system. In purchasing a ticket, the destination, number of the class, and whether it is a single or return ticket have to be given. The passenger then descends by generally well lighted stairways to the station below, and his ticket is punched by the man at the gate. He then has to be careful about two things; first, to place himself on that part of the platform where the particular class which he wishes to take stops, and secondly, to get on to the right train. In the formation of the train the first class coaches are placed in the center, the second and third class respectively at the front and rear end. There are signs which indicate where passengers are to wait, according to the class. There is a sign at the front end of the engine, which to those initiated sufficiently indicates the destination of the train. The trains are also called out, and at some stations there is an obscure indicator which also gives the desired information. The stations are from imperfectly to well lighted, generally from daylight which sifts down from the smoky London atmosphere through the openings above. The length of the train averages about eight carriages of four compartments, each compartment holding ten persons, making a carrying capacity of 320 passengers. The equipment of the cars is very inferior. The first class compartments are upholstered and cushioned in blue cloth, the second class in a cheaper quality, while most of the third class compartments have absolutely nothing in the way of a cushion or covering either on the seat or back, and are little better than cattle pens. The width of the compartment is so narrow that the feet can easily be placed on the opposite seat, that is, a very little greater distance than would be afforded by turning two of our seats face to face. The length of the compartment, which is the width of the car, is about a foot and a half less than the width of our passenger cars, about equal to our freight cars. Each compartment is so imperfectly lighted by a single lamp put into position through the top of the car that it is almost impossible to read.

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The length of time which a train remains at a station is from thirty to forty seconds, or from three to four times the length of time employed at the New York elevated railroad stations. The reason for this is that a large proportion of the doors are opened by passengers getting in or out, and all these have to be shut by the station porter or guard of the train before the train can start. If the train is crowded one has to run up and down to find a compartment with a vacant seat, and also hunt for his class, and as each class is divided into smoking and non-smoking compartments, making practically six classes, it will be observed that all this takes time, especially when you add the lost time at the ticket office and gate.

The ventilation of the tunnels and even the stations is oftentimes simply abominable, and although the roads are heavily patronized there is a great amount of grumbling and disfavor on this account. The platforms of the stations are flush with those of the cars, so that the delay of getting in or out is very small, but the doors are so low that a person above the average height has to stoop to get in, and cannot much more than stand upright with a tall hat on when he is once in the car. The monitor roof is unknown.

The trains move with fair speed and the stations are plainly and liberally marked, so that the passenger has little difficulty in knowing when to get out. There are two signs in general use on English railroads which are very simple and right to the point, namely, "Way Out" and "Way In," so that when a passenger arrives at a station he has no question how to get out of it. The ticket is given up as the passenger leaves the station. There is nothing to prevent a passenger with a third class ticket getting into a first class compartment excepting the ominous warning of 40 shillings fine if he does so, and the liability of having his sweet dreams interrupted by an occasional inspector who asks to see the denomination of his ticket. All compartments intended for the use of smokers are plainly marked and are to be found in each class. Almost the entire part of the railroads within the thickly settled portions of the city run in closed tunnels. Outside of this they frequently run in open cuttings, and still further out they run on to elevated tracks.

With regard to the equipment of the suburban or surface lines not belonging to the underground system the description is about the same. The cars are generally four compartments long and sometimes not exceeding three. They are coupled together with a pair of links and fastened to the draw bar on one car and the other thrown over a hook opposite and brought into tension by a right and left hand screw between the links. This is obviously very inconvenient for shunting purposes, especially as the cars are not provided with hand brakes and no chance to get at them if there were any. Consequently it appears that when a train is made up it stays so for an indefinite

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period. A load of passengers is brought into the station and the train remains in position until it is ready to go out. As the trains run very frequently this appears to be a very economical arrangement, as no shunting tracks are needed for storage. The engine which brings the train in of course cannot get out until the train goes out with the next load. Turn tables for the locomotives are but very little used, as they run as double enders for suburban purposes.

In conclusion it will be safe to say that the problem of rapid transit for a city as large as London is far from solved by the methods described. Although there are a great many miles of underground lines and main lines, as they have been called throughout the paper, and although grade crossings have been entirely abolished, allowing the trains to run at the greatest speed suitable to their frequency, still there are a great many sections which have to depend entirely upon the omnibus or tram car. The enormous expense entailed by the construction of the elevated structures can hardly be imagined. We have but one similar structure in this country, which is that running from the Schuylkill River to Broad Street station, in Philadelphia. The underground system is even more expensive, especially in view of the tremendous outlay for damages. This goes to show that money has not been spared to obtain rapid transit.

After all, the means to be depended upon when one desires to make a rapid trip from one part of the city to another is the really admirable, cheap, always ready, convenient and comfortable London hansom; while the way to see London is from the top of an omnibus, the most enjoyable, if not the most expeditious, means of conveyance.

\* \* \* \* \*

[Continued from *supplement*, no. 809, page 12930.]

### **RIVETED JOINTS IN BOILER SHELLS.[1]**

[Footnote 1: A paper read at a meeting of the Franklin Institute.  
From the journal of the Institute.]

By *William Barnet Le Van*.

[Illustration: *Fig. 11*.]

Fig. 11 represents the spacing of rivets composed of steel plates three-eighths inch thick, averaging 58,000 pounds tensile strength on boiler fifty-four inches diameter, secured by iron rivets seven-eighths inch diameter. Joints of these dimensions have been in constant use for the last fourteen years, carrying 100 pounds per square inch.



*Punching Rivet Holes.*—Of all tools that take part in the construction of boilers none are more important, or have more to do, than the machine for punching rivet holes.

That punching, or the forcible detrusion of a circular piece of metal to form a rivet hole, has a more or less injurious effect upon the metal plates surrounding the hole, is a fact well known and admitted by every engineer, and it has often been said that the rivet holes ought all to be drilled. But, unfortunately, at present writing, no drilling appliances have yet been placed on the market that can at all compare with punching apparatus in rapidity and cheapness of working. A first-class punching machine will make from forty to fifty holes per minute in a thick steel plate. Where is the drilling machine that will approach that with a single drill?

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The most important matter in punching plates is the diameter of the opening in the bolster or die relatively to that of the punch. This difference exercises an important influence in respect not only of easy punching but also in its effect upon the plate punched. If we attempt to punch a perfectly cylindrical hole, the opening in the die block must be of the same diameter as the point of the punch, or, at least, a very close fit. The point of the punch ought to be slightly larger in diameter than the neck, or upper part, as shown in Figs. 12 and 13, so as to clear itself easily. When the hole in the bolster or die block is of a larger diameter than the punch, the piece of metal thrust out is of larger diameter on the bottom side, and it comes out with an ease proportionate to the difference between the lower and upper diameters; or, in other words, it produces a taper hole in the plate, but allows the punching to be done with less consumption of power and, it is said, with less strain on the plate.

[Illustration: *Fig. 12.*]

[Illustration: *Fig. 13.*]

As to the difference which should exist between the diameter of the punch and the die hole, this varies a little with the thickness of the plate punched, or should do so in all carefully executed work, for it is easy to understand that the die which might give a suitable taper in a three-fourths inch plate would give too great a taper in a three-eighths inch plate. There is no fixed rule; practical experience determines this in a rough and ready way—often a very rough way, indeed, for if a machine has to punch different thicknesses of plate for the same size of rivets, the workman will seldom take the trouble to change the die with every variation of thickness. The maker of punches and dies generally allows about three sixty-fourths or 0.0468 of an inch clearance.

The following formula is also used by punch and die makers:

$$\text{Clearance} = D = d + 0.2t$$

where

- D = diameter of hole in die block;
- d = diameter of cutting edge of punch;
- t = thickness of plate in fractions of an inch;

that is to say, the diameter of the die hole equals diameter of punch plus two-tenths the thickness of the plate to be punched.

*Example.*—Given a plate  $\frac{3}{8}$  or 0.375 of an inch thick, the diameter of the punch being  $\frac{13}{16}$  or 0.8125 of an inch, then the diameter of the die hole will be as follows:

$$\text{Diameter of die hole} = 0.8125 + 0.375 \times 0.2 = 0.8875 \text{ inch diameter,}$$

or say  $\frac{7}{8}$  or 0.875 inch diameter.

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Punches are generally made flat on their cutting edge, as shown in Fig. 12. There are also punches made spiral on their cutting edge, as shown in Fig. 13. This punch, instead of being flat, as in Fig. 12, is of a helical form, as shown in Fig. 13, so as to have a gradual shearing action commencing at the center and traveling round to the circumference. Its form may be explained by imagining the upper cutter of a shearing machine being rolled upon itself so as to form a cylinder of which its long edge is the axis. The die being quite flat, it follows that the shearing action proceeds from the center to the circumference, just as in a shearing machine it travels from the deeper to the shallower end of the upper cutter. The latter is not recommended for use in metal of a thickness greater than the diameter of the punch, and is best adapted for thicknesses of metal two-thirds the diameter of the punch.

Fig. 14 shows positions of punch and attachments in the machine.

[Illustration: *Fig. 14.*]

It is of the greatest importance that the punch should be kept sharp and the die in good order. If the punch is allowed to become dull, it will produce a fin on the edge of the rivet hole, which, if not removed, will cut into the rivet head and destroy the fillet by cutting into the head. When the punch is in good condition it will leave a sharp edge, which, if not removed, will also destroy the fillet under the head by cutting it away.

Punching possesses so many advantages over drilling as to render it extremely important that the operation should be reduced to a system so as to be as harmless as possible to the plate. In fact, no plate should be used in the construction of a boiler that does not improve with punching, and further on I will show by the experiments made by Hoopes & Townsend, of Philadelphia, that good material is improved by punching; that is to say, with properly made punches and dies, by the upsetting around the punched hole, the value of the plate is increased instead of diminished, the flow of particles from the hole into the surrounding parts causing stiffening and strengthening.

*Drilling Rivet Holes.*—In the foregoing I have not referred to the drilling of rivet holes in place of punching. The great objection to drilling rivet holes is the expense, from the fact that it takes more time, and when drilled of full rivet size we are met with the difficulty of getting the rivet holes to correspond, as they are when punched of full rivet diameter. When two plates are drilled in place together, the drill will produce a *burr* between the two plates—on account of their uneven surfaces—which prevents them being brought together, so as to be water and steam tight, unless the plates are afterward separated and the burr removed, which, of course, adds greatly to the expense.

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The difference in strength between boiler plates punched or drilled of full rivet size may be either greater or less than the difference in strength between unperforated plates of equal areas of fracture section. When the metal plates are very soft and ductile, the operation of punching does no appreciable injury. Prof. Thurston says he has sometimes found it actually productive of increased strength; the flow of particles from the rivet hole into the surrounding parts causing stiffening and strengthening. With most steel and hard iron plates the effect of punching is often to produce serious weakening and a tendency to crack, which in some cases has resulted seriously. With first class steel or iron plates, punching is perfectly allowable, and the cost is twenty-five per cent. less than drilling; in fact, none but first class metal plates should be used in the construction of steam boilers.

In the original punching machines the die was made much larger than the punch, and the result was a conical taper hole to receive the rivet. With the advanced state of the arts the punch and die are accurately fitted; that is to say, the ordinary clearance for a rivet of (say) three-fourths of an inch diameter, the dies have about three sixty-fourths of an inch, the punch being made of full rivet size, and the clearance allowed in the diameter of the die.

Take, for example, cold punched nuts. Those made by Messrs. Hoopes & Townsend, Philadelphia, when taken as specimens of "commercial," as distinguished from merely experimental punching, are of considerable interest in this connection, owing to the entire absence of the conical holes above mentioned.

When the holes are punched by machines properly built, with the punch accurately fitted to the die, the effect is that the metal is made to flow around the punch, and thus is made more dense and stronger. That some such action takes place seems probable, from the appearance of the holes in the Hoopes & Townsend nuts, which are straight and almost as smooth as though they were drilled.

Therefore I repeat that iron or steel that is not improved by proper punching machinery is not of fit quality to enter into the construction of steam boilers.

*Strength of punched and drilled iron bars.*

*Hoopes & Townsend.*

Thickness of bar in inches.	Thickness outside of hole in inches.	Punched bars broke in pounds.	Drilled bars broke in pounds.
-----+	-----+	-----+	-----
-----+			
-----+	-----+	-----+	-----
-----+			



# BOOKRAGS

$\frac{3}{8}$ or 0.375		$\frac{3}{8}$ or 0.375		31,740		28,000	
$\frac{3}{8}$ or 0.375		$\frac{3}{8}$ or 0.375		31,380		26,950	
$\frac{5}{8}$ or 0.625		$\frac{1}{4}$ or 0.25		18,820		18,000	
$\frac{5}{8}$ or 0.625		$\frac{1}{4}$ or 0.25		18,750		17,590	
$\frac{5}{8}$ or 0.625		$\frac{3}{16}$ or 0.1875		14,590		13,230	

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5/8 or 0.625		3/16 or 0.1875		15,420		13,750	
5/8 or 0.625		1/8 or 0.125		10,670		9,320	
5/8 or 0.625		1/8 or 0.125		11,730		9,580	
-----							
-----+							

It will be seen from the above that the punched bars had the greatest strength, indicating that punching had the effect of strengthening instead of weakening the metal. These experiments have given results just the reverse of similar experiments made on boiler plates; but the material, such as above experimented upon, is what should be placed in boilers, tough and ductile, and the manner of, and care taken in, punching contribute to these results.

It is usual to have the rivet holes one-sixteenth of an inch in diameter larger than the rivets, in order to allow for their expansion when hot; it is evident, however, that the difference between the diameters of the rivet hole and of the rivet should vary with the size of the rivet.

The hole in the die is made larger than the punch; for ordinary work the proportion of their respective diameters varies from 1:1.5 to 1:2.

As I have before stated, the best plate joint is that in which the strength of the plate and the resistance of the rivet to shearing are equal to each other.

In boilers as commercially made and sold the difference in quality of the plates and rivets, together with the great uncertainty as to the exact effect of punching the plates, have, so far, prevented anything like the determination either by calculation or experiment of what might be accepted as the best proportions of riveted joints.

In regard to steel plates for boilers Mr. F.W. Webb, of Crewe, England, chief engineer of the London and Northwestern Railway, has made over 10,000 tests of steel plates, but had only two plates fail in actual work; these failures he thought were attributable solely to the want of care on the part of the men who worked the plates up.

All their rivet holes for boilers were punched in a Jacquard machine, the plates then annealed, and afterward bent in rolls; they only used the reamer slightly when they had three thicknesses of plate to deal with, as in butt joints with inside and outside covering strips. These works turn out two locomotive boilers every three days.

The Baldwin Locomotive Works, which turn out on an average three locomotives per day, punch all their rivet holes one sixteenth inch less in diameter and ream them to



driven rivet size when in place. They also use rivets with a fillet formed under head made in solid dies.

*Rivets.*—Rivets of steel or iron should be made in solid dies. Rivets made in open dies are liable to have a fin on the shank, which prevents a close fit into the holes of the plates. The use of solid dies in forming the rivet insures a round shank, and an accurate fit in a round hole. In addition, there is secured by the use of solid dies, a strong, clean fillet under the head, the point where strength is most needed.

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Commencing with a countersunk head as the strongest form of head, the greater the fillet permissible under the head of a rivet, or bolt, the greater the strength and the decrease in liability to fracture, as a fillet is the life of the rivet.

If rivets are made of iron, the material should be strong, tough, and ductile, of a tensile strength not exceeding 54,000 pounds per square inch, and giving an elongation in *eight inches* of not less than twenty-five per cent. The rivet iron should be as ductile as the best boiler plate when cold. Iron rivets should be annealed and the iron in the bar should be sufficiently ductile to be bent cold to a right angle without fracture. When heated it should be capable of being flattened out to one-third its diameter without crack or flaw.

[Illustration: *Fig. 15. Solid Die Rivet.*]

[Illustration: *Fig. 16. Open Die Rivet.*]

If rivets are made of steel they must be low in carbon, otherwise they will harden by chilling when the hot rivets are placed in the cold plates. Therefore, the steel must be particularly a low grade or mild steel. The material should show a tensile strength not greater than 54,000 pounds per square inch and an elongation in *eight inches* of thirty per cent. The United States government requirements are that steel rivets shall flatten out cold under the hammer to the thickness of one-half their diameter without showing cracks or flaws; shall flatten out hot to one-third their diameter, and be capable of being bent cold in the form of a hook with parallel sides without cracks or flaws. These requirements were thought at first to be severe, but the makers of steel now find no practical difficulty in meeting these specifications.

The forming of the head of rivets, whether of steel or iron, and whether the heads are conical or semi-spherical, should not be changed by the process of riveting. The form of the head is intended to be permanent, and this permanent form can only be retained by the use of a "hold fast," which conforms to the shape of the head. In the use of the flat hold fast (in general use in a majority of boiler shops) the form of the head is changed, and if the rivet, by inadequate heating, requires severe hammering, there is danger that the head of the rivet may be "punched" off. By the use of a hold fast made to the shape of the rivet head, this danger is avoided and the original form of the head is retained. This feature of the use of proper rivet tools in boiler shops has not received the attention it deserves. Practical use of the above named hold fast would soon convince the consumers of rivets of its value and efficiency.



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The practice of driving rivets into a punched rivet hole from which the fin or cold drag, caused by the movement of the punch, has not been removed by reaming with a countersunk reamer, or better still a countersunk set, should be condemned, as by driving the hot rivet head down against the fin around the hole in the cold plate caused by the action of punching the countersunk fillet is not only destroyed, but it is liable to be driven into the head of the rivet, partially cutting the head from the shank. If the rivet is driven into a hole that has been punched with a sharp punch and sharp die, the result is that the fillet is cut off under the head, and the riveted end is also cut, and does not give the clinch or hold desired. That is to say, rivet holes in plates to be riveted should have the burr or sharp edge taken off, either by countersinking, by reamer, or set.

*Heating of Rivets.*—Iron rivets are generally heated in an ordinary blacksmith's or rivet fire having a forced blast; they are inserted with the points down into the fire, so that the heads are kept practically cool.

Steel rivets should be heated in the hearth of a reverberatory furnace so arranged that the flame shall play over the top of the rivets, and should be heated uniformly throughout the entire length of the rivet to a cherry red. Particular attention must be given to the thickness of the fire in which they are heated.

Steel, of whatever kind, should never be heated in a thin fire, especially in one having a forced blast, such as an ordinary blacksmith's or iron rivet furnace fire. The reason for this is that more air passes through the fire than is needed for combustion, and in consequence there is a considerable quantity of free oxygen in the fire which will oxidize the steel, or in other words, burn it. If free oxygen is excluded steel cannot burn; if the temperature is high enough it can be melted and will run down through the fire, but burning is impossible in a thick fire with a moderate draught.

This is an important matter in using steel rivets and should not be overlooked; the same principle applies to the heating of steel plates for flanging.

*Riveting.*—There are four descriptions of riveting, namely:

- (1) Hammered or hand riveting.
- (2) Snapped or set.
- (3) Countersunk.
- (4) Machine.

For good, sound work, machine riveting is the best.

Snapped riveting is next in quality to machine riveting.



Countersunk riveting is generally tighter than snapped, because countersinking the hole is really facing it; and the countersunk rivet is, in point of fact, made on a face joint. But countersinking the hole also weakens the plate, inasmuch as it takes away a portion of the metal, and should only be resorted to where necessary, such as around the front of furnaces, steam chests or an odd hole here and there to clear a flange, or something of that sort.

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Hammered riveting is much more expensive than machine or snapped riveting, and has a tendency to crystallize the iron in the rivets, causing brittleness.

In the present state of the arts all the best machine riveters do their work by pressure, and not by impact or blow.

The best machines are those of the hydraulic riveting system, which combines all of the advantages and avoids all the difficulties which have characterized previous machine systems; that is to say, the machine compresses without a blow, and with a uniform pressure at will; each rivet is driven with a single progressive movement, controlled at will. The pressure upon the rivet after it is driven is maintained, or the die is retracted at will.

[Illustration: *Fig. 17.*]

Hydraulic riveting has demonstrated not only that the work could be as well done without a blow, but that it could be *better done without a blow*, and that the riveted material was stronger when so secured than when subjected to the more severe treatment under impact.

What is manifestly required in perfect riveting is that the metal of the rivet while hot and plastic shall be made to flow into all the irregularities of the rivet holes in the boiler sheets; that the surplus metal be formed into heads as large as need be, and that the pressure used to produce these results should not be in excess of what the metal forming the boiler shall be capable of resisting.

It is well known that metals, when subjected, either cold or hot, to sufficient pressure, will obey almost exactly the same laws as fluids under similar conditions, and will flow into and fill all the crevices of the chamber or cavity in which they are contained. If, therefore, a hot rivet is inserted into the holes made in a boiler to receive it, and is then subjected to a sufficient pressure, it will fill every irregularity of the holes, and thus fulfill one of the conditions of perfect riveting. This result it is impossible to accomplish with perfection or certainty by ordinary hand riveting, in doing which the intermittent blows of an ordinary hammer are used to force the metal into the holes. With a hydraulic riveting machine, however, an absolutely uniform and continuous pressure can be imparted to each rivet, so as to force the hot metal of the rivet into all the irregularities of the holes in the same way as a hydraulic ram will cause water to fill any cavity, however irregular.

[Illustration: *Fig. 18.*]

In order to illustrate the relative advantages of machine over hand riveting, two plates were riveted together, the holes of which were purposely made so as not to match perfectly. These plates were then planed through the center of the rivets, so as to expose a section of both the plates and rivets. From this an impression was taken with

printer's ink on paper and then transferred to a wooden block, from which Figs. 17 and 18 were made.

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The machine-driven rivet is marked *a*, and *b* represents the hammered rivet.

It will be observed that the machine rivet fills the hole completely, while the hand rivet is very imperfect. This experiment was tried several times, with similar results each time.

The hand rivet, it will be observed, filled up the hole very well immediately under the head formed by the hammer; but sufficient pressure could not be given to the metal—or at least it could not be transferred far enough—to affect the metal at some distance from the driven head. So great is this difficulty that in hand riveting much shorter rivets must be used, because it is impossible to work effectively so large a mass of metal with hammers as with a machine. The heads of the machine rivets are, therefore, larger and stronger, and will hold the plates together more firmly than the smaller hammered heads.

To drive rivets by hand, two strikers and one helper are needed in the gang, besides the boy who heats and passes the rivets; to drive each five-eighths inch rivet, an average of 250 blows of the hammer is needed, and the work is but imperfectly done. With a machine, two men handle the boiler, and one man works the machine; thus, with the same number of men as is required in riveting by hand, five rivets are driven each minute.

The superior quality of the work done by the machine would alone make its use advantageous; but to this is added greatly increased amount of work done.

The difference in favor of the riveting machine over hand riveting is at least *ten to one*.

In a large establishment a record of the number of rivets driven by the hand-driving gang, also by the gang at the steam-riveting machine for a long period of time, in both cases making no allowances of any kind of delays, the rivets driven per month by each was—for the hand driven rivets at the rate of twelve rivets per hour, and for the machine driven rivets, 120 per hour. In the case of the hand driven rivets the boiler remains stationary and the men move about it, while the machine driven rivets require the whole boiler to be hoisted and moved about at the riveting machine to bring each hole to the position required for the dies. Notwithstanding the trouble involved in handling and moving the boiler, it shows that it is possible to do ten times as much work, and with less skilled labor, by the employment of the riveting machine.

*Calking.*—One great source of danger in boiler making is excessive joint calking—both inside and out—where a sharp nosed tool is employed, and for the reason that it must be used so close to the inner edge of plate as to indent, and in many cases actually cut through the skin of the lower plate. This style of calking puts a positive strain upon the rivets, commencing distortion and putting excessive stress upon rivets—already in high tension before the boiler is put in actual use. It is, I hope, rapidly becoming a thing of the past.

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With a proper proportion of diameter and pitch of rivet, all that is required is the use of a light “fuller tool” or the round-nosed tool used in what is known to the trade as the “Connery system.”

There is but little need of calking if means are taken to secure a clean metal-to-metal face at the joint surfaces. When the plates are put together in ordinary course of manufacture, a portion of the mill scale is left on, and this is reduced to powder or shaken loose in the course of riveting and left between the plates, thus offering a tempting opening for the steam to work through, and is really cause of the heavy calking that puts so unnecessary a pressure on both plate and rivet. A clean metallic joint can be secured by passing over the two surfaces a sponge wet with a weak solution of sal-ammoniac and hot water, an operation certainly cheap enough both as to materials and labor required.

[Illustration: FIG. 19]

The above cut, Fig. 19, gives an illustration of calking done by sharp-nosed and round nosed tools, respectively. It will be seen by Fig. 20 that the effect of a round-nosed tool is to divide the plate calked, and as the part divided is well driven toward the rivets, a bearing is formed at *a*, from one-half to three-fourths of an inch, which increases the strength of joint, and will in no way cut or injure the surface of the under plate. A perfect joint is thus secured.

[Illustration: Fig. 20.]

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## THE NEW BRITISH BATTLE SHIP EMPRESS OF INDIA.

The launching of this first-class battle ship was successfully carried out at Pembroke Dockyard on May 7. She is the second of a class of eight battle ships built and building under the Naval Defense Act of 1889, which were specially designed to take part in general fleet actions in European waters. The leading dimensions are: Length, between perpendiculars, 380 ft.; breadth, extreme, 75 ft.; mean draught of water, 27 ft. 6 in.; and displacement at this draught, 14,150 tons, which surpasses that of any other ship in the navies of the world. Previous to the launching of the Royal Sovereign—a sister vessel—which took place at Portsmouth in February last, the largest war ships in the British navy were the Nile and Trafalgar, each of 12,500 tons, and these were largely exceeded in displacement by the Italia, of 13,900 tons, and the Lepanto, of 13,550 tons, belonging to the Italian navy.

The Empress of India is built throughout of mild steel, the stem and stern post, together with the shaft brackets, being of cast steel. Steel faced armor, having a maximum

thickness of 18 in., extends along the sides for 250 ft. amidships, the lower edge of the belt being 5 ft. 6 in. below the normal water line. The belt is terminated at the fore and after ends by transverse armored bulkheads, over which is built a 3 in. protective

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steel deck extending to the ends of the vessel and terminating forward at the point of the ram. Above the belt the broadside is protected by 5 in. armor, the central battery being inclosed by screen bulkheads of the same thickness. The barbetstes, which are formed of armor 17 in. thick, rise from the protective deck at the fore and after ends of the main belt. The principal armor throughout is backed by teak, varying in thickness from 18 in. to 20 in., behind which is an inner skin of steel 2 in. thick. The engines are being constructed by Messrs. Humphreys, Tennant & Co, London, and are of the vertical triple expansion type, capable of developing a maximum horse power of 13,000 with forced draught and 9,000 horse power under natural draught, the estimated speeds being 16 and 17 1/2 knots respectively at the normal displacement. The regular coal supply is 900 tons, which will enable the ship to cover a distance of 5,000 knots at a reduced speed of ten knots and about 1,600 knots at her maximum speed. The main armament of the Empress will consist of four 67 ton breechloading guns mounted in pairs *en barbette*. The secondary armament includes ten 6 in. 100 pounder quick firing guns, four being mounted on the main deck and six in the sponsons on the upper deck, sixteen 6 pounder and nine 3 pounder quick-firing guns, in addition to a large number of machine guns.

The largest guns at present mounted in any British warship are the 110 ton guns mounted in the Benbow class, and the difference between these weapons and those to be carried by the Empress of India is very marked.

The projectile fired from either of the Benbow's heavy gun weighs 1,800 lb., and is capable of penetrating 35 in. of unbacked wrought iron at a distance of 1,000 yards. The projectile fired from the 67 ton guns of the Empress of India will have much less penetrating power, being only equal to 27 in. of wrought iron with a full charge of 520 lb. of prismatic brown powder, the missile weighing 1,250 lb. or about one-half less than the weight of the shot used with the 110 ton gun. It will thus be seen that the ordnance of the Benbow can penetrate armor that would defy the attack of the guns of the Empress. It should be said, however, that the heavy artillery of the latter vessel is capable of penetrating any armor at present afloat, and is carried at a much greater height above the designed load water line than in any existing battle ship, either in the British or foreign navies. The armor being of less weight, too, enables the new ship, and others of her class, to carry an auxiliary armament of unprecedented weight and power.

The Empress will be lighted throughout by electricity, the installation comprising some 600 lights, and will be provided with four 25,000 candle power search lights, each of which will be worked by a separate dynamo. The ship has been built from the designs of Mr. W.H. White, C.B., Director of Naval Construction, and will be fitted out for the use of an admiral, and when commissioned her complement of officers and men will number 700.—*Industries*.



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### THE “IRON GATES” OF THE DANUBE.

The work of blowing up the masses of rock which form the dangerous rapids known as the Iron Gates, on the Danube, was inaugurated on September 15, 1890, when the Greben Rock was partially blown up by a blast of sixty kilogrammes of dynamite, in the presence of Count Szapary, the Hungarian premier; M. Baross, Hungarian minister of commerce; Count Bacquehem, Austrian minister of commerce; M. Gruitch, the Servian premier; M. Jossimovich, Servian minister of public works; M. De Szogyenyi, chief secretary in the Austro-Hungarian ministry of foreign affairs; and other Hungarian and Servian authorities. Large numbers of the inhabitants had collected on both banks of the Danube to witness the ceremony, and the first explosion was greeted with enthusiastic cheers. The history of this great scheme was told at the time the Hungarian Parliament passed the bill on the subject two years ago. It is known that the Roman Emperor Trajan, seventeen centuries ago, commenced works, of which traces are still to be seen, for the construction of a navigable canal to avoid the Iron Gates.

For the remedy of the obstruction in the Danube, much discussed of late years, there were two rival systems—the French, which proposed to make locks, and the English and American, which was practically the same as that of Trajan, namely, blasting the minor rocks and cutting canals and erecting dams where the rocks were too crowded. The latter plan was in principle adopted, and the details were worked out, in 1883, by the Hungarian engineer Willandt. The longest canal will be that on the Servian bank, with a length of over two kilometers and a width of eighty meters. It will be left for a later period to make the canal wider and deeper, as was done with the Suez Canal. For the present it is considered sufficient that moderate sized steamers shall be able to pass through without hindrance, and thus facilitate the exchange of goods between the west of Europe and the east.

The first portion of the rocks to be removed, and of the channels to be cut, runs through Hungarian territory; the second portion is in Servia. The new waterway will, it is anticipated, be finished by the end of 1895, and then, for the first time in history, Black Sea steamers will be seen at the quays of Pesth and Vienna, having, of course, previously touched at Belgrade. The benefit to Servian trade will then be quite on a par with that of Austria-Hungary. Even Germany will derive benefit from this extension of trade to the east. These, however, are by no means the only countries which will be benefited by the opening of the great river to commerce. Turkey, Southern Russia, Roumania, and Bulgaria, not to speak of the states of the west of Europe, will reap advantage from this new departure. England, as the chief carrier of the world, is sure to feel the beneficial effects of the Danube being at length navigable from its mouth right up to the very center of Europe.

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The removal of the Iron Gates has always been considered a matter of European importance. The treaty of Paris stipulated for freedom of navigation on the Danube. The London treaty of 1871 again authorized the levying of tolls to defray the cost of the Danube regulation; and article 57 of the treaty of Berlin intrusted Austria-Hungary with the task of carrying out the work. By these international compacts the European character of the great undertaking is sufficiently attested.

[Illustration: THE "IRON GATES" OF THE DANUBE]

The work of blasting the rocks will be undertaken by contractors in the employ of the Hungarian government, as the official invitation for tenders brought no offers from any quarter. The construction of the dams, however, and the cutting of several channels to compass the most difficult rocks and rapids, will be carried out by an association of Pesth and other firms. The cost, estimated altogether at nine million florins, will be borne by the Hungarian exchequer, to which will fall the tolls to be levied on all vessels passing through the Gates until the original outlay is repaid.

Very few persons know, says the *American Architect*, what an enormous work has been undertaken at the Iron Gates of the Danube, where operations are rapidly progressing, mainly in accordance with a plan devised many years ago by our distinguished countryman, Mr. McAlpine. The total length of that part of the river to be regulated is about two hundred and fifty miles, so that the enterprise ranks with the cutting of the Panama and Suez canals as one of the greatest engineering feats ever attempted. Work has been begun simultaneously at three points: at Greben, where there are reefs to be taken care of; at the cataract, near Jucz, and at the Iron Gate proper, below Orsova. At Greben, where the stream is shallow, but swift, a channel two hundred feet wide is to be blasted out of the rock, and below it a stone embankment wall is to be built more than four miles long. From a reef which projects into the river a piece is to be blasted away, measuring five hundred feet in length, and about nine feet in depth. The difficulties of working in this part of the river are very great. Not only is the current extremely rapid, but in certain places ridges of rock barely covered at low water alternate with pools a hundred and forty feet deep, which give rise, in the rapid current, to frightful whirlpools and eddies. These deep pools are to be filled at the same time that the reefs are cut away, and it is estimated that nearly three million cubic feet of loose stonework will be needed for this purpose alone. In addition to the excavation, artificial banks and breakwaters, for modifying the course of the stream, are to be built; so that it is estimated that the masonry to be executed in this section will amount to about five and one-half million cubic feet.

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In the cataract section, at Jucz, a channel two hundred feet wide, and more than half a mile long, is to be blasted out of the rock, and a breakwater built, to moderate the suddenness of the fall. This breakwater is to be about two miles long, and ten feet thick at the top, increasing in thickness toward the bottom. The rock in which the channel must be cut at this point is partly serpentine greenstone, partly chrome iron ore, and is intensely hard. In the section of the Iron Gate, the work to be done consists in "canalizing" the river for a distance of a mile and a half, by building a wall on each side, and excavating the bed of the river between. The channel between the walls will be two hundred and fifty feet wide. It is estimated that nearly three million cubic feet of rock will have to be excavated here, all of which will be used to fill in behind the embankment walls. Of course, the greater part of the rock will be removed by means of blasting with high explosives, but some of it is to be attacked with a novel instrument, which was first tried, on a small scale, on the Panama Canal, and is to be used for serious work here. This instrument, as it is to be employed on the Danube, consists of an enormous steel drill, thirty-three feet long, and weighing ten tons. By means of a machine like a pile driver, this monstrous tool is raised to a height of about fifty feet, and allowed to drop, point first. So heavy a mass of metal, falling from a considerable height, meets with comparatively little resistance from the water, and the point shatters and grinds up the rock on which it strikes. Fifty or sixty blows per minute can be struck with a tool of this kind, and ten thousand blows in all can be inflicted before the tool is so worn as to be past service. Several of these drills will be at work at the same time, and to remove the fragments of rock which they break off, a huge dredge of three hundred and fifty horse power is to be employed. For excavating by means of explosives, arrangements have been made for drilling the holes for the cartridges with the greatest possible rapidity, as on this depends the celerity with which the work can be pushed forward. Much of the work will be done by means of diamond drills, which are mounted on boats. Five of these boats have been provided, each with seven diamond drills, arranged so as to work perfectly in twenty feet of water. Other boats are fitted with pneumatic drills, which are operated by means of air, compressed to a tension of seven hundred and fifty pounds to the square inch. The pressure of the compressed air is transmitted by means of water to the drills, which act by percussion, and work very rapidly. These drills are curiously automatic in their operation. After boring the holes to the allotted depth, the machine automatically sets in each a tube, washes out the dust, inserts a dynamite cartridge, withdraws the tube, and connects the wire of the electric fuse in the cartridge with the battery wire in the boat.



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The cartridges are charged with a pound of dynamite to each. In hard rock only one charge is fired at a time, but in softer material four are fired at once. If the water over the work is deep, the boat is not moved from its position, but in shallow water it is towed a few yards away from the spot where the explosion is to take place. The drill holes are about six feet deep, and are spaced at the rate of about one to every three square feet, something, of course, depending upon the character of the rock. The whole work is now under contract, the mechanical engineering firm of Luther, of Brunswick, having undertaken to complete it in five years, for a payment of less than four million dollars.

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### **THE NEW GERMAN SHIP CANAL.**

The gates which admit the water into the new canal which is to connect the Baltic with the North Sea have been recently opened by the Emperor William. This canal is being constructed by the German government principally for the purpose of strengthening the naval resources of Germany, by giving safer and more direct communication for the ships of the navy to the North German ports. The depth of water will be sufficient for the largest ships of the German navy. The canal will also prove of very great advantage to the numerous timber and other vessels trading between St. Petersburg, Stockholm, Dantzic, Riga, and all the North German ports in the Baltic and this country. The passage by the Kattegat and Skager Rack is exceedingly intricate and very dangerous, the yearly loss of shipping being estimated at half a million of money. In addition to the avoidance of this dangerous course, the saving in distance will be very considerable. Thus, for vessels trading to the Thames the saving will be 250 miles, for those going to Lynn or Boston 220, to Hull 200, to Newcastle or Leith 100. This means a saving of three days for a sailing vessel going to Boston docks, the port lying in the most direct line from the timber ports of the Baltic to all the center of England. The direction of the canal is shown by the thick line in the accompanying sketch map of the North Sea and Baltic. Considering that between 30,000 and 40,000 ships now pass through the Sound annually, the advantage to the Baltic trade is very apparent.

[Illustration: THE NEW GERMAN SHIP CANAL.]

The new canal starts at Holtenau, on the north side of the Kiel Bay, and joins the Elbe fifteen miles above the mouth. From Kiel Bay to Rendsborg, at the junction with the Eider, the new canal follows the Schleswig and Holstein Canal, which was made about one hundred years ago, and is adapted for boats drawing about eight feet; thence it follows the course of the Eider to near Willenberg, when it leaves that river and turns southward to join the Elbe at Brunsbuttel, about forty miles below Hamburg. The canal is 61 miles long, 200 ft. wide at the surface, and 85

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ft. at the bottom, the depth of water being 28 ft. The surface of the water in the two seas being level, no locks are required; sluices or floodgates only being provided where it enters the Eider and at its termination. The country being generally level there are no engineering difficulties to contend with, except a boggy portion near the Elbe; the ground to be removed is chiefly sandy loam. Four railways cross the canal and two main roads, and these will be carried across on swing bridges. The cost is estimated at L8,000,000. About six thousand men are employed on the works, principally Italians and Swiss.—*The Engineer*.

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### THE KIOTO-FU CANAL, IN JAPAN.

Japan is already traversed by a system of railways, and its population is entering more and more into the footsteps of western civilization. This movement, a consequence of the revolution of 1868, is extending to the public works of every kind, for while the first railway lines were being continued, there was in the course of excavation (among other canals) a navigable canal designed to connect Lake Biwa and the Bay of Osaka, upon which is situated Kioto, the ancient capital of Japan.

The work, which was begun in 1885, was finished last year, and one of our readers has been kind enough to send us, along with some photographs which we herewith reproduce, a description written by Mr. S. Tanabe, engineer in chief of the work.

The object of the Kioto-Fu Canal is not only to provide a navigable watercourse, putting the interior of the country in connection with the sea, but also to furnish waterfalls for supplying the water works of the city of Kioto with the water necessary for the irrigation of the rice plantations, and that employed for city distribution. It starts from the southwest extremity of Lake Biwa, the largest lake in Japan, and the area of which is 800 square kilometers. This lake, which is situated at 84 meters above the level of the sea, is 56 kilometers from the Bay of Osaka. As this bay is already in communication with Kioto by a canal, the Kioto-Fu forms a junction with the latter after a stretch of 11 kilometers and a difference of level of 45 meters between its extremities.

[Illustration: FIG. 1.—EXTREMITY OF LAKE BIWA AND BEGINNING OF THE CANAL.]

The lake terminates in a marshy plain (Fig. 1), in which the first excavation was made. This is protected by longitudinal dikes which lead back the water to it in case of freshets. At the end of this cutting, which is 100 meters in length, begins the canal properly so called, with a width of 5.7 meters, at the surface, and a depth of 1.5 meters, for a length of 540 meters. It then reaches the first tunnel for crossing the Nagara-yama

chain. This tunnel is 2,500 meters in length, 4.8 in width and 4.2 in height. The water reaches a depth of 1.8 meters upon the floor. It was pierced through

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very varied materials, such as clay, schists, sandstone and porphyry, and is lined throughout with brick masonry. The construction was effected by means of a working shaft 45 meters in depth, sunk in the axis of the work, at a third of its length from the west side. At the upper extremity are established sluices that permit of securing to the canal a constant discharge of 8.5 cubic meters per second. Fig. 2 represents the head of this work.

[Illustration: FIG. 2.—HEAD OF THE PRINCIPAL TUNNEL.]

Starting from the tunnel, the canal extends in the open air for a length of 4,500 meters. To reach the basin of Kioto, it traverses the Hino-oko-yama chain of hills, through two tunnels of the same section and construction as the one just mentioned, and of the respective lengths of 125 and 841 meters. Traction in the tunnels is to be effected by means of an immersed chain.

On leaving tunnel No. 3, at about 8,400 meters from its origin, the canal divides into two branches. The first of these, which is designed to serve as a navigable way, has a slope 0.066 per meter for a length of 540 meters. It is a true inclined plane, which the boats pass over by means of a cradle carried by trucks and drawn by a cable actuated by the fall furnished by the other branch. At the foot of the inclined plane, the canal widens out to 18 meters at the surface, with a depth of 1.5 meter, and, through a sluice, joins the Osaka Bay Canal, after a stretch of 2 kilometers.

[Illustration: FIG. 3.—AQUEDUCT OVER THE VALLEY OF THE TOMBS OF THE EMPERORS.]

The second branch traverses a small tunnel, crosses the valley of the emperors' tombs upon an aqueduct of 14 arches (Fig. 3), and reaches Kogawa, a faubourg north of Kioto, after a stretch of 8 kilometers. Its slope is greater than that of the main canal, from which it derives but 1.4 cubic meter. The 7 cubic meters remaining may be employed for the production of motive power under a fall of 56 meters. It is proposed to utilize a portion of it, at the point of bifurcation and at the top of the inclined plane, in a hydraulic installation that will drive electric machines. The total cost of the work was one million dollars, a third of which was furnished by the imperial treasury, a quarter by the central government, and the rest by various taxes.—*La Nature*.

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HOW TO FIND THE CRACK.—Most mechanics know that by drilling a hole at the inner end of a crack in cast metal its extension can be prevented. But to find out the exact point where the crack ends, the *Revue Industrielle* recommends moistening the cracked surface with petroleum, then, after wiping it, to immediately rub it with chalk. The oil that



has penetrated into the crack will, by exudation, indicate the exact course and end of the crack.

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## **FAST AND FUGITIVE DYES.[1]**



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[Footnote 1: A paper recently read before the Society of Arts, London.]

By Prof. J.J. HUMMEL.

As it is with many other arts, the origin of dyeing is shrouded in the obscurity of the past; but no doubt it was with the desire to attract his fellow that man first began to imitate the variety of color he saw around him in nature, and colored his body or his dress.

Probably the first method of ornamenting textile fabrics was to stain them with the juices of fruits, or the flowers, leaves, stems, and roots of plants bruised with water, and we may reasonably assume that the primitive colors thus obtained would lack durability.

By and by, however, it was found possible to render some of the dyes more permanent, probably in the first instance by the application of certain kinds of earth or mud, as we know to be practiced by the Maori dyers of to-day, and in this way, as it appears to me, the early dyers learnt the efficacy of what we now call "mordants," which I may briefly describe as fixing agents for coloring matters.

At a very remote period therefore, I imagine, the subject of fast and fugitive dyes engaged the attention of textile colorists.

Our European knowledge of dyeing seems to have come to us from the East, and although at first indigenous dyestuffs were largely employed, with the discovery of new countries many of these fell slowly and gradually into disuse, giving way to the newly imported dyestuffs of other lands, which possessed some advantage, being either richer in coloring matter, yielding brighter or faster colors, or being capable of more easy application. Thus kermes gave way to cochineal, woad to indigo, and so on.

Down to about the year 1856, natural dyestuffs alone, with but one or two exceptions, were employed by dyers; but in that year a present distinguished member of this Society, Dr. Perkin, astonished the scientific and industrial world by his epoch-making discovery of the coal tar color mauve. From that time down to the present, the textile colorist has had placed before him an ever increasing number of coloring matters derived from the same source.

Specially worthy of notice are the discoveries of artificial alizarin, in 1868, by Graebe and Liebermann, and of indigotin, in 1878, by Adolf Baeyer, both coloring matters being identical with the respective dyes obtained from plants.

In view of the vast array of coal tar colors now at our disposal, and their almost universal application in the decoration of all manner of textile fabrics, threatening even the continued use of well known dyestuffs of vegetable origin, it becomes of the greatest

importance to examine most thoroughly, and to compare the stability of both old and new coloring matters.

The first point in discussing this question of fast and fugitive dyes is to define the meaning of these terms "fast" and "fugitive." Unfortunately, as frequently employed, they have no very definite signification. The great variety of textile fabrics to which coloring matters are applied, the different stages of manufacture at which the coloring matter is applied, and the many uses to which the fabrics are ultimately put, all these are elements which cause dyed colors to be exposed to the most varied influences.

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The term a “fast color,” then, may convey a different meaning to different individuals. To one it implies that the color will not fade when exposed to light and atmospheric conditions; to another that it is not impoverished by washing with soap and water; to a third it may indicate that the color will withstand the action of certain manufacturing operations, such as scouring, milling, stoving, *etc.*; while a fourth person might be so exacting as to demand that a fast color should resist all the varied influences I have named.

It is well to state at once that no dyed color is absolutely fast, even to a single influence, and it certainly cannot pass unscathed through all the operations to which it may be necessary to submit individual colors applied to this or that material. Many colors are fast to washing or milling, and yet very fugitive to light; others are fast to light, but fugitive toward milling; while others again are fast to both influences. In short, each color has its own special, characteristic properties, so that colors may be classified with respect to each particular influence, and may occupy a very different rank in the different arrangements.

It is, however, by no means necessary to demand absolute fastness from any color. A color may “bleed” in milling, and therefore be very unsuitable for tweeds, and yet be most excellent for curtains and hangings, because of its fastness to light. So, too, a dye capable of yielding rich or delicate tints, but only moderately fast to light, may still be perfectly well adapted for the silks and satins of the ball room, or even the rapidly changing fashion, although it would be quite inadmissible for the pennon at the masthead.

The colors of carpets, curtains, and tapestry should certainly be fast to light, but no one expects them to undergo the fatigue of the weekly washtub; and just as little as we look for the exposure of flannels and hosiery, day by day and week by week, to the glare of sunlight, much as we desire that the colors shall not run in washing.

For all practical purposes, then, it seems reasonable to define a “fast color” as one which will not be materially affected by those influences to which, in the natural course of things, it will be submitted. Hence, in speaking of a fast color, it becomes necessary to refer specially to the particular influences which it resists before the term acquires a definite meaning. To be precise, one should say that a color is “fast to light,” or “fast to washing,” or “fast to light and washing,” and so on. Further, it is necessary, as we shall see afterward, to give always the name of the fiber to which the color is applied.

All that I have said with respect to the term “fast” may be applied with equal propriety to the term “fugitive.” This, too, has no very definite meaning until a qualifying statement, such as I have referred to, gives it precision.

The most important question to be considered is

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### THE ACTION OF LIGHT ON DYED COLORS.

That light can effect radical changes in many substances was known to the ancients. Its destructive action on artists' pigments, *e.g.*, the blackening of vermilion, was recorded 2,000 years ago by Vitruvius. Since that time it has been well established, by numerous observations and experiments, that light possesses, in a high degree, the power of exerting chemical action, *i.e.*, causing the combination or decomposition of a large number of substances. The union of chlorine with hydrogen gas, the blackening of silver salts, the reduction of bichromate of potash and of certain ferric salts in contact with organic substances, are all familiar instances of the action of light. In illustration of this, I show here some calico prints produced by first preparing the calico with a solution of potassium bichromate, then exposing the dried calico under a photographic negative, and, after washing, dyeing with alizarin or some similar coloring matter. During the exposure under the negative, the light has reduced and fixed the chromium salt upon certain parts of the fiber as insoluble chromate of chromium ( $\text{Cr}_2\text{O}_3\text{CrO}_3$ ) in the more protected portions, the bichromate remains unchanged, and is subsequently removed by washing. During the dyeing process, the coloring matter combines with the chromium fixed on the fiber, and thus develops the colored photograph.

The prints in Prussian blue are produced in a similar manner, the sensitive salt with which the calico is prepared being ammonium ferricitrate, and the developer potassium ferricyanide.

Investigation has shown that the most chemically active rays are those situated at the blue end of the solar spectrum; and although all the rays absorbed by a sensitive colored body affect its change, it is doubtless the blue rays which are the chief cause of the fading of colors. Experiments are on record, indeed, which prove this.

Depierre and Clouet (1878-82) exposed a series of colors, printed and dyed on calico, to light which had passed through glasses stained red, orange, yellow, green, blue, and violet, corresponding to definite parts of the spectrum. They found that the blue light possessed the greatest fading power, red light the least.

More recently (1886-88) Abney and Russell exposed water colors under red, green, and blue glass, and came to the same conclusion.

But the chemical energy of the sun's rays is not the sole cause of the fading of colors. There are certain contributory causes as important as the light itself.

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About fifty years ago, Chevreul showed what these accessory causes are, by exposing to light a number of dyed colors under varied conditions, *e.g.*, in a vacuum, in dry and moist hydrogen, dry and moist air, water vapor, and the ordinary atmosphere. He found that such fugitive colors as orchil, safflower, and indigo-carmin fade very rapidly in moist air, less rapidly in dry air, and that they experience little or no change in hydrogen or in a vacuum. The general conclusion arrived at was, that light, when acting alone, *i.e.*, without the aid of air and moisture, exercises a very feeble influence. Further, it was determined that the air and moisture, without aid of light, have also comparatively little effect on dyed colors. Abney and Russell, in their experiments with water colors, obtained similar results.

These conclusions are exactly in accordance with our common knowledge of the old fashioned method of bleaching cotton and linen, in which the wetted fabric is exposed to light on the grass, and frequently sprinkled with water. If the material becomes dry through the absence of dew or rain, or the want of sprinkling, little or no bleaching takes place.

The one color which Chevreul found to behave abnormally was Prussian blue. This faded even in a vacuum; but, strange to say, on keeping the faded color in the dark, and exposed to air, the color was restored. It was shown that, during the exposure to light, the color lost cyanogen, or hydrocyanic acid, while in the dark and exposed to the air, oxygen was absorbed. Chevreul concluded, therefore, that the fading of Prussian blue was due to a process of reduction.

The prevailing opinion, however, is that the fading of colors is a process of oxidation, caused by the ozone, or hydrogen peroxide, which is probably formed in small quantity during the evaporation of the moisture present, and both these substances are powerful bleaching agents.

It would be extremely convenient to have some rapid method of testing colors for fastness to light, and I believe it is the custom with some to apply certain chemical tests with this object in view. The results of my own experiments in this direction lead me to the conclusion that at present we have no sufficient substitute for sunlight for this purpose, since I have not found any oxidizing or reducing substance which affects dyed colors in all respects like the natural color-fading agencies; further, I am inclined to the opinion that the action of light varies somewhat with the different coloring matters, according to their chemical constitution and the fiber upon which they are applied.

With respect to this last point, Chevreul actually found that colors are faster to light on some fibers than on others, and this fact, which is generally known to practical men, is abundantly shown in the diagrams on the wall. As a rule we may say that colors are most fugitive on cotton and most permanent on wool, those on silk holding an intermediate position. Still there are many exceptions to this order, especially as between silk and wool.



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Since the time of Chevreul, the action of light on dyed colors has not been seriously and exhaustively studied. From time to time, series of patterns dyed with our modern colors have been exposed to light, *e.g.*, by Depierre and Clouet, Joffre, Muller, Kallab, Schmidt, and others; but the published results must at best be considered as more or less fragmentary. Under the auspices of the British Association, and a committee appointed at its last meeting in Leeds, I hope to have the pleasure during the next few years of studying this interesting subject.

To-night I propose to give you some of the prominent results already obtained in past years, in the dyeing department of the Yorkshire College, where it has been our custom to expose to light and other influences the patterns dyed by our students. Further, I wish to give you an ocular demonstration of the action of light on dyed colors, by means of these silk, wool, and cotton patterns, portions of which have been exposed for 34 days and nights on the sea coast near Bombay, during the month of February of this year.

I may remark that this test has been a very trying one, for I estimate that it is equal to more than a year's exposure in this country. During the whole period there was cloudless sunshine, without any rain, and each evening heavy dew. I have pleasure in acknowledging the services of Mr. W. Reid, a former student, who superintended the exposure of the patterns, and from time to time took notes of the rate at which individual patterns faded.

These diagrams contain, perhaps, the most complete series of both old and new dyes, on the three fibers, which have been simultaneously exposed to sunlight, and they form an instructive object lesson.

Let me first direct your attention to the diagram containing the *natural coloring matters*—those dyestuffs which were in use previous to 1856. Broadly speaking, they are of two kinds; those which dye textile materials “direct,” and those which give no useful color without the aid of certain metallic salts, called “mordants.”

Now, among the natural coloring matters, these “mordant dyes,” as they may be conveniently termed, are much more numerous than the “direct dyes;” but be it observed, we have fast and fugitive colors in both classes.

Referring first to the wool patterns and to the “direct dyes,” we find that the only really fast colors are Prussian blue and Vat indigo blue. Turmeric, orchil, catechu, and indigo carmine are all extremely fugitive.

As to the “mordant dyes,” some yield fast colors with all the usual mordants, *e.g.*, madder, cochineal, lac dye, kermes, *viz.*, reds with tin and aluminum, claret browns with copper and chromium, and dull violets with iron.

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Other dyestuffs, like camwood, brazilwood, and their allies, also young fustic, give always fugitive colors whatever mordant be employed; others again, *e.g.*, weld, old fustic, quercitron bark, flavin, and Persian berries, give fast colors with some mordants and fugitive colors with others; compare, for example, the fast olives of the chromium, copper, and iron mordants with the fugitive yellows given by aluminum and tin. A still more striking case is presented by logwood, which gives a fast greenish-black with copper and very fugitive colors with aluminum and tin. Other experiments have shown that the chromium and iron logwood blacks hold an intermediate position. Abnormal properties are found to be exhibited by camwood and its allies, with aluminum and tin, the colors at first becoming darker, and only afterward fading in the normal manner.

When we examine the silk patterns, we find, generally speaking, a similar degree of fastness among the various natural dyes, as with wool; in some instances the colors appear even faster, notice, for example, the catechu brown and the colors given by brazilwood and its allies, with iron mordant.

On examining the cotton patterns, we are at once struck with the marked fugitive character of nearly all the natural dyes. The exceptions are: the madder colors, especially when fixed on oil-prepared cotton, as in Turkey red; the black produced by logwood, tannin, and iron; and a few mineral colors, *e.g.*, iron buff, manganese brown, chromate of lead orange, *etc.*, and Prussian blue. Cochineal and its allies, which are such excellent dyes for wool and silk, give only fugitive colors on cotton.

The main point which arrests our attention in connection with the natural dyes seems to me to be the comparatively limited number of fast colors. Very remarkable is the total absence of any really fast yellow vegetable dye, and it is probably on this account that gold thread was formerly so much introduced into textile fabrics. Notice further the decided fastness of Prussian blue, especially on wool and silk; while we cannot but remark the comparatively fugitive character of vat indigo blue on cotton, and even on silk, compared with the fastness of the same color when fixed on wool.

Now, let us turn our attention to the *artificial coloring matters*, derived with few exceptions from coal tar products.

Here again we have two classes, "mordant dyes" and "direct dyes." Both classes are somewhat numerous, but whereas the former may be conveniently shown on a single diagram sheet, it requires a considerable number to display the latter.

First let us examine the wool patterns dyed with the "mordant dyes."

We find there a few yellow dyes quite equal in fastness to those of natural origin, or even somewhat surpassing them, *e.g.*, two of the alizarin yellows, *viz.*, those marked R and G G W. Except in point of fastness and mode of application, I may say that these are not true alizarin colors, neither are they analogous to the natural yellow dyestuffs,

for they are incapable of giving dark olives with iron mordants. Truer representatives of the natural yellow dyes appear, however, to exist in galloflavin and the alizarin yellows marked A and C, and, as you see, they are of about the same degree of fastness.

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Among the red dyes we have alizarin and its numerous allies, and these are certainly fit representatives of the madder root, which indeed they have almost entirely displaced. The most recent additions to this important class are the various alizarin Bordeaux. The only dyes in this group which appear somewhat behind the rest in point of fastness are purpurin and alizarin maroon.

On this same diagram we notice, also, fast blues and dark greens, of which we have no similar representatives among the natural coloring matters. I refer to alizarin blue, alizarin cyanin, alizarin indigo, alizarin green, and coerulein.

Further, an excellent group of coloring matters, giving fast browns and greens with copper and iron mordants respectively, is formed by naphthol green, resorcinol green, gambin, and dioxin.

The only fugitive dyes of the class now under consideration are some of the yellows, gallamin blue and gallocyanin.

If we now turn to examine the colors given by these artificial "mordant dyes" on silk, we notice, also, a good series of fast colors similar to those which they give on wool; and even on cotton we see many fast colors, of which we have no representatives among the dyewoods.

If we were not prepared to find so few really fast natural dyes, surely we cannot but be surprised to find what a considerable number of fast dyes are to be met with among the coal tar coloring matters requiring the aid of mordants.

On these diagrams, the first vertical column shows the stain given by the coloring matter alone; the remaining columns show the colors obtained when the same coloring matters are applied in conjunction with the several mordants—chromium, aluminum, tin, copper, and iron.

It was formerly held that the office of a mordant was merely to fix the coloring matter upon the fiber; we now know, however, and it is plainly illustrated by these diagrams, that this view is erroneous, for the mordant not only fixes but also develops the color; the mordant and coloring matter chemically combine with each other, and the resultant compound represents the really useful pigment or dye. If a coloring matter is combined with different mordants, the dyes thus obtained represent distinct chemical products, and it is quite natural, therefore, to find them differing from each other in color, and their resistance toward light.

Knowing this, it is clearly the duty of the dyer to apply each coloring matter of this class with a variety of mordants, and to select the particular combination which gives him the desired color and fastness. By adopting this method, however, his selection would ultimately comprise a large number of coloring matters paired with a great variety of

mordants. In order, therefore, to avoid the intricacy involved in the use of several mordants, and to simplify the process of dyeing, especially when dyeing compound shades, the dyer prefers to limit himself as far as possible to the use of a single mordant, and to employ along with it a mixture of several coloring matters.

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Now the woolen dyer has largely adopted an excellent mordant in bichromate of potash; it is cheap, easily applied, and not perceptibly injurious to the fiber. It is his desire, therefore, to have a good range of red, yellow, blue, and other coloring matters, all giving fast dyes with this mordant. This action and desire on the part of the dyer has more and more placed the problem of producing fast colors upon the shoulders of the color manufacturer or chemist, and right well has the demand been met, for in the diagram on the wall we see how, in the alizarin colors and their allies, he has already furnished the dyer with a goodly number of dyestuffs yielding fast dyes with this chosen mordant of the woolen dyer. Since, however, they yield fast colors with other useful mordants, and upon other fibers than wool, these alizarin colors prove of the greatest value to the dyer of textile fabrics generally. Let us not forget the fact, then, that it is among the "mordant dyes," the very class to which belong most of the natural coloring matters, that we find our fastest coal tar dyes.

When we examine the results of actual exposure experiments, such as are here shown on these four diagram sheets, surely we have no hesitation in declaring how utterly false is the popular opinion that all coal tar colors are fugitive to light, while the good old-fashioned natural dyes are all fast. The very opposite indeed is here shown to be the case. For myself, I feel persuaded that at the present time the dyer has at his command a greater number of fast dyes derived from coal tar than from any other source, and I believe it possible to produce with dyes obtained from this source alone, if need be, tapestries, rugs, carpets, and other textile fabrics which shall vie successfully in point of color and duration of color with the best productions of the East, either of this or any other age.

How, then, does it happen that these coal tar colors have been so long and so seriously maligned by the general public? Apart from the fact that public opinion has been based upon an imperfect knowledge of the subject, we shall find a further explanation when we examine the diagrams showing the "direct dyes" obtained from coal tar. According to their mode of application I have here arranged them in three large groups, *viz.*, basic, acid, and Congo colors. A fourth group, comprising comparatively few, is made up of those colors which are directly produced upon the fiber itself.

The "basic colors" have a well known type in magenta. They are usually applied to wool and silk in a neutral or slightly alkaline bath; on cotton they are fixed by means of tannate of antimony or tin. The "acid colors" are only suitable for wool and silk, to which they are applied in an acid bath. A typical representative of this group is furnished by any one of the ordinary azo scarlets which in recent years have come into prominence as competitors of cochineal. The "Congo

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colors” are comparatively new, and are conveniently so named from the first coloring matter of the group which was discovered, *viz.*, Congo red. They are applicable to wool, silk, and cotton, usually in a neutral or slightly alkaline bath. Of the dyes produced directly upon the fiber itself, one may take aniline black and also primulin as a type, the latter a dye somewhat recently introduced by Mr. A.G. Green, of this city.

Our first impression, in looking at these “direct dyes,” is that they are more numerous and more brilliant than the “mordant dyes,” and that they are for the most part fugitive. Still, if we examine the different series in detail, we shall find here and there, on the different fibers, colors quite equal in fastness to any of the “mordant dyes.”

Among the “basic colors” we search in vain, however, for a really fast dye on any fiber. Still, Magdala red, perhaps, appears faster than the rest on silk, and among the greens and blues we find a few dull blues on cotton, which, for this fiber, have been recommended as substitutes for indigo, *viz.*, Indophenin, paraphenylene, blue, cinerein, Meldola’s blue, *etc.* The azine greens, also, appear tolerably fast on cotton and on silk, but although possessing some body of color, after exposure, the original dark green has changed to a decided drab.

When we examine the “acid colors,” however, we meet with a number of scarlets, crimsons, and clarets, possessing considerable fastness both on wool and on silk. Some, indeed, appear almost, if not entirely, as fast as cochineal scarlet, *e.g.*, Biebrich scarlet, brilliant crocein, *etc.*

Among the “acid oranges and yellows,” we also find a goodly number which are of medium fastness. About ten, either on wool or on silk, may even be accounted really fast, and are fit, apparently, to rank with alizarin colors. Note, for example, on wool: Crocein orange, aurantia, orange crystal, tartrazin, milling yellow, palatine orange; on silk, acid yellow D, brilliant yellow, azo acid yellow, metanil yellow, curcumin S, *etc.* I may remark that these are some of the fastest yellows on wool and silk with which we are acquainted. It is interesting to note the decided fugitive character, on silk, of tartrazin, aurantia, orange crystal, *etc.*, compared with their great fastness on wool. Observe, also, how, on wool, the pale lemon yellow of picric acid has changed to a full reddish brown.

Among the “acid greens and blues,” all the colors are fugitive, both on wool and on silk. Patent blue appears slightly better than the rest. Of the “acid blacks and violets,” a few colors are of medium fastness, both on wool and silk, *e.g.*, naphthol black, naphthylamine, black, resorcinol brown, fast brown, *etc.*

When we examine the Congo colors, amid a number of very fugitive colors, we find a few which are satisfactorily fast. Among the reds, for example, diamine fast red is quite

remarkable for its fastness, both on wool and silk, and may certainly rank with alizarin; but on cotton, it is quite as fugitive as the rest. Of medium fastness on wool are brilliant Congo G and R, Congo G R; and on silk, diamine scarlet B, deltapurpurin 5 B, and brilliant Congo R.

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Among the “Congo oranges and yellows,” we find some of the fastest on cotton of this class of colors. Still they deserve only the rank of medium fastness. They are Mikado orange 4 R, R, G. Hessian yellow, curcumin S, chrysophenin. On wool, we have about half a dozen of medium fastness, *viz.*, benzo-orange, Congo orange R, chrysophenin G, chrysamin R, brilliant yellow. On silk, however, we find in this group about a dozen of the fastest oranges and yellows with which we are acquainted for this fiber, *viz.*, Congo orange R, chrysophenin G, diamine yellow N, brilliant yellow, curcumin W, benzo orange, Hessian yellow, chrysamin R and G, cresotin yellow R and G, cotton yellow G, and carbazol yellow.

Does it not appear somewhat remarkable that we should find among this generally fugitive group of coloring matters colors which are so eminently fast on silk, and which we entirely fail to meet with among those groups which usually furnish our fast colors, *e.g.*, the alizarin group?

Passing on to the “Congo violets, blues, and purples,” we find few colors worthy of particular notice for fastness. Diamine violet N appears, perhaps, of medium fastness on wool and silk, while sulphonazurin, benzo-black blue, and direct gray may claim the same distinction on silk.

In the small group of colors which are produced directly upon the fiber, none seems to call for special notice, except aniline black, which, notwithstanding its direct derivation from aniline, is probably the fastest color we have upon any fiber.

Now, in classifying the whole range of coal tar coloring matters into “mordant dyes” and “direct dyes,” and the latter into acid, basic, Congo colors, *etc.*, I have looked at them from the point of view of the dyer and arranged them according to color and mode of application. The chemist, however, classifies them quite differently, *viz.*, according to their chemical constitution, *i.e.*, the arrangement of the atoms of which they are composed, and thus we have nitro colors, phthaleins, azines, and so on.

In studying the action of light on the coal tar colors from this point of view, we find that whereas the members of some groups are for the most part fugitive, the members of other groups are nearly all fast, and it becomes at once apparent that the chemical constitution of a coloring matter exercises a profound influence upon its behavior toward light. Members of the rosaniline group are all similarly fugitive, while those of the alizarin group possess generally the quality of fastness. Particularly fugitive are the eosins, and yet some of these, by a slight modification of constitution, *e.g.*, the introduction of an ethyl group, as in ethyl-eosin, are rendered distinctly faster.

In the azo group some colors are fugitive, others are moderately fast, and it is generally recognized that certain classes of the tetrazo compounds are distinctly faster than the ordinary diazo colors.

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By a careful study of the influence of the atomic arrangement upon the stability of colors, information useful to the color manufacturer may possibly be gained, but at present my facts are not yet sufficiently tabulated to enable one to recognize any generally pervading law in this direction.

It is scarcely necessary to say that the fastness to light of a color is independent of its commercial value, this being mainly determined by the price of the raw material from which it is manufactured, the working expenses, and the profit desired by the manufacturer. Neither must we suppose that facility of application necessarily interferes with its fastness to light, for some of our fastest coal tar colors on wool, *e.g.*, diamine fast red, tartrazin, *etc.*, are applied in the simplest possible manner. On the other hand, the intensity or depth of a color has considerable influence on its fastness. Dark full shades invariably appear faster than pale ones produced from the same coloring matter, simply because of the larger body of pigment present. A pale shade of even a very fast color like indigo will fade with comparative rapidity. The fugitive character of many of the coal tar colors is, in my opinion, rendered more marked, because, owing to their intense coloring power, there is often such an infinitesimal amount of coloring matter on the dyed fiber. Hence it is that in the Gobelin tapestries pale shades on wool are frequently obtained by the use of more or less unchangeable metallic oxides and other mineral colors, to the exclusion of even fast vegetable dyes.

It is interesting to examine what is the action of light upon compound colors. Is a fugitive color rendered faster by being applied along with a fast color?

My own opinion, based upon general observation, is that it is not, and that when light acts upon a compound color the unstable color fades, while the stable color remains behind. A woaded color, for example, is only fast in respect of the vat indigo which it contains, and yet how frequent is the custom to unite with the indigo such dyes as barwood, orchil, and indigo-carmine, the fugitive character of which I have pointed out.

Having thus rapidly surveyed these numerous coal tar colors, both in their dyed and exposed conditions, I again ask why are they so generally regarded as altogether fugitive?

First, because we have, especially among these "direct dyes," a very large number which are undoubtedly very fugitive.

Moreover, all the earlier coal tar dyes—mauve, magenta, Nicholson blue, *etc.*, belonged to a class which, even up to the present time, has only furnished us with fugitive colors. They were indeed prepared from aniline, and it appears to me that the defects of these early aniline colors, as well as their designation, have been handed down to their successors without due discrimination, so that in the popular mind the term "aniline color" has become, as a matter of habit, synonymous with "fugitive color." But science is progressive, fields of investigation other than aniline have been opened up, so that

now, although a large number of fugitive dyes are still manufactured from coal tar, there are others, as we have seen, which are as fast and permanent as we have ever had from natural sources.

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Finally, and perhaps this is the most important cause of all, many of the fugitive coal tar colors are gifted, I will not say with fatal beauty, but with a facility of application, and such comparative cheapness in consequence of their intense coloring power, that the dyer, tempted by competition, applies them not unfrequently to materials for which, because of their ultimate uses, they are altogether unsuited; and so it comes about that we find the most fugitive colors applied indiscriminately and without due discretion.

As we look upon these multitudinous colors, one other thought cannot fail to cross our minds. Is there not surely an overproduction of these fugitive coal tar colors? Is not the dyer bewildered with an *embarras de richesses*, so that he knows not where to choose?

There is indeed much truth in this. With rare skill and ingenuity an army of chemists is busy elaborating these wonderful dyes; but in such quick succession are they introduced into the dye house that the busy dyer has no time sufficiently to prove them, and it is not surprising therefore that he is liable to commit errors in their application.

But if there is an over-production of fugitive colors, there is also at work, as in the organic world around us, the counteracting influence of the law of the survival of the fittest. Sooner or later, the fugitive colors must give way to those which are more permanent, and already the number of coal tar colors which have been discarded, for one reason or another, is considerable.

Not unfrequently one is asked the question, Is there no method whereby these fugitive colors can be made fast? Knowing the efficacy of mordants with certain coloring matters, is there no mordant which we can generally apply with this desirable object in view? The discovery of such a universal mordant I believe to be somewhat chimerical, and yet, curiously enough, a number of experiments have been recorded in recent years, which almost seem to point in the direction of selecting for such a purpose ordinary sulphate of copper.

Some of these diagrams before you this evening show clearly the fastness to light generally of the lakes formed with copper mordant. This peculiarity of the copper compounds has not escaped the notice of other observers. Dr. Schunck, for example, during the progress of his research on chlorophyl, noticed the very permanent green dye which this otherwise fugitive coloring matter gives in combination with copper.

Then there is the assertion of practical dyers, that the use of copper sulphate in dyeing catechu brown on cotton assists materially in rendering this color fast to light.

The use of copper mordant with phenolic coloring matters is perfectly natural. Some time ago, however, it was successfully applied, for the purpose of rendering more permanent, to certain of the Congo colors on cotton, *e.g.*, benzo-azurine, *etc.*, in the application of which, metallic salts had not hitherto been deemed necessary.

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Noelting and Herzberg have also observed that the fastness to light, even of basic colors, *e.g.*, magenta, methyl violet, malachite green, *etc.*, is increased by a subsequent treatment of the dyed fabric with copper sulphate solution, although in many cases the color is much soiled thereby.

Still more recently, A. Scheurer records that by impregnating or padding certain dyed fabrics with an ammoniacal solution of copper sulphate, the colors gain considerably in fastness to light. As the result of his experiments Scheurer concludes that this protective influence of copper on dyed colors is a general fact, apparently applicable to all colors; that it is not necessarily due to its action as a lake-forming substance, since intimate union between the coloring matter and the copper salt is not necessary. He seems rather inclined to ascribe its efficacy to the light being deprived of its active rays during its passage through the oxide of copper.

Knowing, however, the strong reducing action of light in many cases, and with the absence of positive knowledge concerning the cause of the fading of colors, it seems to me that the beneficial influence of the copper may just as probably be due to its well known oxidizing power, which counteracts the reducing action of the light.

It is interesting to note, in connection with Scheurer's view, that, many years ago, Gladstone and Wilson (1860) proposed to impregnate colored materials with some colorless fluorescent substance, *e.g.*, sulphate of quinine, evidently with the idea of filtering off the active ultra-violet rays. How far some such method as this might prove successful I cannot say, but since we cannot keep our dyed textile materials in a vacuum, as Chevreul did, nor is it desirable to impregnate them with mastic varnish for the purpose of excluding air and moisture, as Mr. Laurie proposes, in order to preserve the colors of oil paintings, it is perhaps well to bear in mind the principle here alluded to as a possible solution of the difficulty.

I have dwelt rather long on this important question of the action of light on dyed colors, but I have done so because I thought it would most interest you. With the remaining portions of my subject I must be more brief.

*(To be continued.)*

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To introduce free fat acids from an oil, it must be decomposed. This may be done by the use of lead oxide and water or by analogous processes. To clarify an oil, expose to the sun in leaden trays. Often washing with water will answer the purpose.

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## **COMPOSITION OF WHEAT GRAIN AND ITS PRODUCTS IN THE MILL.**

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Probably the most striking difference in the average mineral composition of the grain of wheat is the very much lower proportion of phosphoric acid, and of magnesia also, in the dry substance of the best matured grain; and it is now known that these characteristics point to a less proportion of bran to flour, or, in other words, of a greater accumulation of starch in the process of ripening, and consequently of a whiter and better quality of bakers' flour. The study of the chemical composition of wheat and its products in the mill, therefore, and of the amount of fertilizing matters (nitrogen, phosphoric acid and potash) removed from the soil by the crop, becomes of direct interest not only to the producer from whose soil these ingredients are removed, but to the consumer of the byproducts as well, who desires to know what proportion of these elements of fertility he is returning to his own soil in the different products he may use as animal food. It is desirable also to determine what is the average composition of wheats and the flour made from them, in order to see in what direction efforts should be turned, by the selection of seed wheats, to improve the present varieties for the production of the best quality of flour. This can only be done after we determine what variation there is for different years due to climatic influences and variations of soil, for it has been shown in our former papers that environment very largely influences the quality of wheat grain, and also of the flour. When these have been determined, than we may hope to be able to determine which factors under our control enter in to permanently improve the better flour-producing quality of wheats.

A mixture, in equal proportions, was made of Clawson, Mediterranean, and early amber wheats, and submitted to the mill, using the Hungarian roller process. From this mixture for each one bushel of the grain of 60 lb. weight was furnished the following proportion of products:

Lb. per Bushel.	Per cent.	
Flour.	44	73.3
Middlings.	4	6.7
Shipstuff.	2	3.3
Bran.	10	16.7
--	----	
Total.	60	100.0

These data furnish us a means of estimating the amount of the different ingredients removed in the various products in one bushel of wheat with the foregoing component parts.



## FLOUR.

The analysis of the flour shows us that the 44 lb. obtained from the one bushel of grain would contain the following ingredients:

Lb. per Bushel  
of Wheat.

Water.	5.834	
Ash.	0.167	
Albuminoids.	4.620	
Woody fiber.	0.532	
Carbo-hydrates (starchy matters).		33.391
Fat.	0.453	

## WHEAT MIDLINGS.



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The middlings form the inner coating of the wheat grain, next the floury or starchy portion, and contain particles of the germ and a larger percentage of carbohydrates than either shipstuff or bran, and a less proportion of fiber, while the percentage of albuminoids usually stands between that of shipstuff and bran. The following data are obtained from the 4 lb. procured from a bushel of wheat:

Lb. per Bushel of Wheat.		
Water.	0.562	
Ash.	0.138	
Albuminoids.	0.657	
Woody fiber.	0.142	
Carbo-hydrates (starchy matters).		2.307
Fat.	0.193	

### SHIPSTUFF.

That part separated and known as shipstuff is a very thin layer next outside of the middlings, and contains the germ not found in the middlings or left as a part of the flour. The quantity produced, 2 lb. from a bushel of wheat, is very small and rarely kept separate from the bran. The following shows the analysis:

Lb. per Bushel of Wheat.		
Water.	0.282	
Ash.	0.101	
Albuminoids.	0.349	
Woody fiber.	0.160	
Carbo-hydrates (starchy matters).		1.088
Fat.	0.099	

### BRAN.

Bran, the outer coating of the wheat, contains twice or three times as much fiber as does either of the other products from wheat, and proportionately less of each of the other ingredients except ash, which is greater, perhaps partly due to foreign matter adhering to the kernel. The following analysis shows the amount of constituents removed by the bran (10 lb.) from one bushel of wheat:



Lb. per Bushel  
of Wheat.

Water.	1.459
Ash.	0.506
Albuminoids.	1.416
Woody fiber.	1.000
Carbo-hydrates (starchy matters).	5.277
Ash.	0.342

From the foregoing milling products obtained from one bushel of wheat of 60 lb. in weight, the ash on analysis gave the following constituents, which shows the amount that was abstracted from the soil by its growth:

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|  
 | CONSTITUENTS FROM ONE BUSHEL OF WHEAT. |  
 |

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Nitrogen.	Phosphoric	Potash.	Lime.	
	Acid.			
+-----+	+-----+	+-----+	+-----+	+-----+
Flour.	0.739	0.092	0.054	0.013
Middlings.	0.105	0.064	0.024	0.002



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Shipstuff.	0.056	0.044	0.021	0.003
Bran.	0.228	0.251	0.083	0.012
+-----+-----+-----+				
Totals.	1.118	0.454	0.182	0.030

Or we may express the results in another form, the amount contained in one ton of straw, and the products of 30 bushels of wheat, which may be reckoned as an average crop, expressing the amounts in pounds as follows:

AMOUNTS OF SELECTED CONSTITUENTS IN THIRTY BUSHELS OF WHEAT AND ITS PROPORTION OF STRAW.

Nitrogen.	Phosphoric	Potash.	Lime.	
Acid.				
+-----+-----+-----+				
Straw.	11.20	2.67	13.76	6.20
Flour.	22.17	2.76	1.62	0.39
Middlings.	3.15	2.01	0.72	0.06
Shipstuff.	1.68	1.32	0.63	0.09
Bran.	6.84	7.53	2.49	0.36
+-----+-----+-----+				
Totals.	45.04	16.29	19.22	7.10

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From numerous investigations it has been found that in regard to the nitrogen and the ash constituents, there is striking evidence of the much greater influence of season than of manuring on the composition of a ripened wheat plant, and especially of its final product—the seed. Further, under equal circumstances the mineral composition of the wheat grain, excepting in cases of very abnormal exhaustion, is very little affected by different conditions as to manuring, provided only that the grain is well and normally ripened. Again, it is found that the composition may vary very greatly with variations of season, that is, with variations in the conditions of seed formation and maturation, upon which the organic composition of the grain depends. In other words, differences in the mineral composition of the ripened grain are associated with differences in its organic



composition, and hence the great value of proper selection both for seed and for milling purposes.

## **AMERICAN WHEATS.**

In a comprehensive treatise on the composition of American wheats, Mr. Clifford Richardson says we cannot attribute the poverty of American wheats in nitrogen as a whole to an enhanced starch formation, and for the following reasons: An enhanced formation of starch, there being no poverty of nitrogen in the soil, increases the weight of the grain and diminishes the relative percentage of nitrogen. Were this the cause of the relatively low percentage of nitrogen in the American wheats, the grain from the Eastern States, which are poorest in this respect, would be

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heavier than those from the middle West, which are richer in albuminoids; but this is not the case. Formation of starch is attributed by Messrs. Lawes & Gilbert to the higher ripening temperature in America, but Clifford Richardson has found that there is scarcely any difference in composition or weight between wheats from Canada and Alabama, and if anything those from Canada contain more starch than those from the South, and the spring wheat from Manitoba with its colder climate more than those from Dakota and Minnesota, with its milder temperature. In Oregon is found a striking example of the formation of starch and increase in the size of the grain, at the relative expense of the nitrogen, due to climate, but not to high ripening temperature. The average weight per hundred grains of wheat from this State has been found to be 5.044 grains, and the relative percentage of nitrogen 1.37, equivalent to 8.60 per cent. of albuminoids. These are the extremes for America, and are due, as has been said, to the enhanced formation of starch. This, however, is said to be not owing to high ripening temperature, because most of the specimens examined were grown west of the Cascade Range, which has an extremely moist climate and a summer heat not exceeding 82 deg. F. for any daily mean. The climate in another way, however, is, of course, the cause, by producing luxuriant growth, as illustrated by all the vegetation of the country. Numerous other analyses form illustrations of the important effect of surroundings and season upon the storing up of starch by the plant, and consequent relative changes in the composition of the grain.

As a whole, the poverty of American wheats in nitrogen, decreasing toward the less exhausted lands of the West, seems to be due more to influences of soil than of climate, while locally the influence of season is found to be greater than that of manure, confirming the conclusions of Messrs. Lawes & Gilbert. Also from the analyses of the ash of different parts of the grain, as from the analyses of roller milling products, we learn that a large percentage of ash constituents, other things being equal, is indicative of large proportion of bran, and consequently of a low percentage of flour.—*The Miller*.

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## PRECIOUS AND ORNAMENTAL STONES AND DIAMOND CUTTING.[1]

[Footnote 1: Abstract from Census Bulletin No. 49, April, 1891.]

By GEORGE FREDERICK KUNZ.

The statistics of this report are divided into two sections: First, the discoveries and finds of precious stones in the United States and the mineral specimens sold for museums



and private collections or for bric-a-brac purposes; second, the diamond cutting industry.

## **DISCOVERIES OF PRECIOUS STONES.**



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Up to the present time there has been very little mining for precious or semi-precious stones in the United States, and then only at irregular periods. It has been carried on during the past few years at Paris, Maine; near Los Cerrillos, New Mexico; in Alexander County, North Carolina, from 1881 until 1888; and on the Missouri River near Helena, Montana, since the beginning of 1890. True beryls and garnets have been frequently found as a by-product in the mining of mica, especially in Virginia and North Carolina. Some gems, such as the chlorastrolite, thomsonite, and agates of Lake Superior, are gathered on beaches, where they have fallen from rock which has gradually disintegrated by weathering and wave action.

*Diamond.*—A very limited number of diamonds have been found in the United States. They are met with in well-defined districts of California, North Carolina, Georgia, and recently in Wisconsin, but up to the present time the discoveries have been rare and purely accidental.

*Sapphire.*—Of the corundum gems (sapphire, ruby, and other colored varieties), no sapphires of fine blue color and no rubies of fine red color have been found. The only locality which has been at all prolific is the placer ground between Ruby and Eldorado bars, on the Missouri River, sixteen miles east of Helena, Montana. Here sapphires are found in glacial auriferous gravels while sluicing for gold, and until now have been considered only a by-product. Up to the present time they have never been systematically mined. In 1889 one company took the option on four thousand acres of the river banks, and several smaller companies have since been formed with a view of mining for these gems alone or in connection with gold. The colors of the gems obtained, although beautiful and interesting, are not the standard blue or red shades generally demanded by the public.

At Corundum Hill, Macon County, North Carolina, about one hundred gems have been found during the last twenty years, some of good blue color and some of good red color, but none exceeding \$100 in value, and none within the past ten years.

*Beryl Gems.*—Of the beryl gems (emerald, aquamarine, and yellow beryl) the emerald has been mined to some extent at Stony Point in Alexander County, North Carolina, and has also been obtained at two other places in the county. Nearly everything found has come from the Emerald and Hiddenite mines, where during the past decade emeralds have been mined and cut into gems to the value of \$1,000, and also sold as mineralogical specimens to the value of \$3,000; lithia emerald, or hiddenite, to be cut into gems, \$8,500, and for mineralogical specimens, \$1,500; rutile, cut and sold as gems, \$150, and as specimens, \$50; and beryl, cut and sold as gems, \$50.

At an altitude of 14,000 feet, on Mount Antero, Colorado, during the last three years, material has been found which has afforded \$1,000 worth of cut beryls. At Stoneham, Maine, about \$1,500 worth of fine aquamarine has been found, which was cut into gems.



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At New Milford, Connecticut, a property was extensively worked from October, 1885, to May, 1886, for mica and beryl. The beryls were yellow, green, blue, and white in color, the former being sold under the name of "golden beryl." No work has been done at the mine since then. In 1886 and 1887 there were about four thousand stones cut and sold for some \$15,000, the cutting of which cost about \$3,000.

*Turquoise.*—This mineral, which was worked by the Aztecs before the advent of the Spaniards, and since then by the Pueblo Indians, and largely used by them for ornament and as an article of exchange, is now systematically mined near Los Cerrillos, New Mexico. Its color is blue, and its hardness is fully equal to that of the Persian, or slightly greater, owing to impurities, but it lacks the softness of color belonging to the Persian turquoise.

From time immemorial this material has been rudely mined by the Indians. Their method is to pour cold water on the rocks after previously heating them by fires built against them. This process generally deteriorates the color of the stone to some extent, tending to change it to a green. The Indians barter turquoise with the Navajo, Apache, Zuni, San Felipe, and other New Mexican tribes for their baskets, blankets, silver ornaments, and ponies.

*Garnet and Olivine (Peridot).*—The finest garnets and nearly all the peridots found in the United States are obtained in the Navajo Nation, in the northwestern part of New Mexico and the northeastern part of Arizona, where they are collected from ant hills and scorpion nests by Indians and by the soldiers stationed at adjacent forts. Generally these gems are traded for stores to the Indians at Gallup, Fort Defiance, Fort Wingate, etc., who in turn send them to large cities in the East in parcels weighing from half an ounce to thirty or forty pounds each. These garnets, which are locally known as Arizona and New Mexico rubies, are the finest in the world, rivaling those from the Cape of Good Hope. Fine gems weighing from two to three carats each and upward when cut are not uncommon. The peridots found associated with garnets are generally four or five times as large, and from their pitted and irregular appearance have been called "Job's tears." They can be cut into gems weighing three to four carats each, but do not approach those from the Levant either in size or color.

*Gold Quartz.*—Since the discovery of gold in California, compact gold quartz has been extensively used in the manufacture of jewelry, at one time to the amount of \$100,000 per annum. At present, however, the demand has so much decreased that only from five to ten thousand dollars' worth is annually used for this purpose.

In addition to the minerals used for cabinet specimens, etc., there is a great demand for making clocks, inkstands, and other objects.

*Quartz.*—During the year 1887 about half a ton of rock crystal, in pieces weighing from a few pounds up to one hundred pounds each, was found in decomposing granite in

Chestnut Hill township, Ashe County, North Carolina. One mass of twenty and one-half pounds was absolutely pellucid, and more or less of the material was used for art purposes. This lot of crystal was valued at \$1,000.

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In Arkansas, especially in Garland and Montgomery Counties, rock crystals are found lining cavities of variable size, and in one instance thirty tons of crystals were found in a single cavity. These crystals are mined by the farmers in their spare time and sold in the streets of Hot Springs, their value amounting to some \$10,000 annually. Several thousand dollars' worth are cut from quartz into charms and faceted stones, although ten times that amount of paste or imitation diamonds are sold as Arkansas crystals.

Rose quartz is found in the granitic veins of Oxford County, Maine, and in 1887, 1888, and 1889 probably \$500 worth of this material was procured and worked into small spheres, dishes, charms, and other ornamental objects.

The well-known agatized and jasperized wood of Arizona is so much richer in color than that obtained from any other known locality that, since the problem of cutting and polishing the large sections used for table tops and other ornamental purposes was solved, fully \$50,000 worth of the rough material has been gathered and over \$100,000 worth of it has been cut and polished. This wood, which was a very prominent feature at the Paris Exposition, promises to become one of our richest ornamental materials.

Chlorastrolite in pebbles is principally found on the inside and outside shores of Rock Harbor, a harbor about eight miles in length on the east end of Isle Royale, Lake Superior, where they occur from the size of a pin head to, rarely, the size of a pigeon's egg. When larger than a pea they frequently are very poor in form or are hollow in fact, and unfit for cutting into gems. They are collected in a desultory manner, and are sold by jewelers of Duluth, Petoskey, and other cities, principally to visitors. The annual sale ranges from \$200 to \$1,000.

Thomsonite in pebbles occurs with the chlorastrolite at Isle Royal, but finer stones are found on the beach at Grand Marais, Cook County, Minnesota. Like the chlorastrolites, they result from the weathering of the amygdaloid rock, in which they occur as small nodules, and in the same manner are sold by jewelers in the cities bordering on Lake Superior to the extent of \$200 to \$1,000 worth annually.

## **THE DIAMOND CUTTING INDUSTRY.**

In New York there are sixteen firms engaged in cutting and recutting diamonds, and in Massachusetts there are three. Cutting has also been carried on at times in Pennsylvania and Illinois, but has been discontinued. The firms that were fully employed were generally the larger ones, whose business consisted chiefly in repairing chipped or imperfectly cut stones or in recutting stones previously cut abroad, which, owing to the superior workmanship in command here, could be recut at a profit, or in recutting very valuable diamonds when it was desired, with the certainty that the work could be done under their own supervision, thus guarding against any possible loss by exchange for inferior stones.

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The industry employed 236 persons, of whom 69 were under age, who received \$148,114 in wages. Of the 19 establishments, 16 used steam power. The power is usually rented. Foot power is only used in one establishment. Three of the firms are engaged in shaping black diamonds for mechanical purposes, for glass cutters and engravers, or in the manufacture of watch jewels.

The diamonds used in this industry are all imported, for, as already stated, diamonds are only occasionally found in the United States.

The importation of rough and uncut diamonds in 1880 amounted to \$129,207, in 1889 to \$250,187, and the total for the decade was \$3,133,529, while in 1883 there were imported \$443,996 worth, showing that there was 94 per cent. more cutting done in 1889 than 1880, but markedly more in 1882 and 1883. This large increase of importation is due to the fact that in the years 1882 to 1885 a number of our jewelers opened diamond cutting establishments, but the cutting has not been profitably carried on in this country on a scale large enough to justify branch houses in London, the great market for rough diamonds, where advantage can be taken of every fluctuation in the market and large parcels purchased, which can be cut immediately and converted into cash; for nothing is bought and sold on a closer margin than rough diamonds.

There has been a remarkable increase in the importation of precious stones in this country in the last ten years. The imports from 1870 to 1879, inclusive, amounted to \$26,698,203, whereas from 1880 to 1889, inclusive, the imports amounted to \$87,198,114, more than three times as much as were imported the previous decade.

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## **SOME EXPERIMENTS ON THE ELECTRIC DISCHARGE IN VACUUM TUBES.[1]**

[Footnote 1: From a recent communication made to the Physical Society, London.]

By Prof. J.J. THOMSON, M.A., F.R.S.

[Illustration: FIG. 1.—Coil of Glass Tube for Vacuum Discharge Experiments. The primary coils are filled with mercury, the secondary coils form continuous closed circuits.]

The phenomena of vacuum discharges were, he said, greatly simplified when their path was wholly gaseous, the complication of the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in tubes devoid of electrodes was, however, not easy to



accomplish, for the only available means of producing an electromotive force in the discharge circuit was by electromagnetic induction. Ordinary methods of producing variable induction were valueless, and recourse was had to the oscillatory discharge of a Leyden jar, which combines the two essentials of a current whose maximum value is enormous, and whose rapidity of alternation is immensely great.

[Illustration: FIG. 2.—Exhausted Bulb Surrounded by Primary Spiral Consisting of a Coiled Glass Tube Containing Mercury.]

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[Illustration: FIG. 3.—Exhausted Bulb Surrounded by Primary Coils, Inclosed in Bell Jar.]

The discharge circuits, which may take the shape of bulbs, or of tubes bent in the form of coils, were placed in close proximity to glass tubes filled with mercury, which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with the mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary nor secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing self-induction of the primary reduces the E.M.F. induced in the secondary, while lengthening the secondary does not increase the E.M.F. per unit length. Two or three turns (Fig. 1) in each were found to be quite sufficient, and on discharging the Leyden jar between two highly polished knobs in the primary circuit, a plain uniform band of light was seen to pass round the secondary. An exhausted bulb (Fig. 2) containing traces of oxygen was placed within a primary spiral of three turns, and, on passing the jar discharge, a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow, which lasted for a second or more. On heating the bulb the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electromagnet. Another exhausted bulb (Fig. 3), surrounded by a primary spiral, was contained in a bell jar, and when the pressure of air in the jar was about that of the atmosphere the secondary discharge occurred in the bulb, as is ordinarily the case. On exhausting the jar, however, the luminous discharge grew fainter, and a point was reached at which no secondary discharge was visible. Further exhaustion of the jar caused the secondary discharge to appear outside the bulb. The fact of obtaining no luminous discharge either in the bulb or jar the author could only explain on two suppositions, *viz.*, that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished until a certain point was reached, and afterward diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the presence of the electrodes. One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would prevent a luminous discharge in that tube.



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[Illustration: FIG. 4.—Exhausted Secondary Coil of One Loop Containing Bulbs. The discharge passed along the inner side of the bulbs, the primary coils being placed within the secondary.]

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### **THE ELECTRICAL MANUFACTURE OF PHOSPHORUS.**

Dr. Readman, at the May meeting of the Glasgow Section of the Society of Chemical Industry, gave a description of the new works and plant which have been erected at Wolverhampton for the manufacture of phosphorus by the Readman-Parker patents. The process consists in decomposing the mixture of phosphoric acid, or acid phosphates and carbon, by the heat of the electric arc embedded in the mass.

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### **LAYING A MILITARY FIELD TELEGRAPH LINE.**

The 1st Division of the Royal Engineers, Telegraph Battalion, now encamped at Chevening, close to Lord Stanhope's park, as a summer exercise is engaged in running a military telegraph field line from Aldershot to Chatham. Along the whole of the line the wire is supported on light fir and bamboo poles. The work has been carried out with unusual celerity. From Aldershot to Chevening, a distance of fifty miles, the line was erected in a day and a quarter, or under thirty hours, the detachments employed having worked or marched all night. This is, it is said, the greatest length of telegraph line ever laid within so short a time. The result cannot fail to be useful, for by the new line communication is now established both by telegraph and telephone between Aldershot and Chatham. For laying such telegraph lines to accompany calvary, a light cable is made use of. This is carried on reels on a wheeled cart, and can be laid at the rate of six to seven miles an hour. The Telegraph Battalion of the Royal Engineers comprises two divisions. One is employed in time of peace under the Post Office in the construction and maintenance of postal lines; the other, stationed at Aldershot, is equipped with field telegraph material.—*Daily Graphic*.

[Illustration: LAYING A MILITARY FIELD TELEGRAPH LINE.]

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### **AN ELECTROSTATIC SAFETY DEVICE.**

This device, as shown in the accompanying illustration, is a glass cylinder fixed on an ebonite base, and closed at the top by an ebonite cap. A solid brass rod runs from top



to bottom, and near the bottom, and at right angles to it, is fixed a smaller adjustable rod, terminating in a flat head. Opposite to this flat disk there is a brass strip secured to the ebonite cap. From the top of this brass strip hangs a gold or aluminum foil. The foil and strip are placed to earth, and the solid brass rod is connected to the circuit to be protected. Should the difference of potential between the foil and the terminal opposite to it attain more than a certain amount, electrostatic attraction will cause the foil to touch the disk and place the circuit to earth. The apparatus, which is a modification of the Cardew earthing device, is constructed by Messrs. Drake & Gorham, of Victoria Street.  
—*The Electrician*.



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[Illustration.]

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### EXPERIMENTS WITH HIGH TENSION ALTERNATING CURRENTS.

Messrs. Siemens and Halske, of Berlin, recently invited the members of the Elektrotechnische Verein of that city to their works to witness the demonstration of a series of experiments on alternating currents under a pressure of 20,000 volts. In order to show that the desired pressure was really *en evidence*, the high tension was conducted through a pair of wires of only 0.2 mm. diameter to a battery of 200 100-volt incandescent lamps, all connected up in series. An ordinary Siemens electric light cable was inserted, and broke down at a pressure of some 15,000 volts.

At the end of the meeting a few experiments on the formation of the arc under this enormous pressure were shown. The sparking distance varied considerably, according to the shape of the electrodes. At 20,000 volts a spark jumped from a ball to a ball about 10 millimeters, while between two points a sparking distance of 30 millimeters, and sometimes even more, was reached. This arc is shown half size in the accompanying engraving.

[Illustration: A 20,000 VOLT ALTERNATING ARC (half size).]

The arc which followed the jumping over of a spark made a loud humming and clapping noise, and flapped about, being easily carried away by the slightest draught. The arc could be drawn out horizontally to something like 100 millimeters distance between the electrodes, and even to a distance of 150 millimeters, when carbon pencils were used as electrodes, but it always remained standing up in a point. —*Electrical Engineer*.

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### THE RELATION OF BACTERIA TO PRACTICAL SURGERY.[1]

[Footnote 1: The address in surgery delivered before the Medical Society of the State of Pennsylvania, June 4, 1890.]

By JOHN B. ROBERTS, A.M., M.D., Professor of Surgery in the Woman's Medical College and in the Philadelphia Polyclinic.



The revolution which has occurred in practical surgery since the discovery of the relation of micro-organisms to the complications occurring in wounds has caused me to select this subject for discussion. Although many of my hearers are familiar with the germ theory of disease, it is possible that it may interest some of them to have put before them in a short address a few points in bacteriology which are of value to the practical surgeon.

It must be remembered that the groups of symptoms which were formerly classed under the heads "inflammatory fever," "symptomatic fever," "traumatic fever," "hectic fever," and similar terms, varying in name with the surgeon speaking of them, or with the location of the disease, are now known to be due to the invasion of the wound by microscopic plants. These bacteria, after entering the blood



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current at the wound, multiply with such prodigious rapidity that the whole system gives evidence of their existence. Suppuration of wounds is undoubtedly due to these organisms, as is tubercular disease, whether of surgical or medical character. Tetanus, erysipelas, and many other surgical conditions have been almost proved to be the result of infection by similar microscopic plants, which, though acting in the same way, have various forms and life histories.

A distinction must be made between the “yeast plants,” one of which produces thrush, and the “mould plants,” the existence of which, as parasites in the skin, gives rise to certain cutaneous diseases. These two classes of germs are foreign to the present topic, which is surgery; and I shall, therefore, confine my remarks to that group of vegetable parasites to which the term bacteria has been given. These are the micro-organisms whose actions and methods of growth particularly concern the surgeon. The individual plants are so minute that it takes in the neighborhood of ten or fifteen hundred of them grouped together to cover a spot as large as a full stop or period used in punctuating an ordinary newspaper. This rough estimate applies to the globular and the egg-shaped bacteria, to which is given the name “coccus” (plural, cocci). The cane or rod shaped bacteria are rather larger plants. Fifteen hundred of these placed end to end would reach across the head of a pin. Because of the resemblance of these latter to a walking stick they have been termed bacillus (plural, bacilli).

The bacteria most interesting to the surgeon belong to the cocci and the bacilli. There are other forms which bacteriologists have dubbed with similar descriptive names, but they are more interesting to the physician than to the surgeon. Many micro-organisms, whether cocci, bacilli, or of other shapes, are harmless, hence they are called non-pathogenic, to distinguish them from the disease-producing or pathogenic germs.

As many trees have the same shape and a similar method of growing, but bear different fruits—in the one case edible and in the other poisonous—so, too, bacteria may look alike to the microscopist’s eye, and grow much in the same way, but one will cause no disease, while the other will produce perhaps tuberculosis of the lungs or brain.

Many scores of bacteria have been, by patient study, differentiated from their fellows and given distinctive names. Their nomenclature corresponds in classification and arrangement with the nomenclature adopted in different departments of botany. Thus we have the pus-causing chain coccus (*streptococcus pyogenes*), so-called because it is globular in shape, because it grows with the individual plants attached to each other, or arranged in a row like a chain of beads on a string, and because it produces pus. In a similar way we have the pus-causing grape coccus of a golden color (*staphylococcus pyogenes aureus*). It grows with the individual plants arranged somewhat after the manner of a bunch of grapes, and when millions of them are collected together, the

mass has a golden yellow hue. Again, we have the bacillus tuberculosis, the rod-shaped plant which is known to cause tuberculosis of the lungs, joints, brain, *etc.*



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It is hardly astonishing that these fruitful sources of disease have so long remained undetected, when their microscopic size is borne in mind. That some of them do cause disease is indisputable, since bacteriologists have, by their watchful and careful methods, separated almost a single plant from its surroundings and congeners, planted it free from all contamination, and observed it produce an infinitesimal brood of its own kind. Animals and patients inoculated with the plants thus cultivated have rapidly become subjects of the special disease which the particular plant was supposed to produce.

The difficulty of such investigation becomes apparent when it is remembered that under the microscope many of these forms of vegetable life are identical in appearance, and it is only by observing their growth when in a proper soil that they can be distinguished from each other. In certain cases it is quite difficult to distinguish them by the physical appearances produced during their growth. Then it is only after an animal has been inoculated with them that the individual parasite can be accurately recognized and called by name. It is known then by the results which it is capable of producing.

The various forms of bacteria are recognized, as I have said, by their method of growth and by their shape. Another means of recognition is their individual peculiarity of taking certain dyes, so that special plants can be recognized, under the microscope, by the color which a dye gives to them, and which they refuse to give up when treated with chemical substances which remove the stain from, or bleach, all the other tissues which at first have been similarly stained.

The similarity between bacteria and the ordinary plants with which florists are familiar is, indeed, remarkable. Bacteria grow in animal and other albuminous fluids; but it is just as essential for them to have a suitable soil as it is for the corn or wheat that the farmer plants in his field. By altering the character of the albuminous fluid in which the micro-organism finds its subsistence, these small plants can be given a vigorous growth, or may be actually starved to death. The farmer knows that it is impossible for him to grow the same crop year after year in the same field, and he is, therefore, compelled to rotate his crops. So it is with the microscopic plants which we are considering.

After a time the culture fluid or soil becomes so exhausted of its needed constituents, by the immense number of plants living in it, that it is unfit for their life and development. Then this particular form will no longer thrive; but some other form of bacterium may find in it the properties required for functional activity, and may grow vigorously. It is probable that exhaustion or absence of proper soil is an important agent in protecting man from sickness due to infection from bacteria. The ever-present bacteria often gain access to man's blood through external wounds, or through the lungs and digestive tracts; but unless a soil suited for their development is found in its fluids, the plants will not grow. If they do not grow and increase in numbers, they can do little harm.

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Again, there are certain bacteria which are so antagonistic to each other that it is impossible to make them grow in company, or to co-exist in the blood of the same individual. For example, an animal inoculated with erysipelas germs cannot be successfully inoculated immediately afterward with the germs of malignant pustule. This antagonism is illustrated by the impossibility of having a good crop of grain in a field overrun with daisies.

On the other hand, however, there are some micro-organisms which flourish luxuriantly when planted together in the same fluid, somewhat after the manner of pumpkins and Indian corn growing between the same fence rails. Others seem unwilling to grow alone, and only flourish when planted along with other germs. It is very evident, therefore, that bacteriology is a branch of botany, and that nature shows the same tendencies in these minute plants as it does in the larger vegetable world visible to our unaided eyes.

As the horticulturist is able to alter the character of his plants by changing the circumstances under which they live, so can the bacteriologist change the vital properties and activities of bacteria by chemical and other manipulations of the culture substances in which these organisms grow. The power of bacteria to cause pathological changes may thus be weakened and attenuated; in other words, their functional power for evil is taken from them by alterations in the soil. The pathogenic, or disease producing, power may be increased by similar, though not identical, alterations. The rapidity of their multiplication may be accelerated, or they may be compelled to lie dormant and inactive for a time; and, on the other hand, by exhausting the constituents of the soil upon which they depend for life, they may be killed.

It is a most curious fact, also, that it is possible by selecting and cultivating only the lighter colored specimens of a certain purple bacterium for the bacteriologist to obtain finally a plant which is nearly white, but which has the essential characteristics of the original purple fungus. In this we see the same power which the florist has to alter the color of the petals of his flowers by various methods of selective breeding.

The destruction of bacteria by means of heat and antiseptics is the essence of modern surgery. It is, then, by preventing access of these parasitic plants to the human organism (aseptic surgery), or the destruction of them by chemical agents and heat (antiseptic surgery), that we are enabled to invade by operative attack regions of the body which a few years ago were sacred.



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When the disease-producing bacteria gain access to the tissues and blood of human and other animals by means of wounds, or through an inflamed pulmonary or alimentary mucous membrane, they produce pathological effects, provided there is not sufficient resistance and health power in the animal's tissues to antagonize successfully the deleterious influence of the invading parasitic fungus. It is the rapid multiplication of the germs which furnishes a *continuous* irritation that enables them to have such a disastrous effect upon the tissues of the animal. If the tissues had only the original dose of microbes to deal with, the warfare between health and disease would be less uncertain in outcome. Victory would usually be on the side of the tissues and health. The immediate cause of the pathogenic influence is probably the chemical excretions which are given out by these microscopic organisms. All plants and animals require a certain number of substances to be taken into their organisms for preservation of their vital activities. After these substances have been utilized there occurs a sort of excretion of other chemical products. It is probably the excretions of many millions of micro-organisms, circulating in the blood, which give rise to the disease characteristic of the fungus with which the animal has been infected. The condition called *sapraemia*, or *septic intoxication*, for example, is undoubtedly due to the entrance of the excretory products of putrefaction bacteria into the circulation. This can be proved by injecting into an animal a small portion of these products obtained from cultures of germs of putrefaction. Characteristic symptoms will at once be exhibited.

*Septicaemia* is a similar condition due to the presence of the putrefactive organisms themselves, and hence of their products, or *ptomaines*, also in the blood. The rapidity of their multiplication in this albuminous soil and the great amount of excretion from these numerous fungi make the condition more serious than *sapraemia*. Clinically, the two conditions occur together.

The rapidity with which symptoms may arise after inoculation of small wounds with a very few germs will be apparent, when it is stated that one parasitic plant of this kind may, by its rapidity of multiplication, give rise to fifteen or sixteen million individuals within twenty-four hours. The enormous increase which takes place within three or four days is almost incalculable. It has been estimated that a certain bacillus, only about one thousandth of an inch in length, could, under favorable conditions, develop a brood of progeny in less than four days which would make a mass of fungi sufficient to fill all the oceans of the world, if they each had a depth of one mile.

Bacteria are present everywhere. They exist in the water, earth, air, and within our respiratory and digestive tracts. Our skin is covered with millions of them, as is every article about us. They can circulate in the lymph and blood and reach every tissue and part of our organisms by passing through the walls of the capillaries. Fortunately, they require certain conditions of temperature, moisture, air, and organic food for existence and for the preservation of their vital activities.

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If the surroundings are too hot, too cold, or too dry, or if they are not supplied with a proper quantity and quality of food, the bacterium becomes inactive until the surrounding circumstances change; or it may die absolutely. The spores, which finally become full-fledged bacteria, are able to stand a more unfavorable environment than the adult bacteria. Many spores and adults, however, perish. Each kind of bacterium requires its own special environment to permit it to grow and flourish. The frequency with which an unfavorable combination of circumstances occurs limits greatly the disease-producing power of the pathogenic bacteria.

Many bacteria, moreover, are harmless and do not produce disease, even when present in the blood and tissues. Besides this, the white blood cells are perpetually waging war against the bacteria in our bodies. They take the bacteria into their interiors and render them harmless by eating them up, so to speak. They crowd together and form a wall of white blood cells around the place where the bacteria enter the tissue, thus forming a barrier to cut off the blood supply to the germs and, perhaps, to prevent them from entering the general blood current.

The war between the white blood cells and the bacteria is a bitter one. Many bacteria are killed; but, on the other hand, the life of many blood cells is sacrificed by the bacteria poisoning them with ptomaines. The tissue cells, if healthy, offer great resistance to the attacks of the army of bacteria. Hence, if the white cells are vigorous and abundant at the site of the battle, defeat may come to the bacteria; and the patient suffer nothing from the attempt of these vegetable parasites to harm him. If, on the other hand, the tissues have a low resistive power, because of general debility of the patient, or of a local debility of the tissues themselves, and the white cells be weak and not abundant, the bacteria will gain the victory, get access to the general blood current, and invade every portion of the organism. Thus, a general or a local disease will be caused; varying with the species of bacteria with which the patient has been affected, and the degree of resistance on the part of the tissues.

From what has been stated it must be evident that the bacterial origin of disease depends upon the presence of a disease-producing fungus and a diminution of the normal healthy tissue resistance to bacterial invasion. If there is no fungus present, the disease caused by such fungus cannot develop. If the fungus be present and the normal or healthy tissue resistance be undiminished, it is probable that disease will not occur. As soon, however, as overwork, injury of a mechanical kind, or any other cause diminishes the local or general resistance of the tissues and individual, the bacteria get the upper hand, and are liable to produce their malign effect.



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Many conditions favor the bacterial attack. The patient's tissues may have an inherited peculiarity, which renders it easy for the bacteria to find a good soil for development; an old injury or inflammation may render the tissues less resistant than usual; the point, at which inoculation has occurred may have certain anatomical peculiarities which make it a good place in which bacteria may multiply; the blood may have undergone certain chemical changes which render it better soil than usual for the rapid growth of these parasitic plants.

The number of bacteria originally present makes a difference also. It is readily understood that the tissues and white blood cells would find it more difficult to repel the invasion of an army of a million microbes than the attack of a squad of ten similar fungi. I have said that the experimenter can weaken and augment the virulence of bacteria by manipulating their surroundings in the laboratory. It is probable that such a change occurs in nature. If so, some bacteria are more virulent than others of the same species; some less virulent. A few of the less virulent disposition would be more readily killed by the white cells and tissues than would a larger number of the more virulent ones. At other times the danger from microbic infection is greater because there are two species introduced at the same time; and these two multiply more vigorously when together than when separated. There are, in fact, two allied hosts trying to destroy the blood cells and tissues. This occurs when the bacteria of putrefaction and the bacteria of suppuration are introduced into the tissues at the same time. The former cause sapraemia and septicaemia, the latter cause suppuration. The bacteria of tuberculosis are said to act more viciously if accompanied by the bacteria of putrefaction. Osteomyelitis is of greater severity, it is believed, if due to a mixed infection with both the white and golden grape-coccus of suppuration.

I have previously mentioned that the bacteria of malignant pustule are powerless to do harm when the germs of erysipelas are present in the tissues and blood. This is an example of the way in which one species of bacteria may actually aid the white cells, or leucocytes, and the tissues in repelling an invasion of disease-producing microbes.

Having occupied a portion of the time allotted to me in giving a crude and hurried account of the characteristics of bacteria, let me conclude my address by discussing the relation of bacteria to the diseases most frequently met with by the surgeon.

Mechanical irritations produce a very temporary and slight inflammation, which rapidly subsides, because of the tendency of nature to restore the parts to health. Severe injuries, therefore, will soon become healed and cured if no germs enter the wound.

Suppuration of operative and accidental wounds was, until recently, supposed to be essential. We now know, however, that wounds will not suppurate if kept perfectly free from one of the dozen forms of bacteria that are known to give rise to the formation of pus.



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The doctrine of present surgical pathology is that suppuration will not take place if pus-forming bacteria are kept out of the wound, which will heal by first intention without inflammation and without inflammatory fever.

In making this statement I am not unaware that there is a certain amount of fever following various severe wounds within twenty-four hours, even when no suppuration occurs. This wound fever, however, is transitory; not high; and entirely different from the prolonged condition of high temperature formerly observed nearly always after operations and injuries. The occurrence of this "inflammatory," "traumatic," "surgical," or "symptomatic" fever, as it was formerly called, means that the patient has been subjected to the poisonous influence of putrefactive germs, the germs of suppuration, or both.

We now know why it is that certain cases of suppuration are not circumscribed but diffuse, so that the pus dissects up the fascias and muscles and destroys with great rapidity the cellular tissue. This form of suppuration is due to a particular form of bacterium called the pus-causing "chain coccus." Circumscribed abscesses, however, are due to one or more of the other pus-causing micro-organisms.

How much more intelligent is this explanation than the old one that diffuse abscesses depended upon some curious characteristic of the patient. It is a satisfaction to know that the two forms of abscess differ because they are the result of inoculation with different germs. It is practically a fact that wherever there is found a diffuse abscess there will be discovered the streptococcus pyogenes, which is the name of the chain coccus above mentioned.

So, also, is it easy now to understand the formation of what the old surgeons called "cold" abscesses, and to account for the difference in appearance of its puriform secretion from the pus of acute abscesses. Careful search in the fluid coming from such "cold" abscesses reveals the presence of the bacillus of tuberculosis, and proves that a "cold" abscess is not a true abscess, but a lesion of local tuberculosis.

Easy is it now to understand the similarity between the "cold abscess" of the cervical region and the "cold abscess" of the lung in a phthisical patient. Both of them are, in fact, simply the result of invasion of the tissues with the ubiquitous tubercle bacillus; and are not due to pus-forming bacteria.

Formerly it was common to speak of the scrofulous diathesis, and attempts were made to describe the characteristic appearance of the skin and hair pertaining to persons supposed to be of scrofulous tendencies. The attempt was unsuccessful and unsatisfactory. The reason is now clear, because it is known that the brunette or the blond, the old or the young, may become infected with the tubercle bacillus. Since the condition depends upon whether one or the other become infected with the generally present bacillus of tubercle, it is evident that there can be no distinctive diathesis. It is



more than probable, moreover, that the cutaneous disease so long described as lupus vulgaris is simply a tubercular ulcer of the skin, and not a special disease of unknown causation.



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The metastatic abscesses of pyaemia are clearly explained when the surgeon remembers that they are simply due to a softened blood clot containing pus-causing germs being carried through the circulation and lodged in some of the small capillaries.

A patient suffering with numerous boils upon his skin has often been a puzzle to his physician, who has in vain attempted to find some cause for the trouble in the general health alone. Had he known that every boil owed its origin to pus bacteria, which had infected a sweat gland or hair follicle, the treatment would probably have been more efficacious. The suppuration is due to pus germs either lodged upon the surface of the skin from the exterior or deposited from the current of blood in which they have been carried to the spot.

I have not taken time to go into a discussion of the methods by which the relationship of micro-organisms to surgical affections has been established; but the absolute necessity for every surgeon to be fully alive to the inestimable value of aseptic and antiseptic surgery has led me to make the foregoing statements as a sort of *resume* of the relation of the germ theory of disease to surgical practice. It is clearly the duty of every man who attempts to practice surgery to prevent, by every means in his power, the access of germs, whether of suppuration, putrefaction, erysipelas, tubercle, tetanus, or any other disease, to the wounds of a patient. This, as we all know, can be done by absolute bacteriological cleanliness. It is best, however, not to rely solely upon absolute cleanliness, which is almost unattainable, but to secure further protection by the use of heat and antiseptic solutions. I am fully of the opinion that chemical antiseptics would be needless if absolute freedom from germs was easily obtained. When I know that even such an enthusiast as I myself is continually liable to forget or neglect some step in this direction, I feel that the additional security of chemical antiseptics is of great value. It is difficult to convince the majority of physicians, and even ourselves, that to touch a finger to a door knob, to an assistant's clothing, or to one's own body, may vitiate the entire operation by introducing one or two microbic germs into the wound.

An illustration of how carefully the various steps of an operation should be guarded is afforded by the appended rules, which I have adopted at the Woman's Hospital of Philadelphia for the guidance of the assistants and nurses. If such rules were taught every medical student and every physician entering practice as earnestly as the paragraphs of the catechism are taught the Sunday school pupil (and they certainly ought to be so taught) the occurrence of suppuration, hectic fever, septicaemia, pyaemia, and surgical erysipelas would be practically unknown. Death, then, would seldom occur after surgical operations, except from hemorrhage, shock, or exhaustion.



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I have taken the liberty of bringing here a number of culture tubes containing beautiful specimens of some of the more common and interesting bacteria. The slimy masses seen on the surfaces of jelly contained in the tubes are many millions of individual plants, which have aggregated themselves in various forms as they have been developed as the progeny of the few parent cells planted in the jelly as a nutrient medium or soil.

With this feeble plea, Mr. President and members of the Society, I hope to create a realization of the necessity for knowledge and interest in the direction of bacteriology; for this is the foundation of modern surgery. There is, unfortunately, a good deal of abominable work done under the names of antiseptic and aseptic surgery, because the simplest facts of bacteriology are not known to the operator.

*Rules to be observed in Operations at Dr. Roberts' Clinic at the Woman's Hospital of Philadelphia.*—After wounds or operations high temperature usually, and suppuration always, is due to blood poisoning, which is caused by infection with vegetable parasites called bacteria.

These parasites ordinarily gain access to the wound from the skin of the patient, the finger nails or hands of the operator or his assistants, the ligatures, sutures, or dressings.

Suppuration and high temperature should not occur after operation wounds if no suppuration has existed previously.

Bacteria exist almost everywhere as invisible particles in the dust; hence, everything that touches or comes into even momentary contact with the wound must be germ-free—technically called “sterile.”

A sterilized condition of the operator, the assistant, the wound, instruments, *etc.*, is obtained by removing all bacteria by means of absolute surgical cleanliness (asepsis), and by the use of those chemical agents which destroy the bacteria not removed by cleanliness itself (antiseptics).

Surgical cleanliness differs from the housewife's idea of cleanliness in that its details seem frivolous, because it aims at the removal of microscopic particles. Stains, such as housewives abhor, if germ-free, are not objected to in surgery.

The hands and arms, and especially the finger nails, of the surgeon, assistants, and nurses should be well scrubbed with hot water and soap, by means of a nail brush, immediately before the operation. The patient's body about the site of the proposed operation should be similarly scrubbed with a brush and cleanly shaved. Subsequently the hands of the operator, assistants, and nurses, and the field of operation should be immersed in, or thoroughly washed with, corrosive sublimate solution (1:1,000 or



1:2,000). Finger rings, bracelets, bangles, and cuffs worn by the surgeon, assistants, or nurses must be removed before the cleansing is begun; and the clothing covered by a clean white apron, large enough to extend from neck to ankles and provided with sleeves.

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The instruments should be similarly scrubbed with hot water and soap, and all particles of blood and pus from any previous operation removed from the joints. After this they should be immersed for at least fifteen minutes in a solution of beta-naphthol (1:2,500), which must be sufficiently deep to cover every portion of the instruments. After cleansing the instruments with soap and water, baking in a temperature a little above the boiling point of water is the best sterilizer. During the operation the sterilized instruments should be kept in a beta-naphthol solution and returned to it when the operator is not using them.

[The antiseptic solutions mentioned here are too irritating for use in operations within the abdomen and pelvis. Water made sterile by boiling is usually the best agent for irrigating these cavities, and for use on instruments and sponges. The instruments and sponges must be previously well sterilized.]

Sponges should be kept in a beta-naphthol or a corrosive sublimate solution during the operation. After the blood from the wound has been sponged away, they should be put in another basin containing the antiseptic solution, and cleansed anew before being used again. The antiseptic sutures and ligatures should be similarly soaked in beta-naphthol solution during the progress of the operation.

No one should touch the wound but the operator and his first assistant. No one should touch the sponges but the operator, his first assistant, and the nurse having charge of them. No one should touch the already prepared ligatures or instruments except the surgeon and his first or second assistants.

None but those assigned to the work are expected to handle instruments, sponges, dressings, *etc.*, during the operation.

When any one taking part in the operation touches an object not sterilized, such as a table, a tray, or the ether towel, he should not be allowed to touch the instruments, the dressings, or the ligatures until his hands have been again sterilized. It is important that the hands of the surgeon, his assistants, and nurses should not touch any part of his own body, nor of the patient's body, except at the sterilized seat of operation, because infection may be carried to the wound. Rubbing the head or beard or wiping the nose requires immediate disinfection of the hands to be practiced.

The trailing ends of ligatures and sutures should never be allowed to touch the surgeon's clothing or to drag upon the operating table, because such contact may occasionally, though not always, pick up bacteria which may cause suppuration in the wound.

Instruments which fall upon the floor should not be again used until thoroughly disinfected.



The clothing of the patient, in the vicinity of the part to be operated upon, and the blanket and sheets used there to keep him warm, should be covered with dry sublimate towels. All dressings should be kept safe from infection by being stored in glass jars, or wrapped in dry sublimate towels.



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### INFLUENCE OF REPOSE ON THE RETINA.

Some interesting researches have lately been published in an Italian journal concerning the influence of repose on the sensitiveness of the retina (a nervous network of the eye) to light and color. The researches in question—those of Bassevi—appear to corroborate investigations which were made some years ago by other observers. In the course of the investigations the subject experimented upon was made to remain in a dark room for a period varying in extent from fifteen to twenty minutes. The room was darkened, it is noted, by means of heavy curtains, through which the light could not penetrate. After the eyes of the subject had thus been rested in the darkness, it was noted that the sensitiveness of his sight had been increased threefold. The mere sense of light itself had increased eighteen times. It was further noted that the sensitiveness to light rays, after the eye had been rested, was developed in a special order; the first color which was recognized being red, then followed yellow, while green and blue respectively succeeded. If color fatigue was produced in the eye by a glass of any special hue, it was found that the color in question came last in the series in point of recognition. The first of these experiments, regarded from a practical point of view, would appear to consist in an appreciation of the revivifying power of darkness as regards the sight. The color purple of the retina is known to become redeveloped in darkness; and it is probable, therefore, that the alternation of day and night is a physical and external condition with which the sight of animals is perfectly in accord.

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### SUN DIALS.

An article on the subject, recently published by us, has gained for us the communication of two very interesting sun dials, which we shall describe. The first, which we owe to the kindness of General Jancigny, is of the type of the circular instrument, of which we explained the method of using in our preceding article. The hour here is likewise deduced from the height of the sun converted into a horary angle by the instrument itself; but the method by which such conversion operates is a little different. Fig. 1 shows the instrument open for observation. We find here the meridian circle, M, and the equator E, of the diagram shown in Fig. 3 (No. 4); but the circle with alidade is here replaced by a small aperture movable in a slide that is placed in a position parallel with the axis of the world. Upon this slide are marked, on one side, the initials of the names of the months and on the other side the corresponding signs of the zodiac. The sun apparently describing a circle around the axis,  $PP^1$ , the rays passing through a point of the axis (small aperture of the slide) will travel over a circular cone around such axis.

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If, then, the apparatus be so suspended that the circle, M, shall be in the meridian, the slide parallel with the earth's axis, and the circle, E, at right angles with the slide, the pencil of solar light passing through the aperture will describe, in one day, a cone having the slide for an axis; that is to say, concentric with the equator circle. If, moreover, the aperture is properly placed, the luminous pencil will pass through the equator circle itself; to this effect, the aperture should be in a position such that the angle, a (Fig. 3, No. 4), may be equal to the declination of the sun on the day of observation. It is precisely to this end that the names of the months are inscribed upon the slide....

[Illustration: FIG. 1.—TRAVELER'S SUN DIAL.]

The accessories of the instrument are as follows: A ring with a pivot for suspending the meridian circle, and the position of which, given by a division in degrees marked upon this circle, must correspond with the latitude of the place; two stops serving to fix the position of the equator circle; finally the latitude of various cities. The instrument was constructed at Paris, by Butterfield, probably in the last quarter of the eighteenth century.

The second instrument, which is of the same nature as the cubical sun dial—that is to say, with horary angle—is, unlike the latter, a true trinket, as interesting as a work of art as it is as an astronomical instrument. It is a little mandolin of gilded brass, and is shown of actual size in Fig. 2. The cover, which is held by a hook, may be placed in a vertical position, in which it is held by a second hook. It bears in the interior the date 1612. This is the only explicit historic datum that this little masterpiece reveals to us. Its maker, who was certainly an artist, and, as we shall see, also a man of science, had the modesty not to inscribe his name in it.

[Illustration: FIG. 2.—SUN DIAL IN THE FORM OF A MANDOLIN, CONSTRUCTED IN 1612.]

No. 2 of Fig. 3 represents the instrument open. It rests upon the tail piece and neck of the mandolin. The cover is exactly vertical. The bottom of the mandolin is closed by a horizontal silver plate, beneath which is soldered the box of a compass designed to put the instrument in the meridian, and carrying upon its face an arrow and the indications S. OR. M. OC., that is to say, "Septentrion" (north), "Orient" (east), "Midi" (south), "Occident" (west). One of the ends of the needle of the compass is straight, while the other is forked. It is placed in a position in which it completes the arrow, thus permitting of making a very accurate observation (Fig. 2, No. 3). Around the compass, the silver plate carries the lines of hours. It is perfectly adjusted, and held in place by a screw that traverses the bottom of the instrument. In front of the compass it contains a small aperture designed to permit of the passage of the indicating thread, which, at the other end,

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is fastened to the cover. The silver plate is not soldered, in order that the thread may be replaced when it chances to break. On the inner part of the cover are marked in the first place the horary lines, traversed by curves that are symmetrical with respect to the vertical and having the aspect of arcs of hyperbolas. At the extremity of these lines are marked the signs of the zodiac. At the top, a pretty banderole, which appears at first sight to form a part of the *ensemble* of the curves, completes the design. Such is this wonderful little instrument, in which everything is arranged in harmonious lines that delight the eye and easily detract one's attention from a scientific examination of it. Let us enter upon this drier part of our subject; we shall still have room to wonder, and let us take up first the higher question.

[Illustration: FIG. 3.—DIAGRAM EXPLANATORY OF THE MANDOLIN SUN DIAL.]

Let us consider a horizontal plane (Fig. 3, No. 2)—a plane perpendicular to the meridian, and a right line parallel with the axis of the world. Let P be a point upon this line. As we have seen, such point is the summit of a very wide cone described in one day by the solar rays. At the equinox this cone is converted into a plane, which, in a vertical plane, intersects the straight line A B. Between the vernal and autumnal equinoxes the sun is situated above this plane, and, consequently, the shadow of P describes the lower curves at A B. During winter, on the contrary, it is the upper curves that are described. It is easily seen that the curves traced by the shadow of the point P are hyperbolas whose convexity is turned toward A B. It therefore appears evident to us that the thread of our sun dial carried a knot or bead whose shadow was followed upon the curves. This shadow showed at every hour of the day the approximate date of the day of observation. The sun dial therefore served as a calendar. But how was the position of the bead found? Here we are obliged to enter into new details. Let us project the figure upon a vertical plane (Fig. 3, No. 1) and designate by H E the summits of the hyperbolas corresponding to the winter and summer solstices. If P be the position of the bead, the angles, P H H<sup>1</sup>, P E E<sup>1</sup>, will give the height of the sun above the horizon at noon, at the two solstices. Between these angles there should exist an angle of 47 deg., double the obliquity of the ecliptic, that is to say, the excursion of the sun in declination: now P E E<sup>1</sup>-P H H<sup>1</sup> = E P H = 47 deg..

Let us carry, at H and E, the angles, O H E = H E O = 43 deg. = 90 deg.-47 deg.; the angle at O deg. will be equal to 180-86 = 94 deg.. If we trace the circumference having O for a center, and passing through E and H, each point, Q, of such circumference will possess the same property as the angle, H Q E = 47 deg.. The intersection, P, of the circumference with the straight line, N, therefore gives the position of the bead.



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Let us return to our instrument. We have traced upon a diagram the distance of the points of attachment of the thread, at the intersection of the planes of projection. We have thus obtained the position of the line, N S. Then, operating as has just been said, we have marked the point, P. Now, accurately measuring all the angles, we have found:  $N S R = 50 \text{ deg.}$ ;  $P H H^1 = 18 \text{ deg.}$ ;  $P E E^1 = 65 \text{ deg.}$ . The first shows that the instrument has been constructed for a place on the parallel of  $50 \text{ deg.}$ , and the others show that, at the solstices, the height of the sun was respectively  $18 \text{ deg.}$  and  $65 \text{ deg.}$ , decomposed as follows:

$18 \text{ deg.} = \text{polar height of the place} - 23\frac{1}{2} \text{ deg.}$   
 $65 \text{ deg.} = \text{ " " " " } + 23\frac{1}{2} \text{ deg.}$

The polar height of the place where the object was to be observed would therefore be  $41\frac{1}{2} \text{ deg.}$ , that is to say, its latitude would be  $48\frac{1}{2} \text{ deg.}$

Minor views of construction and measurement and the deformations that the instrument has undergone sufficiently explain the divergence of  $1\frac{1}{2} \text{ deg.}$  between the two results, which comprise between them the latitude of Paris.

After doing all the reasoning that we have just given at length, we have finally found the means by which the hypothetic bead was to be put in place. A little beyond the curves, a very small but perfectly conspicuous dot is engraved—the intersection of two lines of construction that it was doubtless desired to efface, but the scarcely visible trace of which subsists. Upon measuring with the compasses the distance between the insertion of the thread and this dot, we find exactly the distance, N P, of our diagram. Therefore there is no doubt that this dot served as a datum point. The existence of the bead upon the thread and the use of it as a rude calendar therefore appears to be certain.

The compass is to furnish us new indications. After dismounting it—an operation that the quite primitive enchasing of the face plate renders very easy—we took a copy of it, which we measured with care. The arrow forms with the line O C-O R an angle of  $90 \text{ deg.} + 8 \text{ deg.}$ . The compass was therefore constructed in view of an eastern declination of  $8 \text{ deg.}$ .

Now, here is what we know with most certainty as to the magnetic declination of Paris at the epoch in question:

Years. Declinations. 1550.  $8 \text{ deg. east.}$  1580.  $11.30$  1622.  $6.30$  1634.  $4.16$

On causing the curve (Fig. 3, No. 3) to pass through the four points thus determined, we find, for 1612, the declination  $8\frac{1}{2} \text{ deg.}$ . This is, with an approximation closer than that of the measurements that can be made upon the small compass, the value that we found. From these data as a whole we draw the two following conclusions: (1) The

instrument was constructed at Paris; and (2) the inventor was accurately posted in the science of his time.

Certain easily perceived retouchings, moreover, show that this sun dial is not a copy, but rather an original. We are therefore in an attitude to claim, as we did at the outset, that the constructor of this pleasing object was not only an artist, but a man of science as well.



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Let us compare a few dates: In 1612, Galileo and Kepler were still living. Thirty years were yet to lapse before the birth of Newton. Modern astronomy was in its tenderest infancy, and remained the privilege of a few initiated persons.—*C.E. Guillaume, in La Nature.*

\* \* \* \* \*

[MIND.]

### **THE UNDYING GERM PLASM AND THE IMMORTAL SOUL.**

By Dr. R. VON LENDENFELD.

[The following article appeared originally, last year, in the German scientific monthly, *Humboldt*. It is reproduced here (by permission)—the English from the hand of Mr. A.E. Shipley—as a specimen of the kind of general speculation to which modern biology is giving rise.—EDITOR.]

To Weismann is due the credit of transforming those vague ideas on the immortality of the germ plasma which have been for some time in the minds of many scientific men, myself among the number, into a clear and sharply-defined theory, against the accuracy of which no doubt can be raised either from the theoretical or from the empirical standpoint. This theory, defined as it is by Weismann, has but recently come before us, and some time must elapse before all the consequences which it entails will be evident. But there is one direction which I have for some time followed, and indeed began to think out long before Weismann's remarkable work showed the importance of this matter. I mean the origin of the conception of the immortal soul.

Before I approach the solution of this problem, it may be advisable to recall in a few words to my readers the theory of the immortality of the germ plasm.

All unicellular beings, such as the protozoa and the simpler algae, fungi, *etc.*, reproduce themselves by means of simple fission. The mother organism may split into two similar halves, as the amoeba does, or, as is more common in the lowest unicellular plants, it may divide into a great number of small spores. In these processes it often happens that the whole body of the mother, the entire cell, may resolve itself into two or more children; at times, however, a small portion of the mother cell remains unused. This remnant, in the spore-forming unicellular plants represented by the cell wall, is then naturally dead.

From this it follows that these unicellular beings are immortal. The mother cell divides, the daughter cells resulting from the first division repeat the process, the third

generation does the same, and so on. At each division the mother cell renews its youth and multiplies, without ever dying.

External circumstances can, of course, at any moment bring about the death of these unicellular organisms, and in reality almost every series of beings which originate from one another in this way is interrupted by death. Some, however, persist. From the first appearance of living organisms on our planet till to-day, several such series—at the very least certainly one—have persisted.



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The immortality of unicellular beings is not at any time absolute, but only potential. Weismann has recently directed attention to this point. External occurrences may at any moment cause the death of an individual, and in this way interrupt the immortal series; but in the intimate organization of the living plasma there exist no seeds of death. The plasma is itself immortal and will in fact live forever, provided only external circumstances are favorable.

Death is always said to be inherent in the nature of protoplasm. This is not so. The plasm, as such, is immortal.

But a further complication of great importance affects the reproduction and the rejuvenescence of these unicellular organisms; this is the process of conjugation. Two separate cells, distinct individuals, fuse together. Their protoplasmic bodies not only unite but intermingle, and their nuclei do likewise; from two individuals one results. A single cell is thus produced, and this divides. As a rule this cell seems stronger than the single individual before the union. The offspring of a double individual, originated in this way, increase for some time parthenogenetically by simple fission without conjugation, until at length a second conjugation takes place among them. I cannot consider further the origin of this universally important process of conjugation. I will only suggest that a kind of conjugation may have existed from the very beginning and may have been determined by the original method of reproduction, if such existed.

At any rate conjugation has been observed in very many plants and animals, and is possibly universally present in the living world.

Conjugation does not affect the theory of immortality. The double individual produced from the fusion of two individuals, which divides and lives on in its descendants, contains the substance of both. The conjugating cells have in no way died during the process of conjugation; they have only united.

If we examine a little more closely the history of such a "family" of unicellular beings from one period of conjugation to the next, we see that a great number of single individuals, that is, single cells, have proceeded from the double individual formed by conjugation. These may all continue to increase by splitting in two, and then the family tree is composed of dichotomously branching lines; or they may resolve themselves into numerous spores, and then the family tree exhibits a number of branches springing from the same point.

The majority of these branches end blindly with the death, caused by external circumstances, of that individual which corresponds with the branch. Only a few persist till the next period of conjugation, and then unite with other individuals and afford the opportunity for giving rise to a new family tree.



All the single individuals of such a genealogical table belong to one another, even though they be isolated. Among certain infusoria and other protista, they do, in fact, remain together and build up branching colonies. At the end of each branch is situated an infusorian (vorticella), and the whole colony represents in itself the genealogical family tree.



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In the beginning, there existed no other animal organisms than these aggregations of similar unicellular beings, all of which reproduced themselves. Later on, division of labor made its appearance among the individuals of the animal colony, and it increased their dependence upon one another, so that their individuality was to a great extent lost, and they were no longer able to live independently of one another.

By the development of this process, multicellular metazoa arose from the colonies of similar protozoa, and at length culminated in the higher animals and man.

If we examine the human body, its origin and end, in the light of these facts, we shall see that a comparison between the simple immortal protozoa and man leads us to the result that man himself, or at least a part of him and that the most important, is immortal.

When we turn to the starting point of human development, we find an egg cell and a spermatozoon, which unite and whose nuclei intermingle. Thus a new cell is produced. This process is similar to the conjugation of two unicellular beings, such as two acinetiform infusoria, one of which, the female ([Symbol: Female]), is larger than the other, the male ([Symbol: Male]). This difference of size in the conjugating cell is, however, without importance.

From this double cell produced by conjugation many generations of cells arise by continual cell division in divergent series. Among the infusoria these are all immortal, but many of them are destroyed, and only a few persist till conjugation again takes place. The same is the case with man. Numerous series of cell families arise, which are all immortal: of these but few—strictly speaking, only one—live till the next period of conjugation and then give the impulse which results in the formation of a new diverging series of cells. The difference between man and the infusorian is only that in the former the cells which originate from the double cell (the fertilized ovum) remain together and become differentiated one from another, while in the latter the cells are usually scattered but remain alike in appearance, *etc.*

The seeds of death do not lie, as Weismann appears to assume, in the differentiation of the cells of the higher animals. On the contrary, all the cell series, not only those of the reproductive cells, are immortal. As a matter of fact all must die; not because they themselves contain the germs of death and have contained them from the beginning, but because the structure which is built up by them collectively finally brings about the death of all. The living plasm in every cell is itself immortal. It is the higher life of the collective organism which continually condemns countless cells to death. They die, not because they cannot continue to exist as such but because conditions necessary for their preservation are no longer present.

Thus, while the cells are themselves immortal, the whole organism which they build up is mortal. The complex inter-dependence between the single cells, which, since they have adapted themselves to division of labor, has become necessary, carries with it,

from the beginning, the seeds of death. The mutual dependence ceases to work, and the various cells are killed.



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The death of the individual is a consequence of the defective precision in the working of the division of labor among the cells. This defect, after a longer or shorter time, causes the death of all the cells composing the body. Only those which quit the body retain their power of living.

Of all those countless cells which, in the course of a lifetime, are thrown off from the body, only one kind is adapted for existence outside the body, namely, the reproductive cells.

Among the lower animals the reproductive cells often leave the body of their parents only after the death of the latter. This is not the case in man.

All the cell series which do not take part in the formation of reproductive cells, as well as all the reproductive cells without exception, or with only a few exceptions, die through unfavorable external conditions; just as all, or almost all, of the infusoria which arose from the double cell die before they can conjugate again.

At times, however, some of the infusoria persist till the next period of conjugation, and in the same way, from time to time, some of the human reproductive cells succeed in conjugating, and from them a new individual arises.

A man is the outgrowth of the double cell produced from the conjugation of two human reproductive cells, and consists of all the cells which arise from this and remain in connection with each other. The human individual originates at the moment of the mingling of the nuclei of the reproductive cells; and the details of this mingling determine his individual peculiarities.

The end of man is manifestly to preserve, to nourish, and to protect the series of reproductive cells which are continually developing within him, to select a suitable mate and to care for the children which he produces. His whole structure is acquired by means of selection with this one object in view, the maintenance of the series of reproductive cells.

From this standpoint the individual loses his significance and becomes, so to speak, the slave of the reproductive cells. These are the important and essential and also the undying parts of the organism. Like raveled threads whose branches separate and reunite, the series of reproductive cells permeate the successive generations of the human race. They continually give off other cell series which branch out from this network of reproductive cells, and, after a longer or shorter course, come to an end. Twigs from these branches represent the human individuals, and any one who considers the matter must recognize that, as was said above, apart from the preservation of the reproductive cell series the individuals are purposeless.

It is on this basis that the moral ordering of the world must place itself if it is to stand on any basis at all. It is an easy and a pleasant task to interpret the facts of history from this standpoint. Everything fits together and harmonizes, and each turn in the historical development of civilization when observed from this point of view acquires a simple and a clear causality.

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I cannot enlarge on this topic, engaging as it is, but here a further question obtrudes itself. May there not be some connection between the actual immortality of the germ cells, the continuity of their series and the importance of the part they play, and the origin of the idea of an immortal soul? May not the former have given rise to the latter?

As a matter of fact, the series of reproductive cells possess the essential attributes of the human soul; they are the immortal living part of a man, which contain, in a latent form, his spiritual peculiarities. The immortality of the reproductive cells is only potential and is essentially different from that absolute eternal life which certain religions ascribe to the soul.

We must not, however, forget that at the time when the conception of a soul arose among men, owing to a defective knowledge of the laws of logic, no clear distinction was made between a potential immortality and an absolute life without end.

Herbert Spencer has pointed out that all religions have their origin in reverence paid to ancestors. Each religion must have a true foundation, and the deification of our forefathers has this true and natural foundation inasmuch as they belong to the same series of reproductive cells as their descendants. Of course our barbaric ancestors who initiated the ancestor worship had no idea of this motive for their religion, but that in no way disproves that this and this alone was the *causa efficiens* of the origin of such religions. It is indeed typical of a religion that it depends upon facts which are not discerned and which are not fully recognized.

With the origin and development of every religion the origin and development of the conception of the soul progresses step by step.

We find the justification of ancestor worship in the immortality of the reproductive cells, and in the continuity of their series. This should also take a part in the origin of the conception of the soul.

Spencer derives the conception of the existence of the soul from dreams, and from the imagination of the mentally afflicted. The savage dreams he is hunting, and wakes up to find himself at home. In his dream he talks with friends who are not present where he sleeps; he may even in the course of his dream encounter the dead. From this he draws the conclusions—(1) that he himself has two persons, one hunting while the other sleeps; (2) that his acquaintances also have a double existence; and, from those cases in which he met with the dead, (3) that they are not only double persons, but that one of the persons is dead while the other continues to live.

Thus, according to Spencer, the idea arises that man consists of two separable thinking parts, and that one of these can survive the other.



When a person faints and recovers, we say he comes to himself. That is, a part of his person left him and has returned. But in this case, as in the dream, the body has not divided, so that in a swoon the outgoing portion is not corporeal.

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The savage will think that this is what remains alive after death, for he is incapable of distinguishing between a swoon and death. Then he will associate the part which leaves the body during a swoon with that which gives life, and some will regard the heart, which fails to beat after death, and others the breath, which ceases when life does, as this life-giving part or soul.

Thus far I am quoting from Spencer.

The conception of the soul, which has thus arisen, has been utilized by astute priests to obtain power over their fellow-men; while the genuine founders of religions have made use of it, and by threats of punishment, and promises of reward, have tried to induce mankind to live uprightly.

With this purpose in view, the teachers of religion have changed the original conception of the soul and have added to it the attribute of absolute immortality and eternal duration, an attribute which is in no way connected by people in a low state of development with their conception of the soul.

At the present time among the religions of all civilized people the undying soul plays an extraordinarily important part.

I start from the position that no doctrine can receive a general acceptation among men which does not depend on a truth of nature. The various religions agree on one point, and this is the doctrine of the immortal soul. Such a point of universal agreement, I am convinced, cannot have been entirely derived from the air. It must have had some foundation in fact, and the question arises, What was this foundation? Dreams and phantasms, as Spencer believes? No; there must have been something real and genuine, and the path we have entered upon to find traces of this true foundation of the conception of the soul cannot be distrusted.

We must compare the conception of the soul as held by various related religions, and strip off from it all those attributes which are not common to all. But those which all the various religions agree in ascribing to the soul we may regard as its true attributes.

It would take too long to go into the details of this examination of the conception of the soul. As the general result of a comparison of the various views of the soul we may put down the following characteristics which are invariably ascribed to it:

- (1) The soul is living.
- (2) It survives the body, and can continue to exist without it.
- (3) During life it is contained in the body, but leaves it after death.



(4) The soul participates in the conduct of the body: after the death of the latter, causality (retribution) can still affect the soul.

The characteristics (1) to (3) hold also for the series of reproductive cells continually developing within the body; and these attributes of the germ cells may well be the true but unrecognized cause of the origin of those conceptions of the soul's character.



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This like holds true for (4), although the connection is not so obvious. For this reason it will be advisable to consider the point in more detail.

It has been already indicated that the founders of religions have made use of the survival of the soul after death to endeavor to lead mankind to live righteously, by threats of punishments or promises of reward, which will affect the soul after the death of the body.

It is precisely on this point that in the most highly developed religions there is the greatest falling off from the original conception of the after-effect of human conduct on the soul, and the most astounding things are inculcated by the Koran and other works with respect to this.

But here again we may separate the true kernel from the artificial shell, and reach the conclusion that good conduct is advantageous for the soul after the death of the body, and that bad conduct is detrimental. In no other way can the Mohammedan paradise or the Christian hell be explained than as sheer anthropomorphic realizations of these facts, which can appeal even to the densest intellect.

What then is good conduct, or bad?

The question is easily asked, but without reference to external circumstances impossible to answer. *Per se* there is no good or bad conduct. Under certain circumstances a vulgar, brutal murder may become a glorious and heroic act, a good deed in the truest sense of the word; as, for example, in the case of Charlotte Corday. Nor must the view of one's fellow creatures be accepted as a criterion of good or bad conduct, for different parties are apt to cherish diametrically opposed opinions on one and the same subject. There remains then only one's own inner feeling or conscience. Good conduct awakes in this a feeling of pleasure, bad conduct a feeling of pain. And by this alone can we discriminate. Now let us further ask. What sort of conduct produces in our conscience pleasure and what sort of conduct induces pain? If we investigate a great number of special cases, we shall recognize that conduct which proves advantageous to the individual, to the family, to the state, and finally to mankind, produces a good conscience, and that conduct which is injurious to the same series give rise to a bad conscience. If a collision of interests arise, it is the degree of relationship which determines the influence of conduct on the conscience. As, for instance, among the clans in Scotland, a deed which is advantageous for the clan produces a good conscience, even if it be injurious to the state and to mankind.

The conscience is one of the mental faculties of man acquired by selection and rendered possible by the construction and development of the commonwealth of the state. Conscience urges us to live rightly, that is, to do those things which will help ourselves and our family, whereby our fellow creatures according to their degree of relationship may be benefited. These are good deeds, and they will merit from the

teachers of religion much praise for the soul. We find, therefore, that the only possible definition of a good deed is one which will benefit the series of germ cells arising from one individual, and further which will be of use to others with their own series of germ cells, and that in proportion to the degree of connection (relationship).



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It is clear that in this point also the ordinary conception of the future fate of the soul agrees fundamentally with the result of observation on the prosperity of the series of germ cells.

As all the forces of nature, known to the ignorant barbarian only by their visible workings, call forth in him certain vague and, therefore, religious ideas, which are but a reflection of these forces in an anthropomorphically distorted form, so the apparently enigmatical conception of the eternal soul is founded on the actual immortality and continuity of the germ plasma.

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### COCOS PYNAERTI.

This is an acquisition to the dwarf growing palms, and a graceful table plant. It first appeared in the nurseries of M. Pynaert, Ghent, and is evidently a form of *C. Weddelliana*, having similar character, though, as shown by the accompanying illustration, it is quite distinct. The leaves are gracefully arched, the pinnules rather broader than in the type, more closely arranged, and of a deep tone of rich green. Such a small growing palm possessing elegant and distinct character should become a favorite.—*The Gardener's Magazine*.

[Illustration: COCOS PYNAERTI—A NEW PALM.]

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### THE MISSISSIPPI RIVER.[1]

[Footnote 1: Read May 17, 1890, before the Engineers' Club of Philadelphia.]

By JACQUES W. REDWAY.

### INTRODUCTION.

The purport of the following paper is to show that corrosion of its banks and deposition of sediment constitute the legitimate business of a river. If the bed of the Mississippi were of adamant, and its drainage slopes were armored with chilled steel, its current would do just what it has been doing in past ages—wear them away, and fill the Gulf of Mexico with the detritus.



Many thoughts were suggested by Mr. S.C. Clemens, erstwhile a Mississippi pilot, and by Mr. D.A. Curtis. Both of these gentlemen *know* the river.

## GENERAL GEOGRAPHY.

The Mississippi River, as ordinarily regarded, has its head waters in a chain of lakes situated mainly in Beltrami and Cass counties, Minnesota. The lake most distant from the north is Elk Lake, so named in the official surveys of the U.S. Land Office. A short stream flows from Elk Lake to Lake Itaska, a beautiful sheet of water, considerably larger than Elk Lake. From Lake Itaska it flows in a general northeasterly direction, receiving the waters of innumerable springs and ponds, among them Lake Bemidji, a body of water equal in size to Lake Itaska. After a course of 135 miles the stream flows into Cass Lake, absorbing in the meantime the waters of another chain of lakes, discharged through Turtle River. From

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Cass Lake the waters flow a distance of twenty miles, and are poured into Lake Winnibigoshish. The latter has an area of eighty square miles; it is twice the size of Cass Lake and more than six times that of Lake Itaska. From Lake Winnibigoshish to the point where it receives the discharge of Leech Lake, the river flows through an open savannah, from a quarter of a mile to a mile in width. Forty miles beyond are Pokegama Falls. Here the river flows from Pokegama Lake, falling about fourteen feet before quiet water is reached. All the country about the headwaters is densely wooded with Norway pine on the higher ground, and with birch, maple, poplar and tamarack on the lower ground. Between Pokegama Falls and the Falls of St. Anthony, the river receives the waters of a number of other similar streams, all flowing from the lake region.

At St. Paul the navigable stage of the river practically begins, although there is more or less navigable water above the falls at certain seasons. From St. Paul to Cairo the river flows between bluffs, the terraces of Champlain times, from ten to fifty miles apart. Between the bluffs are the bottom lands, often coincident with the flood plain, along which the river channel wanders in a devious course of 1,100 miles. The soil of the bottom lands is, of course, alluvial, and was deposited by the river during past ages; that beyond the bluffs is a part of the great intermontane plain, and is sedentary—that is, it has not been materially disturbed since the plain was raised above the sea level by the uplift of the continent.

From Cairo, at the junction of the Ohio River, the plain to the southward is nearly all made land, and in a few spots only does the river touch soil which it has not itself made. Here the Lower Mississippi proper begins, and here, at some not far distant time in the past,[2] was the head of the Gulf of Mexico. A fuller description of the Lower Mississippi is unnecessary here, inasmuch as the following pages are mainly devoted to this part alone.

[Footnote 2: Estimated at from 100,000 to 150,000 years. Such estimates, however, are but little better than guesses.]

## HISTORICAL.

Nearly three and a half centuries have elapsed since De Soto, that prince among explorers, traversed the broad prairies that lie between the border highlands of the Western continent, and beheld the stream which watered the future empire of the world. His chroniclers tell us that he was raised to an upright position, so that he could catch a fleeting glimpse of the restless, turbulent flood; for even then the hand of death was upon him, and soon its waters were to enshroud his mortal remains. “His soldiers,” says Bancroft, “pronounced his eulogy by grieving for their loss, and the priests chanted



over his body the first requiems ever heard on the Mississippi. To conceal his death, his body was wrapped in a mantle, and, in the stillness of midnight, was silently sunk in the middle of the stream." Just across the river the Arkansas was pouring in its tumultuous flood, and its confluence was the site of the future town of Napoleon, which in coming years was to be historic ground.

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Worn by suffering, hardships and peril, and racked by the pestilential fever that still hovers about the river lowlands, De Soto paid the debt of nature, and his thrice decimated followers made their way back to France. It seemed a strange, incredible story that they told, for such a mighty river, with its vast plain, was beyond conception. Its source, they said, was in the north—among the eternal snows—farther than it had ever been given to man to penetrate. Its waters, they thought, were poured into the Gulf of California, or perhaps into the great Virginia Sea. Its flood, they said, was so great that if all the rivers of Europe were gathered into one channel, they would not be a tithe as large. But the people who heard these wonderful accounts were unconcerned. The French monarch knew naught but to debauch his heritage; the French courtier intrigued and plundered; the French peasant, dogged and sullen in his long suffering, dragged out his miserable existence. The flood of waters rolled on, and a hundred and thirty years must come and go before the next white man should see the sheen of its rippling.

Let us cast a retrograde glance to the history of this period. It was only fifty years before that Columbus had dropped anchor off the coral reef of Samana Cay, and thrilled the Old World by announcing the discovery of the New. Elizabeth, the virgin Queen of England, was a proud, haughty girl just entering her teens, all unmindful of her eventful future. Mary Queen of the Scots was a tiny infant in swaddling clothes. The labors of Rafael Sanzio were still fresh in the memory of his surviving pupils. Michael Angelo was in the zenith of his fame, bending his energies to the beautifying of the great cathedral. Martin Luther was in the sere old age of his life, waiting for the command of the Master, which should bid him lay down his armor. A hundred years were to elapse before Charles I. of England must pay with his life the price of his folly.

Joliet, a French trader, was a man possessed of far more brains than marked the average men of his times. He had not only the indomitable courage which is essential to the successful explorer, but he had also the rare ability to manage men; and we find him in 1672 with a commission from the French king directing him to explore the valley which was to be a part of New France. The lands which he visited must be his fee to the king; certain rights of trade he wisely secured to himself. So, with Pere Marquette, a Jesuit priest, he undertook the mission, which we may doubt whether to call a journey of discovery or an errand of diplomacy. Crossing the ocean, their route lay along the St. Lawrence River to the Great Lakes; through the Great Lakes to the country of the Illini; down the Illinois to the Mississippi, and down the Mississippi to its junction with the Arkansas. Here they encamped near the site of Napoleon. Everywhere along their route they had won the hearts of the savage Illini.

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They possessed that rare tact which was born in French travelers, and which no English explorer ever had. When they had reached the junction of the Arkansas, “they were kindly received by the Indian tribes.” They held a council with the various chiefs, with whom they made a treaty. The treaty was celebrated by a feast, and, if we may believe the record thereof, libations of wine were freely poured forth to pledge the stipulations of the business transaction. For a heavenly possession in the uncertain future, the Indian acknowledged, by the cross raised in commemoration, that he had bartered away his earthly kingdom. The title by which the Indian held the soil wrested from the Mound-builder may not have been perfect; that of the wily Joliet may have been equally defective. But Joliet builded more wisely than he knew, for to this day, fraud, treachery and broken faith are the chief witnesses to our treaties with the aboriginal owners of the land.

Nine years after the business venture of Joliet, La Salle received letters extraordinary from the King of France, directing him to make additional explorations along the course of the great river. He organized an expedition, crossed the ocean, and made his way rapidly to the scene of his explorations. Preparing his canoes and launches, he followed the sinuous course of the river to Napoleon. His arrival was celebrated by another feast and post-prandial business agreement, and New France began its brief existence. Never in the history of the world had such an empire been founded—such another could not be formed until the domains of this had been widened from sea to sea, and the energy of Saxon, Teuton and Kelt mingled to build a greater.

To La Salle belongs the honor of tracing the true course of the Mississippi river. He charted it with a faithfulness and accuracy that would do credit to the surveys of the present day. He seemed to have noted all the important feeders and tributaries, correctly locating their points of confluence. He did not cease his work until he reached the Gulf of Mexico.[3] So not only was La Salle the most indefatigable explorer of this region, but he also earned the credit of having made the most important discovery.

[Footnote 3: From the best information I can gather I am unable to decide to my own satisfaction whether or not La Salle discovered the Red River. It is not improbable that he never saw this stream, for it is more than likely that at that time, Red River poured its waters directly into the Gulf of Mexico, through Atchafalaya and Cocoudrie Bayous. That these were formerly a part of the channel of Red River, there can be no doubt. The sluggish swale that now leads from the river to the Gulf is a silted channel that was formerly large enough to carry the whole volume of Red River. Such changes in the channel of a river, when the latter flows through “made” soil, are by no means infrequent. It is only a few years since

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the Hoang River, “the sorrow of Han,” broke through its restraining banks, and poured its flood into the Gulf of Pe-chee-lee, 350 miles distant from its former mouth.]

With La Salle’s exploration the future importance of the Mississippi began; and though the railway has of late years largely supplanted it as a commercial highway, yet, with the possible exception of the Ganges, no other river in the world transports yearly a greater tonnage of merchandise. The early traders were content to carry their supplies back and forth in canoes. As settlement and business increased, the canoe gave place to the raft, and the raft yielded to the flatboat. In the course of time, steam was applied to the propulsion of boats, and the flatboat yielded to the inevitable: the palatial steamboat was supreme. But the days of the steamboat were numbered when the civil war cast its blight over the land; and when the years of strife were over, so also was the river traffic which had created the floating palaces of the Mississippi. There were several things that operated to prevent the reorganization of the fleet of steamboats which for size, beauty and capacity were found in no other part of the world. Many of these boats had been destroyed, and the companies that owned them were financially ruined. Most of those remaining were purchased or confiscated for military purposes, and rebuilt either as transports or as gunboats. A period of unparalleled railway construction began at the close of the war, and most of the traffic was turned to the railway. Finally, it was discovered that a puffy, wheezy tug, with its train of barges, costing but a few thousand dollars, and equipped with half a score of men, could, at a much less rate, tow a vastly greater cargo than the river steamer. That discovery was the knell of the old-time steamboat, and the beginning of a new era of navigation. Powerful as the railway may be, we cannot shut our eyes to the fact that a tug and train of barges will carry a cargo of merchandise from St. Paul to St. Louis for one-tenth the sum the consignee must pay for railway transportation. So, to-day, the river is just as important as a highway of commerce as it was in the palmy days of the floating palace and river greyhound. Railway traffic has enormously increased, but river traffic along the most wonderful of streams has not materially lessened.

The Mississippi is certainly a wonderful river. From Elk Lake to the Gulf of Mexico it has a variable length of about 2,800 miles; from Pass a l’Outre to the head of the Missouri its extent is nearly 4,200 miles—a length not equaled by any other river in the world. It is evident, by a moment of reflection, that a river which traverses a great extent of latitude offers much greater facilities for commerce and settlement than a longitudinal river. The Mississippi traverses a greater breadth of latitude than any other river, except the Nile, for its sources are in regions of almost arctic cold, while its delta



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is in a land that is practically tropical. The volume of its flood is surpassed by the Amazon and, perhaps, the Yukon. It discharges, however, three times as much water as the Danube, twenty-five times as much as the Rhine, and almost three hundred and fifty times as much as the Thames. It has several hundred navigable tributaries, and its navigable waters, stretched in a straight line, would reach nearly three-fourths the distance around the earth. It is one of the most sinuous of rivers. In one part of its course it flows in a channel nearly 1,400 miles long to accomplish, as the crow flies, the distance of 700 miles. In more than one place the current forms a loop ten, twenty and even thirty miles around, rather than to cut through a neck perhaps not half a mile in width. It is one of the most capricious of rivers, for its channel rarely lies in the same place during two successive seasons. The river manifests a strong inclination to move east; and were La Salle to repeat his memorable voyage, he would touch in scarcely half a score of places the course he formerly traveled; or if he were to go over exactly the same course, he must of necessity have his boats dragged over the ground, for almost the entire course over which he traveled is now dry land. Since that time the river has deserted almost all of its former channel, as if to repudiate its connection with the after-dinner treaties of two hundred years lang syne; in places its channel lies to the west, but for the greater extent it is to the eastward.[4]

[Footnote 4: "The bed of the river is so broad that the channel meanders from side to side within the bed, just as the bed itself meanders from bluff to bluff; and, as by erosions and deposits, the river, in long periods of time, traverses the valley, so the channel traverses the bed from bank to bank, justifying the remark often heard, that 'not a square rod of the bed could be pointed out that had not, at some time, been covered by the track of steamboats.'"—J.H. SIMPSON, *Col. Eng., Brevet Brig.-Gen., U.S.A.*]

### PHYSICAL.

The lower Mississippi is among the muddiest streams in the world. During the average year it brings down 7,500,000,000 cubic yards of sediment, discharging it along the lower course, or pushing it into the Gulf. As one thinks of the small amount of sediment held in a gallon or two of river water, a comprehension of this vast amount of silt is impossible. It is enough to cover a square mile in area to a depth of 268 feet. In five hundred years it would build above the sea level a State as large and as high as Rhode Island. Thus, by means of this sediment, the river has pushed its mouths fifty miles into the sea, confining its flow within narrow strips of land—natural levees made by the river itself.



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The Mississippi is notable for its varying length. Within the memory of the oldest pilot the length of the river between St. Louis and New Orleans has varied more than one hundred and fifty miles, being sometimes longer and sometimes shorter, as the year may be one of drought or of excessive rainfall. Occasionally the river will shorten itself a score of miles at a single leap. The shortening invariably takes place at one of its long sinuous curves for which it is so remarkable. At a season when the volume of water begins to increase, the narrow neck of the loop gives way little by little under the continuous impact of the strengthening current. Narrower and narrower it grows as the water ceaselessly cuts away the bank. Finally the barrier is broken; there is a tumultuous meeting of waters; the next steamboat that comes along goes through a new cut; and a moat or ox-bow lake is the only reminder of the former channel.[5]

[Footnote 5: One of the most noteworthy examples of these cut-offs is Davis'. This cut-off occurred at Palmyra Bend, eighteen miles below Vicksburg. The mid-channel distance around the bend was not far from twenty miles; the neck was only twelve hundred feet across. The fall of the river, measured around the bend, was about four inches per mile; the slope, measured across the neck, was about five and one-half feet, nearly twenty feet per mile. Inasmuch as the soil in the neck was wholly alluvial, the current cut its new channel with exceedingly great rapidity, soon clearing it out a mile in width and more than one hundred feet in depth. The water rushed through the channel with such a velocity that steamboats could not breast its flow for many weeks, while the roaring of its flood could be heard many miles away. The influence of the cut-off was felt both above and below Vicksburg for several years after. The rate of erosion has been perceptibly increased above Vicksburg: and it is not unlikely that the cut-off which occurred a few years later at Commerce, about thirty miles below Memphis, was a result of Davis' Cut. Other recent cut-offs have occurred near Arkansas City, below Greenville, near Duncansby, below Lake Providence at Vicksburg, and at Kienstra. The latter place is below Natchez; all the others are between Natchez and Memphis. A double cut-off is strongly threatened at Greenville.]

In 1863 the city of Vicksburg was situated on the outer curve of such a loop. At that time General Grant and his army were on the opposite side of the river, and the whole power of the Federal government was directed upon devising how the army might cross it and capture the long-beleagured city. So an army engineer conceived the idea of turning the river around the rear of the army. Accordingly, a canal was cut across the loop, in order to make an artificial channel through which its current might run. But the river steadfastly refused to accept any channel it had not itself made, and the ditch soon silted

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up. Twelve years or more afterward there was trouble; for the river, which had all this time so persistently ignored the canal, one stormy night, when its current was considerably swollen, took a notion to adopt the canal that it had so long refused. Next morning the good people of Vicksburg woke to find their metropolis, not on the river channel, but practically an inland town overlooking a stagnant mud flat. The town of Delta, which, the night before, was three miles below Vicksburg, was, in the morning, two miles above it. Since that time, energy and intelligence have conspired in its behalf, and Vicksburg is still an important river port; but the channel of the river is persistent, and constant effort and watchfulness alone keep a depth of water sufficient for the needs of navigation before the wharves.

The average inhabitant of the flood plain of the Mississippi is not surprised at this capriciousness of the river, for long experience has taught him to look for it. During seasons of mean or of low water, there is little or no trouble; but when floods begin to swell the current, then it is high time to be on the alert, for no one knows what a day or even an hour may bring forth. Perhaps a snag, loosened from the bank above, may come floating down the stream. It strikes a shallow place somewhere in the river, and thereupon anchors in mid-channel. Directly it does, a small riffle or bar of silt will form around it, and this, in turn, sends an eddying current over against the bank. By and by the latter begins to be chipped away, little by little. Perhaps the corrosion of the bank might not be noticed except by a bottom land planter or a riverman. But there is no time to be lost. If some unfortunate individual happens to possess belongings in that vicinity, he simply lays aside his coat and works as if he were a whole legion doing Caesar's bidding; he well knows that in a very few hours the river will be swallowing up his real estate at the rate of half an acre to the mouthful. It is certainly hard to see one's earthly possessions disappear before the angry flood of the river, but the bottom land planter does not complain, because the experience of generations has taught him that he must expect it. A queer fortune befell Island No. 74.

Between the States of Arkansas and Mississippi there is a large island, which, for want of a name, is commonly known as Island No. 74.[6] This slip of insular land is probably the only territory within the United States and not of it, for this island is without the boundaries of either State, county or township. It is not under control of the government, because it is in the possession of an owner whose claim is acknowledged by the government. The anomalous position of the island as to political situation is due to the erosion of the river as an active and the defects of statutory law as a passive agent. According to the enactment whereby the States of Arkansas and Mississippi were created, the river boundary of the



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former extends to *mid-stream*; that of the latter to *mid-channel*. Herein is the difficulty. A dissipated freshet turned the current against the Mississippi bank, and shifted the former position of mid-channel many rods to the eastward, so that the fortunate or unfortunate owner found his possessions lying beyond both the mid-river point of Arkansas and the mid-channel line of Mississippi. The owner of the plantation may be unhappy at time of election, for he is practically a non-resident of any political division. His grief, however, is somewhat assuaged when the tax gatherer calls, for, being outside of all political boundaries, he has no taxes to pay.

[Footnote 6: For convenience to navigation, the islands in the lower Mississippi, beginning at St. Louis, are numbered. Many of them, however, have local names by which they are frequently known.]

Within a few years the town of Napoleon, which has already been mentioned as the site which beheld the cross erected by Marquette and the seizure of La Salle, was the scene of still another chapter in history. Almost two hundred years from the time when Joliet and Marquette beheld the historic ground, the river turned its current against the banks, and in a few hours the crumbling walls of an old stone building, half a mile or more from the river banks, were the surviving monument that marked the former location of the town.

The Mississippi is indeed a grand study, and the people who have lived in its valley during past ages have seen the river doing just what it is doing to-day; and as race has succeeded race, each in turn has seen the landmarks of its predecessors swept away by its angry flood and buried beneath its sediment. Ever since the crests of the Appalachian and Rocky Mountains were thrust up above the sea, the river has been wearing them away, and bearing the scourings to the vast plain below. In the time of its building it has made the greatest and the richest valley on the face of the earth; next to that of the Amazon it is the largest, covering an area of one and one-quarter million square miles. The river and its tributaries drain twenty-eight States and Territories—an area equal to that of all Europe except Russia. This basin includes half the area of the United States, exclusive of Alaska. It is five times as large as Austria-Hungary, six times the size of France or Germany, nine times the area of Spain, and ten times that of the British Isles. Measured by its grain-producing capacity, this valley is capable of supporting a larger population than any other physical region on the face of the earth. Already it is the foremost region in the world in the production of grain, meat and cotton. The rich soil, sedentary on the prairie and alluvial in the bottomlands, is almost inexhaustible in its nutritious qualities. The soil cannot be “worn out” in the bottomlands, for nature restores its vitality by bringing fresh supplies from

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the highlands as fast or faster than the seed crop exhausts it. Sixty bushels of wheat or two bales of cotton may be harvested from an acre of bottom lands. So vast in proportions is the yearly crop of food stuffs that more than three hundred thousand freight cars and about two thousand vessels are required to move the crop from farm to market. One hundred and twenty-five thousand miles of railway, fifteen thousand miles of navigable water, exclusive of the Great Lakes, and several thousand miles of canals are insufficient to transport this enormous production; thousands of miles of railway are therefore yearly built in order to keep pace with the growth of population and the settlement of new lands. To the natural resources of the soil add the enormous mineral wealth hidden but a few feet below the surface, and wonder grows to amazement. Coal fields surpassing in extent all the remaining fields in the world; iron ore sufficient to stock the world with iron and steel for the next thousand years; copper of the finest quality; zinc, lead, salt, building stone and timber, all in quantities sufficient for a population a hundred times as great. Is it strange that wise economists point to this territory and say, "Behold the future empire of the world"? Where in the wide world is another valley in which climate, latitude and nature have been so liberal?

It is only a few years since the Indian and the bison divided between them the sole possession of this region. What a change hath the hand of destiny wrought! What a revelation, had some unseen hand lifted the curtain that separated the past from the future! Iron, steam and electricity have in them more of mysterious power than ever oriental fancy accredited to the genii of the lamp, and the future of the basin of the Mississippi will be a greater wonder than the past.

The feast of La Salle was the death warrant of the Indian, and the Aryan has crowded out the Indian, just as the latter evicted the mound builder—just as the mound builder overcame the people whose monuments of burned brick and cut stone now lie fifty feet below the surface. Only a few centuries have gone by since these happenings; can we number the years hence when rapacious hordes from another land shall drive out the effete descendants of the now sturdy Aryan?

*(To be continued.)*

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## **FREEZING MIXTURES.**

The following selection of mixtures causing various degrees of cold, the starting point of the cooling being indicated in the first column, will probably serve many purposes. It should be stated that the amount of depression in temperature will practically be the same, even if the temperature to start from is higher. Of course in the case of snow it

cannot be higher than 0 deg. C. (32 deg. F.) But in some cases it is necessary to start at a temperature below 0 deg. C. For instance, the temperature of -49 deg. C. may be reached by mixing 1 part of snow with 1/2 part of dilute nitric acid. But then the snow must have the temperature -23 deg. C. If it were only at 0 deg. C., the depression would be only to about -26 deg. C.:

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The temperature sinks  
 Substances to be mixed in parts by -----  
 weight. | from | to

1. Water.	1		+10 deg. C.		-15.5 deg. C.
Ammonium nitrate.	1				
2. Dil. hydrochloric acid.	10		+10		-17.8
Sodium sulphate.	16				
3. Dil. hydrochloric acid.	1		+10		-16
Sodium sulphate.	1 1/2				
4. Snow.	1		+ 0		-32.5
Sulphuric acid.	4				
Water.	1				
5. Snow.	1		— 7		-51
Dil. sulphuric acid.	1				
6. Snow.	1		-23		-49
Dil. nitric acid.	1/2				
7. Snow.	1		0		-17.8
Sodium chloride.	1				
8. Snow.	1		0		-49
Calcium chloride.	1.3				
9. Snow.	1		0		-33
Hydrochloric acid.	0.625				
10. Snow.	1		0		-24
Sodium chloride.	0.4				
Ammon. chloride.	0.2				
11. Snow.	1		0		-31
Sodium chloride.	0.416				
Ammon. nitrate.	0.416				

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## **THE APPLICATION OF ELECTROLYSIS TO QUALITATIVE ANALYSIS.**

By CHARLES A. KOHN, B.Sc., Ph.D., Assistant Lecturer in Chemistry, University College, Liverpool.

The first application of electrolysis to chemical analysis was made by Gaultier de Claubry, in 1850, who employed the electric current for the detection of metals when in solution. Other early workers followed in this direction, and in 1861 Bloxam published two papers (J. Chem. Soc., 13, 12 and 338) on "The application of electrolysis to the detection of poisonous metals in mixtures containing organic matters." In these papers a description is given of means for detecting small quantities of arsenic and of antimony by subjecting their acidulated solutions to electrolysis. The arsenic was evolved as hydride and recognized by the usual reactions, while the antimony was mainly deposited as metal upon the cathode. The electrolytic method for the detection of arsenic, in which all fear of contamination from impure zinc is overcome, has since been elaborated by Wolff, who has succeeded in detecting as little as 0.00001 gm. arsenious oxide by this means (this Journal, 1887, 147).

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In a somewhat different manner the voltaic current is made use of in ordinary qualitative analysis for the detection of tin, antimony, silver, lead, arsenic, *etc.*, by employing a more electro-positive metal to precipitate a less electro-positive one from its solution.

The quantitative electrolytic methods of analysis, some of which I had the honor of bringing before the notice of the Society some time back (this Journal, 1889, 256), have placed a number of methods of determination and separation of metals in the hands of chemists, which can be employed with advantage in qualitative analysis, especially in case of medical and medico-legal inquiry. These methods are not supposed to supersede in any way the ordinary methods of qualitative analysis, but to serve as a final and crucial means of identification, and thus to render it possible to detect very small quantities of the substances in question with very great certainty. As such they fulfill the required conditions admirably, being readily carried out, comparatively free from contamination with impure reagents, and capable of being rendered quantitative whenever desired.

In conjunction with Mr. E.V. Ellis, B.Sc., I have examined the applicability of the electrolytic methods for the detection of the chief mineral poisons (with the exception of arsenic, an electrolytic process for the detection of which has already been devised, as described), *viz.*, antimony, mercury, lead, and copper.

*Antimony.*—The method employed in the case of antimony is that adopted in its quantitative estimation by means of electrolysis, a method which insures a complete separation from those metals with which it is precipitated in the ordinary course of analysis—arsenic and tin. This fact is of considerable importance in reference to the special objects for which these methods have been worked out.

The precipitated sulphide is dissolved in potassium sulphide, and the resultant solution, after warming with a little hydrogen peroxide to discolorize any poly-sulphides that may be present, electrolyzed with a current of 1.5-2 c.c. of electrolytic gas per minute (10.436 c.c. at 0 deg. and 760 mm. = 1 ampere), when the antimony is deposited as metal upon the negative electrode. One part of antimony (as metal) in 1,500,000 parts of solution may be thus detected, a reaction thirty times more delicate than the deposition by means of zinc and potassium. The stain on the cathode, which latter is best used in the form of a piece of platinum foil about 1 sq. cm. in diameter, is distinct even with a solution containing 1/28 mgrm. of antimony; and by carefully evaporating a little ammonium sulphide on the foil, or by dissolving the stain in hot hydrochloric acid and then passing a few bubbles of sulphureted hydrogen gas into the solution, the orange colored sulphide is obtained as a satisfactory confirmatory test. The detection of 0.0001 grm. of metal can be fully relied on under all conditions, and one hour is sufficient to completely precipitate such small quantities.

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*Mercury.*—Mercury is best separated from its nitric acid solution on a small closely wound spiral of platinum wire. The solution to be tested is acidified with nitric acid and electrolyzed with a current of 4-5 c.c. (c.c. refer to c.c. of electrolytic gas per minute). The deposition is effected in half an hour. The deposited metal is removed from the spiral by heating the latter gently in a test tube, when the mercury forms in characteristic globules on the upper portion of the tube. As a confirmatory and very characteristic test, a crystal of iodine is dropped into the tube, and the whole allowed to stand for a short time, when the presence of mercury is indicated by the formation of the red iodide. 0.0001 gram. of mercury in 150 c.c. of solution can be clearly detected.

Wolff has applied this test under similar conditions, using a special form of apparatus and a silver-coated iron anode (this Journal, 1888, 454).

*Lead.*—Lead is precipitated either as  $PbO_2$  at the anode from a nitric acid solution or as metal at the cathode from an ammonium oxalate solution. In both cases a current of 2-3 c.c. suffices to effect the deposition in one hour.

Here, again, 0.0001 gram. of metal in 150 c.c. of solution can be easily detected. With both solutions this amount gives a distinct discoloration to the platinum spiral, on which the deposition is best effected. As a confirmatory test the deposited metal is dissolved in nitric acid and tested with sulphureted hydrogen, or the spiral may be placed in a test tube and warmed with a crystal of iodine, when the yellow iodide is formed. This latter reaction is very distinct, especially in the case of the peroxide.

Of the above two methods, that in which an ammonium oxalate solution is used is the more delicate, although it cannot be employed quantitatively, owing to the oxidation of the metal that takes place.

An addition of 1 gram. of ammonium oxalate to the suspected solution is sufficient.

*Copper.*—0.00005 gram. of copper can be very readily detected by electrolyzing an acid solution in the usual way. A spiral of platinum wire is employed as the cathode, and the presence of the metal confirmed for by dissolving it in a little nitric acid, diluting with water and adding potassium ferrocyanide.

To detect these metals in cases of poisoning, the organic matter with which they are associated must first be destroyed in the usual way by means of hydrochloric acid and potassium chlorate, and the precipitates obtained in the ordinary course of analysis, then subjected, at suitable stages, to electrolysis. As the solutions thus obtained will be still contaminated by some organic matter, it is necessary to pass the current for a longer time than indicated above. On the other hand, *urine* can be tested directly for these poisons.



The presence of mercury or of copper may be detected by acidifying the urine with 2-3 c.c. of nitric acid (conc.), and electrolyzing as described. 0.0001 gm. of metal in 30 c.c. of urine can be detected thus, or 1 part in 300,000 of urine.

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Lead does not separate well as peroxide from urine, but if ammonium oxalate be added, and the lead deposited as metal, the reaction is quite as delicate as in aqueous solution, and 0.0001 gm. of lead can be thus detected.

With antimony it is advisable to precipitate it first as sulphide, but it can be detected directly, though not so satisfactorily, by acidifying the urine with 2-3 c.c. of sulphuric acid (dil.), and electrolyzing with a current of 1-5 to 2 c.c. In this case also it is precipitated as metal upon the cathode (cp. Chittenden, Proceedings Connecticut Acad. Science, Vol. 8).

In the presence of urine it is advisable to continue the passage of the current for about twice the time required in the case of aqueous solutions.

That an approximately quantitative result can be obtained under the above conditions was shown in several cases in which deposition of 0.001 gm. of metal was confirmed with considerable accuracy, the spiral or foil being weighed before and after the experiment.

A comparison of the delicacy of these tests with the ordinary qualitative tests for antimony, mercury, lead, and copper by means of sulphureted hydrogen, showed that the two were equally delicate in the case of antimony and of copper, but that in that of mercury and of lead the electrolytic test was at least eight times the more delicate. These comparisons were made in aqueous solutions. In testing urine the value of the electrolytic method is still more evident, for here the color of the liquid interferes materially with the reliability of the ordinary qualitative tests when only very small quantities of the metals referred to are present.

Beyond the detection of mineral poisons, qualitative electrolysis can only offer attraction to analysts in special cases, and the data on the subject are to be found in the many electrolytic methods already published. Beyond testing for gold and silver in this manner, I have not therefore examined the applicability of these methods further.

The detection of small quantities of gold and silver is of considerable importance, and advantage can be taken of the ease with which they are separated from potassium cyanide solution by the electric current for this purpose.

*Silver.*—Silver is obtained as chloride in the course of analysis. To confirm for the metal electrolytically, this precipitate is dissolved in potassium cyanide and the resulting solution electrolyzed with a current of 1-1.5 c.c. A spiral of platinum wire is employed as the anode, from which the silver may be dissolved by means of nitric acid, and tested for by hydrochloric acid or by sulphureted hydrogen. 0.0001 gm. of silver in 150 c.c. of solution can be detected thus, and one hour is sufficient for the deposition.

*Gold.*—Gold is deposited under similar conditions to silver from cyanide solutions. The deposit, which is rather dark colored, can be dissolved in aqua regia and confirmed for by the Cassius' purple test. Here again 0.0001 gm. of metal in 150 c.c. of solution can be detected without any difficulty.

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As gold and silver are both extracted from quartziferous ores by treatment with potassium cyanide solution according to the MacArthur-Forrest process of gold extraction (this Journal, 1890, 267), this electrolytic method should prove very useful. By electrolyzing the resulting solution a mixture of gold and silver will be deposited upon the cathode, which can then be parted by nitric acid and tested for as described.

### **DISCUSSION.**

The chairman said that there was little doubt but that further investigation into electrolytic methods of chemical analysis would give even more valuable results than those already obtained. Systematic investigations of the subject, such as have been given by Dr. Kohn, would go far to prove the adaptability of this method as a substitute for or aid in ordinary qualitative examinations. The remarks of Dr. Kohn respecting quantitative examinations were very interesting, and well worth following up by other practical work.

Professor Campbell Brown said that Dr. Kohn had shown that electricity brought the same kind of elegance, neatness, and simplicity into analysis that it did into lighting and silver plating.

In its applications to the detection of poisons, he understood Dr. Kohn to say that the poisons must first be extracted by chemical means. That would not be sufficient, and he had no doubt that if the subject was pursued farther they would have a paper from him (Dr. Kohn) some day, indicating that he had obtained arsenic and such poisons without the previous separation of the metal from organic matter. It was a very great desideratum to have a method for detecting arsenic and separating it from the contents of the stomach and food directly without previous destruction of the organic matter, and he hoped Dr. Kohn would pursue his work in that direction.

Dr. Hurter said he was about to construct a new laboratory, and he would assure them that one of its arrangements would be the installation of electricity, by which to carry out researches similar to those described. He was very glad to learn that the presence of arsenic, *etc.*, could be readily proved by means of electrolysis.

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