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A NEW TORPEDO BOAT.

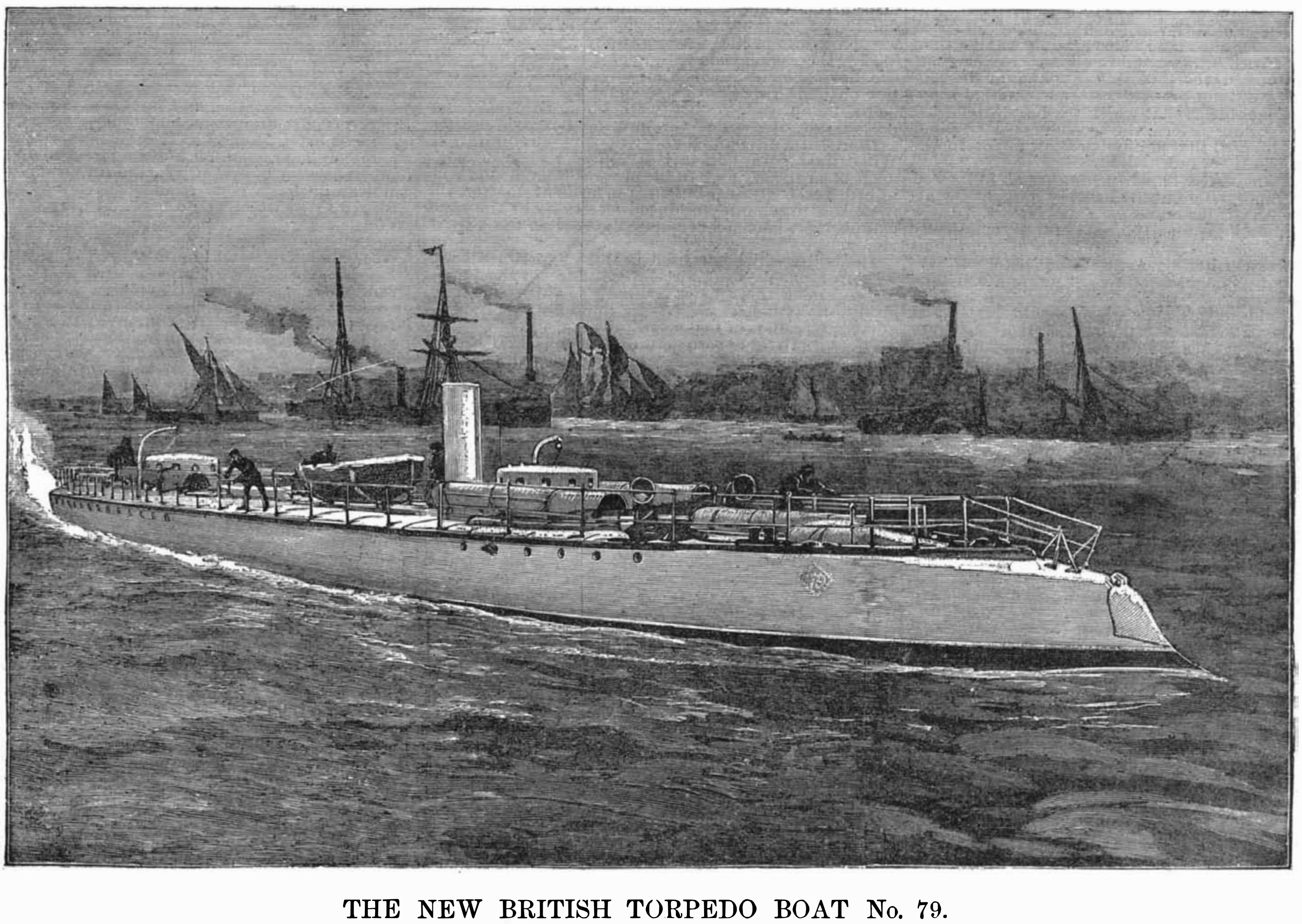
THIS boat is the last completed of an order for twenty-three given to Messrs. Yarrow by the Admiralty during one of our recent "Russian scares." No. 79, as she is called, is 125 ft. long by 13 ft. wide. She is propelled by triple expansion engines, having piston valves to all cylinders, with ordinary link motion and bar links, all parts being adjustable. The condenser in this boat is supplied with refrigerating water automatically; that is to say, the water is taken on board and forced through the condenser entirely by the passage of the boat through the water.

The arrangement of air pump is very good, and affords several advantages. It is worked, together with the feed pumps, direct from a prolongation forward of the engine crankshaft. The air pump is sunk below the engine room floor, and has a stroke of 3¾ in. The cover is secured by nuts screwed on in the usual way, leaving the reversing wheel. In this matter of lubrication great improvements have been made since the early days of torpedo boats. We have frequently alluded to the excellence of the work put into these engines; and, indeed, had we not done so, it would hardly be necessary to lay any stress on it here, for nothing but the perfection of workmanship and material could go through the test of running an extended trial such as that to which torpedo boats are subject.

We are not aware that the boiler possesses any features of novelty in general design, and we have already illustrated the loco-marine type of boiler used by Messrs. Yarrow. The grate surface is about 30 sq. ft., and the firebox of this boiler, when the boat is traveling at speed, is a sight to see and remember. It is estimated that about 950 to 1,000 indicated horse power is given off by the engines when working at their best and running 400 revolutions. Briquettes are used for fuel, not because they give more steam than Nixon's navigation, but because they are easier to handle. At ordinary full speed, ¾ cwt. will be burned per square foot of grate per hour. On the official trial this boat made a speed of 23 knots (almost 26½ miles) per hour as a maximum, the mean of the two hours' run being 22·39 knots. This was with a boiler pressure of 140 lb. and 400 revolutions. The speed going astern was 18 knots. The trial displacement was about 70 tons.

We believe indicator diagrams were taken on the trial, but Messrs. Yarrow's engineering staff do not, apparently, place implicit reliance on this mode of arriving at the power of very quick running engines: an opinion in which they by no means stand alone. From what could be learned from the diagrams, however, coupled with previous knowledge of these boats, it is estimated that not less than the power we have stated, *i. e.*, 950 to 1,000 indicated horse power, was given off when running at top speed. To get this from a single locomotive boiler, under the restrictions as to weight, etc., necessary in torpedo boat practice, speaks much for the advances made within the last few years in the science of boiler construction.

Remarkable, however, as is the speed of this boat, it is for her turning and maneuvering powers that she will be chiefly admired. We understand that on her official trial the mean of all the circle turning trials—*i. e.*, one each to port and starboard both ahead and astern—gave a circle with a radius of rather less than the boat's length, the mean time of turning being under one minute. This result is the more remarkable as the boat has but one rudder. This is hung in the usual position at the stern, a piece of information perhaps not altogether superfluous, considering the independence of precedent sometimes displayed by the rudders of torpedo boats. The rudder is, so far as we are aware, altogether novel in shape and arrangement. Out of water, it has exactly the appearance of the rudder of a New England cat-boat, a large square piece showing above the surface. In spite of this, when the helm is put hard over and the boat is going full speed, the water pours over the top, we were about to say "like a sluice," but this would be a quite inadequate simile. As a matter of fact, it would be impracticable to carry the rudder area high enough to stop all the water, for the stream rises solidly above the boat's deck when at broad angles of helm and with top speed. Below the water line the width of the rudder is carried well down, and, so far, it does not differ in general principle from an ordinary rudder. The lower part, however, is carried forward of the stern post, thus hanging below the extreme after part of the boat, and forming a partially balanced rudder. The dead wood is entirely removed, the propeller shaft emerging from the boat's bottom several feet forward, and being supported close up to the propeller by a two-arm bracket. The after part of the boat may thus be roughly compared to the very much immersed counters that have occasionally been put on some extreme types of racing yachts; but on deck the appearance is that of an ordinary torpedo boat. So far as constructive purposes are concerned, however, the stern-post is in the usual position at the extreme end of the vessel, and it is to this the rudder is hung in a novel manner. The rudder, it should be stated, is made in one solid piece. It has no pintle or gudgeons, the stern-post itself acting in the former capacity, while two blocks are attached to the rudder in place of the gudgeons. The rudder stock is formed by a swelling on that part of the rudder which lies parallel with the stern-post of the vessel. The rudder, as before stated, extends below the rudder post, so that the rudder stock is not carried down the whole depth of the rudder, but only as deep as the stern-post. To the bottom of the rudder stock is solidly attached one of the blocks referred to, and this extends forward, so that the keel of the stern-post fits into a recess made in it, and it thus forms what may be likened to a footstep bearing, supposing the stern-post were a vertical shaft. The top block, which fits over the top of the stern-post, is in one with the tiller, being immediately forward of that part of the latter which fits on to the top of the rudder stock, and its position is thus immediately forward of the rudder head. It will be thus seen that the axis of the rudder coincides with the axis of the stern-post, and the rudder stock, when the helm is put over, makes a partial revolution round



THE NEW BRITISH TORPEDO BOAT No. 79.

but the whole is made sufficiently rigid to form a foundation plate for the pedestals which carry the bearing in which the journals of the air pump crankshaft work; in fact, these pedestals are cast in one with the cover. The air pump crankshaft is attached to the prolongation of the main crankshaft by a slot coupling, so that by simply removing the top bearings the crankshaft can be taken out; or by removing the nuts that hold down the air pump cover, the latter can be lifted off, together with crankshaft, etc., all attached, thus allowing the valves to be examined. The operation can easily be performed in ten minutes by a couple of men. In order to be accurate, however, it should be stated that in No. 79 the feed pumps are forward of the air pump, and this necessitates four more bolts being loosened; but in most of these boats the feed pumps are, we understand, next the engine, so that they need not be disturbed. In addition to the advantage of accessibility, the arrangement allows of the air pump being very low down, a point all engineers will appreciate. It is also well out of harm's way in case of shot flying about, and does not take up valuable room at the side, as when worked by side levers.

In the engine room there are also two air-compressing engines of the usual type, a fresh water condenser for making up in boiler and drinking purposes, the usual fire engine, and a steam steering engine. The thrust bearing is made with adjustable collars with water circulation; the thrust plates are separate, and can be removed without stopping the engines. The lubricating arrangements have been well devised, so that all points are under control of one man without

the stern-post. The action appears strange and somewhat unmechanical at first, but it is, in reality, quite sound. It will also be seen that there is no stern frame, in the ordinary acceptation of the term, to this boat. There is only one stern-post, the place of the forward post being taken by the two armed depending brackets before mentioned. An incidental, but still important, advantage of this arrangement that must be mentioned is the great ease with which the rudder may be unshipped. By simply taking off one nut and removing the tiller, the whole can be lowered clear.

The whole construction must be one of extraordinary strength. During the run on which we recently had the opportunity of being present, several circles were made at full speed, or, at any rate, what must have been very little short of it. The helm was put over at once, as fast as the powerful steam gear would work it, either to port or starboard. The result was remarkable, not to say startling. The enormous rudder area would at once throw the stern round, and the great column of water we have described would rise up aft, the boat would heel inward somewhat, and the circle was completed in a marvelously short space of time. The most extraordinary thing, however, was to stand right aft and look at the surface of the water near the boat's side. Looking inward toward the circle, there was, immediately against the boat's skin, a narrow stream of water running aft with immense rapidity. The outer edge of this stream was clearly defined, and beyond it the water could be seen, following the stern as it swung round, in stream lines at right angles to the stream of water that was running aft. This vessel, in turning ahead, appears to pivot more toward the bow than any craft we remember to have seen. The heeling inward, we understand, will be able to be remedied before the boat is put in commission, although it seems hardly reasonable to expect that any craft can turn at such a speed and in such small circles without a considerable heeling effect being set up.

In going astern the action was not so remarkable in appearance, although it was, perhaps, more so in effect. Mr. Yarrow seemed to have no hesitation in jamming the helm hard over when steaming full speed astern, and the circles made were certainly smaller than those formed with headway on the boat. In this case, however, although there was a fine spume at the rudder, the water did not present the same remarkable appearance at the side as that which we have attempted to describe. Going astern, the boat seemed to pivot about the center, so that neither the bow nor stern was swung so violently round.

The vibration of No. 79, when running at full speed was slight, and, no doubt, this may largely be attributed to the three-crank engine. Messrs. Yarrow have devised an ingenious apparatus for automatically recording the number and amplitude of vibrations made by a vessel running at speed; but before the records of this instrument can be of use, except to Messrs. Yarrow themselves for trial among their own craft, a universal standard of comparison would have to be formed. The arrangement consists of a revolving drum worked by clockwork, and round this is wound a continuous paper. Against the paper a pencil is pressed, the latter being attached to a weight suspended by India rubber springs, and free to reciprocate vertically as it would be actuated by the vibrations set up.

Altogether, there is no doubt that Messrs. Yarrow & Co. have produced a very successful boat. They have combined speed and steering power in a very remarkable degree, to say nothing of the strength of construction that enables the stern to stand the heavy strains that must be put upon it by the very large rudder. The absence of dead wood is, of course, by no means a novelty; in fact, this same firm built some boats possessing this feature about six years ago, and, as our readers are aware, another firm engaged in the construction of small fast vessels have made this a special feature in their design.

The boat we have described will be naturally compared with the two Austrian boats, Falke and Adler, but these were larger craft, and naturally got a higher speed, viz., 22½ knots with 17 tons on board, and 24 knots with 8 tons. Messrs. Yarrow have recently received a copy of the official report of the officer who was in charge of the Falke during the voyage from London to Pola. In view of the attention attracted by the unprecedentedly large loco-marine boiler of that vessel, it may be interesting to state that there was no trouble from priming or otherwise during the voyage, and that the total amount of fresh water required for "make up" was one ton.—*Engineering.*

SIBLEY COLLEGE LECTURES.—1886-87.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

IV.—STEAM BOILER EXPLOSIONS.

By J. M. ALLEN, of Hartford, Conn.

IT was my privilege nearly one year ago to speak in this hall on the subject of steam boilers, their construction and management, with a view to safety and economy. The importance of proper construction and management is forced upon us almost daily, by the accounts of steam boiler explosions, often attended with great loss of property and life. During the six years ending January 1, 1886, there were 992 boiler explosions in this country, by which more than 1,500 persons were killed, and many more injured. A large amount of property was destroyed and damaged, besides the loss resulting from delays in rebuilding and replacing boilers and machinery destroyed or rendered useless. These figures are taken from a record which has been kept for many years in the office of the company with which I am connected. They are gathered through our agents in all parts of the country, also from the daily papers. The list may not contain every case of a ruptured or exploded boiler, but it is perhaps as near correct as any such list could be made. The loss or damage to the owners of these mills or works can be only roughly estimated. In some cases it has amounted to $10,000 and even $20,000, while in others it would be covered by a few hundred dollars.

If we assume an average of $3,000 in each case, it gives a grand total of about $3,000,000. These facts are of sufficient importance to lead to earnest inquiry and investigation into the cause of these frightful accidents. The importance of such investigations was recognized more than fifty years ago. The whole subject was shrouded in mystery, and some of the theories put forth were laughable. One of the earliest was that all boilers were exploded by electricity. This theory is said to have become popular in this country more than fifty years ago, from the explosion of a locomotive on the Baltimore and Ohio Railroad during a thunder storm. It was asserted that it was struck by lightning. Subsequently, another exploded on a clear day, but as the subject of boiler explosions had at that time been little studied, and as there seemed to be no ready explanation, it was assigned to the same cause. About this time, at the request of the Treasury Department of the United State, the Franklin Institute, of Philadelphia, instituted a series of experiments to test the truth or falsity of the various causes assigned for the explosion of steam boilers. Before speaking of the experiments of the Franklin Institute, I will say a word about the theory of explosions from electricity. Some forty years ago, in England, a locomotive at rest was found to emit brilliant sparks while the safety valve was blowing. This was thought by some to be conclusive evidence that electricity was stored up in a boiler under pressure, and that, under certain conditions, it might act with explosive results. This led to a careful investigation of the subject by men of high scientific attainments. The result was that the presence of electricity in a jet of steam issuing from an orifice was not due to free electricity within the boiler, but to the friction of the escaping steam upon the inner surfaces of the discharging channel.

If electricity should be developed in a steam boiler by ebullition, or in steam when confined under pressure in an iron boiler in perfect electric communication with the earth, it could not be collected, but would be immediately conveyed away. Prof. Faraday investigated this matter, and his conclusions were:

1st. "The production of electricity is not due to any change in the state of the liquid contained in the boiler."

2d. "A current of dry steam produces no development of electricity. The production of electricity is due to the friction in the nozzle of the drops of water formed by the partial condensation of the steam."

3d. "Increasing the pressure of the steam increased the development of electricity by increasing the friction of the issuing jets of steam and water."

4th. "The same results were obtained from compressed air, discharged through the boxwood nozzles, as from steam discharged under the same circumstances. When the air was perfectly dry, there was no development of electricity; when the air was humid, and contained, besides, a very little pulverulent matter, the friction of discharge produced electricity in the same manner as when steam was employed in the experiments."

The boiler which was used in these experiments was insulated on glass supports or legs, and yet the experiments under these most favorable conditions conclusively showed that electricity could not be counted among the causes of boiler explosions.

To return to the experiments of the Franklin Institute. Among the causes of boiler explosions to be investigated were the following: 1st. That injecting water into a boiler in which there was no water, but only hot, unsaturated steam. This would be a case of extreme "low water" or no water at all. The theory was, that when water was thus injected into a boiler containing hot and unsaturated steam, the water would immediately flash into steam of lower temperature, but of sufficient pressure to rend the boiler in pieces. Without going through with this experiment in detail, I will simply give their conclusions, which are as follows: *

"We see that in no case was an increase of elasticity produced by injecting water into hot and unsaturated steam, but the reverse; and in general that the greater the quantity of water thus introduced, the more considerable was the diminution in the elasticity of the steam." There is a very prevalent opinion that injecting water into a hot boiler in which the water has been allowed to get very low is a fruitful cause of boiler explosions.

This is called the "low water theory." It is maintained that the water, coming in contact with hot plates, suddenly flashes into steam of great pressure. Assuming that the severe overheating of the plates has taken place, and water is suddenly thrown upon them, there is reason to believe from the foregoing that the steam disengaged would not be sufficient to greatly increase the pressure already in the boiler. We know that plunging a mass of red hot iron into three or four times its weight of cold water disengages comparatively little steam, and there is no good reason for believing that any more steam would be disengaged if the iron were disposed of in the form of a boiler, and heated to the same temperature. But there are other arguments against this theory. If I remember correctly, a government commission was appointed in 1873 to make some experiments with a view to ascertain the cause of boiler explosions. Among those experiments was one bearing upon this theory. They injected water into an overheated or hot boiler. The result was, contorted plates, leaky seams, and a general demoralization of the boiler, but no explosion.† It must not be inferred from this that no damage arises to a boiler that has been overheated from low water, nor that after such an experience a boiler is suitable for use. On the contrary, it may have been so strained and weakened as to be totally unfit for use at any pressure. I have no doubt that this has been the indirect cause of many boiler explosions. The engineer or fireman allows the water to get low—very low; the plates are overheated and weakened, the strength of the iron is greatly reduced, but instead of drawing the fires and ascertaining what damage is done, he immediately starts the pump, and thinks to cover his carelessness by filling the boiler with water. His fires are urged to keep up steam, but the boiler has been so weakened that it is utterly unable to sustain the pressure, and it "gives out" or "lets go," with more or less destructive results. Another cause which had many advocates was investigated by this Franklin Institute Commission, viz., "decomposed steam." This is often called the "gas theory." It is this: The steam coming in contact with hot iron is decomposed; that is, the hydrogen is set free, which, uniting with a certain portion of oxygen, forms an explosive gas, which is sufficient to account for many of the destructive explosions.

The experiments of the commission extended over several days, and in one or two instances they succeeded in producing a combustible gas. But other experiments proved that this result was due to the packing of the handholes at each end of the experimental boiler. This packing, consisting of cloth and putty, was highly heated, and the cloth mainly disappeared. They further showed, at least satisfied themselves, that when the bottom of the boiler was heated to redness, no hydrogen was liberated by the decomposition of the water injected. Their conclusions were that "water in contact with heated iron in a steam boiler, the surface being in its ordinary state, clean, but not bright, is not decomposed by the metal."

At a meeting of the American Academy of Sciences, in 1877, it was shown that steam could be decomposed by simple heat into the constituent gases of water, viz., hydrogen and oxygen. The apparatus consisted of a flask in which water was heated, a tube conveying the steam to a closed platinum crucible, where it was again heated by a spirit lamp, and a tube which carried thence the superheated steam and the liberated gases to an ordinary pneumatic trough, where the mixed gases were collected in a test tube while the steam was absorbed. The gases thus collected were exploded by a lighted match. But the question arises, Could this or a similar condition of things take place in a steam boiler? In order to produce an explosive gas in a steam boiler, a large portion of the plates inclosing the steam space must be raised to a bright red heat, then the steam must be condensed by the injection of cold water, which must not come in contact with the red-hot plates, for if the plates are cooled down, how is the explosive gas to be ignited? These conditions are hardly supposable in a steam boiler.

The injection of feed water into a red-hot boiler would weaken the plates and joints and very likely produce rupture. This theory has few advocates now among those who have made the subject a study. The opinions of Professors Faraday, Taylor, and Brande go to show that the cause of boiler explosions by the decomposition of steam is without any support whatever. Another theory, which has some advocates, is that known as the deaerated and superheated water theory. It is sometimes known as the Donny theory, because advanced by M. Donny, in 1770. It is this: That water completely deprived of air may be raised to a very high temperature without ebullition, and that under these conditions it has explosive tendencies.

Superheated water would be water heated above the boiling point, due to the pressure on the water at the time, without giving off vapor. If this were possible in a steam boiler, it would be a source of great danger. Many persons have attributed violent and destructive steam boiler explosions to this cause. But we have no evidence whatever that these conditions ever exist in a boiler. The conditions absolutely necessary for the production of superheated water, according to the experiments of Prof. Donny, were: "No portion of the surface of the water can be exposed to the atmosphere or any other vapor or gas." Again, the contact of a solid body or the smallest particle of air or gas is fatal to the success of the experiment; and again, if steam once begins to form, it goes on, and cannot be stopped until the water is all evaporated. These conditions could not exist in a steam boiler. The experiments of Mr. A. Guthrie, formerly United States Supervising Inspector of Steam Boilers, were conclusive in showing that this theory had little or no foundation as a cause of boiler explosions. The results of his experiments were published originally in the *American Artisan*, and can be found in the August *Locomotive*, 1882. I have spent some time in telling you what, in my judgment, are not causes of boiler explosions, and you are no doubt impatient to learn by this time what are some of the causes of these frightful accidents.

A well constructed steam boiler of good material cannot be exploded except by great force. Knowing the quality of the material, the type of boiler, and assuming that it is well constructed, we can easily calculate the force or pressure of steam which it is capable of resisting, and the pressure which would burst such a boiler asunder would be much higher than any pressure which would ever be allowed on such a boiler under the ordinary conditions of use. A boiler explosion under such circumstances would be called an explosion from over-pressure, and such accidents do not occur except from carelessness or oversight in their management. A stop valve may be closed or the safety valve may be inoperative from corrosion or other cause, rendering relief impossible.

The following illustrated cases will show that through carelessness a boiler may be exploded by over-pressure. In a Southern city, the fire sheets of a boiler became weakened, and repairs were necessary. The boiler was connected with another boiler, but a stop valve in the main steam pipe between this boiler and its companion allowed it to be shut off and put out of use for repairs. The boiler was 48 inches in diameter and 31 feet long, with two flues, each 16 inches in diameter and 27 feet long. Each boiler was provided with a safety valve attached to the nozzle on cast iron head of dome. The main steam pipe was also connected with this nozzle. While the men making repairs were at work in the boiler, hot water from the condensed steam that leaked through the stop valve trickled down upon them and greatly annoyed them. To prevent this, one of the men made a pine plug to fit the hole in the nozzle, and drove it in from the inside. When the repairs were completed, the men gathered up their tools and got out of the boiler, entirely forgetting the pine plug. The manhole was put in place, the boiler filled to a proper height with water, and the fire started. The boiler is said to have behaved very strangely. No steam could be raised. But after an hour or two, the top of the dome was raised several hundred feet, and was found a long distance away the following day. Fig. 1 gives a correct view of it when it was found.

This was a case of explosion from over-pressure. The boiler was abundantly strong for the ordinary pressure required, but the only outlet for the steam was securely closed, and the safety valve rendered useless. Another case of explosion from over-pressure occurred in a Western town. There were two boilers set and connected together as shown in the following, Fig. 2.

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* See *Journal Franklin Institute*, volume for 1836.

† Prof. Thurston informs me that the commission that made the experiments at Sandy Hook did succeed in exploding a boiler by injecting water into it when the plates were red hot. But very little energy was developed, and it could not be considered as among the causes of destructive boiler explosions. See SCIENTIFIC AMERICAN, 1875.

It will be seen that there are stop valves between the domes and the steam drum, on which the safety valve for the two boilers was located. This arrangement was made so that one or both boilers could be used. The owner was warned of the danger of such an

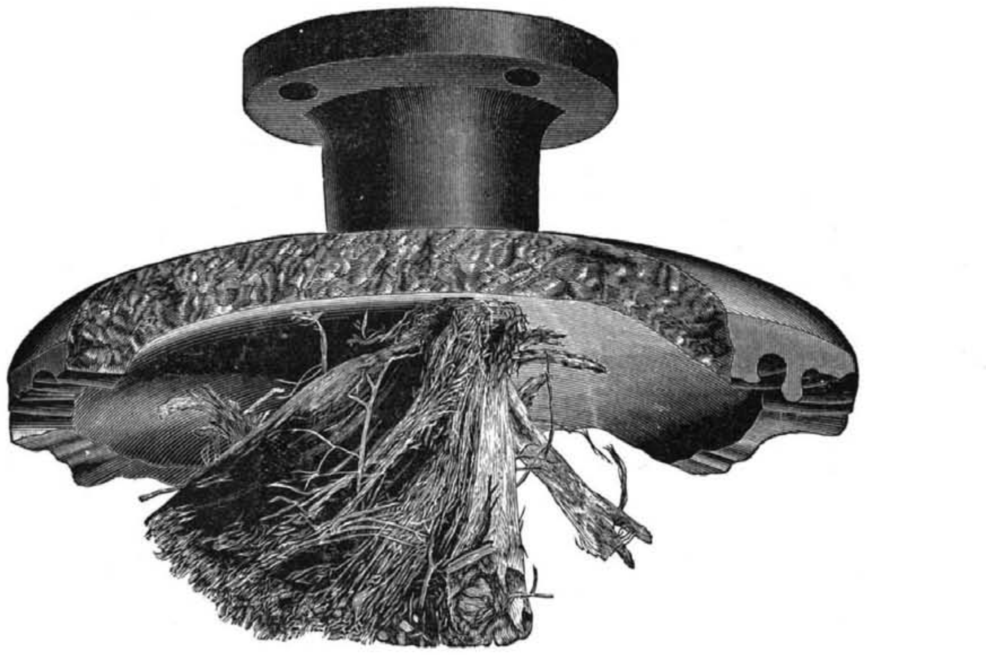


Fig. 1.

arrangement, and advised to put a safety valve on each of the boilers, as shown in Fig. 3.

But he neglected to do so. And one day, after shutting off one boiler, he built a fire under it, forgetting to open the stop valve. There being no escape for the accumulating steam, the boiler was blown in pieces, as shown by the following Figs. 4, 5, and 6. There are no doubt many explosions from over-pressure through carelessness, similar to these cases.

Mr. Fairbairn was of the opinion that all boilers exploded from over-pressure, that is, that the pressure used or allowed was greater than the ability of the boiler to withstand. The element of carelessness

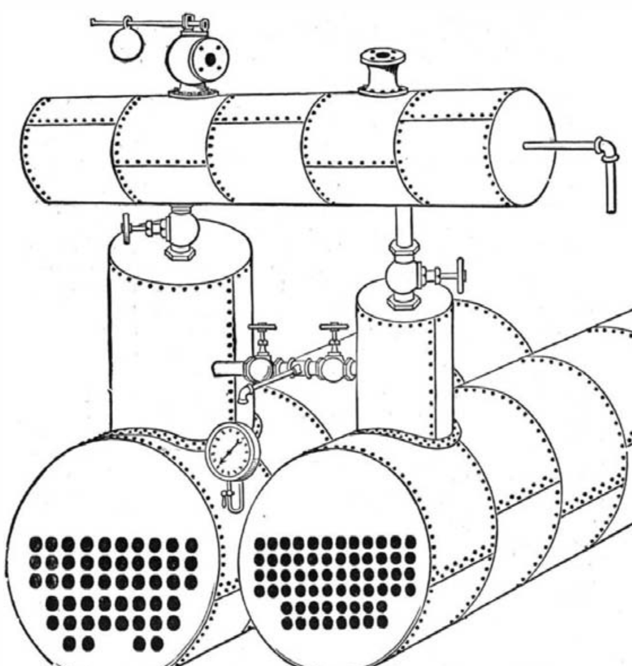


Fig. 2.

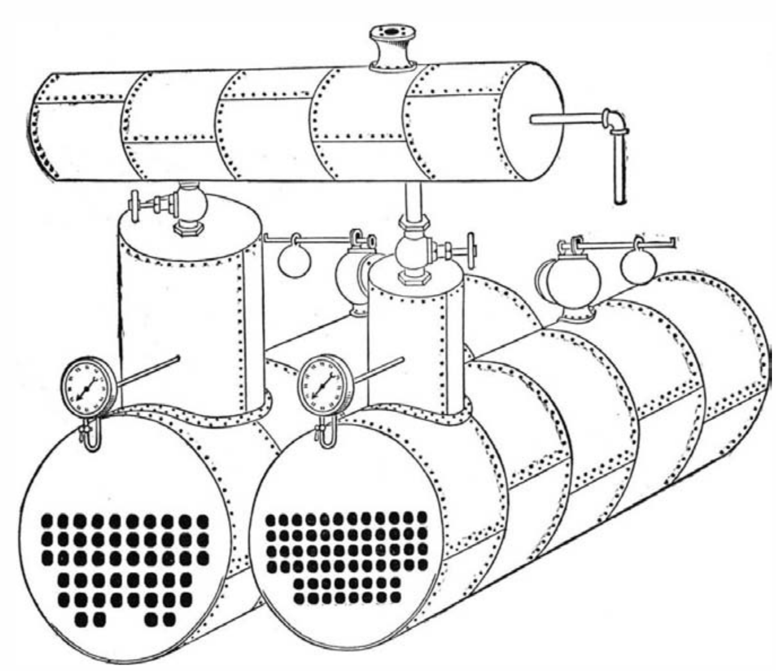


Fig. 3.

entered into his calculations, but his opinion was that no boiler exploded except from excessive pressure. His experiments were made many years ago, since which time the use of steam power has vastly increased, and with its increase, boiler explosions have increased as well. We have indisputable evidence that boilers, even those which appear to be good boilers, explode with great violence, at ordinary pressures and at comparatively low pressures. When we examine the fragments of such exploded boilers, we rarely fail to find some hidden weakness from corrosion or from some defect in material or in construction. The careless use of the drift pin in the construction of boilers has no doubt been the cause of many accidents. I have been in boiler shops where this instrument was wickedly used. The rivet holes failing to come fair when the plates were brought together, one riding over the other, the drift pin was used to so adjust them that a rivet could be inserted. The drift pin under the blows of an 8 or 10 pound sledge hammer, with a handle four feet long, causes great distress of the material, and if it does not fracture under the treatment, it is fair to assume that a strain is brought to bear which under ordinary steam pressure will be aggravated, until from weakness and utter inability to "hold on" longer, rupture occurs.

Another case of explosion from carelessness is illustrated by the annexed figures.

Fig. 7 shows the boilers as they appeared just before the explosion. The boilers were nearly new, each 54 inches in diameter and 17 feet long. After using them for some months, some changes were made in the steam drum connections, which being completed the boilers were put in use. The manhole plate of one did not fit tightly; probably from some small portions of the old gasket adhering to the seat. Steam issued from the joint, and instead of waiting until the work of the day was over, so that the cause of the leak could be ascertained, two men secured a wrench with a long handle, and endeavored to force the manhole plate on to its seat by screwing down the nut of the bolt that held it in place. They were not successful in stopping the steam leak. So a long piece of pipe was secured and slipped over the handle of the wrench, and with this increased leverage these two men exerted their whole force to bring the manhole plate into place. The frame of the manhole, which was cast iron and sufficiently strong for the purposes intended, was fractured by this careless and violent usage. The rupture extended into the sheet, and a very destructive explosion followed. The pressure of steam on the boilers at the time was about 80 lb. This shows how important it is to secure men of intelligence and good sense to properly care for boilers under steam.

Another defect is grooving, which arises from a channeling of the plate. This is caused by some strain, generally brought to bear from the uneasy resting of the boiler in its setting. It may arise from strains caused in construction. But it generally appears along the edge of the lap of both horizontal and girth seams. The continued bending back and forth of the metal loosens up the fiber, and opens it to the attack of any impurities that may be in the water. The channels or grooves extend sometimes nearly through the plate; fracture occurs, and disaster is very liable to follow. A boiler originally well constructed and strong may become weak from low water—I mean by this, overheating from low water—and be in a condition inviting rupture or explosion when used under ordinary working steam pressure. The deposits from bad boiler water work great mischief. Their accumulation in the form of scale of greater or less thickness on the plates of boilers is a source of much trouble and danger. Plates become overheated and burned, and have little ability left to withstand the pressure within. These are some of the conditions attending the use of boilers; and when I remember how many of these cases there are, the wonder is that more boilers do not rupture and explode. In a horizontal tubular boiler 60 inches diameter and 16 feet long, ready for use, there would be 1,135·91 gallons, or 9,465·8 pounds, of water. When we start the fires under the boiler, the heat is communicated to the water, which rises in temperature until at 212 degrees Fahr. it begins to emit steam from its surface. The steam, however, is formed at the heating surface of the boiler, and forces its way up through the water to its surface. As the fires are continued, this process goes on with great energy, and violent ebullition is the result. If there is no outlet for the steam thus generated, and the safety valve is weighted to say 80 lb., the steam will accumulate in the steam room above the surface of the water, until it reaches a pressure of 80 lb. to the square inch, when it will begin to issue from the safety valve. The temperature of the steam and water at this pressure is 324 degrees Fahr., or 112 degrees above the temperature of steam at atmospheric pressure. The velocity of discharge of steam at this pressure is about 1,450 feet per second, or at the rate of 16 miles a minute, or 960 miles an hour. The pounds of steam discharged per minute per square inch of opening at this pressure would be about 82 pounds, which multiplied by 4·56, the volume of one pound of steam at 80 pounds pressure, will give us 373·92 cubic feet. I give these figures in order to give some adequate idea of the velocity of steam under pressure of 80 pounds. At 100 pounds pressure, its actual velocity of efflux would be not less than 1,600 feet per second. But from investigation, we have good ground for believing that steam alone at this pressure would not be sufficient to cause a disastrous explosion, even if rupture were to occur. Steam cylinders of engines sometimes fail. The steam is nearly at boiler pressure, and the cylinder is usually of cast iron, but the pieces are not thrown violently away. The pressure is immediately released and its force is gone. We must look, then, for some other cause than steam alone for destructive boiler explosions.

To refer again to the boiler with a steam pressure of 80 lb., what are the conditions? We have a boiler 60 inches in diameter under 80 lb. pressure of steam. The quantity of water is 168·17 cubic feet, or 1,135·91 gallons, or 9,465·8 pounds. This water is heated up to a temperature due to the pressure of steam, or 324 degrees Fahr. All this contained heat in excess of 212 degrees is ready to flash into steam if it had the opportunity but the superincumbent pressure of steam on the surface of the water holds it in subjection, as a reservoir of power from which to draw as the steam above is used. If we now suppose a rupture to occur above or near the water line, the steam already formed would rush out at a velocity, at first, of at least 1,450 feet per second. The steam space of the boiler would be nearly emptied before the heat contained in the water could so far overcome the inertia of the water as to disengage additional steam. The steam which would rise from the water, carrying a great quantity of water with it, would strike with great velocity upon the upper part of the boiler, and in my judgment be sufficient to rend

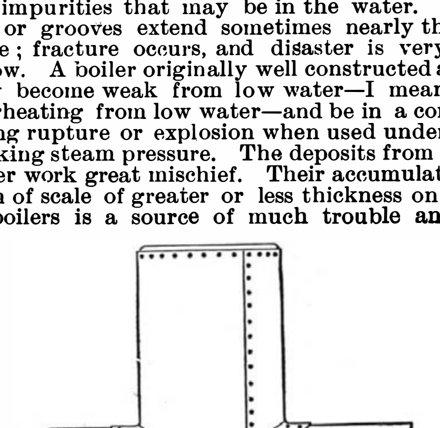


Fig. 4.

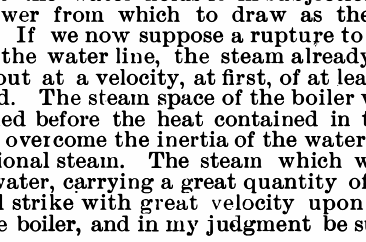


Fig. 5.

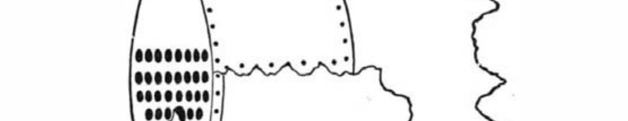


Fig. 6.

the boiler in pieces and project the broken parts to a great distance. I have always found that the most destructive boiler explosions were those where there was evidence of the usual supply of water. In discussing one of the experiments at Sandy Hook in 1871, Prof. R. H. Thurston presented the following calculations of the

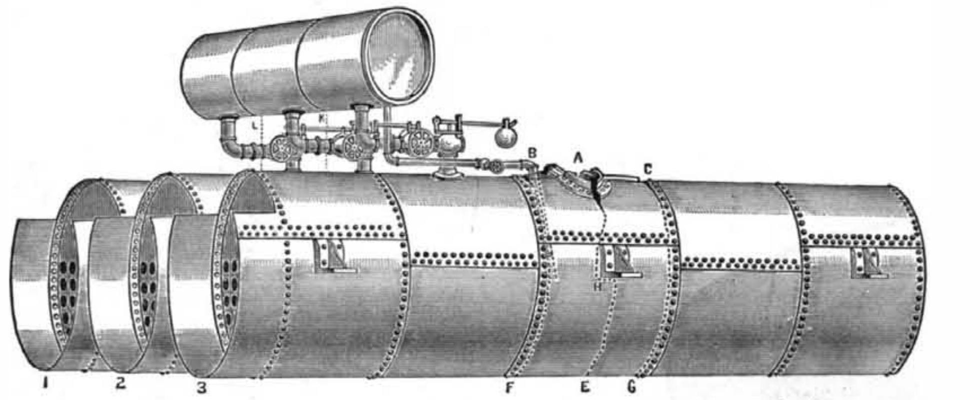


FIG. 7.—Showing the relative position of the boilers 2 and 3, the two that exploded, breaking first at the man-hole of No. 3. B F, A E, and C G, secondary lines of rupture. K L, dotted lines showing location of brick piers built for the support of the steam drum, upon the mid walls of the setting.

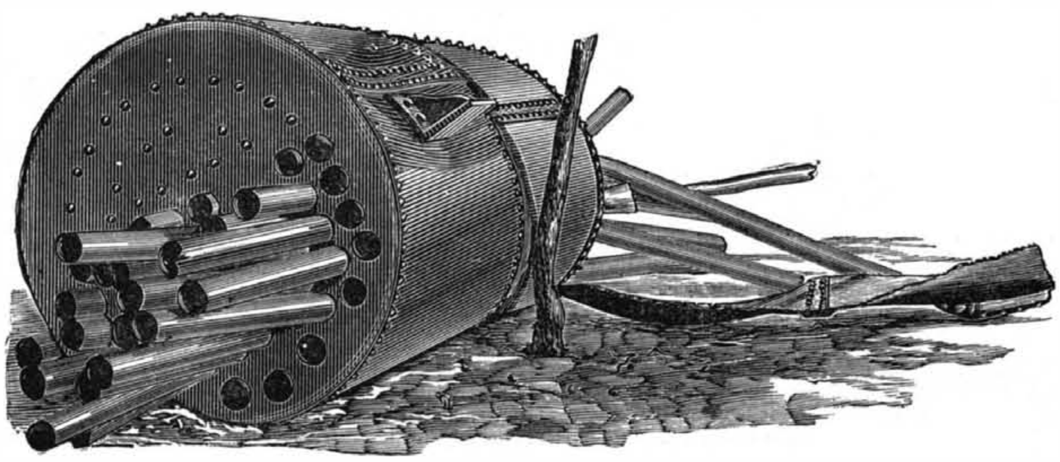


FIG. 8.—Rear view of the part of No. 3 boiler which is shown in Fig. 7.

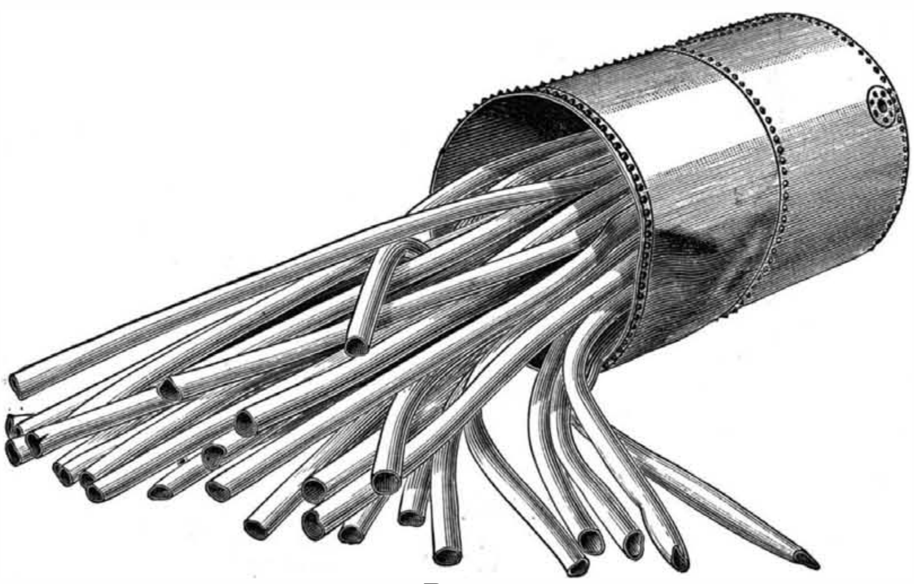


FIG. 9.

energy stored up in the boiler and of the work done by the liberated forces. The steam boiler referred to weighed 40,000 pounds, and contained about 30,000 pounds of water and 150 pounds of steam in the steam space, all of which had a temperature of 301 degrees Fahr., when, at the moment before the explosion, the steam pressure was 53½ pounds above that of the atmosphere. Prof. Thurston says: "When the explosion took place, the whole mass at once liberated its heat until it had cooled down to the temperature of vapor under the pressure of the atmosphere." I will not follow Prof. Thurston's calculations through, but he concludes that the maximum possible effect by these liberated forces was sufficient, had it acted in one direction, to have thrown the boiler more than five miles high. As it was, with the liberated forces acting in all directions, portions of the boiler were projected from 200 to 400 feet high. You can find this discussion in full in the *Journal of the Franklin Institute* for March, 1872.* I quote this with great satisfaction because it so fully corroborates the views which I have always maintained from the examination of many boilers which have exploded under the conditions common to boilers in use. The question now arises, Why do not all boilers that rupture explode with such violence? It depends upon the locality of the rupture, and its dimensions. If a crack or fracture occurs on the bottom of a boiler and does not extend to any great length, the water will run out no faster than the steam is liberated into the steam space; but a large rupture at or near the bottom of the boiler, sufficiently large to suddenly discharge a large quantity of water, would be followed alike with destructive results. For by this great disturbance in the steam space of the boiler, the disengaging steam from the water, together with the water, would act upon the shell with great force and destructive results.

[The lecturer here displayed photographs of exploded boilers under these conditions.]

Another cause of boiler explosions is the effort to connect boilers under different pressures of steam by opening the stop valve between them. The water races from the boiler of higher pressure to that of lower pressure with a velocity and force due to the difference of pressure and volume of water so disturbed. Very destructive explosions have resulted from carelessness of this nature. Photographs of boilers exploded from this cause were also shown. I desire now to call your attention to a case that is of special interest as bearing upon the many theories of boiler explosions which have been advanced from time to time. The drawing (Fig. 10) illustrates the explosion of a rotary bleacher, such as are used in paper mills. It was 20 feet long and about 5 feet in diameter.

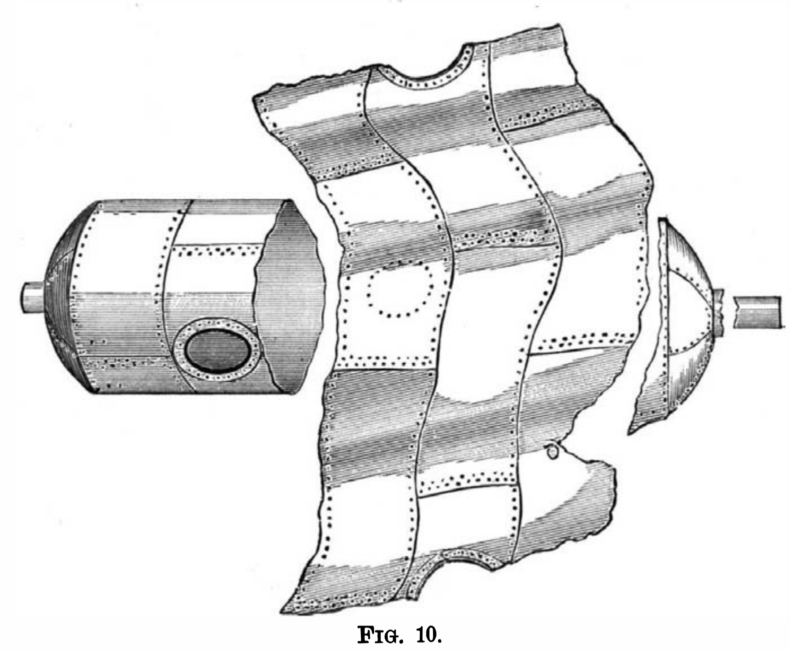


FIG. 10.

The plate ruptured at the manhole or stock door, and instead of quietly dropping its load, it exploded with great force, entirely demolishing the mill and doing great destruction to life and property. This vessel was 150 feet from the boiler which supplied it with steam. There was no fire near it, and no heat save that due to the pressure of steam which supplied it. The pressure of steam was about 50 lb. Here we have a case which will be difficult of explanation by any of the "mysterious agency" theories. It certainly was not electricity, nor deaerated water. There were no over-heated plates, hence no place for decomposed steam. But there was an explosion that caused fearful destruction. The heat in this large amount of water became destructively energetic as soon as an opportunity was given it to act. What weakness might have existed in the material I am unable to say, but there was a rupture sufficiently large to change its potential energies into terribly destructive activities. I will add that up to this time we have the record of some thirty explosions of similar vessels. They are always destructive, because the contained water at a high temperature is a reservoir of power which nothing can resist when it is once liberated. Is there any remedy for these terrible accidents? Yes, within certain limits. I say within certain limits, because certain conditions are involved, and first, if the material of which the boiler is constructed is of inferior quality, it can never be considered as safe at the pressures at which boilers in these days are used. A difference of a cent or a cent and a half per pound in the material often decides as to what material shall be used; for the boiler must be built for a certain price. Thus very inferior material often finds its way into boilers. Then there are defects in construction. The drift pin is wickedly used. The work is not properly laid out, and undue strains are brought to bear in different parts of the boiler, which are greatly aggravated when the boiler is subjected to the conditions of use. These defects cannot be detected by visual examination. The boiler is subjected to a cold water test 50 per cent. greater than the pressure required when the boiler is to be put in use. It shows no leaks. But this does not reveal any of the defects which may exist, and which could only be detected by cutting the boiler in pieces. Another source of danger is the tendency to employ cheap and ignorant men to have the care of boilers. Some steam users utterly fail to comprehend the responsible position of an engineer who has charge of the steam plant of a large mill. Some of the cases of explosions which I have cited go to show the ignorance and carelessness of men who are intrusted with these responsible duties, and in this connection I desire to say a word for the competent stationary engineer. He stands before his engine and boilers day after day, watching with care every detail, and upon his efficiency depends to a certain extent the successful operation of the whole plant. The economical use of fuel is, in a great measure, in his hands, provided the boilers are properly constructed, set, and connected. It is economy to employ intelligent men for such responsible duties, and pay them adequately for it. There has been of late an effort made on the part of stationary engineers to organize themselves into associations for the purpose of mutual improvement. It is a movement in the right direction, and so long as such associations are kept free from politics and other disturbing influences, they should be encouraged. Another means by which boiler explosions can be greatly reduced in number is by thorough inspections. These will not prevent carelessness nor some other of the causes which lead to boiler explosions. As I have already said, it is next to impossible to detect the inferior quality of the material when once the boiler is completed and set. But a careful inspection does detect the defects and weakness of such a boiler after it has been put in use, and I have no hesitation in saying that many very destructive explosions have been prevented by careful inspections. To sum up, then, I will repeat what I have often said. Boiler explosions are mainly due to inferior quality of material, faults in type, poor construction, and ignorance and carelessness in management. We must be honest in whatever we do. Money making is the ambition of all or nearly all, but if it is made at the expense of honesty, it brings little comfort. A person once detected in a dishonest trick will find it difficult to gain the confidence of the public afterward.

[The lecture was illustrated by large drawings and numerous photographs.]

* See especially Trans. Am. Soc. Mech. Engrs., 1884, and *Journ. Frank. Inst.*, Dec., 1884, for Professor Thurston's latest paper on this subject, giving the amount of this stored energy.

ASPHALT MASONRY FOR ENGINE BEDS.

THREE years ago we described to the Society of Civil Engineers a system of bituminous masonry beds, designed to deaden the shocks and annul the vibrations produced by steam engines and other apparatus that are accompanied with a jarring motion. The communication was accepted with a certain amount of curiosity, mingled with a slight incredulity which was sympathetically disguised.

Every one expressed himself as much interested in the novelty of the process; but there was instinctively a distrust of it, just as there is of everything that clashes with ideas that have been accepted for a long time.

The owner of a printing establishment on one of the principal streets of Paris, being threatened with a lawsuit on account of the noise at night, decided, however, to have recourse to it, and is now at peace with his neighbors, whose sleep he has ceased to trouble. As far as we know, this is the only service that our system has had an opportunity of rendering to any one since our communication of Oct. 6, 1883, to the Society of Civil Engineers.

Such distrust explains itself perfectly, and we cannot think of being astonished at it. We scarcely know, even in public technics, any other application of asphalt than those into which the heels of gaiters and the legs of chairs sink, provided the sun be a little hot. It is allowable to those who, unlike ourselves, have not lived many a year in familiarity with it, to doubt that this soft substance, so easily affected by heat, can, under certain conditions that we shall presently point out, become one of the most tenacious and non-distortable of building materials.

We have just tried a new experiment, the most conclusive and important of all that we might cite. We had to set up a 100 horse power condensing engine, that had a normal velocity of 75 revolutions per minute. The nature of the place did not allow of the condensing chamber being put wholly underground. So it became necessary to establish the apparatus upon a bed, 11½ feet in height, and we had no hesitation in employing bituminous masonry for the purpose.

It was hard to meet the difficulty in a better way. The fly wheel shaft, forming a pulley, bears, on the one hand, against the engine frame, and on the other against a solid mass of bituminous masonry of less size. Provided that one of the two blocks should get out of shape (and, as their bulk is very different, the distribution would be very unequal), disturbances of the points of the apparatus would ensue that would render its operation impossible. As may be seen, there were great risks to be taken.

The engine has now been running for four months, and has not ceased to operate with unexceptionable regularity. These four months of trial suffice to assure of absolute success; for, if the least distortion had occurred, it would have shown itself at the outset, especially since the time at which things were set in operation was midsummer.

We believe that it will prove interesting to the reader if we give a few data in regard to this work, which will certainly be found to be less strange and rash when the circumstances are better known. But before we do this, it appears to us to be prudent to recall, in a few words, the origin and nature of the substance of which it is composed. Although asphaltum has been employed for forty years in road making and building, it seems to be still as unknown to those who use it as if it had been discovered only last week. Even those who daily make use of it scarcely know whence it is derived, how it is prepared, and what are its properties and various uses. The engineers who, with their own eyes, have seen an asphaltum mine may be counted upon one's fingers. It will not appear superfluous, then, if we give here a few words of explanation in regard to this unknown substance.

Asphaltum is a mineral whose quite rare deposits are necessarily found in calcareous soil. The most important of these are in France that of Seyssel, in Switzerland that of Val de Travers, and in Italy that of Ragusa (Sicily). The substance is a soft carbonate of lime, perfectly pure, impregnated with bitumen through a geological phenomenon which as yet has not been well explained. The uses of asphaltum are twofold. In its natural state, it is used without any other preparation than that of being pulverized when cold and then being moderately heated for the construction of compressed asphaltum roadways. Such a practice has no analogy with the subject under consideration. Yet we have employed it with success in a forge in the basin of the Loire, where we placed a layer of this compressed asphaltum under the anvil bed of two power hammers, whose blows shook the edifice. A layer of asphaltum, 10 inches thick, compressed into an iron frame, sufficed to render the blows harmless.

It is in the state of a fusible cement that asphaltum has been used in the construction that forms the subject of this article. This cement is made as follows: If, after the mineral has been powdered in a cold state, it be thrown in small quantities at a time into a bath of bitumen, kept constantly stirred up, until the mixture represents a proportion of from 7 to 8 of bitumen to 92 or 93 of asphaltum, we obtain, at the end of about six hours of boiling at 225°, a paste which, when run into moulds, forms what is called asphaltum cement. This cement, remelted with the addition of its own weight of gravel and four or five per cent. of bitumen, gives the material of which sidewalks are made.

It is this substance, too, that we use for constructing the bed blocks under consideration. If, in a mould of, say, 25 cubic feet, we build up masonry formed of ashlar arranged with irregular joints, and pour this asphaltum cement into the crevices, we shall, after the cement has cooled, obtain a block of absolute solidity and tenacity. When exposed to no matter what climatic temperature, this block will not become distorted the least particle; and if it be desired to destroy it, it will be necessary to employ the most powerful explosives. At the same time, the block will possess a slight elasticity which will permit it to absorb vibrations to such a point that the jarring of one of its surfaces will be imperceptible at the other.

It was after having experimented several times on a large scale on these unexpected properties that we decided to construct the large foundation whose general arrangement is shown in vertical section in Fig. 2. The following are a few brief data as to the mode of constructing this monolith, the bulk of which exceeds 600 cubic feet.

After making the necessary excavations in the rock, we constructed a plank mould, which was strongly braced and strengthened all around, to prevent any distortion during the running in of the cement. The internal surfaces of this were lined with common coarse paper, in order to prevent the asphaltum from adhering to them. For the passage of the foundation bolts, apertures were secured by means of slightly conical wooden cores placed in the mass and supported by planks, as shown in Fig. 3. These cores also were covered with paper. After the cooling of the mass, they were merely driven through the small chamber beneath reserved for the collars.

The condensing parts were fixed by means of bolts to dressed stones embedded in the asphalt block, which were held firmly in place by the simple adhesion of the cement (Figs. 4 and 5).

The mould having been set up, the cores put in place, and the dressed stones arranged in the places that they were to definitely occupy, we proceeded to run in the cement.

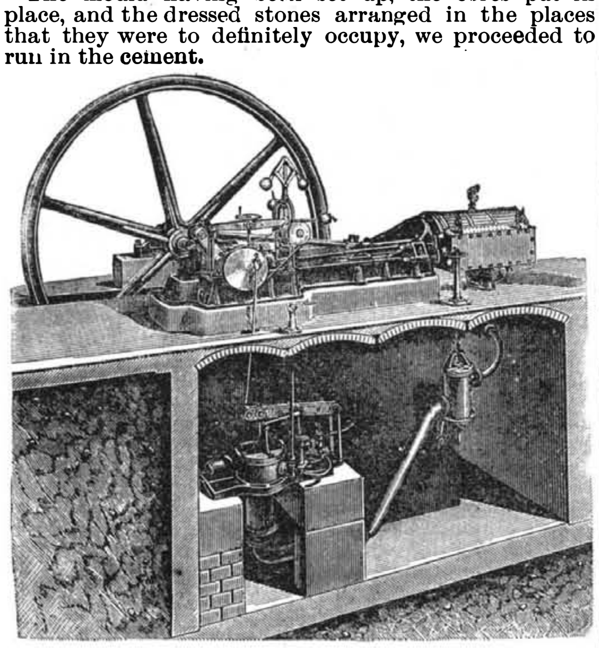


FIG. 1.—ASPHALT MASONRY BED OF 100 H. P. ENGINE.

We began by spreading over the bottom of the mould a layer of very hot (about 200°) liquid cement, in which was immersed a bed of broken stones of various sizes, that had been previously heated, and that were so arranged as to leave as little space between them as possible. Small pebbles were introduced into all the joints that were too wide, so as to reduce the interspaces to a minimum. When this first course was finished (and we may remark in passing that every irregularly jointed course must be so prepared as to engage with the ones above and below it, as shown in Fig. 1), we laid a second one in the same way, that is to say, after covering the first with a new layer of liquid asphaltum. The operation was continued in this way until the block was finished.

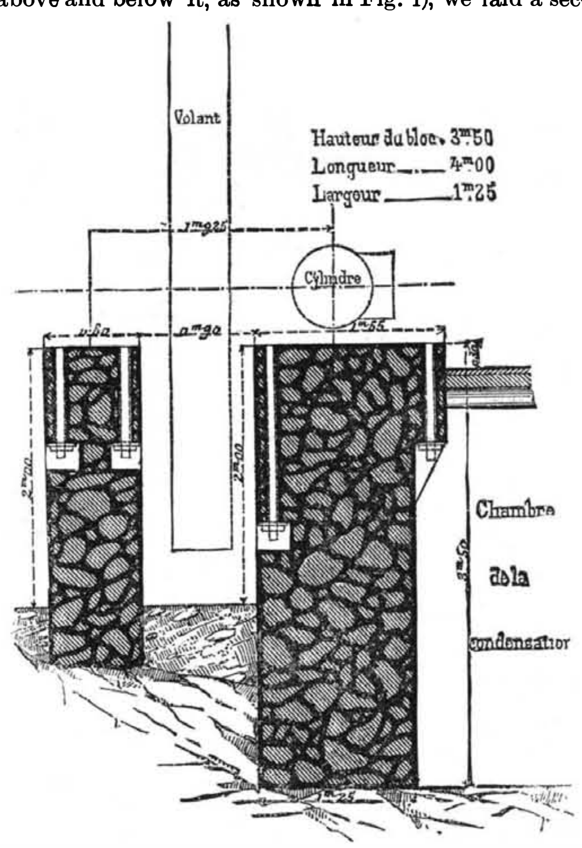


FIG. 2.—TRANSVERSE SECTION OF MASONRY.

As the construction of the masonry under consideration took several days, it was effected through successive runnings in of cement of 140 or 175 cubic feet each. Care was taken every evening to leave projecting a certain number of stones that were embedded beneath in the cement, and which served to connect the course of one day with that of the next.

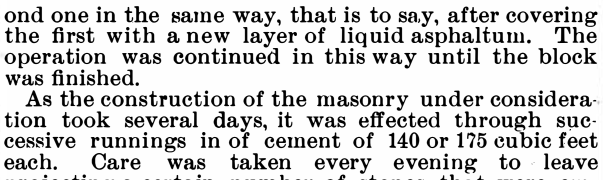


FIG. 3. FIG. 4. FIG. 5.

The junction of these various daily courses was effected in an unexceptional manner. It required twelve days for the mass to cool sufficiently to keep in shape after the mould should be removed. Immediately after the mould was removed, we began setting up the engine, which, as we have said above, has ever since been running perfectly.

The problem as to suppressing the vibrations transmitted to the ground by engines seems to us, then, definitely solved.

We must, however, in the installation just described, point out two slight inconveniences, which are easily avoided, and which engineers who propose adopting this system must look out for, and we shall, at the same time, give the means of remedying them.

We have stated that the heat of the atmosphere, no matter how great, has no influence upon asphaltum masonry of a certain bulk. The same is not the case with the heat of a flame, which, if applied to it permanently, may soften the surface of contact, although it may not distort the mass. For example, let us suppose the frame of an engine to be placed directly upon a layer of asphaltum. The steam, at a pressure of fifteen pounds, enters the cylinder at a temperature exceeding 150°, and the frame, heated thereby, renders the surface upon which it rests pasty to a depth of a few fractions of an inch. This may suffice to bring about a subsidence and a change of level that shall interfere with the proper running of the engine. The way to avoid such a trouble is to simply interpose between the iron and asphalt a substance insensible to heat. Upon the bed of the engine that we have just set up we placed a cap of cement, one inch thick, and this has sufficed to prevent any distortion. We likewise, as a measure of precaution, isolated the cylinder by means of brick and cement masonry and a metallic covering.

The second inconvenience alluded to above is the following: Lubricating oils are solvents of bitumen, and especially so are the mineral oils that are now so extensively used. Now, in the long run, such oils, either when poured carelessly on the surface or filtering through the parts of the apparatus, spread over the asphaltum, dissolve its bitumen, and slightly soften the surfaces, the effect being exactly the same as that produced by heat. To point out the trouble is to teach the remedy: Force the stokers to observe strict cleanliness, and provide the places situated under the parts to be lubricated with tin or zinc drip pans. This will prove a benefit to the owner of the engine.

In order to render this study complete, we ought to add a few words as to the cost of the system whose technical economy we have just set forth; but we shall not do so, since in this respect the question appears to us to be too complex as yet. The expense will vary considerably, according to the size of the block to be constructed, to the degree of complication of its form, and to the distance from the place where the asphaltum is produced. Moreover, a large enough number of experiments have not been made to allow us to deduce fixed rules from them on the subject. Until more applications have been made of the system, it will, therefore, be necessary to make a special study for each piece of work, as well as an estimate calculated according to the peculiar circumstances. The rules for such an estimate will soon gradually be established. What is now beyond a doubt is that the system has entered definitely into the domain of industrial practice, and that it has satisfactorily disposed of a problem whose solution, we think, has hitherto been sought without success—that is, the problem of stopping the jarring produced by high-speed engines, and thus preventing its transmission to neighboring buildings.

The slight elasticity of the asphaltum is very advantageous as regards the perfect running of engines, and to this peculiar property of bituminous masonry we attribute the exceptional state of preservation of the various apparatus that we have for several years past been mounting upon this sort of foundation.

We shall not terminate this article without informing those who would like to employ the system just described that it has never been patented, and any one is welcome to use it. The preceding explanations have been given with no other object in view than to facilitate the application of it.—*L. Malo, in Le Genie Civil.*

ELECTRICAL AND MECHANICAL UNITS.

AT a recent meeting of the Engineers' Club of Philadelphia, Mr. Carl Hering read a paper upon analogies between electrical and mechanical units and phenomena.

After explaining why electrical quantities cannot be expressed in the ordinary mechanical units, he stated that the only units which were alike, or interchangeable, in the two systems were those of *time* and *energy*. The others, although not interchangeable, are quite similar, in their nature and their effect, to certain mechanical units. Electrical quantity expressed in coulombs has no equivalent, but quantity flowing per second, or current, expressed in amperes, is analogous, in most respects, to a current of water, and it follows most of the laws governing the latter. Electrical pressure, or electromotive force, is analogous to mechanical pressure, or to water motive force, as it might be called when referring to water. In both it is that which causes a current to flow, and without which no current can flow. A great pressure exists similarly in a friction electric machine and a fired pistol; in both it will overcome great resistances. In either case, if it readily overcomes the high resistance of the human body, it becomes dangerous.

The zero level of pressure of electricity is taken as that of the infinitely large quantity of electricity in the earth, just as the zero level of the water is that of the ocean, or the normal pressure of air is that of one atmosphere. The terms positive and negative pressures, or currents, may be applied similarly to all these three cases, assuming the zero or normal levels as explained. It is not known whether electricity flows at all, but for all practical purposes it may be supposed to do so. The "earth return" circuit used in telegraphy, in which the two ends of a wire are connected to the earth, was compared to a single pneumatic tube, the two ends of which communicated with the open air, or an "air return circuit," thus showing that the electricity does not necessarily flow back through the earth.

Resistance is similar in both. Self-induction may be compared to inertia, being the apparent resistance to a sudden stopping or starting of a current. The increased electrical pressure at breaking a circuit is analogous to that in the hydraulic ram. Electrical work, which is pressure multiplied by quantity, is equivalent to foot pounds, as of a quantity of air at a certain pressure. In both cases, if the pressure is high, the quality of the work or the effect will be analogous; similarly, if the quantity is great. The discharge of a pistol is analogous to that of a Leyden jar, and an air

blast or a wind, analogous to incandescent lighting currents. Similar analogies exist with power, as in a watch and a telegraph current. An Edison telephone consumes about one thousandth of the power in a watch. The power of a bolt of lightning is said to be equivalent, in some cases, to the work of a 100 horse power engine for 10 hours. The discharge of a small Leyden jar is about one two-thousandth of that of a small pistol. A series of arc lamps is represented quantitatively by a series of waterfalls, each 50 ft. high, discharging 45 gallons per minute. A set of incandescent lamps, by a single fall of 100 ft., divided into small falls, each of 4 gallons per minute.

Generators of electricity, or dynamos, do not produce electricity. They are analogous to a pump or an air-blower, in which *pressure* is generated, but not *quantity* of electricity, water, or air. Similarly, a storage battery does not store electricity, but pressure. The current, passing through them, stores its pressure, similarly to the storing, in the steam, of the heat of the gases in a boiler.

PLOTTING NATURAL CURVES.

To the Editor of the Scientific American:

When Nicodemus invented his method of finding two mean proportionals, he called the curve by which this was done a conchoid or shell-shaped curve, from its fancied resemblance to a sea shell.

Being interested to know what the equations of the whorls on some univalve shells were, I took several of the commoner *Gastropoda* and projected their spirals upon a plane perpendicular to the axes of the shells.

The projection of the whorl of the *Crepidula fornicata*, a common shell on our coasts, was a logarithmic spiral, the locus of the equation $r = 2\left(\frac{2\theta}{\pi}\right)$, where r equals the radius at the successive values of the angle θ.

The *Fulgur canaliculatus*, also a common Atlantic shell, *Dolium perdix*, and *Phyllonatus regis* increased according to $r = 2\left(\frac{\theta}{2\pi}\right)$.

In *Cassio cameo* the spiral was rather more irregular, but evidently followed the law $r = a\left(\frac{\theta}{\pi}\right)$, where $a = a^3 - 1$, or 1·3258 very nearly.

In *Turbo sarmaticus* the equation was $r = a\left(\frac{\theta}{\pi}\right)$, where $a = a^2 - 1$, or 1·61803 very nearly.

In all of these shells and in others which I examined the curves were regular and corresponding in different specimens, and followed some simple law by varying the value of a in the equation $r = a\left(\frac{\theta}{\pi}\right)$.

HENRY W. BLAKE.

New Haven, Conn., December 31, 1886.

COPYING DRAWINGS BY CHEMICAL PROCESS.

By ROBERT MARSHALL.

THERE are so many methods of copying drawings or tracings on sensitized paper by exposure to light, that to describe them all would require a good deal more space than is usually at the disposal of correspondents. I will therefore only give a description of those most usually employed.

There are two processes, of which the others are mere modifications or developments. They are, 1, that in which the drawing appears in *white lines* upon a blue ground; and 2, that in which the drawing appears in *blue lines* on a white ground. The first is called the cyanotype or ferro-prussiate process; the second, the cyano-ferric process.

THE FERRO-PRUSSIATE PROCESS.

The tracing to be copied is made from the drawing in the usual manner, care being taken that as clear and transparent a tracing paper or linen as possible be selected, and to have the Indian ink as thick and as opaque as it can be used. The sensitized paper is prepared as follows: 10 oz. of red prussiate of potash (K_3FeCy_6) is dissolved in 32 oz. of water; then 15 oz. of ammonio-citrate of iron $\left(\begin{matrix}NH_3\\Fe_2\end{matrix}\right\}C_6H_8O_7)$ are dissolved in 32 oz. of water. The two solutions thus separately made are mixed together in a dark room and filtered. (The dark room used here and in subsequent operations need not be *dark*, for if yellow paper be carefully pasted over the glass windows admitting the light, or if the glass itself be stained yellow, the light passing is innocuous so far as the sensitized paper is concerned, as the actinic or chemical rays are cut off.) The solution thus prepared is applied to the surface of ordinary web drawing paper, either by drawing evenly across it a soft sponge saturated with the solution, or, better, by pouring the solution into a large shallow bath and floating the paper in it, having first turned up the edges of the sheet all round to prevent the solution getting on the back. Two or three minutes' floating will suffice. The paper is then hung up to dry. All these operations are conducted in the dark room, care being taken to prevent the actinic light getting at the solution or the prepared paper. A wooden frame containing a sheet of plate glass, and furnished with a sheet of soft thick felt and a removable wooden back—practically similar to the printing frame of the photographer—is required. The wooden back and felt pad are removed, and the tracing to be copied is laid *face* downward on the glass. The sensitized paper is then placed with the sensitized face upon the tracing, and upon the top of these the sheet of felt. The wooden back is then fixed in place, and the pressure exerted by this acting on the soft and elastic felt presses the tracing closely and smoothly without wrinkles against the glass. The frame thus arranged is exposed to the direct rays of light, the time of exposure varying with the intensity of the light. It is usual to arrange test slips of the sensitized paper in the frame with their ends projecting, so that they can be withdrawn and washed from time to time to mark the progress. Over-exposure is preferable to under-exposure, as extra flushing with water will bring out a dark copy; but there is no remedy for under-exposure. The washing is conducted in the dark room in a shallow wooden bath. When the white lines and blue ground are seen to be fully developed, the copy is hung up to dry.

The baths and frame are usually constructed of a size to admit of the largest drawings that may require to be copied.

The chemical reaction in this process appears to be as follows: When the actinic rays penetrate through the transparent tracing paper, the ferric citrate is partly reduced to a ferrous salt, which immediately unites with the red prussiate of potash (K_4FeCy_6) to form a compound, which, in the action of washing, forms Prussian blue $\left\{\begin{matrix}Fe_2\\Fe\end{matrix}\right\}(FeCy_6)_3$, which deeply stains the paper. The parts where the opaque Indian ink lines have obstructed the action of light remain unchanged and are perfectly soluble, and in the process of washing are entirely removed, leaving the surface of the paper quite white.

This process is by far the simplest, but it has two very serious disadvantages: Alterations in the copies thus produced are with difficulty made - Chinese white being usually employed for this purpose, but with by no means satisfactory results. And, again, when these copies are sent to the shops for the guidance of workmen as working drawings, dirty hands soon effectually remove all traces of the white lines, with the result that the copy becomes useless.

To overcome these difficulties or objections, a process has been devised whereby a copy can be obtained in blue lines on a white ground. This is called the

CYANO-FERRIC PROCESS.

The sensitized paper for this process is prepared by floating the common web drawing paper in a liquid mixture composed as follows: 1. Dissolve 2½ oz. of perchloride of iron (Fe_2Cl_6) in twice its weight of water. 2. Dissolve 6 oz. of gum arabic in 28 oz. of water. 3. Dissolve 4 oz. of ammonio-citrate of iron in water. Mix the three solutions thus separately made together in the dark room; float the paper in the bath as before, and hang up to dry. The solution should be used at once, as it soon alters. The sensitized paper will keep for almost any length of time if, after drying, it be rolled up and kept in a dry and dark place.

The method of exposure is the same as before, only, the paper being much more sensitive, less exposure suffices; but the processes of developing and washing are different. Three baths are required, and the copy is immersed in them consecutively in the order in which they are here described: 1, a bath of a saturated solution of yellow prussiate of potash (K_4FeCy_6); 2, a water bath; 3, a bath of diluted hydrochloric acid (HCl)—about twelve of water to one of acid.

The action is explained as follows: Where the light penetrates through the tracing paper, the perchloride of iron (Fe_2Cl_6) is reduced to the protochloride $(FeCl_2)$; and at the same time the gum arabic appears to be so altered as not to be readily soluble in the yellow prussiate bath in which the copy is first immersed. Where, however, the Indian ink lines of the tracing have obstructed the passage of the light, the gum is unaltered and readily dissolves. The ferric salt in the line and the ferrous salt in the bath immediately combine to form Prussian blue. The copy is kept in this bath until the lines are strongly developed; it is then removed to the water bath, which arrests the action and removes *nearly* all the chemical mixture unacted upon; but this cannot be entirely removed by the water, owing to the gum; it is therefore immersed in the third bath—the hydrochloric acid—which immediately removes the gum and all it contains, leaving the copy quite white. It is washed again in the water bath, and then allowed to dry.

The copy thus obtained is free from the objections to those produced by the former process. Erasures of the blue lines may be effected by the application of a weak solution of carbonate of soda or potash; and blue lines can be added by means of blue ink or paint; and the copy can be colored, like an ordinary drawing.

There are other processes by which *black* lines may be produced on a white ground, but they are chiefly developments of the last described process, and the results obtained hardly compensate for the extra trouble and expense.—*Watchmaker, J., and S.*

THE JORDAN FINISHER, AND THE MANUFACTURE OF PAPER.

IN the manufacture of paper, the comminuting of the rags, which is suspended at a given moment in order to permit of bleaching, or a mixture of different pulps, is resumed and finished by a beating engine or finisher.

The pulp engine, which is rendering great service in the manufacture of paper from straw and other materials, and which is very useful in the grinding down of paper trimmings, seems to have been the starting point of cone finishers, such as that of Brightman, and especially that of Jordan, which, since the latest improvements made in it, has been introduced into nearly every paper mill on the American continent.

The pulp engine, as well as the finishers that derive from it, does not operate like the old beating engine. It has some analogy with a flour mill, and consists of a single metallic grinder revolving around a horizontal axis. The two surfaces of this bear against the inner surfaces of a tight cast iron jacket, which gives passage to the shaft of the comminutor and to the stream of pulp.

In the Brightman finisher, this straight grinding cylinder becomes conical and double, that is to say, the two relatively short, hollow cones are united by their bases, and a solid double cone fills the cavity. These solid and hollow cones are provided with corresponding blades and sharp edges, similar to those that we find in the Jordan apparatus. This latter now consists of but a single hollow cone (and a very long one), in which revolves a solid cone of the same length (Figs. 1 and 2).

The recent improvements made in this machine are such as to allow of the easy renewal or change of the blades on the solid cone. In the old style of machine these were fixed, and lasted much longer, but it caused much trouble and loss of time to renew them. A hand wheel at the wide end of the cone (Fig. 1) permits of regulating the fineness of the pulp by varying the interval between the blades of the solid cone and those of the hollow one. In this way the machine is adapted for the treatment of all pulps designed for the manufacture of paper for journals, books, writing, envelopes, cardboard, packing, blotting, etc. The stream of pulp is admitted at the top of the apparatus and makes its exit at the bottom, near the small end of the cones. The machine is capable of producing from 2,500 to 17,500 lb. of refined pulp per twenty-four hours of work. It is preferable, however, to place one on each paper machine. At the rate of 250 revolutions per minute, the power absorbed is that of fifteen horses, but the work can be increased up to thirty horses with a velocity of 350 revolutions.

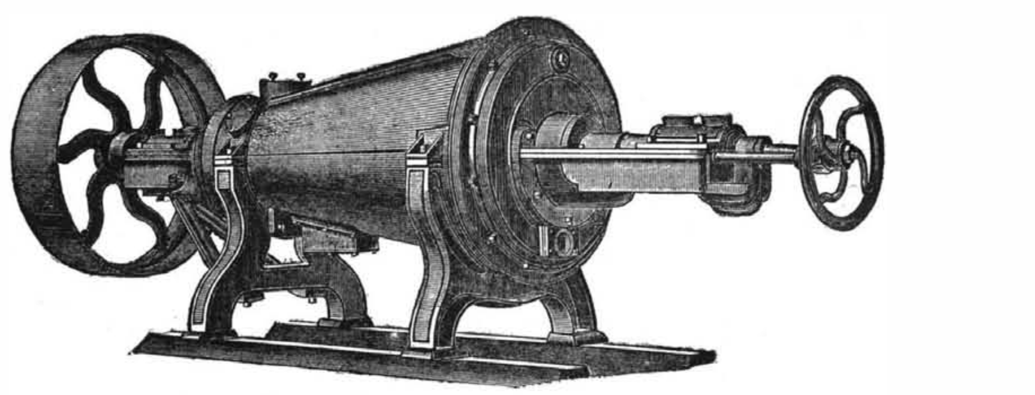


FIG. 1.

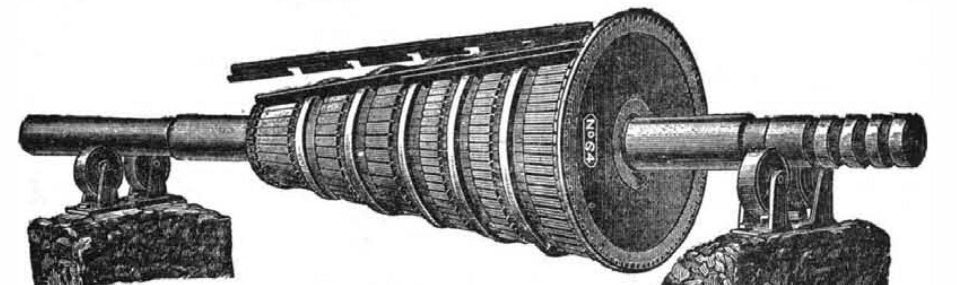


FIG. 2.

THE JORDAN FINISHER.

Analogous apparatus are employed in Germany; and must we not look for the cause of the continuous decrease in the business of our French paper mills in the use of superannuated machines? Despite pretty high internal and external imposts, German papers, often all printed, reach our own market at prices less than those of our own production. Germany, moreover, as results from the following statistics, possesses more paper mills and paper machines than any other country in Europe, for she has 809 of the former, and 891 of the latter. France has but 420 paper mills, with 525 machines; Great Britain, 364 mills and 541 machines; Italy, 228 mills, of which 70 have no machines; Russia, 133 mills and 137 machines; and Austria and Hungary, 220 mills and 270 machines. Australia already has 4 mills with 6 machines, while in Egypt we find but a single mill, and here the paper is made by hand. The United States occupy the first rank, with 884 mills and 1,103 machines. The entire world, then, possesses a total of 3,419 paper mills, with 3,952 machines.

None of these American paper mills is destitute of finishers, while in France it is rarely that one of these machines is met with. Our paper industry, far from progressing, remains stationary, and that, too, at a moment when paper is tending to become more and more an essential factor in the spread of civilization.

Let us suppose for a moment that paper had not been invented, or that the secret of its manufacture happened to get lost, and we at once return to the engraving of characters on stone or to the tracing of them on papyrus by a few privileged persons. It is possible to conceive of the operation of our modern

society without the railway, telegraph, telephone, and even the steam engine, but it is difficult to conceive of such operation after the disappearance of paper.

Mr. De Boutarel, in a communication made to the Academy of Moral and Political Sciences a few months ago, gave the following figures:

In Europe, the annual production of paper reaches a million tons. In the United States, where it was *nil* at the beginning of this century, it exceeded 500,000 tons in 1883. It has become necessary to look for new raw material, and to utilize an extraordinary number of substances, from second-hand paper up to straw and wood, and from moss up to the Algerian alfa, of which the English consume more than twenty million dollars' worth, while we do not know what to do with it.

The first elaboration of all these raw materials is capable of giving 1,500,000 tons of paper, whose net value is two hundred million dollars. Of these 1,500,000 tons of paper, writing paper represents about 120,000, of an approximate value of thirty-two million dollars. As for the consumption of paper in printing, that reaches fabulous figures: 800,000 tons for book printing; 300,000 tons per day for periodicals; and 120,000 tons for printed matter for public and private administrative services.

Including work and the second elaboration due to printing, this makes something like three hundred and fifty million dollars.

Let us add 60,000 tons of cardboard, 60,000 tons of wall paper, 60,000 tons of papers of secondary importance, such as blotting, tissue, filtering, tracing, and cigarette, and finally 700,000 tons of wrapping paper—say one hundred and twenty million dollars, which, with the value of the writing paper and of the products of the second elaboration coming from printing offices, gives a total of five hundred million dollars, to which may be added three hundred million more, representing the work of the freight and retail industries.

It is not an exaggeration, says Mr. De Boutarel, to suppose, in the absence of authentic documents, that the production of paper in Asia reaches half the above figures. It would then be a value of about one thousand million dollars that human industry annually extracts from a pile of debris, straw, shavings, and rags, which, without that, would be good for nothing.

But these are merely the ordinary uses of paper. In addition, it is now being made into collars and cuffs, and we shall soon make of it sheets, Chinese napkins, etc. It is even being converted into sugar. There are also being manufactured from it shoes, boats, barrels, gas pipes, bottles, flooring, doors, ceilings, roofs, and architectural ornaments, and at Breslau there is a spinning mill which has a paper chimney fifty feet in height.

Paper has the advantage over wood of not warping or splitting. Strongly compressed, it can be polished like ivory, and will resist fire better than any other material. It is also capable of being used as a substitute for metal, and it is already being used for making guns, locomotive wheels, and rails.—*Le Genie Civil.*

OIL OF PEPPERMINT.*

By ALBERT M. TODD.

IN the paper which I have the honor to present you, the history of the plant will be briefly noticed, and attention directed to some characteristics of the essential oil as observed in the practical manufacture, some being of such phenomenal nature as to invite further investigation.

Mentha piperita, from which the true oil of peppermint is derived, was first introduced or noticed in Hertfordshire, England, and given the name "pepper-mint" by Ray in his "Historia Plantarum," published in 1704. Its commercial history dates from about the year 1750, when its cultivation was commenced in a very small way at Mitcham, in Surrey, England. Fifty years later the amount under cultivation was about 100 acres, but the growers having had, as yet, no distilleries built, still continued to convey the plant to London for the distillation of the oil.

The industry in England reached its zenith about 1850, just one hundred years after its introduction, when the area cultivated was about 500 acres, but, owing to successful American competition, it was reduced during the next fifteen years to about 250 acres. From personal observation when visiting the peppermint districts of England in 1875, I attribute the success of American competition to a more perfect system of distillation and apparatus therefor (which I will again refer to), and the more heathful growth of the plants in our country.

Distillation of oil of peppermint was first accomplished in America by a Mr. Burnett, in the year 1816, in the county of Wayne, State of New York, who collected on the banks of a little stream sufficient wild plants to produce about 40 pounds of the oil. In the year 1835, the industry was established in Michigan, in St. Joseph County, on White Pigeon Prairie, about two miles north of a village of that name, a distillery being erected the following year. Up to this time, and for ten years later, the distilling apparatus used was very crude, being the same as has been used in England, with but slight modifications, consisting of a copper kettle in which the plants were placed, immersed in water, to which direct heat was applied by a furnace from beneath, a condensing worm of the usual character being connected with the kettle by a pipe from its apex.

The year 1846 marks a new and important era in the evolution of a more perfect system of distillation and the apparatus therefor, viz., that of distillation by the diffusion of steam through the plants, which were now, for the first time, placed in large wooden vats, to which steam was conveyed by a long pipe entering at the bottom; the kettle which had been used heretofore as the still being now used for the generation of steam. Distillation was now effected in a much more perfect manner, as the scorching of plants and the consequent formation of empyreumatic products was rendered impossible. Furthermore, distillation could now be conducted with much greater rapidity and economy. The primitive stills had a capacity of about 15 pounds of essential oil in the twenty-four hours, the new form a capacity of 75 to 100 pounds. This system of steam distillation originated in St. Joseph County, Michigan, and was soon introduced into New York.

I might state here that nearly every improvement in the construction of the stills has originated in St. Joseph County, Michigan, and it would be of great interest to mark the further development of these improvements to their present high state of perfection, but the limits of this paper render it impossible. On some other occasion I may have the honor to give some practical and technical information relating to the methods of erecting the more perfect plants of distilleries.

Briefly as to the cultivation of the plants. In early spring the ground, having been plowed, is marked out in furrows 2½ ft. apart. In these furrows are placed the roots and runners which have multiplied from the setting the preceding year. One acre of good roots usually furnishes sufficient to set from 5 to 10 acres of new ground. These roots and runners are from one-eighth to one-fourth of an inch in diameter, and from 1 to 3 feet in length when in the healthy state. In setting, they are carried in large sacks, strung over the shoulders of the workmen, who place them in the rows so that there shall be one or two living roots or runners at every point in the row. While placing the roots with their hands, they at the same time cover them with their feet. It is quite an interesting sight, owing to the queer motions of the workmen, to see these roots planted. A good, experienced workman, in mellow ground, with good roots, can set about one acre per day. New plants appear above the ground about two weeks after setting, and are carefully hoed and cultivated until July or August, when, if the season is fair, the plants have thrown out such a quantity of runners as to render further cultivation very difficult, and indeed unnecessary.

The proper time for distillation is when the plants are in full bloom in the case of the new crop, that is, the crop which has been set the preceding spring. This usually occurs in September. What is known as the "second crop" (which has sprung up spontaneously, from being the second year's growth) matures usually in August. For distillation, the plants are cut down and allowed to dry for a while in the sun before being drawn to the distilleries. Many growers, however, believing that a loss of the oil is sustained by diffusion in the atmosphere if the plants are fairly dried, bring them to the still in the green state. As distillation can be effected with much greater rapidity from dry plants, this question of thorough drying is one in which the owners of distilleries and the producers in general have long been greatly interested. For, if the plants are worked in the green state, it will require, ordinarily, about ninety minutes for distillation, with a yield of perhaps 5 to 7 pounds of oil to the charge, whereas, if thoroughly dried, distillation can be effected in about thirty-five minutes, with a yield of from eight to nine pounds, since the dried plants will pack much more closely in the vats than the green ones. Each owner of a distillery on the average distills the crops of ten other growers with his own, charging therefor twenty-five cents for each pound of oil obtained, whereas in England the charge is made for each vat of plants, whatever the amount of oil produced.

The former method is much more equitable for the grower, since, if his crop is poor, he is not obliged to pay an exorbitant rate per pound, and the latter method is more equitable for the distiller, since it requires as much labor to distill a charge of poor plants as green and productive ones, and, as stated, much more when the plants are green.

To test the question as to whether a loss of essential oil occurred by diffusion in the atmosphere when the plants were thoroughly dried, I made a careful experiment, the results of which may be found in the September number of the *American Druggist*; the dried plants used having been exposed to atmospheric action for six months, and having been reduced by such exposure 49·4 per cent. in weight. As there are about 15,000 tons of the plants produced annually in America, the settlement of this question is of material interest to owners of distilleries and growers; saving the former greatly in manufacturing and the latter in transportation.

The average yield of essential oil varies greatly, according to the quality of the plants, depending mostly on the fact whether they are fine and well covered with leaves and blossoms (in which the essential oil is entirely contained). The difference in quality of plants is so great that, while from 2,000 pounds of well-leaved plants I have distilled 18 pounds of essential oil, but 1 and 1½ pounds have been obtained in some instances from a like quantity of coarse plants devoid of leaves. The average yield, however, is about one-third of 1 per cent. from green plants.

There are now in America about 175 small distilleries, where the natural oil is distilled. The average annual production in America for the last ten years has been about 100,000 pounds of oil. The average yield per acre of the crops of the first and second year is about 11 pounds; this would show an annual area under cultivation of about 9,000 acres.

As to the nature of the essential oil: regarding this there are many tests, which are so generally known as not to require notice at this time. Some of them may, however, be briefly stated. Oil of peppermint, when freshly distilled, or when two or three years of age, if kept in well-filled vessels, should dissolve readily in alcohol in all proportions, making a clear solution without need of filtration. When a few drops of the oil are placed upon white paper and held over a lamp or gas jet, it should volatilize quickly and perfectly without undergoing change or leaving any residue. When 3 drops of peppermint are placed upon 4 grains of resublimed iodine (or such quantity as will thoroughly saturate, but not drown, the iodine), there should be but a slight reaction, and what little vapor is produced should be almost invisible, becoming entirely so after having arisen about twelve inches above the mixture, the color of the vapor assuming a bluish cast. The color of the mixture in this test should be carefully noticed, which, in the case of pure peppermint, is of a brown or brownish-black color, the iodine dissolving slowly and imperfectly. If oil of turpentine, erigeron, fireweed, ragweed, or other terebinthinate oils are present, there will be quite a violent reaction (according to the quantity of the adulterant), with the evolution of considerable heat, and a red or reddish-yellow vapor will be produced, of a rank odor, partaking considerably of the nature of the adulterant, and the mixture will change to a bright violet. If the color of the mixture is most carefully noted, a very slight quantity of such adulterants can be detected. When to 25 drops of alcohol 1 drop of nitric acid, specific gravity 1·2, is added, and then 1 drop of pure oil of peppermint, there will be produced, within about half an hour, a blue or bluish-green color, which will remain permanent for a long time. Oil of pennyroyal and *Mentha arvensis* produce no coloration. A much more intense coloration will be produced when 1 drop of nitric acid, of the strength as stated, is mixed with 50 or 60 drops of the essential oil, without alcohol. Some specimens of oil of peppermint imported from Germany and England showed by this test a mixture with *Mentha arvensis*. To make this test valuable, however, to chemists and pharmacists, they should first operate upon samples of known purity, and notice the depth of coloration required.

Another test for the detection of pennyroyal, which also indicates *Mentha arvensis* when in sufficient quantity, is the following: Take 1 drachm each chloral hydrate and pure sulphuric acid, adding 12 drops of alcohol. When this solution is mixed with a like quantity of pure oil of peppermint, a dark cherry color is quickly produced and maintained for a long time. Pennyroyal (or oil of peppermint heavily adulterated with this oil) gives no such color, being more of a yellowish cast, and changing to an olive green. With *Mentha arvensis* a yellowish-brown color is produced, which is maintained for ten or twelve hours, and, thirty-six hours later has a slight tendency to assume a cherry color or one intermediate between the cherry and the brown. It was noticed that, when the true oil of peppermint was mixed in equal proportions with that of the *Mentha arvensis*, a deficiency in the intensity of the cherry color was plainly observable. Whether the significance which I have discovered in these tests, showing similar reactions in pennyroyal and *Mentha arvensis*, has a bearing on the chemical relationship of the oils of these plants, which are related botanically, is a question of interest.

I will now refer to the two physical tests, those of specific gravity and boiling point, in which the results of my experience vary greatly from the tests published in official and standard works.

The difficulty which scientific men seem to have experienced in establishing accurate tests for the purity of essential oils has been that they could not conveniently obtain the plants from which they themselves could distill the specimens used in their investigations; and while undoubtedly every possible precaution was taken, the result shows that they have in many instances operated upon impure samples; and although pure specimens undoubtedly were, in some instances, received, yet they had, in many cases, no positive knowledge, *per se*, which were pure and which were impure; hence too great a range of differences has been allowed in physical characteristics and chemical reactions. In correspondence with some well-known chemists, they give it as their opinion that a wide range of specific gravity, etc., might result from variations in soil and climate. On account of this we took greater pains to verify our determinations by testing samples grown under much varying conditions of soil and climate, both in Europe and America. Forty-three samples were examined, including oils produced in St. Joseph, Wayne, Ionia, Hillside, and Kalkaska Counties, Michigan, Wayne County, New York, and vicinity (all of which were produced from American roots long acclimated), also one specimen grown in America from roots imported from England, and one specimen grown and distilled in England. The specific gravity has been variously stated in the dispensatories and other standard works at from 0·840 to 0·950 at 60° F. But there were none of the samples which were pure which had a specific gravity below 0·910 at 60° F., except the two last mentioned, grown from English roots; the one grown in America being 0·9085, the one distilled in England being 0·9088. Nor were any specimens of pure oil found having the specific gravity above 0·917 which were in a perfectly soluble condition. One sample distilled by myself in 1875, and consequently eleven years old, had, on account of its age, a specific gravity of 0·924; one sample from New York 0·933, and from the same district 0·940 for another. However, those three samples were found to be not readily soluble; the latter sample, when submitted to rectification, being found to contain 9 per cent. of insoluble resin. Of five samples imported from Europe, but one was found pure; two from Germany were found to contain dementholized *Mentha arvensis*; one from London, which bore a fraudulent and forged label (as Michigan oil of peppermint, manufactured at Evart, Michigan County, U. S.), had the specific gravity 0·899. This oil, when submitted to fractional distillation, was found to contain 50 per cent. oil turpentine and no Michigan peppermint whatever. The sample imported from London as German oil of peppermint consisted chiefly of pennyroyal and *Mentha arvensis*. Allowing a slightly wider range of difference than was really intended, it is evident that whether from English or American plants, pure oil of peppermint is never below 0·908 specific gravity, nor when fresh and soluble, above 0·917 specific gravity, so that the difference formerly allowable, that is, from 0·840 to 0·950, is reduced to one-tenth.

As to the boiling point: this is stated in the dispensatories at 365° F. and 374° F. By placing the oil of peppermint in a distilling flask, the body of which was immersed in a mercury bath, and attached to the condenser, the following times and temperatures were noticed, the distilling being divided into eight fractions. Applying the heat slowly, the slightest possible ebullition was noticed at 363° F., but so slight as to be almost imperceptible. Ten minutes later the temperature had risen to 401·5° F., at which time but 2 drachms of fluid were collected, one-half of which was found to be water. It will hence be observed that the true boiling point of the oil could hardly be placed below 400° F. Ten minutes later the temperature had risen to 406·9° F., with distillation progressing at the rate of but 6 drops per minute, and it was found, upon reducing the temperature to 406°, that the speed of distillation was reduced to 1 drop in forty-two seconds; so that the first fraction could not be recovered easily, except at a temperature higher than this. Counting from the time when the oil commenced to drop into the receiver, the distillation of the first fraction of 1 ounce occupied fifty minutes, being concluded at a temperature of 412·8 F. It would seem, then, that the true boiling point should not be placed below 400° F.

I would here call the attention of the association to the need of a more definite and complete method for recording experiments in fractional distillation, in which

* Read at a meeting of the American Pharmaceutical Association.

not only the form of apparatus and method of applying the heat should be noticed, and the temperatures of each fraction, but also the speed at which it is affected in its various stages. This matter would form a very interesting matter for discussion. I will now call attention to one phenomenal characteristic observed in fractional distillation, and which I briefly alluded to one year ago, that is, the changes of direction from the ascending to the descending scale in the specific gravity of the different fractions. It had formerly been supposed that the specific gravities increased constantly after the first until the last fraction was obtained. The law discovered is that when the distillate is divided into a number of fractions, the specific gravities continue to rise only until about half the oil is recovered, they then strangely commence to descend until 80 per cent. or 90 per cent. is obtained, and the point is reached of the specific gravity about as low as that of the third fraction. The direction now again changes to an ascending scale, increasing with great rapidity. To illustrate this, I will give you the specific gravities obtained in the distillation of 300 pounds oil of peppermint by the diffusion of steam. The times and temperatures and other conditions will be referred to in some future paper.

The specific gravities were as follows:

Number of fraction.	Specific gravity.	Number of fraction.	Specific gravity.
1	0·89423	8	0·91275
2	0·90650	9	0·91175
3	0·91000	10	0·91100
4	0·91275	11	0·91075
5	0·91375	12	0·91065
6	0·91400	13	0 91050
7	0·91425	14	0 91265

There now remains in the still one full fraction of 20 pounds not yet recovered; subdividing this fraction, the following specific gravities are found: The first 5 pounds is 0·925; the next 2 pounds 0·955, and the distillation being continued as far as possible, the last portion obtained is 4 ounces specific gravity 0·970. There now remain in the still 12 pounds 14 ounces of resin, which, if mixed with 7 pounds 4 ounces last obtained, would raise the specific gravity of the last full fraction to about 0·980.

In calling the attention of Professor Fluckiger, of Strassburg, to the subject, he attributes it to the splitting up of the component parts. This, however, seems hardly possible when the aroma and chemical reactions of the fractions are investigated.

There are other tests and characteristics of interest which I would gladly notice if time permitted, but which will better form the subject of a future article.

BORACIC ACID, BORAX, AND THEIR USES.

FOR nearly forty years I have been engaged more or less in promoting the introduction and useful application of borax. I have also visited many of the districts where it is found in its crude state, and have gained much information respecting its valuable properties and important uses—an almost inexhaustible subject, into which it would take too long to attempt to enter fully. I will therefore try, as briefly as possible, to give an outline of its mode of occurrence in the natural state, describe how it is collected and manufactured, and explain as briefly as possible its uses. Borax is no new article of commerce, but was known to and used by the ancients from time immemorial. Nero used it. Pansa regretted that he was not sufficiently rich to buy borax to cover the arena after the death of the combatants at the time of the combat between the gladiators Lydon and Tetrides. Doubtless its use on the arena was to deodorize the blood. At this time there is no record of borax being found in its crude state in any part of Europe, but it was known to the Arabians, who called it baurach. Hence its name. They used it to assist in reducing the oxides of metals. The conclusion at which I have arrived is that the borax used by Geber, who lived in the eighth century, was made from tincal, or crude borax, which is found in many lakes in Thibet.

In some of these lakes are numerous hot springs, the vapor of which contains boron, and the surface water is impregnated by it. Evaporation taking place, the tincal is found crystallized at the sides of the lakes. In addition to this, solid borax is found in some form or other in the soil around this district, and there is ample proof that unlimited supplies can be obtained. Tincal has been obtained from Yandok Cho from time immemorial. It is exported in small quantities hence to Lassa, where it is used by various workers in metal. After the tincal has been collected it is bartered for cowrie shells, Sheffield cutlery, and Birmingham ware. It is then sold to the Kassawaris and Khampos traders, who arrange for its transport to India on sheeps' backs. Each sheep carries from 40 to 60 lb. The transport across the Himalayas takes about nine weeks. Each driver carries a distaff, which they use to spin wool dragged from the sheeps' back, to make bags in which to pack the tincal. Should a sheep die on the way, its flesh is eaten by the drivers, and the wool taken off and spun as described. On the way vegetation is sometimes so scarce that boughs of trees have to be cut down and the leaves stripped, to feed the sheep.

From Moradabad and other parts of the foot-hills of the Himalayas the tincal is sent to Calcutta, and shipped from thence to Liverpool, where it is refined into borax, and used in making the glaze for china and earthenware. I may mention that tincal was the only form in which borax was known in Europe until the year 1742, when a Tuscan traveler and geologist paid a visit to Monte Cerboli, Castel Nuovo, where he discovered a large number of hot springs, and noticed dense vapors arising from them; but it was not till the year 1777 that Hoeffer found out that the steam contained boracic acid at Monto Rotondo and Castel Nuovo In 1816 Hoeffer and Mascagni proposed to make borax from them, but the latter was too much engaged with other scientific labors, although he had obtained a patent during Napoleon's rule in Italy to make boracic acid from the fumeroles. This right he ceded to Fossi, who was the first to make it in any quantities. Gazzeri and Browret worked some of the lagoons at Monte Rotondo, but made only about 3½ tons in twelve months —a most unfortunate speculation for them.

In 1818 Laderet, a Frenchman, who was staying in Italy, hit upon the brilliant idea of utilizing the natural steam jets oozing up so plentifully from the soil, to evaporate the water, and so increase the supply of borax at a much cheaper rate, as the great cost hitherto had been the wood for fuel. I must now try and describe the very simple mode of preparing this boracic acid, and when I first visited Italy I was never more astonished in my life. I made my headquarters Castel Nuovo, which is the very center of these curious steam puffs or fumeroles, and visited the most important places of production, Sasso, Lustignano, Ladarello, Lago, and San Federigo. Scarcely any one could give me any idea why the steam puffs contained the boracic acid, and, as I am neither a scientific nor a learned man, I can but give you what I think may be the cause, though I may be altogether mistaken in my supposition.

My exact meaning will be best understood from the accompanying diagram—all that is seen below the surface being, of course, imaginary, but, I believe, correct. The subterranean lake, A, is supposed to be surrounded with crude borax vapor generated from the lake by deep-seated heat or fire; the vapor rises through the crevices, B, of the rocks; C are artificial lakes on the surface of the earth; D is a tank wherein any impurities fall to the botton, boracic acid still remaining in solution; F is the evaporating house; E is a soffione vaulted over with stone and firmly bound with wrought iron bars; and G are the crystallizing tubs or casks. Now, it appears to me that for many miles round this district there exist subterranean lakes and seas—the sides containing borax in some solid form; and that the internal heat of the earth affects the water, dissolving the borax. The steam forces its way through crevices and fissures, sometimes puffing up to a height of eight or ten feet.

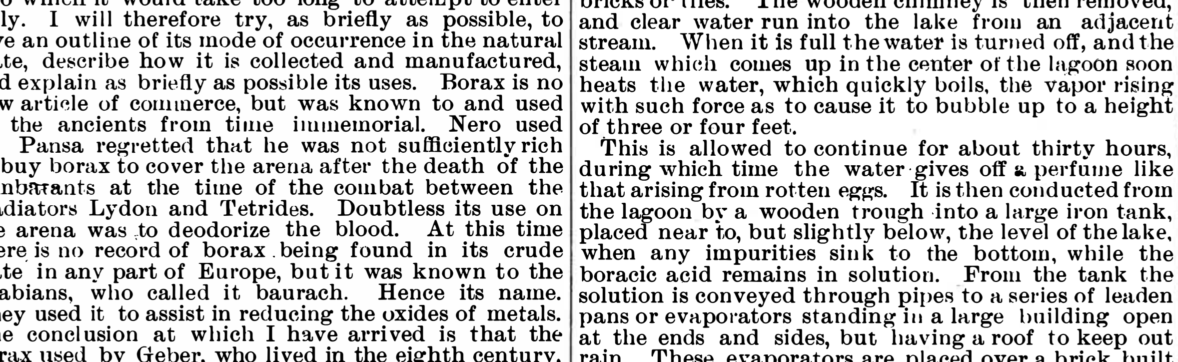
To utilize the steam jets, a wooden chimney is constructed round those selected, which conducts the steam high up in the air, in order to protect the workmen while preparing the lagoon or lake. Around this is dug an artificial lagoon, about six feet in depth and twenty feet in diameter. This lagoon is faced with bricks or tiles. The wooden chimney is then removed, and clear water run into the lake from an adjacent stream. When it is full the water is turned off, and the steam which comes up in the center of the lagoon soon heats the water, which quickly boils, the vapor rising with such force as to cause it to bubble up to a height of three or four feet.

This is allowed to continue for about thirty hours, during which time the water gives off a perfume like that arising from rotten eggs. It is then conducted from the lagoon by a wooden trough into a large iron tank, placed near to, but slightly below, the level of the lake, when any impurities sink to the bottom, while the boracic acid remains in solution. From the tank the solution is conveyed through pipes to a series of leaden pans or evaporators standing in a large building open at the ends and sides, but having a roof to keep out rain. These evaporators are placed over a brick built chamber, into which steam from another fumerole is conducted by a pipe at one end of the building, and after traversing the entire length of the building, escapes through a pipe at the other end. By this means the leaden pans become heated, and drive off a good deal of the superfluous water, the solution thus becoming more dense, and while in this condition it is run off through wooden pipes into large casks. When cool, the boracic acid forms on the sides of the casks in a thickness of about five inches. The liquor being drawn off, the boracic acid is removed and put into wicker baskets. After a short time it is carried to the drying chamber and placed on a brick floor, which is heated by one of the steam jets. When dry, it is packed in casks and conveyed to Leghorn for shipment to England, and refined into borax.

About 3,000 tons of boracic acid are produced annually in Italy. Besides the districts I have already mentioned in Italy, there are others, but they are insignificant.

Chili is the next important district where borax is found in a crude state. It is also found in Peru and Bolivia, but the largest deposits are in Chili. There exist large numbers of dried-up lakes containing great quantities of borate of lime The most important is known as the Laguna de Maricunga, which, besides borate of lime, contains solid masses of salt. It is situated between the two highest ridges of the Andes at an elevation of 1,300 ft. In some parts of the lake there are deposits of borate of lime twenty feet deep, so that when the business gets thoroughly established, borate of lime may be collected and sold comparatively cheap; and when the uses of borax are better known, and more demand for it created, this crude borax will be sent home in thousands of tons. The cost of collecting it is trifling, but the carriage from the place of production to the sea coast is expensive. In my next I will fully refer to the wonderful deposits of borate of soda and borate of lime existing in Nevada and California, United States of America.

I believe I am correct in stating that no case of cholera was ever known to have taken place in any of the villages where the boracic acid is made, the vapors arising from the lagunas acting as a charm against this terrible epidemic.—*Arthur Robottom, Industrial Review.*



BORAX: ITS OCCURRENCE AND PREPARATION.

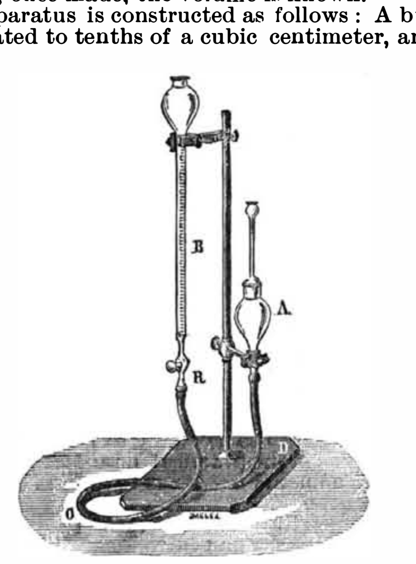
APPARATUS FOR OBTAINING THE DENSITY OF SOLIDS.

THE specific weight of a body, which is usually confounded in physics with density, is the ratio of the weight of such body to the weight of an equal bulk of water, or, what amounts to the same thing, the specific weight of a body is the weight of the unit of volume of such body. The following classical formula,

$$D = \frac{P}{V},$$

which is well known, shows that, in order to obtain D, it is necessary to know P, that is to say, the weight of the body, and V, its volume. The methods ordinarily used for such determinations are those of the hydrostatic balance, the bottle, and aerometers of constant volume. All such methods take time, and require a certain amount of dexterity on the part of the operator. Messrs. Brasse & Vlasto have devised a very simple little apparatus for rapidly estimating the density of solid bodies. With this, it requires but a single weighing, which may be effected up to within a decigramme. A reading once made, the volume is known.

The apparatus is constructed as follows: A burette, B, graduated to tenths of a cubic centimeter, and the



APPARATUS FOR OBTAINING THE DENSITY OF SOLIDS.

upper extremity of which is ovoid, while the lower one is provided with a cock, R, is connected by a rubber tube, C, with a balloon, A, having the shape of the bottles used for taking densities. The aperture is ground and fitted with a hollow stopper surmounted by a capillary tube provided with a datum mark. The lower part of the balloon terminates in a slender tube to which the rubber tube is affixed. The burette and balloon are supported by clamps that are movable around the rod, D.

The mode of using the apparatus is as follows: It is first filled with water, whose temperature should be as near 15° C. as possible. Then the balloon is raised by causing its clamp to slide along the supporting rod, and things are so arranged that when the level of the water reaches the datum mark, the water shall enter from the other side at the base of the burette Then the division at which it stops is read. Let us suppose that we find it to be 5 cubic centimeters. We then weigh the body whose density we wish to take. For the sake of example, we shall take statuary marble. We put on a scale several fragments of this, that are small enough to enter the neck of the balloon, and we find it to weigh 25·4 grammes.

We raise the balloon, and the water then lowers therein, and rises in the burette, filling a portion of the bulb as it does so. We then open the balloon, introduce the fragments of marble, insert the stopper, and lower the balloon again until the water returns to the datum mark of the capillary tube. The body has displaced a volume of liquid equal to its own, and the water has therefore risen in the burette, and has reached a second level. A new reading is now made, and we find 14·4 cubic centimeters. Upon obtaining the difference between the two figures read, we have the volume of the body, which, in the example above selected, is 14·4 — 4 5 = 9 4 cubic centimeters.

Applying the formula,

$$D = \frac{P}{V},$$

we have

$$D = \frac{25{\cdot}4}{9{\cdot}4} = 2{\cdot}702.$$

By the bottle method, we find 2·709, say an error of <0·01.

With bodies soluble in water, or upon which water exerts an action (such as cements, for example), some other liquid (kerosene, for example) is substituted.

The apparatus is simple, and easily and quickly maneuvered.—*Le Génie Civil.*

SOFT STEEL—A NEW TYPE OF FIXED CONVERTER.*

By GEORGE HATTON, Bilston.

THE development of the manufacture of steel has, until recently, been almost entirely in the direction of large outputs, entailing increasingly large and costly plants. Consequently, the revolution from iron in favor of steel has been very severely felt by iron manufacturers, inasmuch as their existing works and plant have not been adaptable to the new order of things.

Some method of making soft steel of the highest quality in moderate but, at the same time, rapid and continuous quantities, and with comparatively inexpensive plant, has, therefore, long been desirable, and for this purpose the fixed converter offers many advantages. The fixed converter is not a new invention. Sir Henry Bessemer conducted his early experiments in one, and it has been used somewhat extensively in Sweden for many years, making steel of very high quality.

In using the old type of fixed converter, a great difficulty experienced has been the necessity for keeping the full pressure of blast on during the tapping out of the metal after the process of conversion was completed, with the risk of more or less oxidation of the bath of metal, which oxidation would, of necessity, be continued till the last of the steel ran from the converter, owing to tuyeres being fixed on a level with the converter bottom.

M. Wittnöfftt, of Bochum, Westphalia, in a paper read before the Cleveland Institute of Engineers, proposed, as a remedy for this undesirable after-blow, the employment of an auxiliary blast engine of considerably smaller dimensions than the engine used in blowing the charge, but which could be made to maintain the full pressure of blast, but with reduced volume. This smaller engine was to be started at the completion of the blow, and at the moment of tapping the converter, the large engine being stopped, or the blast from it shut off, as soon as the smaller one was in motion. Whether this suggestion was ever put into practice or not I am unable to say.

The Clapp & Griffiths converter (a South Wales invention) was specially intended to meet this difficulty, by stopping up the tuyeres at the termination of the blow, and thus preventing further oxidation of the bath; the risk of oxidation being further minimized by fixing the tuyeres in a position about half way between the converter bottom and the surface of the metal, so that, by the time about half the metal had left the converter, the tuyeres were free and oxidation was at an end.

The essential feature of this converter was a very ingenious arrangement for actuating the stoppers to the tuyeres. It consisted of two pistons, of unequal areas, attached to the spindle or rod carrying the stopper. The smaller piston was under the pressure of the blast during the operation of blowing, and served the purpose of holding back the stopper from the tuyere, the larger piston during that time being under atmospheric pressure only; but on the admission of the blast behind the larger piston at the end of the blow, which was done by simply opening a hand cock, the pressure on the larger area overcame the pressure on the smaller area, and the stopper was at once driven against the back of the tuyere, closing it with the exception of a very small hole provided through the center of the stopper, which was necessary to admit sufficient blast to keep the metal from coming back through the tuyere.

A Clapp & Griffiths converter was erected and started at the writer's works at Bilston early in 1884, but several practical difficulties were met with, due to the construction of the converter. The position of the differential piston and stopper appliance, immediately behind the tuyere, and on a lower level than the metal line (a position of danger), was very objectionable, owing to the delay in, and costliness of, replacing them if damaged. The exposure of the back end of the tuyere, and of a large area of lining material, to the full pressure of blast in the blast box, added considerably to this danger, it being difficult to keep the lining tight, the blast having a tendency to penetrate the joints and produce outbreaks of metal into the blast box. These faults, and the general inaccessibility and immovable character of the converter lining and bottom, causing great difficulty and delay when repairs were needed, led the writer, after a short experience, to design a fixed converter upon entirely different lines, with a view to overcoming these difficulties.

A sectional elevation of this new converter is exhibited, from which its general construction will be readily understood. The whole is rigidly supported on four strong cast iron columns, and for convenience of construction is attached to them by the blast chambers, which form part of the middle section of the converter shell. The lower section is readily detachable, and is secured in position by cotter bolts passing through the flanges, or by other suitable means. This lower section is made sufficiently deep to enable the portion of the lining liable to the greatest wear, together with the tuyeres, to be removed with it, so that, by simply changing a lower section, in a very short space of time a converter can be completely renovated, and in this way can be kept at work night and day, almost continuously. The lining of the middle and lower sections consists principally of ganister, rammed hard, according to the usual method of lining Bessemer converters.

It has been found more convenient to line the nose, or upper section, with silica bricks, and a course of silica bricks is used as a support to the ganister lining of the middle section, making it safe and independent when the lower section is removed.

The tuyeres are of fire brick, and preferably of square outer section, with a single round taper hole through the center of each, 1⅛ in. diameter at the inner end. These tuyeres are so placed as to be about 6 in. below the surface of the molten metal, and about 10 in. above the bottom. The bottom of the lower section is made with silica bricks, set in ganister upon a bed of loam sand. One or more duplicate lower sections are provided, and as they are removed, with their linings worn out, they are repaired and placed in a stove to dry and keep warm till wanted.

The method of changing a lower section is simple. A bogie running on rails is placed under the center of the converter, a hydraulic ram—which is actuated by a pair of manual pumps fixed any convenient distance away—then passes up through the center of the bogie, taking the weight of the lower section, and after the cotters are removed from the bolts and the tuyere pipes disconnected, gently lowers it on to the bogie, by which means it is then removed to the repairing shed. The new lower section can now be brought into position under the center of the converter, and raised by the ram and cottered to the middle section, the joint being made with a little plastic ganister, placed on the edge of the lower section, just before raising it into position. When the converter is blowing, the hydraulic ram is at rest, and entirely below the floor level, covered with a plate, and further protected by a bed of sand, some ten or twelve inches thick, from any possible damage from hot steel or cinder.

The blast connections to the tuyeres are so arranged that no costly valves or blast boxes are exposed to danger behind or on a level with the tuyeres, the blast being conveyed separately and directly from the blast chamber to the center of each tuyere, passing through the valve and down the cast iron pipe, which latter has a ball and socket connection to the valve, and is held in position by a bridle and set pin. The lower end of the pipe is faced and bolted to the cast iron tuyere block, which is also faced, and at this point a thin asbestos millboard ring forms an air tight joint.

When changing a lower section, it is not necessary to remove the connecting pipes. They are unbolted, the set pins in the bridles are slackened, the pipes then swing back into an oblique position, and are there held by the bridles by retightening the set pins, and in this position are out of the way of the lower section.

The valves are of the ordinary baffler type, are all connected together by levers, and can all be closed or opened by the movement of one handle.

Each valve has a hole ¼ inch diameter, through which sufficient blast passes while the valve is closed to support the weight of metal in the converter, and keep it out of the tuyeres during the process of tapping. The nose of the converter is accessible from an upper platform, and a movable spout is provided for the purpose of charging scrap during the blow.

The charge is run direct from a cupola, and consists of about 46 cwt. of hematite iron, the blast being put on at the converter at the moment the cupola is tapped. The blow usually lasts about fifteen to eighteen minutes, and just as the carbon blow is commencing, most of the silicon being by then eliminated, a greater portion of the slag is allowed to boil out at the slag hole; this lasts about one to two minutes, when the hole is stopped up for the remainder of the blow. The charge is blown right down—that is, till the carbon flame has disappeared—when the signal is given to tap out; at this moment the valves are closed, and the steel instantly begins to run from the tapping spout. Ferro-manganese, finely crushed, is added in the ladle while the steel is running from the converter, in about the proportion of 20 lb. per ton (for 80 per cent. manganese). The quantity of steel produced per blow is about 2 tons.

The pressure of blast used may be from 5 to 8 lb. per square inch; in no case need it ever exceed about half that required in the ordinary Bessemer process, or say 10 lb. as a maximum.

The rapidity with which the converter can be worked depends very much upon the facilities at hand for dealing with the steel produced.

At the writer's works, twenty blows per shift of twelve hours have been done, but, with more efficient casting-pit arrangements, this output could be very considerably increased.

The usual numbers of Bessemer hematite pig iron are used, the percentage of silicon preferred in the mixture being about 1¾ to 2 per cent. When working rapidly, with surplus heat, a considerable quantity of scrap is added through the nose during the blow.

The steel produced by this process is of the highest quality, remarkably soft, and particularly adapted for welding, it being largely in demand for lap-welded boiler tubes and other similar purposes; it is also made into boiler plates, and is largely made into stamping sheets and tin plates for difficult work. Samples of it are to be seen at the Bingley Hall Exhibition.

The carbon is exceedingly low, averaging from 0·05 to 0·10 per cent., and seldom exceeding 0·15 per cent.

The silicon seems to be more thoroughly removed than in the Bessemer process, which is a great advantage, and is probably due to the less acid character of the slag at the end of the blow, resulting from the removal of the greater portion of the silicious slag at the end of the silicon blow as already described, the following being the analysis of the slag at the termination of the blow:

FeO.	SiO_2.	MnO.	Al_2O_3.
41·90	46·22	6 97	4 89

The tensile strength of the steel is about 24 to 26 tons per square inch, with elongations averaging 25 per cent. Some analyses are as follows:

C.	Si.	S.	P.	Mn.
0·04	trace	0·07	0·06	0·30
0·07	0·009	0·02	0·05	0·37
trace	0·008	0·05	——	0 30

The advantage claimed for the process over the ordinary Bessemer process, apart from the question of cost of outlay, is that a better quality is produced—one that is uniformly softer and more reliable; the reason for this being that the action in the converter is less violent. The charge can always be blown right down, with less risk of oxidation, owing to the fact that the final changes take place less rapidly; this is due to the low pressure of the blast and to the fact that instead of the whole charge being constantly penetrated and oxidized by direct contact with the blast, as is the case in the ordinary bottom-blown Bessemer converter, only about a third of the charge is subject to direct oxidation at any one time, a further indirect process of oxidation at the same time being carried on by circulation and admixture of the oxidized iron with the remaining portion of the bath.

Further, by tapping the steel from the bottom of the charge, all risk of taking up particles of partially converted metal, which may adhere in and around the nose, and contain more or less silicon, is avoided, as is also all unnecessary contact with slag, which remains on the top of the bath, and only runs from the converter after the steel is in the ladle.

Some advantages of this process, compared with the Siemens process, are that—where only a moderate output of steel is required—the constant and regular production of ingots enables soaking pits to be economically used, instead of the more costly method of heating in furnaces. Also, softer material (lower in carbon) can be made with regularity and certainty; also, Welsh or other hematites made from Spanish ore, containing a larger percentage of manganese than West Coast brands, can be used with great advantage—in fact, are preferred—and when not used alone, are almost always used as a mixture with West Coast iron.

This converter is well adapted for making steel castings. Though the plant at the writer's works has not been designed with that view, castings weighing from a few pounds to upward of one ton each have been repeatedly made, and always with success. The following are analyses of some of them, which, though rather variable, the castings were all sound and satisfactory:

C.	Si.	S.	Mn.
0·16	0·113	——	0·18
0·50	0·30	0·027	0·99
0 42	0·046	0·04	0·46
0·66	——	——	0·50
0·28	0·181	——	——

* Read before the British Association, Birmingham meeting, Section B.

ACTION OF MANGANESE ON THE PHOSPHORESCENT POWER OF CALCIUM CARBONATE.

By EDMOND BECQUEREL.

ICELAND spar is one of the first substances which presented to the author a luminous appearance in the phosphoroscope after the previous action of luminous rays. The color of the phosphorescent light is orange, but there are very great differences in the intensity of the light emitted by different specimens. The presence of foreign matter can very much modify the phosphorescent power of certain bodies, and it was therefore important to examine if the differences of luminous effects given by various specimens of calc spar might not be due to the presence of a minute trace of foreign matter mixed or combined with the spathic calcium carbonate. The most luminous crystals of spar, orange in the phosphoroscope, contain a moderately high proportion of manganese, probably in the state of carbonate; there were scarcely any traces of iron carbonate. Fragments of calc spar, still very luminous, contained manganese in less proportions, and less brilliant specimens contained only very little, or none at all if examined by ordinary analytical methods.

Synthetic experiments lead to the same conclusion as the analysis of the natural crystals. These results show distinctly the action of manganese. Calcium carbonate obtained by dissolving fragments of Iceland spar in pure hydrochloric acid, even after several successive precipitations with ammonium carbonate, always led to the preparation of sulphides having an orange phosphorescence, while when the raw material used is arragonite the phosphorescence is always of a bright green. It is probable that the orange phosphorescence is either due to a double manganese-calcium carbonate or to the fact that the presence of manganese gives to the calcareous compound a peculiar molecular arrangement, whence results a phosphorescent power more or less energetic and a luminous emission of a given color. This substance would then merely exalt the intensity of the light emitted by the spar.

The author has shown that the crystalline form may interfere in these luminous reactions, since all the specimens of arragonite studied in the phosphoroscope emit a green instead of an orange light. Other bodies besides manganese can produce, in calcium sulphides, profound modifications in the intensity and the quality of the light emitted; such are lithium carbonate, bismuth, antimony, various sulphides, etc.—*Chem. News.*

CHLORINE IN RAIN WATER.

By EDWARD KINCH, Royal Agricultural College, Cirencester.

DETERMINATIONS of chlorine in the rain water collected in a small five inch rain gauge, at the Royal Agricultural College, 443 feet above the mean sea level, have been made continuously since 1870. The rain collected during the six months April to September is kept apart from that of the six winter months October to March. The chlorine is determined in the mixed waters of each six months.

The amount of chlorides in the rain is nearly always greater in the winter months than in the summer months. An abnormal amount of chlorides can generally be traced to storms from the southwest, bringing salt spray from the Bristol Channel, about thirty-five miles distant. Crystals of common salt have been found after such storms on the windows of the College facing west. On one occasion, in September, 1869, Prof. Church found chlorine equivalent to 6·71 grains of common salt per gallon in storm water.

The rain collected during the winter six months, 1872–73, contained an abnormally large amount of chlorine. Excluding this period, the yearly averages for 16 years, 1870–1885, for the 12 years 1874–85–86, also the means of the last 12 summer periods and 12 winter periods are:

	Rainfall in inches.	Chlorine per million.	Equivalent to NaCl per acre.
Mean of 12 summer periods to 1885	17·04	3·14	19·91
Mean of 12 winter periods to 1885–86	17·65	3·58	23·56
Average for 16 years (excluding winter) 1872–73	33·31	3·25	40·33
Average for 12 years to March, 1886	34·69	3·36	43·47

Lawes, Gilbert, and Warington have found in the rain collected at Rothamsted, as a mean of six years' monthly determinations, 1·99 of chlorine per million, with a mean rainfall of 33·15 inches, equivalent to 24·59 lb. of common salt per acre. They found the amount of chlorides in the summer months to be less than one-half that of the winter months.

WATER, IN SOME OF ITS PHYSICAL AND CHEMICAL ASPECTS.*

By THOMAS NEWBIGGING, M. Inst. C. E.

WHEN it first occurred to me to give a lecture on this subject, my intention was to have treated of water from the point of view, not so much of its constituent elements as of its physical effects, and also of its effects, uses, and drawbacks in relation to gas manufacture. On second thoughts, however, I determined to begin with the A B C of the subject; making an introductory lecture of this, and at a future time, as opportunity offers, pursuing the subject in its more extended and practical applications in one or two further lectures, if I do not weary your patience. Although, therefore, I must needs be somewhat elementary on this occasion, it will do none of us any harm to rub up our early knowledge of and experiences in chemistry; indeed, I sometimes think that by occasionally reverting to first principles, we smooth our way to the understanding and the elucidation of the more difficult problems that engage our attention.

In the wide range of subjects for study outspread before us, each of them full of so much that is useful and interesting, I cannot conceive of one that is so well calculated to arrest our attention, and satisfy our thirst for knowledge, as the study of the science of chemistry. To an assemblage of gas engineers and managers, it is superfluous to say that this knowledge of chemistry is indispensable to their taking a leading position in their profession; but even to outsiders who are almost entirely ignorant of the subject, and who are apt to think that it concerns only those who have to do with the cure or amelioration of disease, or those whose business it is to extract the lovely color from the crude and unsightly substances which exist in nature—even to outsiders.

I say, a knowledge of the principles of chemistry would be of the truest use in their various occupations; nay, to all of us, even in many of our amusements. And why should not we all, whatever our profession or employment, dive into the secrets of nature, and by unraveling or endeavoring to unravel them, reap the reward of expanded intellect and the rich blessing that awaits the discovery of truth? We have not, indeed, arrived at a true conception of our responsibilities until we are convinced that it is a part of our duty in life to make ourselves acquainted with the marvelous works of God—to study and investigate, so far as we have time, means, and ability, the laws which control our existence and the existence of all created nature; and by disseminating correct views among our less privileged fellow creatures, win them from degrading pursuits to the cultivation of the loftiest aspirations, and so increase the sum of human happiness.

At the outset I would have it fully understood, as I have already explained, that, under the circumstances, the present lecture is elementary in character. My experiments will be simple and easy to be understood; you will therefore bear with me if I should seem to trifle with the gravity of your years and larger experience. At the same time, well known though the facts may be that I shall try to elucidate, let it be remembered that only about a century ago some of them were mysteries to the wisest philosophers.

The constitution of water was at that time unknown. As yet no adventurous spirit had explored that untraveled territory, or described its hidden wonders. It had been for a period of many thousands of years a constant associate of mankind—whether as the mighty ocean encircling the land, the broad river sweeping onward to the sea, the gentle streamlet bringing gladness in its track, the dewdrop sparkling in the lily's bosom, or the tear on some fair lady's cheek. As all these, and more, it was, as now, the companion of man; and yet its wealth of hidden poetry was unknown and unrevealed.

You will not therefore deem it trifling to witness the experiments which will be performed, though they may already be familiar to you. In truth, there is so much of mystery yet left about them, that, to the thoughtful mind, they will bear to be repeated again and again. Besides, in one lecture I can only, as it were, "touch the hem" of this wonderful garment of nature.

Water, as you well know, at the ordinary temperature and pressure of the atmosphere, exists as a colorless liquid; having no taste, and being devoid of odor. When its temperature is reduced to 32° Fahr., it assumes the solid state, as ice. If its temperature be raised to 212° Fahr., by the application or heat, water begins to boil, and it is vaporized into steam. Water, therefore, exists in three different states or conditions—the solid, the liquid, and the vaporous. By the application of heat we can convert the ice into the liquid state, and by the agency of cold we can also convert the vapor or steam to the original liquid state; and, as we well know, it is by taking advantage of this latter circumstance that we are enabled to obtain economy in motive power by means of the condensing steam engine.

The late Professor Faraday had a favorite experiment by which he illustrated the condensation of steam into water, and its effects, which I will reproduce. [*Experiment.*—The steam produced by means of water raised to boiling point was condensed within a tin tube 9, inches long and 3 inches in diameter, provided with a stop cock at one end, the effect being to cause the tube to collapse.] Incidentally, we are here taught the lesson that on the condensation of the steam within the tube, a partial vacuum was formed; and as the tube was not of sufficient strength to resist the atmospheric pressure of about 15 lb. to the square inch, it collapsed.

When water is converted into steam by the agency of heat, 1 volume is expanded into 1,700 volumes—that is to say, 1 cubic inch of water can produce about 1 cubic foot of steam. It follows, therefore, that the cubic foot of steam is, by the application of cold, condensed to its original space of 1 cubic inch at the ordinary temperature of our atmosphere, or (say) about 60° Fahr. If we apply a still lower temperature to the water (say, down to 40° Fahr.), we shall find that a further contraction in its bulk will take place.

So far as we have gone, water follows the ordinary rule which we apply to other substances. If they are heated, they expand; if cooled down, they contract in bulk. When, however, we reach 40°, or thereabout, on the Fahrenheit scale, water begins to prove an exception to the general rule of expansion and contraction. Instead of continuing to become less in bulk by the application of further cold, it immediately begins to expand, until, when it reaches a temperature of 32° Fahr. and freezes, the frozen mass is found to occupy more space than the liquid from which it was formed. The force of this expansion is so great as to be irresistible. This can be shown to some extent in the next experiment. [*Experiment.*—An iron bottle was burst by the expansive power of a few drops of water in freezing.]

There is scarcely anything more remarkable than this beneficent provision of nature. Were the water to follow the ordinary law of contraction, by the time it was turned into ice it would be so reduced in size as to be much heavier, bulk for bulk, than water in the liquid state. The consequence of this, if it were possible to occur, would be simply disastrous. Layer after layer of the frozen ice (say of a river or lake, or of the sea) would sink to the bottom, and, in the course of only a brief winter, the myriad forms of life existing in our waters would be extinguished; and all the heat of a long summer would be insufficient to restore the immense body of ice to the liquid form.

Water is never found in nature in a pure state. Many earthy and metallic substances are found dissolved in it, giving it its various objectionable or medicinal qualities, as the case may be. Of these latter are the waters found in the neighborhood of Harrogate and elsewhere. The character of hardness or softness in water also, as you well know, is due to the matter it holds in solution. Even water as it descends in rain from the clouds of heaven—nature's grand distillery—is not perfectly pure. In its downward passage to the earth, it becomes impregnated, more or less, with certain gases existing in the atmosphere. Water in a state of purity can only be obtained by distillation by artificial means; and so obtained it is found to consist of the two simple gases oxygen and hydrogen, and these are combined in the proportion, by weight, of one part of hydrogen to eight parts of oxygen—that is to say, 1 gr., or 1 oz., or 1 lb. of hydrogen chemically joined to 8 grs., or 8 oz., or 8 lb. of oxygen produce in a state of purity 9 grs., or 9 oz., or 9 lb., as the case may be, of the substance which we call water.

It is curious and wonderful, when we come to think of it—and we are here for the purpose of thinking of it to day—that the two gases, oxygen and hydrogen, of which water is composed, in their separate and uncombined state, are quite impalpable to the senses. In their effects they certainly speak a most wonderful language. Now, it always strikes me as something very remarkable indeed that two gases, impalpable to either sight or feeling, should, when chemically combined, go to form that beautiful liquid which links continent to continent, carries our ships upon its bosom to distant lands, turns our water-wheels and drives our steam-engines, refreshes us when we are thirsty, and, in the bath, imparts vigor to our frame. It would be easy also to dilate on the poetical side of water, as it sheds fertility over our otherwise barren fields in the shape of rain and dew—that beautiful dew of which Milton, speaking of Morning in Paradise, makes one of his loveliest pictures:

"Now Morn, her rosy steps in the eastern clime,
Advancing sow'd the earth with orient-pearl."

But I forbear.

It is remarkable, in connection with this branch of our subject, that the elements of which water is composed bear a marked and striking contrast, in their properties and effects, to the effects and properties displayed by the same elements when in a state of chemical combination. Instead of extinguishing flame, as water does, the oxygen gas of which eight-ninths by weight of every drop of water is composed is an extraordinary supporter of combustion. Burning bodies of every description, when immersed in an atmosphere of oxygen gas, burn with greatly increased rapidity and with intense and dazzling brilliancy. Hydrogen gas, of which the remaining one-ninth part of all water is composed, is one of the most combustible substances in nature; and if, when hydrogen gas is being consumed, a stream of oxygen gas is made to flow into its flame, the most intense heat ever yet attained can be produced. Indeed, so extreme is the heat which is developed by this means, that no instrument has yet been invented to measure its intensity.

Let us now speak separately of the two constituent gases of which water is composed. We will turn our attention first to oxygen. This is by far the most widely distributed substance in nature. It constitutes, as I have said, eight-ninths of all the water on the surface of the globe and floating in the atmosphere. One-fifth part of the air we breathe is composed of this gas. Most animal and vegetable substances contain it; and it is computed that one-third of the total weight of the crust of the earth is made up of oxygen. Animal life could not exist without it. It is that which, diluted with nitrogen, we take into our lungs, and which oxidizes, or burns up, the carbon suspended in our blood, thus supporting the heat of our bodies. This gas was discovered in the year 1774 by Dr. Priestley, and was named by him "dephlogisticated air." Lavoisier afterward gave it the name of "oxygen," from its property of forming acids. It is slightly heavier than atmospheric air; its specific gravity being 1·1056 as compared with air as 1·000. Oxygen gas can be obtained from many of the substances which contain it—from water, among others—by decomposition; but the process is expensive when attempted on a large scale. The red oxide of mercury is the substance from which it was first attracted, by heating which in a small glass tube or flask oxygen is readily obtained. When it is desired to have it pure, chlorate of potash is used; and it is from this substance, mixed with a little binoxide of manganese, that I will produce it on the present occasion. [*Experiment.*—The production of oxygen.]

Hydrogen gas is the lightest known substance that can be weighed. It is nearly 15 times lighter than ordinary atmospheric air; its specific gravity being 0·0691 as compared with air as 1·000. Fifty cubic inches, or a measure of about 3 gills, of air weigh 14½ grains. Fifty cubic inches of water weigh, in round numbers, 14,000 grains; 50 cubic inches of mercury weigh 200.000 grains; while 50 cubic inches of hydrogen weigh but a single grain—so light is this gas. Hydrogen is an essential constituent of animal and vegetable substances. Wherever we find animal or vegetable life, there we have hydrogen in a state of combination. The late Mr. Pepper, in one of his lectures at the Polytechnic Institution in London, said that it had been calculated that if a man weighing 10 stones were squeezed flat under a hydraulic press, 7½ stones of water would be produced, and 2½ stones of dry residue would remain; and he facetiously remarked that a man is, therefore, chemically speaking, 35 lb. of carbon and nitrogen diffused through 5½ pailfuls of water. This gas, as, of course, you know, can be produced in many ways. The readiest way of obtaining it for our present purpose is by the action of pieces of zinc or iron on water, assisted by sulphuric acid. [*Experiment.*—Hydrogen gas was obtained by the decomposition of water.] Though highly combustible, it will not support combustion, as you will see when I plunge this ignited taper into a jar of the gas. The gas itself is ignited on contact with the flame in the presence of the oxygen of the air, while the taper itself is extinguished.

The lecturer than proceeded to give a number of interesting experiments, illustrative of the nature and properties of the two gases; and concluded as follows:

We have thus got to the end of our task; and if we rightly apply the moral it conveys, we shall have learnt that it is not necessary to travel to Japan in search of wonders. They lie at each of our doors; they rise around us on every side. The thoughtful mind can always appreciate the sentiment of our immortal bard when he speaks of

"Tongues in trees, books in the running brooks,
Sermons in stones, and good in everything."

The commonest objects under the eye of patient investigation and research assume such shapes of beauty as imagination dreams not of. From "the daisy's shadow on the stone," if we view it in the light of a wise and genial philosophy, we may gather lore not less ennobling in its influence than the lessons taught us by the phenomena of the gravitation of worlds. To understand the rounding of a bubble involves the application of the deepest principles of mathematics. The willfully ignorant man enjoys but a moiety of life:

"A primrose by a river's brim,
A yellow primrose is to him,
And it is nothing more."

Studying nature, we find the true philosopher's stone, we dive into the depths of wisdom. Nay, we grasp the very essence and source of all wisdom; for, in the quaint and beautiful language of Cowley—one of England's sweetest poets of a bygone age—

"If we would open and intend our eye,
We all, like Moses, might espy,
Even in a bush, the radiant Deity."

* A lecture, with experiments, delivered before the Manchester District Institution of Gas Engineers, Saturday, Nov. 27, 1886.

CRYSTALS IN WHISKY.

To the Editor of the Chemical News:

A closely felted mass of fine silky needles was brought to me some time since as having been discovered in a bottle of whisky. Analysis proved them to be Epsom salts, but in a form which was new to me.

I find that such a mass may be produced by mixing a solution of the salt with a proper proportion of alcohol, showing that the salt had been added to the whisky in aqueous solution.

A very pretty experiment on crystallization may be made by adding methylated alcohol to a moderately strong solution of magnesium sulphate till a slight permanent turbidity appears, and immersing the vessel in cold water. Stellate tufts of crystals soon separate, having about the same specific gravity as the liquid, in which they remain suspended, and rapidly grow till the whole liquid has become a mass of matted needles. If the turbid solution, before crystallization commences, is poured into a watch glass and examined under the microscope through an inch objective, the effect is remarkably beautiful.

I have determined the water in the fine, light silky needles, and find them to be $MgSO_4.7H_2O$.

PRACTICAL CHEMIST.

NEW SPECTROSCOPE.

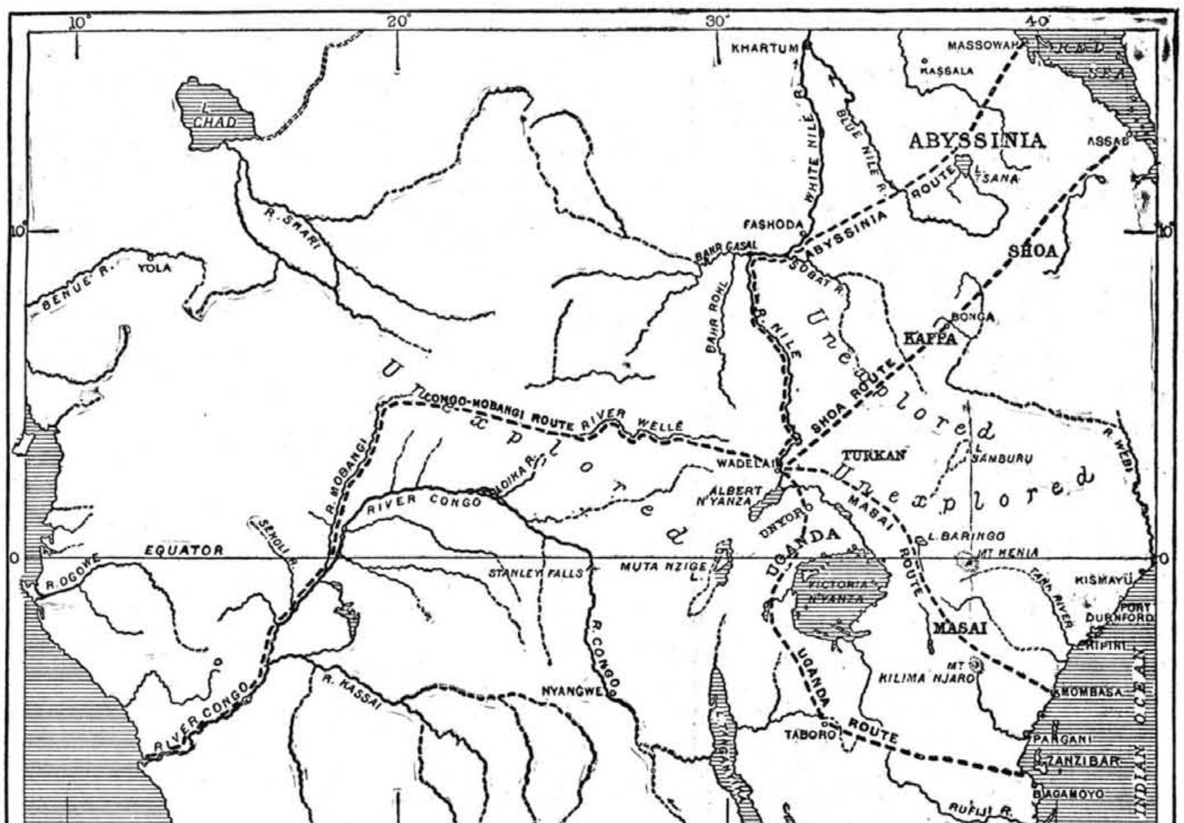
A NEW form of spectroscope has been devised by G. Krüss, which is well adapted for the work of the chemical laboratory, both qualitative and quantitative.* Its fundamental form is that of the Bunsen and Kirchhoff instrument; but a variety of modifications and additions have been made, to render it available as a universal spectroscope. An upright pillar supports a table on which rests the prism, and which carries the observing, collimating, and scale telescopes. The collimating telescope has no draw tube. It is provided with two slit plates, one of which carries the ordinary single slit for qualitative purposes, the other the double slit of Vierordt for quantitative work. These slits are strictly parallel to the axis of the prism and are opened and closed symmetrically on the two sides of this axis, by micrometer screws, whereby the width of the slit may be determined. The knife edges of these slits are made of platinum, and are so accurately worked that no horizontal lines appear in the spectrum even when the slit is open by only one or two divisions of the micrometer head (0·002 to 0·004 mm.). Two prisms are provided; one a single flint prism of 60° of a dispersion of 4° 18′ between A and H_2, the other a so-called Rutherfurd prism, having a dispersion of 8° 2′ between the same limits. By an automatic device the prism is kept at the angle of minimum deviation for the part of the spectrum under observation. The scale is fixed in its telescope so that it is in the principal focus of the object glass and so that its 100th division comes midway between the D lines. The observing telescope magnifies about seven diameters. By means of a micrometer screw with a divided head, it is moved in a horizontal plane about the vertical axis of the instrument, the amount of motion being measured by an index moving over a graduated arc upon the end of the fixed arm carrying the telescope. The value of the divisions on the micrometer head in terms of the graduations upon the arc, and the value of these in terms of the scale divisions, are easily determined. Moreover, this telescope has a micrometer eyepiece; so that spectrum

*Constructed by A. Krüss of Hamburg.

measurements may be made between two colors whose wave lengths differ by only 0·000,000,000,015 millimeter. The slide which carries the cross wires of this micrometer carries also the Vierordt slit, whose width is adjustable by the same screw that moves these cross wires. The author thinks that the results obtained by this instrument when used as a spectrophotometer are fully equal to those obtainable with polarizing instruments.—*Ber. Berl. Chem. Ges.; Amer. Journ.*

THE STANLEY EXPEDITION FOR THE RELIEF OF EMIN PASHA.

EVERYBODY seems agreed that Dr. Schnitzler, better known as Emin Bey, but recently created Emin Pasha, ought to be relieved; for he does not want to be rescued. For ten years he has been in the Egyptian service, most of that time as Governor of the Equatorial Province, which, in spite of the Mahdi and his hordes, the death of Gordon, and the collapse of the Egyptian Soudan, he continues to administer with success, and to the comfort and satisfaction of all but slavers. What Emin Pasha has done for science in the little leisure left him by his arduous duties, the readers of *Petermann's Mittheilungen* and the *Proceedings* of the Zoological Society know. He is a good type of the kind of explorer that is wanted now that mere pioneering work has been pretty well exhausted; a man well qualified by his scientific training to remain in a particular region for years if necessary, and study it in all its aspects. We have had such men in the past. Some of the greatest names in science could be mentioned as examples. We do not insist in these pages on the great services which Emin Pasha has rendered to civilization during his residence in the Soudan, first as the noble-minded Gordon's lieutenant, and latterly as one who, in the spirit of Gordon, resolved to stick to what he conceived to be the post of duty at all hazards. Our own government has virtually admitted its responsibility for the present position of Emin Pasha, but has weakly attempted to shirk its duty by devolving the business of relief on private individuals. Should disaster happen, however, to Emin Pasha or to any expedition sent to his relief, we may be sure that public opinion will not blame any private individuals. Government, however, has gone so far as to promise every assistance short of contributing money.



It is unfortunate that already there has been a delay of several months since first we knew of Emin Pasha's critical position, and since first the Intelligence Department began to make inquiries as to the best route for a relief expedition. Even now, when an expedition has been decided upon, there seems little prospect of a speedy start. Surely, if those to whose hands the 10,000*l.* contributed by the Egyptian Government have been intrusted had the interests of Emin Pasha solely at heart, a competent leader would have by this time been within hail of Zanzibar. A better leader, under the conditions, than Mr. Stanley could probably not be found; but surely there has been unnecessary delay in deciding to send him. The idea of more than one expedition is entertained by many; and, as our map will show, the most direct and safest route is by Masai Land, about which we now know so much through the journeys of Mr. Thomson and the late Dr. Fischer. Dr. Junker telegraphs from Zanzibar that a relief expedition is urgently necessary, and that as fighting is inevitable, Mr. Stanley ought to be sent. By the Masai Land route, as shown on the map, avoiding Unyoro and Uganda, and skirting Lake Baringo and Turkan, we doubt if any fighting would be necessary. We have reason to believe that the King of the Belgians will not object to Mr Stanley undertaking an expedition, and that Mr. Stanley will choose the East Coast route; but whether through Masai Land, or by the west side of Lake Victoria Nyanza, and so on to Albert Nyanza, remains to be seen. What geographers would like most of all would be an expedition by the Congo and Mobangi rivers. In this way, not only would fresh discoveries be combined with the relief of Emin Pasha, but, by sending out two independent expeditions, the latter would almost certainly be accomplished.

Our map is intended to show the various routes that have been proposed. There is, first, the Masai Land route described above, the total length of which, to Wadelai, where Emin Pasha is stationed, is only 820 miles, and thus is the shortest of all the routes. Mr. Thomson has traversed this route to within 300 miles of Wadelai, and these 300 miles are as yet unexplored. The most formidable difficulty here would be the bellicose Masai, but these, Mr. Thomson has shown, can, after all, be managed. By keeping well to the east, there would be little danger of the cruel young potentate of Uganda hearing of the expedition, and so the lives of missionaries and native Christians would not be endangered. Next is the Uganda route, which is understood to be favored by Mr. Stanley, and which is 1,050 miles in length, and all previously traversed. Most tempting of all the routes, if exploration were the only object in view, would be the Congo-Mobangi route. The Mobangi is one of the greatest of the tributaries of the Congo, and has been navigated for about 250 miles by Mr. Grenfell. On the other hand, Dr. Junker has been down the Welle-Makua to 22° E., within about 200 miles of Grenfell's farthest. Now, if we were certain that the two rivers were one, in spite of the rapids on the Makua, this is a route we should be strongly inclined to support. But no risks should be run, and no experiments tried in a matter so critical. By all means send an expedition by this route, and solve one of the few remaining hydrographical problems in African geography. We must say, however, that those best acquainted with the levels in this region still maintain that the Welle does not come down to the Congo at all, or, if it does, not by the Mobangi. This route is 1,900 miles in length. The Abyssinian route, in our opinion, does not deserve any consideration so far as the relief of Emin Pasha is concerned, though there is some exploring work to be done in this direction. The total length from Massowah to Wadelai is 1,400 miles—Massowah to Fashoda 700 miles, of which at least one-half is unexplored, and from Fashoda to Wadelai by the Nile about 700 miles. In the same category as the Abyssinian route is the Shoa route—1,050 miles, from Assab to Wadelai, 300 miles being unexplored. There is also a rumor that the King of the Belgians intends to send Mr. Stanley up the Nile, but this is a rumor that can scarcely be credited.

Altogether, it seems evident that, if Emin Pasha is to be reached with the least possible delay and with substantial relief, the Masai Land route is the one to take. There is one important consideration that must be mentioned. With a caravan consisting solely of men they could take only what they themselves would consume, and it is difficult to see how a supply of ammunition and other necessaries could be conveyed. Now, by Masai Land it is all but certain that camels could be utilized, and these animals could find their own provender. With thirty or forty camels and sixty donkeys, very substantial relief could be taken to Emin Pasha. Indeed, the whole route, at least to the borders of Emin Pasha's province, is so comparatively level that Cape wagons could be taken, though in such an expedition it would not be advisable to try the experiment. The important thing is that there should be no further delay in starting at least one expedition, whoever the leader is to be.—*Nature.*

SOURCE OF THE MISSISSIPPI RIVER.

MESSRS. IVISON, BLAKEMAN, TAYLOR & Co., school book publishers of this city, lately employed Mr. Hopewell Clarke, an experienced engineer, explorer, and surveyor, to visit the Itasca Lake region, Minnesota, the source of the Mississippi, and report upon the same. This was done last fall, and his interesting report has lately been made public in *Science*, and is as follows:

Gentlemen: I herewith submit my report of the trip to the head waters of the Mississippi, undertaken in your interest in the month of October last. Among the causes of delay in forwarding this paper were my sickness immediately after my return from Itasca; the great quantity of facts contained in my field notes, which I desired to condense as much as possible; some mishaps which always enter more or less into such undertakings; and a great pressure of regular work in the line of my daily duties consequent upon my absence and illness.

The route which I selected for my trip was by N. P. R.R. to Morley; thence by stage to Park Rapids; and the balance of the way by wagon conveyance to the southeastern arm of Lake Itasca.

The company consisted of three persons—one a trained land explorer, a second to serve as driver and general assistant, and myself as the leader of the party. I had originally planned taking others with me; but I am satisfied that, with the amount of work we had to do, it would have taken twice as long with help not accustomed to the woods, and I am afraid we would have killed a green man, traveling and working as we did. So, though at first I was disappointed at the loss of one or two whom I had expected to have with me, I am satisfied that the party would not have been better made up than as it was.

In the matter of equipment for measurements and for observations, we had the following: Pocket sextant, aneroid barometer, drainage level, Locke's hand level, thermometers, surveyor's compass and chain, leveling rod, pocket compasses.

We arrived at the southeastern arm of Lake Itasca at noon on the 13th of October, 1886, and after taking dinner embarked at once for the southwestern arm, which we proposed to make the center of our operations. We approached this portion of the lake with considerable curiosity, and as we drew near our journey's end we stopped a few moments to admire the scene before us.

Directly in front, a small, bare, mound like elevation or knoll rises from the edge of Lake Itasca near the center of an open space of about ten acres between it and Elk Lake. The inlet of the principal stream flowing into Lake Itasca is seen on the right, and the outlet of Elk Lake comes in at the left of the knoll. We are looking southward; and to the right the shore of the lake is lined with pine, while the left shore and all the upper (southern) end is bordered with tamarack, except the open space in front, which is bare except for a few bushes and some rice grass. The Height of Land is in plain view two miles and a half to the south; and between these hills and the knoll there is a peculiar light familiar to woodsmen, which indicates an opening or water beyond. It is a striking scene. There is nothing like it anywhere else on the shores of Itasca. And while looking at it, our thoughts went back to the time Nicollet was there; and we could not but reflect that Francis Brunet, or Kegwedzissag, his Indian guide, would call his attention to it, and no doubt they landed and explored Elk Lake before they went in any other direction. The moment we saw this open country between the lakes, we were satisfied that no man accustomed to the wilderness, certainly no explorer of Nicollet's experience, no guide as trained as his Indian was, could go there on the business on which they were engaged and miss seeing Elk Lake, unless he were blind.

As night was rapidly approaching, we landed, and selected a place for camp in the open space between the two lakes; and while one of my assistants was busy pitching camp, and the other prepared supper, I employed the time till dark unpacking and adjusting my instruments, and planning the work for the following days. In all, we spent five days exploring and surveying the basin of Itasca. Wherever there was especial care and detail required, we gave our best and most diligent efforts to the work, and I believe there is no material point regarding the sources of the feeders of Lake Itasca which is not covered by this report.

In presenting the results of our work during our stay at Lake Itasca, I shall not attempt to report the operations of each day, but rather state the general conclusions and facts obtained from the thorough exploration of every part of the basin of the lake.

In following the heights of land which form the southern boundary of the basin of Lake Itasca, the general trend of the crest is from northwest to southeast; but it takes a course almost directly east after striking the northeast quarter of section 33, as shown on the map. It also sends out spurs, one striking northward from section 35, and another, also northward, from section 31, in the eastern of the two townships shown. The spur striking north from section 35 divides the Itasca basin into two parts, the western furnishing the feeders of the southwestern arm of the lake, and the eastern furnishing the single feeder of the southeastern arm. It is not an unbroken ridge of hills, nor are these spurs perfectly defined; but they are, rather, groups and successions of hills with the general direction given above. There is also a marked difference in the character of the springs of these two parts of the Itasca basin. The western bowl furnishes the feeders that are steady and constant during the year, and the largest feeder lies at the extreme western edge of this bowl. The eastern bowl furnishes a single feeder, which is probably nearly dry part of the year. It is thus evident that the western streams are fed mainly by living springs, artesian in their character, being supplied by water which comes through the strata of the earth from ponds to the west and south, some of them, perhaps, miles away. The single stream of the southeastern arm simply drains the bowl in which it flows, and while in the rainy season it may be quite a torrent, part of the year it is comparatively dry. I regard this as important in determining the ultimate sources of the waters of the upper Mississippi, it being evident that all the water which flows into the river from Lake Itasca is either surface drainage or comes from reservoirs and ponds which lie between the head waters of the Mississippi and the head waters of the Red River. To the north the elevation of the crest of the Height of Land varies from 150 to 250 feet above the level of Lake Itasca. In the western half of section 21 the height is about 200 feet; in sections 28 and 33 it rises to 225 and 250 feet; in section 34 it is 250 feet in the west part of the section, and 200 feet in the eastern; 175 feet in section 26. In section 23 the height is 100 feet, sloping gradually to 75 feet in section 14. The knoll in the western part of section 22 is 150 feet above the level of the lake. To the north, along the border of Elk Lake, the ridge is 90 feet high. Just south of the lake marked D the elevation is 120 feet, and just north of the lake marked E it is 100 feet. These data are sufficient to show the irregular and broken character of the land in this region.

One of the most interesting parts of our work was the survey and examination of the narrow strip of land between Lake Itasca and Elk Lake. We found it to be 350 feet wide at the narrowest point between the lakes, and 520 feet measuring along the crooked trail at the base of the knoll. The lakes run nearly parallel for 1,020

feet, and the strip of land contains in all about 10 acres.

The portion shown as hilly on the plat is a small mound-like elevation, nearly devoid of all timber, which rises with a gradual slope south from Lake Itasca to a height of 33 feet, and descends abruptly to the shore of Elk Lake. Its direction between the lakes is nearly east and west. Its height above Lake Itasca at its western base is 10 feet, where it is less than 100 feet wide; and thus, if each lake were a little higher in elevation, they would at this point be within 100 feet of each other. The highest point on the trail between the two lakes is 12 feet. The ridge extends to the outlet of Elk Lake, from which point Lake Itasca is in full view. Another hill rises to the east of the outlet, leaving an opening 12 feet wide, through which the stream flows with a rapid current, in a channel 6 feet wide and 6 inches deep. The balance of the land between the two lakes on either side of the creek is a tamarack swamp. The outlet of Elk Lake flows nearly northeast 80 feet, and enters the tamarack swamp, where its general direction is north for 600 feet, until it reaches a point within 110 feet of Lake Itasca. It then curves back toward Elk Lake, and finally enters Lake Itasca, its whole course from Elk Lake measuring 1,084 feet. Where it debouches into Lake Itasca, it is 7 feet wide and 8 inches deep. We noted its width at numerous places in its course, and found it to vary from 6 to 12 feet, and its depth from 2 to 8 inches. It gains nothing from along its route, and its increased width and depth are caused by back water from Lake Itasca. It is a very pretty little stream, and has been cleared out by the Indians, who go there annually and place fish traps to catch the fish that run between the two lakes. The difference in elevation between the two lakes is 1 foot and 1 inch. The stream between the two lakes falls 6 inches between Elk Lake and a point where it enters the tamarack swamp, in the first hundred feet of its course; the balance, 7 inches, measures the fall in its course through the tamarack swamp of nearly 1,000 feet.

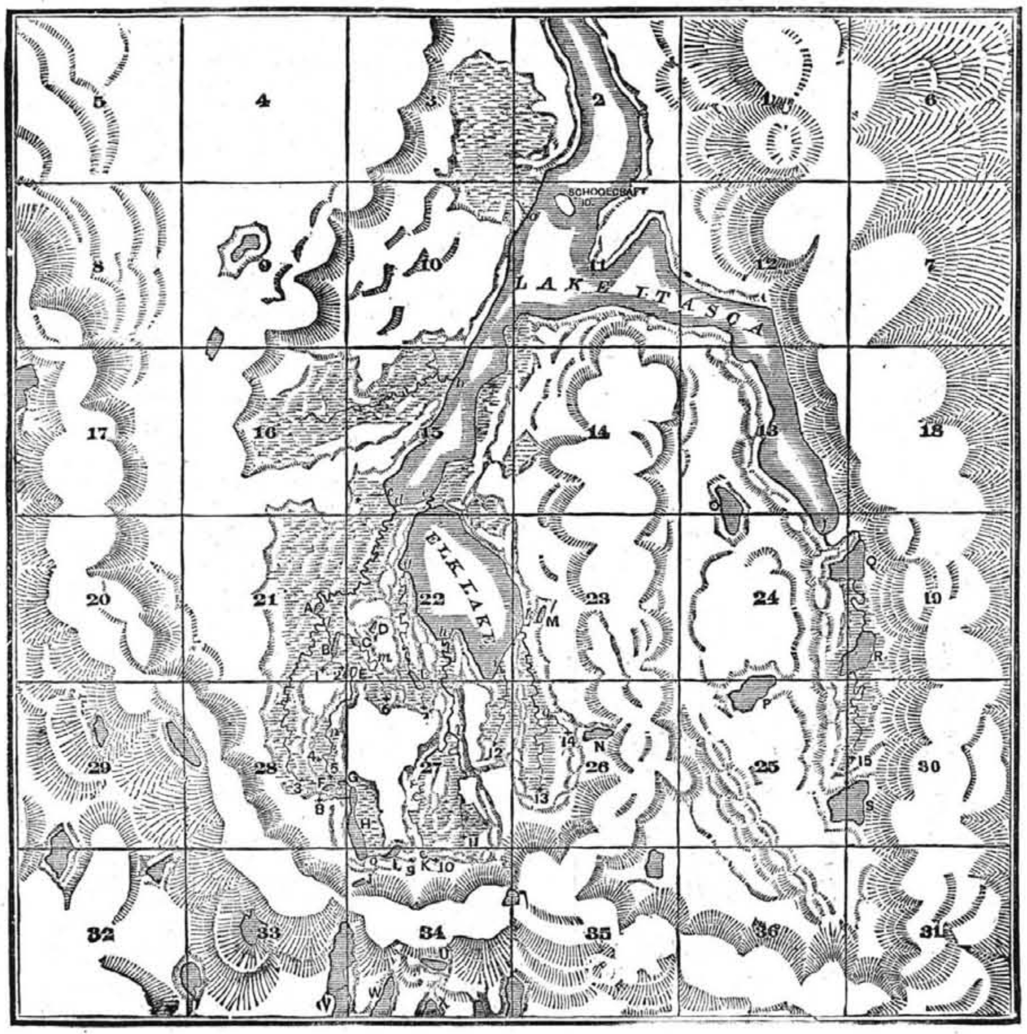
Leaving this interesting part of the lake for a time, I will give some details in regard to the other feeders of the lake. The stream entering the southeast arm, as above remarked, is evidently quite variable in its character. At times, apparently, it is very shallow; but after heavy rains it is quite a torrent, and drains the lakes which form during the wet season, marked Q, R, and S. When the stream is at its best, it is fully 6 feet wide and a foot deep. The stream entering Lake Itasca at *a* is merely a sluggish creek, draining the marsh to the northward in sections 23 and 10. The stream entering at *b* rises in a swamp on section 16, and is joined by a branch in section 15, which rises in section 10. There are numerous springs along its course, and it is 8 feet wide and a foot deep, at its mouth discharging as much water into Lake Itasca as the outlet of Elk Lake does. The inlet at *c* is a small brook, two feet wide and a foot deep, that rises in a swamp less than a quarter of a mile from the lake.

This brings me to the largest feeder of the lake, the one entering at *d*. It is 16 feet wide and 2½ feet deep at the place where it enters into Itasca, and is the stream mentioned by Nicollet, in his report of his explorations in 1836, as "the one remarkable above the others, inasmuch as its course is longer and its waters more abundant; so that, in obedience to the geographical rule that the sources of a river are those that are most distant from its mouth, this creek is truly the infant Mississippi; the others below, its feeders and tributaries." The exploration of this stream was the most complicated and difficult of our undertakings, and it was with considerable difficulty that we were able to identify the three lakes which Nicollet describes; but while on the ground, and after the most careful study of the problem, we came to the conclusion that Nicollet's three lakes were those marked on the map as A, B, and C. At first sight, it would seem, from Nicollet's description, that these could not be the ones he referred to; and I have given much study to the points involved, endeavoring to reconcile his descriptions with some other theory. We followed the stream to the first lake at the edge of the hills and through the swamps; and the course of the brook is two miles in length, and seemed like four. Distances on the ground double up very fast when one follows crooked streams, as you will remember when you compare the length of the stream between Elk Lake and Lake Itasca (1,040 feet) with the actual distance between the two lakes (350 feet). If we add to the actual length of the course of the stream from the lake A to its outlet at *d*, which is in reality 2 miles, the difficulties that Nicollet encountered in wading through the tamarack marsh, we can easily believe that this is the course which he describes as "two or three miles" in length. His report makes the distance between the first and second lakes comparatively short, and that between the second and third lakes still shorter, so that there is no other lake which answers the description for the third or higher lake but the one marked C. This, however, is not the source, at the present time at least, from which Nicollet's stream draws its principal supply of water; and to find that source, after considerable exploration, we were obliged to go to a lake which has its head in the northwestern quarter of section 34. This is the utmost source and fountain head of the water flowing north into Lake Itasca. The lake itself is fed by numerous springs along its borders, and its surface is 92 feet above the level of Lake Itasca. The small inlet from the lake marked I was dry when we visited it, but water runs through it in the wet season. The hills south rise from 20 to 160 feet high, and water has never flowed over them northward. It might be interesting to know how far it flows under them. It is certain that it does, but there is no way to trace its course or distance. All the streams in this part of the basin rise in springs in tamarack swamps, which undoubtedly are fed by water percolating under the hills from lakes and swamps beyond; and no doubt the group of lakes, U, V, W, and X, in the southern part of sections 33, 34, and 35, which spread out to a considerable extent in sections 3, 4, and 5 of the townships next south, are the reservoirs which feed a number of these springs. Beginning with the lake marked H, it spreads northward nearly half a mile. At its northern end the water flows out of this lake in a stream 1½ feet wide and 1 foot deep, and, running west about 200 feet, empties into a small lake about 2 acres in extent, marked G. This lake connects with another of the same size about 20 feet to the west of it.

At the time we were there, both ponds were full of moss and bogs, and apparently almost dried up, the abundant inflow of water running out by underground passages as fast as it came in; but both lakes show that at some seasons of the year they contain 4 feet more of water, caused by the increased flow in the spring time and in the rainy season. At this time the underground passages are not large enough to carry the water off, and so it accumulates and the ponds fill up. Apparently they once had a surface outlet which is now closed by a beaver dam. The water flowing from the two lakes feeds the two springs numbered 3 and 5. Proceeding to the spring marked 5, we find the water bubbling up and flowing away in a rapid, lively stream, in a direction generally northward. It is fed by springs along its course until it reaches the extreme southwestern corner of section 22, where it is 2½ feet wide and 8 inches deep, and discharges into a small pond of about 5 acres in extent. This pond is the most remarkable one in the course of the stream. It has no surface outlet, and, from the formation of the land about it, apparently has never been any larger than it now is; but, with the large volume of water flowing into it, we perceive that it must, of course, have a steady and sufficient outlet underground. This we found to be toward the west, where it bursts forth in an immense spring or pool, marked 2, in the extreme southeastern quarter of section 21. The lowest point on the hill between the pond and the spring is 12 feet above the level of the pond; and the water, dropping underground, bubbles up in the swamp 200 feet away and 33 feet below that level. You will notice that the stream thus passes underground from section 22 into section 21, and is therefore invisible to one following up the course of the section line, a fact which will be referred to again in a latter portion of this report. Proceeding from the spring marked 2, the water flows in a northwesterly direction, and empties into the lake marked B, the second one of Nicollet's chain of lakes. The outlet of this lake is on the west side, a stream 3 feet wide and a foot deep, which is joined at a short distance by another from the south. Following up the stream, which joins the main one on section 21, we find it rises on section 28, at a spring marked 3, evidently fed by an underground passage from the pond F. These streams are re-enforced throughout their course by springs which ooze from the bases of the hills that line the tamarack swamps; so that, when the creek leaves lake A, it flows with a brisk current 12 feet wide and 1 foot deep, which is further re-enforced by numerous springs all the way to Lake Itasca. At the point of its discharge into the lake, it is a broad, well-defined stream, 16 feet wide, and 2½ feet deep at its deepest point. Lake A is ten feet above the level of Lake Itasca.

Recurring to the subject of Nicollet's three lakes, I recall the fact that Nicollet states that, at a small distance from the heights where the head waters originate, they unite to form a small lake, from which the Mississippi issues with a breadth of 1½ feet and a depth of 1 foot. "*At no great distance, however,*" so Nicollet says, "*this rivulet, uniting with other streamlets, supplies a second minor lake.*" So we were obliged to look for the upper of the three lakes at a reasonably short distance from the lake B. If the spring numbered 2 would fill the bill as a lakelet, it would meet all the other requirements of the case perfectly. The only alternative seemed to me to be the lake marked C. At present the outlet of this lake is obstructed by two beaver dams, and no water flows from it except what little may percolate under these obstructions. Its principal feeder, marked *m*, rises in a spring in section 27, and is also nearly dry, but there is a small amount of water flowing through its channel. I leave it to you, or to future explorers, to settle the question as between the spring 2 and the pond C.

There are four small streams flowing into Elk Lake. The first one rises in a spring, the outlet of which flows into a small pond 50 feet in diameter in the northwestern quarter of section 34. It leaves this pond, a brooklet 6 inches wide and 2 inches deep, and flows with a rapid current to the center of section 37, where it is joined by another and larger branch coming from a tamarack swamp in the southeastern quarter of section 27. At the point where it flows into Elk Lake it is 2 feet wide and 6 inches deep. The elevation of the source of this stream at the spring marked 10 is 88 feet above Elk Lake and 89 feet above Lake Itasca. The largest stream flowing into Elk Lake rises in the northwestern quarter of section 26, in a spring marked 13. This is joined, at a short distance from its source, by another branch, which is supplied by a small lake in section 26, marked N. The outlet of this lake is by an underground current, it being closed by a beaver dam; but water has flowed out by a surface outlet at some period, perhaps at the time of Nicollet's visit. Where the main stream enters Elk Lake it is 3 feet wide and a foot deep. This lakelet N, in section 26, and its outlet, were to me among the most interesting things found in this region. To my mind they prove conclusively that Nicollet not only explored Elk Lake, but also its feeders. Referring to the copy of his larger map, which you sent me, I find just such a lake laid down at the head of a small stream flowing into Elk Lake from the southeast. This is the most important feeder of Elk Lake, just as Nicollet indicates it to be. The other two streams flowing into Elk Lake are quite small, and originate as shown on the map. We found a dry channel between the lake M and Elk Lake. No water was flowing from this lake, although it probably does discharge some water in the spring and when the water is high. In measuring the amount of water supplied by the various tributaries of Lake Itasca, we found the three streams discharging at *b*, *d*, and *e* furnishing practically all the perennial water supply of the southwestern arm of the lake; and of this I would estimate that Nicollet's creek furnishes ¾, and the other two each about ⅛.



THE ITASCA LAKE REGION, AS SURVEYED BY HOPEWELL CLARKE, CHIEF OF THE I., B., T. & CO. EXPEDITION, OCTOBER, 1886.

THE WORK OF THE GOVERNMENT SURVEY.

It was an important part of our task to observe the posts and blazings left by the government surveyors, and we carefully ran the main lines with the view of detecting any errors that they might have made. In this part of their work, and also in meandering of the two lakes, our examination proved their work to be correct in every material point. A singular mistake, however, on the government plat, is easily accounted for. The course of the stream from lake H until it crosses the south line of section 22 is substantially correct as laid down on the government map; but, when they ran the line between sections 21 and 22, this stream was not crossed again, and they naturally supposed it ran due north through the western edge of section 22, and that the stream flowing out of section 21 into 22 was a branch running into the main stream; whereas this is the main stream, which, passing westward under their feet into section 21 by an outlet which they did not see because it was undergroud, takes its course through the eastern part of section 21, and crosses into section 21 again at the point where the government surveyors had indicated a feeder to the main stream. The two small lakes C and D on section 22, and the two, A and B, on section 21, would not be crossed by a section line; hence they were not indicated by the surveyors. At a point where the section line between sections 21 and 28 crosses the branch of the spring flowing out of section 28, the course of the stream is through a boggy swamp, and it would hardly be noticed as the stream without going a considerable distance north or south

of the section line; hence it is not shown on the government maps, but in place of it is shown a marsh. In all other respects the work of the government surveyors is well done. Their business was to establish section corners, blaze lines between the sections, note all lakes intercepted by the section lines, meander lakes of more than 40 acres in extent, note streams crossed and indicate their apparent direction, etc. Trifling errors will creep into their work; but, when we take into consideration the difficulties they have to contend with, it is not to be wondered at.

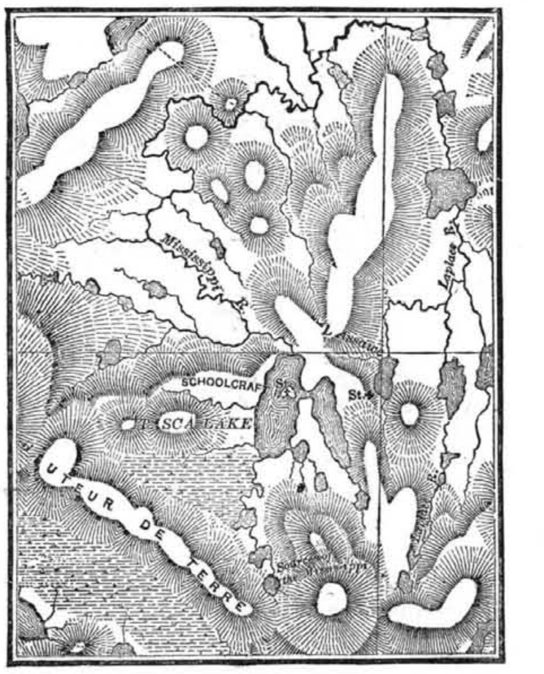
Another part of the duty of the government surveyors is to indicate the names of streams and bodies of water, and, in case no modern name has been given to them, to retain the Indian name or its English translation. Following this rule, the name of Lake Itasca, being generally accepted, was retained.

With regard to the name of Elk Lake, Mr. Hall, who was the chief of the surveying party of 1875, recently told me that when he was surveying township 143 N., range 36, he met an Indian trapper at Lake Itasca, who had made this region his trapping ground for years. He asked him the Indian name of Lake Itasca and Elk Lake, and the Indian gave him the name of "Omushkos," or "Elk," for the lake in section 22, and another name, which Mr. Hall has forgotten, for Itasca. As Lake Itasca had a name already, he simply recommended to the surveyor-general the name "Elk Lake" for the other body. But the Indians are by no means agreed upon the designation for these lakes. They certainly gave Mr. Schoolcraft the name "Omushkos" for Lake Itasca, and to Mr. Gilfillan, "Gabukegumag" for Elk Lake. The latter term signifies "water that juts off to one side" of another lake; that is, branches or projects out from it like the fingers from the hand.

Other travelers have found still other designations applied by the Indians to these lakes. Surveyor-general Baker, in fixing the name finally to be applied to the lake, considered that, whether "Omushkos" was the original designation of Elk Lake or of Lake Itasca, it was worth while, in the absence of any other fitting name, to retain that designation for the lake which was not yet named. I am certainly of the opinion that the name should stand.

NICOLLET'S MAP, ETC.

It is fitting to say a few words in regard to Nicollet's map and possible changes, past and future, in the Itasca region.



ITASCA LAKE AND VICINITY.

Facsimile Copy of Nicollet's Map deposited in the Office of Engineers, U. S. A., 1836–37.

Careful investigation along the shores of Lake Itasca shows plainly that some time in the past it has been nine inches higher than it is at the present. This rise would be sufficient to overflow all that portion of the land shown as tamarack on the plat of land between Elk Lake and Lake Itasca, and back the water up to the narrow strip of high land on the outskirt of Elk Lake, thus bringing the lakes within eighty feet of each other. Whether this was the case when Nicollet was there, I will not attempt to answer. His map would seem to indicate that it was, by the fact that he shows the two lakes so closely connected, Elk Lake so much larger than it is, and the two arms of Lake Itasca so much out of proportion with their present outline. But this can readily be accounted for on other grounds. The shores of the southeastern arm are abrupt and bluffy, while the shores of the southwestern arm are low and swampy. This makes the southwestern arm look wider than it is, and the southeastern arm narrower than it is. The shores of Elk Lake are also abrupt and lined with bluffs, and to one looking south across it, it does not look half as large as it does to one standing on the hills south of it and looking north. Distances across water are always deceiving. The view from different points of Lake Itasca might be sketched by a dozen different parties, and no two sketches would look alike. My impression is that Nicollet sketched the southeastern arm of Lake Itasca from some point on its western shore and Elk Lake, and the southwestern arm of Itasca from the knoll between the lakes; and when we take into consideration how insignificant is the distance between the two lakes, compared to the total length of both, it can readily be understood why he has shown them as though Elk Lake were a bay instead of a separate body of water. From the nature of the springs which feed the principal stream emptying into Lake Itasca, it is evident that very few changes have taken place in that part of the basin since Nicollet was there, and very few will take place in the next fifty years. The springs that feed it are supplied by underground currents and reservoirs from the lakes and the Height of Land, and, as they cannot be drained, no amount of settlement or clearing will change them. They are among the permanent features of the country. Lake Itasca of to-day is the same in its main features that it was when Nicollet was there, and for a hundred years before. Its level may have been a little higher, the surface of Elk Lake may have been a little lower, Itasca may have spread out over some acres more of marsh, Elk Lake may have been somewhat smaller in its surface extent; thus they may have come more nearly together, and nearer to being one continuous body of water. But the main features of this remarkable basin will remain the same for generations to come, and Lake Itasca will be then, as it is now, the first important reservoir of all the springs that feed the head waters of the Mississippi River.

Our meteorological observations were taken with an effort at system; but it is sufficient, perhaps, to say that the atmospheric temperature varied from 20 to 70 degrees during the five days that we were at Lake Itasca, and that we had the extremes of clear weather and invigorating atmosphere and of desolate, soaking rain. The severest storm overtook us when we were within five miles of Lake Itasca, and we passed a most unenviable night in an improvised camp. We took the temperature of the water in Elk Lake and Lake Itasca when the temperature of the atmosphere was 51° F., the temperature of the water being 46°. The temperature of the water in the second lake on Nicollet's Creek was 42°.

Among the mishaps which invariably attend such explorations were two that are worthy of note—the loss of my revolver and the leaving behind, unaccountably, of my copy of the Nautical Almanac. I had intended taking the latitude of the northern end of Elk Lake, and also establishing a meridian and noting the exact variation between the true and magnetic meridian; but when I got on the ground, of course this was impossible without my tables. Still worse luck followed the observations with the barometer. I had arranged with Sergeant Lyon, of the U. S. signal service at St. Paul, to take simultaneous readings of the barometer. The instruments were adjusted together when we set out for Itasca, but when we got back to St. Paul mine read 200 feet higher than his. As there was no way of determining when this change occurred, all that work was of no account. As our first observations were taken at 6 A.M., and the last at 10 P.M., they involved considerable sacrifice of rest, which I am sorry yielded so little result.

The figures given in the first part of this report for the elevation of the crest of the Height of Land are, therefore, necessarily only approximate, as the variation in my aneroid barometer destroyed the value of my observations, on which I largely depended for this part of my work. The heights noted for elevations between the lakes and for the springs and streams were obtained by the drainage level, and these may be relied upon as practically correct.

I considered it very fortunate that our trip was made just at the end of a long spell of dry weather, such as has hardly been known in Minnesota for years. This enabled us to judge of the sources of water supply that are perennial in their flow, as distinguished from the surface drainage in the spring and in the rainy seasons. The rain of the night before we reached the lake was not enough materially to disturb these conditions.

The last thing we did before leaving our camp between the lakes was to erect on the top of the little knoll, in plain view from both lakes, and from Schoolcraft Island on the north, a monument to the memory of Nicollet, on which was inscribed the following: "To the memory of J. N. Nicollet, who discovered the source of the Mississippi River, August 29, 1836." This was done after fully exploring the country for miles around; and our little party of three was fully satisfied that fifty years ago Nicollet had discovered all there was to discover of the sources of the Mississippi; and that if he had lived to complete his report on "the sources of the Mississippi and the North Red rivers," and to give to the world his unpublished map, there would have been no chance for any Glazier to confuse the geographical world, or to play tricks upon the learned societies of two continents. We found our work difficult enough, though we were only a day's ride from civilization and the railroad, and though the whole township had been marked off and blazed at every turn by the government surveyors. What, then, must have been the heroism of the invalid devotee of science, who buried himself for months in the unbroken wilderness, and gave his life to the exploration of the frontiers of his adopted country?

I have done my work without any prejudice or bias, and determined only upon finding out and stating the truth in regard to the sources of the great river of our continent, whose exploration has commanded the service of so many worthy men in every period of our history.

As a preparation for the survey, I had read everything I was able to gather on the subject, and I took with me tracings of all the maps of the region, either published or to be found in the government departments. The work has been done by actual survey, and in such a way that I believe it will bear investigation by any surveyor who wishes to check it.

HOPEWELL CLARKE.

Minneapolis, Minn., Dec. 7, 1886.

HOW TO MAKE COLORLESS SPECIMENS OF PLANTS TO BE PRESERVED IN ALCOHOL.

MANY plants assume a brown color when placed in alcohol for preservation. The coloring matter is partly soluble in the alcohol, partly not, and is the product of the oxidation of colorless substances of the cell sap. This unpleasant change may be prevented in a very easy manner by using acid alcohol. To 100 parts of common strong alcohol add 2 parts of the ordinary concentrated solution of hydrochloric acid of the shops. Parts of plants brought into this liquid while yet living will become absolutely colorless, or nearly so, after the alcohol has been sufficiently often renewed. Such parts as already had a brown color before, being brought into the mixture, usually retain this character.

By this method colorless specimens may be made of such plants as *Orobanche* and *Monotropa*, which when treated in the ordinary manner always become of a dark brown tint. There are only some species with coriaceous leaves that cannot be treated with success with the acid alcohol; colorless specimens of these must be made by plunging them into boiling alcohol. The acidity of the mixture here recommended is nearly 0·2 Aeq. A greater quantity of acid is neither noxious nor does it improve the effect. A lesser quantity was in many cases found not to be sufficiently efficacious. The specimens may remain for months, perhaps forever, in the acid alcohol without any injury.

If the alcohol, after having been used, is to be decolorized by distillation, the acid should be neutralized by a previously determined quantity of ammonia or carbonate of soda.

Old specimens, which have become brown in consequence of being treated in the ordinary manner, cannot, as a rule, be decolorized by using the acid alcohol. This, however, may often be done by adding to the alcohol some chlorate of potassa and some sulphuric acid.

University of Amsterdam, December 1.

—*Hugo de Vries, in Nature.*

ASTRONOMICAL TELESCOPES: THEIR OBJECT GLASSES AND REFLECTORS.

By G. D. HISCOX.

I.

IN view of the rapid growth of a desire for astronomical knowledge, as well as the increasing efforts of amateurs to construct telescopes that will be the means of gratifying their thirst for a more practical understanding of this grandly majestic subject, we give in a series of articles the leading features of the progress of the arts as pertaining to the making of telescopes; as, also, the details of the grinding, polishing, and figuring of object glasses and specula, with methods for correcting chromic and spheric aberration as far as possible, without practical lessons.

It is supposed that all persons interested in the construction of the telescope have obtained some general knowledge of their various forms and mechanical mounting, such as the Galilean, the type of the common opera glass, showing objects erect; the Keplerian, or type of the earliest telescopes, consisting of two convex lenses showing the object inverted—famous in their day for their extravagant focal lengths; as well also the various forms of reflecting telescopes—Gregorian, Cassegrainian, Newtonian, and Herschelian.

Descriptions and illustrations of all these forms may be obtained from various back numbers of the SCIENTIFIC AMERICAN SUPPLEMENT. See "Telescope" in catalogue, and index of each year since 1883.

Dolland, about the middle of the eighteenth century, discovered the method of achromatism, which opened a new field in the researches upon the properties of light, and which also gave a new impulse to stellar discovery. He made some excellent telescopes, and would doubtless have accomplished the work of later men but for being hampered by the then backward condition of the glass industry; for, previous to the present century, four to five inch flint disks were the largest that could be made that were suitable for an achromatic telescope.

About the close of the eighteenth century, Herschel, by his activity and amazing manual dexterity in the figuring of reflecting surfaces, gave an impulse to telescopic progress that has made the nineteenth century the age of progress in astronomy—he having made and used many reflectors ranging from 7 inches to 4 feet in diameter, the latter being completed in 1799.

In the struggle to enlarge the optical power of the refracting telescope, the dialyte came into use in its various forms, and is still somewhat in vogue among amateurs.

Fluid lenses for object glasses, and also for correctors in the dialytic form, have been tried with varying success, but found impracticable from the unstable condition of their fluid element.

Guinand and Fraunhofer, in their time, led to the realization of these large objectives by the progress due to their genius in persistent experimentation in the manufacture of optical glass; but it was left for Chance, in England, and Fiel, in France, to produce the wonderful disks which, under the skillful manipulation of the Clarks, of Cambridge, have brought to such perfection our present great telescopes.

Following closely along with the great advance in the perfecting of refractors, the metallic specula of Lord Rosse, in Ireland, the largest of which is 6 feet in diameter, and Lassell, in England, of 3 feet and 4 feet in diameter, were wonderful advances in their time, and with which splendid results have been achieved.

Continuing in rapid review of the progress of telescope building, we can safely say that the silver on glass reflectors, first suggested by M. Foucault, in France, are advancing rapidly to the front for their light-grasping power, their lightness, and cheapness. Their prospective dimensions seem not to be hampered by the costliness of the great refracting disks or the great weight and liabilities attending the casting of large metallic specula.

The work of the late Dr. Draper in celestial photography is largely known and appreciated in the application of silver on glass specula to celestial photographic work, making this the basis of rapid strides in astronomical record, as continued in the work of Common and Huggins, in England, with silver on glass specula of three feet and more in diameter.

The records plainly show that each kind of telescope has its special merit in its special field of work. The refractor as an instrument of precision in measurement of position and facility of handling has no rival; while the metallic reflector has the sharp definition, freedom from color, large limit as to size, and withal cheapness. It is not an instrument of precision, from the nature of its construction, yet it has given ample fruits of its value by standing in the fore rank of discovery.

The silver on glass reflector, embodying, as it does, the acme of light-grasping power, lightness of material, fine definition for micrometric and photometric work, has only one serious defect—its reflecting surface is perishable. The silver surface, having a thickness of from $\frac{1}{100000}$ to $\frac{1}{200000}$ of an inch, has a strong affinity for sulphur and its compounds, and must be preserved from the action of deleterious gases, such as sulphureted hydrogen, marsh gas, and sewer gas; even the foul air of a dwelling quickly affects them. They at best require to be frequently repolished. This soon destroys the silver surface, which must then be entirely removed, the glass surface resilvered and repolished, so that the owner of such a telescope should be an expert in the manipulation required to preserve his instrument.

SOME OF THE GREAT GUNS OF CELESTIAL CONQUEST.

	Where situated.	Diameter.	Focal length.		Maker.	Date.
Refractors.		Inches.	Ft.	In.		
Lick Observatory	California.	36	57		A. Clark & Sons.	1886
Pulkowa "	Russia.	30	44	10	A. Clark & Sons.	1885
Nice "	France.	29¾	58		Henry Bro.	1884
Vienna "	Austria.	26¾	32		Grubb.	1881
Washington Observatory	United States.	26	31	6	A. Clark.	1873
University of Virginia	United States.	26	33		A. Clark.	1879
Gateshead Observatory	England.	25	29		Cook & Son.	1879
Wansworth Common	England.	24	76		(?) Craig & Cravitt.	
Princeton College Observatory	United States.	23	30		A. Clark & Sons.	1881
Strassburg Observatory	Germany.	19			Merz & Mahler.	1879
Milan "	Italy.	19			Merz.	1881
Dearborn "	United States.	18½	23		Alvan Clark.	1863
Van der Zee "	Buffalo, N. Y.	18			Fitz.	
Warner "	Rochester, N. Y.	16	20		A. Clark & Sons.	1880
Madison "	United States.	15½	20		Alvan Clark.	1879
Dun Echt	England.	15½	15		Grubb.	1875
Royal Society	England.	15½	15		Grubb.	
Pulkowa (first)	Russia.	15½	23		Merz & Mahler.	1840
Cambridge Observatory	United States.	15½	23		Merz & Mahler. (?)	1844
Lisbon "	Spain.	$14\frac{8}{10}$				
Clinton "	United States.	13½			Spencer.	
Dorpat "	Russia.	13				
Kensington "	England.	13				
Alleghany "	United States.	13				
Dudley "	United States.	13	15		Fitz.	
Ann Arbor "	United States.	12½	17		Fitz.	
Greenwich	England.	12½	18			
S. V. White Observatory	Brooklyn, N. Y.	12	18		Alvan Clark.	
Cincinnati "	United States.	12	17			
Paris "	France.	12	15		Secretan Eichens.	
Cambridge "	England.	12	20		Cauchoix.	
Dublin "	Ireland.	12	20		"	
Oxford "	England.	12	20		"	
Bothcamp "	Sweden.	11	16		Schroeder.	
Munich "	Germany.	11	16		Merz.	
Copenhagen "	Denmark.	11	16		"	
Madrid "	Spain.	10½	16		"	
Moscow "	Russia.	10½	16		"	
West Point "	United States.	9½	14			
Parkhurst "	Brooklyn, N. Y.	9	9	4	Fitz.	
Columbia College	New York.	13	18		Fitz.	
Cordoba Observatory	South America.	5		35	Tolles.	
Metallic Reflectors.						
Parsonstown	Ireland.	72	55		Earl of Rosse.	1842–46
Lassell Observatory	England.	48	37		Lassell.	
Melbourne "	Australia.	48	30	6	Cassegranian.	
Lassell "	England.	36	30		Lassell.	
Silver on Glass Reflectors.						
Paris Observatory	France.	48	22	6	Martine.	
Salisbury "	England.	37½	20		Common.	
Marseilles "	France.	30	15	3	Foucault & Eichens.	
....	England.	30			Calver.	
And many others of lesser size, in Europe and the United States, doing excellent educational work.						

The metallic specula have a much better record in retaining their luster, with the ordinary care of covering them closely when not in use; or, removing them from the tube and inclosing in a tin box gives them a long and satisfactory life. The writer has a ten inch metallic speculum that has not been repolished in thirty years, and another that was repolished after twenty-five years' use, with but little gain in luster, both having the black finish.

It may be desirable to consider the weights of some of the noted telescopes. The first 6 foot speculum of Lord Rosse weighed 6,000 pounds; the second 6 foot speculum, 8,000 pounds; the 48 inch Melbourne speculum, 3,500 pounds; the 48 inch silver on glass speculum of the Paris Observatory, 1,300 pounds; weight of telescope and mounting, 9 tons. The telescope and mounting of the Princeton achromatic weighs 7 tons.

A list of some of the noted telescopes, their diameters of object glasses, focal lengths, and names of makers, as far as known to us, is given above, which will be found of use for reference.

The selection of the proper quality and density of glass for object glasses is of vital importance in their future value.

The use of plate glass that is free from porousness, or bubbles near the surface, is only suitable and recommended for silver on glass specula. Such glass has been used for small achromatic objectives, and we have seen some excellent samples obtained from the central portions of large plates that have been accidentally broken, with a density as high as 2·81. This glass, when combined with flint of 3·85 density, has given most excellent results.

Optical glass, and no other, can, with safety, be trusted for satisfactory definition.

The optical faults of bad glass are very puzzling to the amateur, and may cost him much labor in endeavoring to correct them by altering the curves.

The usual density of crown optical glass is found to vary from 2·48 to 2·60, and flint optical from 3·15 to 3·85. The light flint of density 3·30 and under is not recommended for object glasses.

Crown of 2·50 to 2·60, and flint of 3·50 to 3·75 give the best results, although hundreds of telescopes are in use with flint glass of from 3·15 to 3·30 density.

The indices of refraction for given densities are found to vary too much for the computation of exact radii from the measure of the density, or specific gravity alone; yet the specific gravity, being easily obtained, is the most ready means of selection in the purchase of optical glass.

The following table of specific gravities with corresponding indices of refraction for the extreme and mean rays of optical glass of the leading makers will be found convenient for reference; the dispersion being the difference of the extreme indices, while the relative dispersive power is the measure of dispersion divided by the mean index of refraction minus 1.

The mean index of refraction is the point of most luminous power in the chromatic spectrum, and is indicated by the spectral line D by some observers, or a line very near to it, by others, numbered by its wave length, 5,614.

KIND OF GLASS.	Specific Gravity.	Extreme and Mean Index.	Dispersion diff. of indices.	Dispersive Power.
Fiel's Crown	2·482	1·51245 1·51929 1·53445	0·02200	0·4236
Chance's Crown	2·4857	1·51175 1·51711 1·53278	0·0213	0·04066
Chance's Crown	2·510	1·5096 1·5166 1·5323	0·0227	0·04393
Chance's Crown	2·5503	1·50895 1·51458 1·53141	0·02245	0·04324
Fiel's Crown	2·563	1·5241	mean	
Fiel's Flint	3·497	1·6035 1·6163 1·6470	0·0435	0·07058
Fiel's Flint	3·516	1·6176	mean	
Fiel's Flint	3·554	1·6152 1·6280 1·6597	0 0445	0·07086
Chance's Flint	3·6586	1·62241	mean	
Chance's Flint	3·8894	1·63914 1·65037 1·68859	0·04945	0·07603
Dense Flint	4·4216	1·71022	0·06125	0·08624

The price of optical glass in New York varies much with size, quality, and guarantee as to purity and indices of refraction; some disks coming from the makers with polished faces prepared for examination, and to which the indices are affixed.

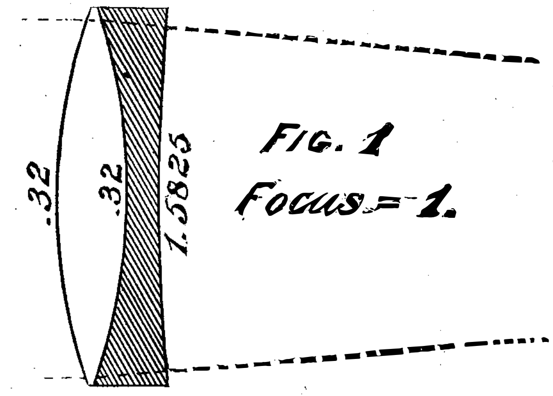
Small, rough disks, 3 in. in diameter, or less, may be purchased for $2 per lb.; 4 in. disks or squares, not guaranteed, but polished on opposite edges for examination, at $2.50 per lb., or about $5 per pair; 5 in. disks at about $7 per pair, and first quality disks, 5 in. diameter, with polished faces, which have been tested, with guarantee and attached index, are held at $50 per pair; 4 in. disks, as above, at $40 per pair.

As the focal lengths of the crown and flint lenses have to be in proportion to their dispersive powers, their radial curves must be so adjusted that the focal lengths shall meet the requirements for achromatism, and also so proportioned to each other that the spherical aberration shall be eliminated coincident with the unequal dispersion. This is the most difficult problem that the mathematician and optician has to deal with. To the mathematician the mechanical element is a stumbling block; while the practical optician generally works by the rule of thumb, or cut and try.

We give a few of the empirical formulas for objectives derived from English sources; but as they all lack the naming of an essential feature, viz., density, refractive index, and dispersive power, they may serve as a partial guide to the amateur when these qualities of their glass are unknown.

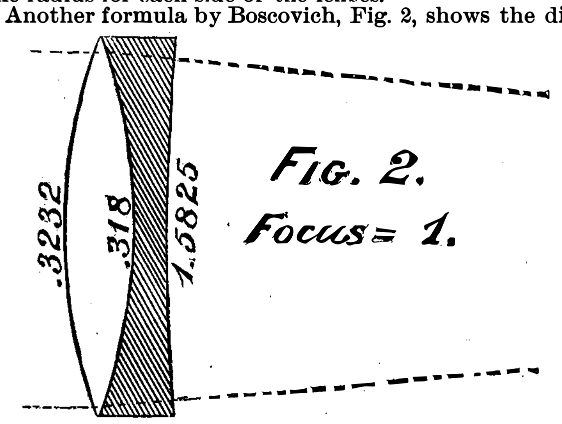
The figures are for radii; all in decimal parts of the required focal length of the proposed telescope.

From Kinkle's formula, Fig. 1, we have three curves exactly alike, and the last curve of the flint lens slightly concave, as in Fig 1.

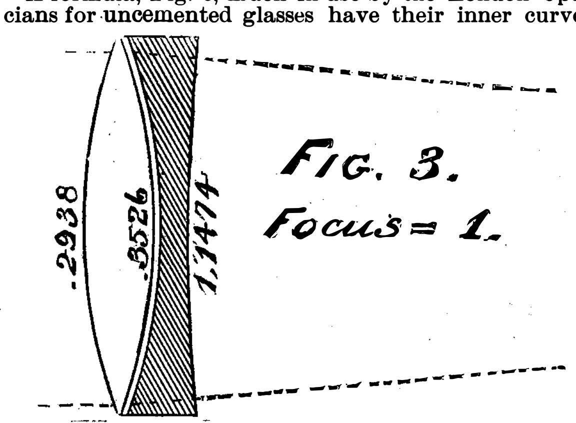


Simply multiplying the proposed length of the telescope by the numbers representing the curves gives the radius for each side of the lenses.

Another formula by Boscovich, Fig. 2, shows the direction in which the radii may be varied to eliminate both the chromatic and spherical aberration.

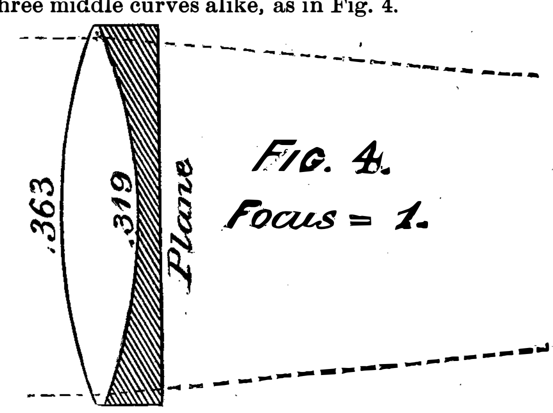


A formula, Fig. 3, much in use by the London opticians for uncemented glasses have their inner curves unlike, so that the flint glass curve shall be slightly deeper than the convex crown.



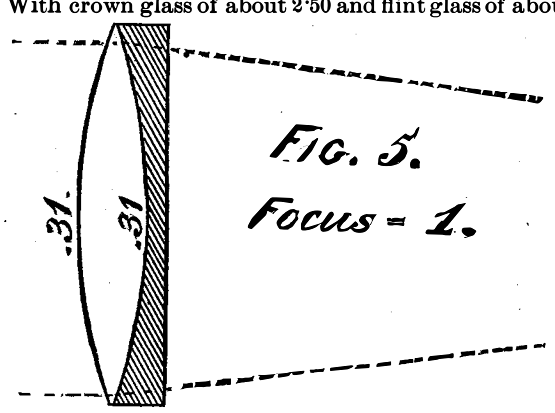
This form requires four pairs of laps, giving additional facility for varying any one of the curves for final correction.

The writer has obtained some excellent results with glass of known high specific gravity, viz., crown 2·81, flint 3·85, with the last surface of the flint plane, and three middle curves alike, as in Fig. 4.



This requires three pairs of laps; the final correction being made by varying the middle curves.

With crown glass of about 2·50 and flint glass of about 3·50 specific gravity, we recommend the amateur to make the three curves equal, and the last surface flat, as in Fig. 5.



Finish the three curves of radii $\frac{31}{100}$ of the proposed focal length of the telescope; then partially polish the last surface flat, and make a trial. Then, if required, concave or convex the last surface slightly, to correct. See SCIENTIFIC AMERICAN, Nov. 14, 1885, Notes and Queries, No. 1, for illustrations of the Washington, Princeton, and Hastings object glasses.

The methods of observation for correction will be given further on.

The proportion of focal length to diameter of object glasses will be found, by an examination of the list of refractors already given, to be anything but empirical, and ranging in focal lengths as widely as from 11 to 23 diameters.

We find the larger number to be about 14 diameters in focal length; the disposition being of late years to shorten the proportional lengths as the proper qualities and densities of glass have become better understood and more readily obtained; the late Mr. Tolles having reduced the proportion to 1 to 10 and 1 to 8 in a 7 ft. and 5 ft. object glass, with greatly increased effect in reducing the apparent size of the image of a star, and by their sharp definition making visible those of lower magnitude than can be seen in telescopes of much larger size. This decreased size of image or disk concentrates the light of the star, and thus enables the use of powers of 120 or more to the inch of diameter, or a power of 600 with a 5 in. objective; while in most telescopes a power of from 60 to 80 per inch of diameter is the limit of satisfactory performance.

A telescope of 5 in. aperture of still shorter proportions, 1 to 7, was made by Mr. Tolles for the observatory at Cordoba, S. A., which is described as *magnificent* in rendering the smaller stars of clusters and the Milky Way.

There is an optical formula for objectives of equal curves or radii of the first three surfaces, when the indices of refraction and derived dispersions are known, of which for a single lens F = focus for parallel rays, R and R′ = radii for first and second surfaces, u = mean index of refraction. Then for the focal distance from the center of the lens, $F = \frac{R R'}{(u-1)(R+R')}$

And by inverting the terms,

$$1. \quad \frac{1}{F} = \frac{(u-1)(R+R')}{R R'}; \text{ or}$$

$$2. \quad \frac{1}{f} = \frac{(u-1)(r+r')}{r r'}$$

In expanding the formula to meet the requirements of a combination of a convex crown lens and a concave flint lens for corrected achromatism, we require two sets of terms, not only for the radii of both the lenses, but also for the measure of the extreme indices of both kinds of glass.

Now let n represent the ray of greatest refraction for crown glass (violet).

n' the ray of greatest refraction for flint glass (violet).

m the ray of least refraction for crown glass (red).

m' the ray of least refraction for flint glass (red).

Also let F = focus for the ray n of crown (violet).

F′ = focus for the ray m of crown (red).

f = focus for the ray n' of flint (violet).

f' = focus for the ray m' of flint (red).

By the terms in formulas 1 and 2,

$$1. \quad \frac{1}{F} = \frac{(n-1)(R+R')}{R R'} \text{ for the crown violet.}$$

$$2. \quad \frac{1}{f} = \frac{(n'-1)(r+r')}{r r'} \text{ for the flint violet.}$$

$$3. \quad \frac{1}{F'} = \frac{(m-1)(R+R')}{R R'} \text{ for the crown red.}$$

$$4. \quad \frac{1}{f'} = \frac{(m'-1)(r+r')}{r r'} \text{ for the flint red.}$$

Since $\frac{1}{F} + \frac{1}{f} = \frac{1}{F'} + \frac{1}{f'}$, or the sum of the foci of the violet rays for both lenses equals the sum of the foci of the red rays for both lenses.

Also $\frac{1}{F} - \frac{1}{F'} = -\frac{1}{f} - \frac{1}{f'}$, or the difference of the foci of the violet and red rays of the crown lens is equal to the difference of the violet and red rays of the flint lens.

Then $n - m$ = the dispersion of the crown lens, and $n' - m'$ = the dispersion of the flint lens. Substituting the dispersion in place of the index of refraction in the equations 1 and 2 for each lens, the positive and negative dispersive powers with their relative curves will be compensated. For

$$+\frac{(n-m)(R+R')}{R R'} = -\frac{(n'-m')(r+r')}{r r'}$$

And consequently, dividing the equation for the crown lens by that for the flint lens, we have

$$\frac{n-m}{n'-m'} = \frac{R R'(r+r')}{(R+R')r r'}$$

Substituting the unit notation for the known radii R R′ and r', we have $\frac{1 \times 1 \times r + 1}{1 + 1 \times r \times 1}$ which by reduction becomes $\frac{r+1}{2r}$, 1 being the radius of the three equal curves.

Then for any given radius $\frac{n-m}{n'-m'} = \frac{r+R}{2r}$

When $\frac{n-m}{n'-m'}$ is greater than ½, the last surface is convex.

When $\frac{n-m}{n'-m'} = ½$, the last surface is plane.

When $\frac{n-m}{n'-m'}$ is less than ½, the last surface is concave.

By substituting in the above equation the value of the dispersion in the foregoing table of Fiel's crown glass of specific gravity 2·482 and flint glass of specific gravity 3·497, we shall have for dispersion,

$$\frac{n-m}{n'-m'} = \frac{0·0220}{0·0435} = \frac{r+R}{2r}$$

By multiplying the first numerator by the denominator of the second term, and transposing, we have,

$$0·0440\ r = 0·0435\ r + 0·0435\ R.$$

Subtracting the first term from the second, we have,

$$\begin{array}{r} 0·0435\ r \\ 0·0440\ r \\ \hline -0·0005\ r \end{array}$$

Dividing the last term by the negative difference of the first and second term, we have

$$\frac{+0·0435\ R}{-0·0005\ r} = -87\ R,$$

or the last curve must be convex and 87 times the radius of the first or crown surface.

Again, substituting the flint of specific gravity 3·554 in the foregoing table with the dispersive index of 0·0445 in place of the above flint, we have

$$\frac{n-m}{n'-m'} = \frac{0·0220}{0·0445} = \frac{r+R}{2r}$$

Again, multiplying the first numerator by the second denominator, and transposing, we have

$$0·0440\ r = 0·0445\ r + 0·0445\ R.$$

Subtracting first from second term,

$$\begin{array}{r} +0·0445\ r \\ 0·0440\ r \\ \hline +0·0005\ r \end{array}$$

Then $\frac{+0·0445\ R}{+0·0005\ r} = +89\ R,$

or the last curve must be concave, and have a radius of 89 times the radius of the first or crown surface.

For the mathematical inquirer in the more complex formulas we refer the reader to "Littrow on Double Object Glasses," Vol. III., Transactions of the Royal Astronomical Society. "The Dialyte Telescope," same volume. "Hastings on Object Glasses," American Journal of Science, April, 1878. "Curves of Gaus and Herschel," Proceedings of the American Academy of Science, Vol. VI. Potter's Optics.

For an elaborate investigation of the indices of refraction and curves of the Washington telescope, see Vol. XXIV., 1877, Washington Observatory Reports.

(*To be continued.*)

THE TULIP TREE, WHITEWOOD, AMERICAN OR YELLOW POPLAR.

This is the *Liriodendron tulipifera* of Linnæus, the tulip-bearing liriodendron, tulip tree, saddle tree, or tulip-bearing lily tree of the arboriculturists, which produces the wood known in commerce by the variant name of poplar, Virginian poplar, white poplar, yellow poplar, whitewood, canary whitewood, canary wood, or canoe wood. The French *Tulipier de Virginie* and the German *Virginischer Tulipeerbaum* are literal translations of the word Virginian tulip tree.

This tree is called *Liriodendron* from *leirion*, a lily, and *dendron*, a tree, from the flowers resembling those of a lily, though more correctly those of a tulip, as the specific name implies. It is called poplar from its general resemblance to trees of that genus; whitewood, and canary wood, from the white or yellow color of the wood, the wood varying in color when grown under different circumstances; canoe wood, from the use to which it is applied by the native Indians; saddle tree, from the cut or scalloped form of the leaves bearing some resemblance to a saddle. There is only one species of this tree, and it is of the first rank. The flowers are yellowish, variegated with green, red, and orange; the corolla is composed of six petals, and it assumes a tulip or bell-shaped form.

The tree has no relation to the poplar; it represents one of three genera, composing the order *Magnoliaceæ*, the genus Magnolia being considered the type of this order.

The tulip tree is a native of North America. It abounds in the Middle States, in the upper part of the Carolinas and of Georgia, and is found still more abundantly in the Western country, particularly in Kentucky. Its comparative rareness in the maritime parts of the Carolinas and of Georgia, in the Floridas, and in lower Louisiana is owing less to the heat of summer than to the nature of the soil, which, in some parts, is too dry, as in the pine barrens, and in others too wet, as in the swamps which border the rivers. Even in the Middle and Western States the tulip tree is less abundant than the oaks, the walnuts, the ashes, and the beeches, because it delights only in deep, loamy, and extremely fertile soils, such as are found in the rich bottoms that lie along the rivers, and on the borders of the great swamps that are inclosed in the forests.

In the Atlantic States, especially at a considerable distance from the sea, tulip trees are often seen seventy feet, eighty feet, and one hundred feet in height, with trunks from eighteen inches to three feet in diameter; but the Western States seem to be the natural soil of this magnificent tree, and there it displays its most powerful vegetation. It is commonly found mingled with other trees, such as the hickories, the black walnut and butternut, the Kentucky coffee tree, and the wild cherry tree; but it sometimes constitutes, alone, pretty large tracts of the forest, as on the road from Beardstone to Louisville. In no other part of the United States is the tulip tree so lofty and of so great a diameter.

The southern extremity of Lake Champlain, in latitude forty-five degrees, may be considered its northern limit, and the Connecticut River, in the longitude of seventy-two degrees, as its eastern limit. Its expansion is repressed in Vermont, and in the upper part of the continent, by the excessive cold and by a mountainous surface unfavorable to its growth.

This tree has what is termed an artificial geography, which may be said to embrace the middle region of Europe, from Berlin and Warsaw on the north to the shores of the Mediterranean and Naples on the south, Ireland on the west, and the Crimea on the east. Although not much known as an introduced tree in Great Britain, it has gained a remarkable footing in Central Europe. The first notice we have of the tulip tree on the Continent is in the "*Catalogue of the Leyden Garden*," published in 1731. From the number of trees existing in France, the south of Germany, and Italy, there can be little doubt that it spread rapidly in those countries. Public avenues are planted with it in Italy, and as far north as Strassburg and Metz. It stands the open air and attains a large size in Vienna.

The uses of the tulip tree in Europe are limited almost entirely to those of ornament; for though there are numerous trees which would produce excellent timber if cut down, we have never heard of any having been felled for this purpose, or, indeed, for any other. Every possessor of a tulip tree in Europe values it far higher for its beauty in a living state than for its products.

Considering the rapid growth of the tree, and the valuable character of the wood, it is somewhat strange that it is not propagated for its timber, to the displacement of other and less valued trees. Loudon informs us that he saw at Syon, in the environs of London, a tree which in about seventy years attained a height of seventy-six feet, the trunk at one foot from the ground being two feet six inches in diameter; another at Mount Grove, Hampstead, eighty years planted, was seventy feet high, with a diameter of trunk three feet ten inches; another in the arboretum at Kew, sixty years planted, was seventy feet high, with a diameter of the trunk of two feet eight inches; a tree at Kinlet, Worcestershire, fifty years planted, sixty feet high and two feet seven inches diameter of trunk; at Croome, in the same county, seventy years planted, seventy-five feet high, and two feet six inches diameter of trunk; at Hopetoun House, Scotland, eighty-six years planted, sixty feet high, and two feet four inches diameter of trunk; at Tyninghaim, seventy-two years planted, thirty-four feet high, and two feet three inches diameter of trunk. Other statistics could be given in Ireland, France, Prussia, Austria, etc., which would prove that it thrives in its adopted home of Europe.

This tree, in its native woods, is often seen from seventy to one hundred feet in height, with a trunk the diameter of which varies from eighteen inches to three feet. Instances are recorded of their being found fifteen feet or sixteen feet in circumference, one near Louisville being twenty-two feet six inches in circumference at five feet from the ground, the height of the tree being from one hundred and twenty to one hundred and forty feet.

Of all the deciduous trees of North America, the tulip tree, next to the buttonwood, attains the amplest dimensions; while the perfect straightness and uniform diameter of its trunk for upward of forty feet entitle it to be considered one of the most magnificent trees of the temperate zone.

The bark, till the trunk exceeds seven inches or eight inches in diameter, is smooth and even; it afterward begins to crack, and the depth of the furrow and the thickness of the bark are proportioned to the size and to the age of the tree. The heart or perfect wood of the tulip tree is yellow, approaching to the lemon color, and its sap or alburnum is white.

In Europe, though not attaining the same magnitude that it does in situations favorable to it in its native country, it still forms a magnificent tree, in some cases reaching the height of ninety feet or one hundred feet.

The timber, though classed among light woods, is much heavier than that of the common poplar; its grain is equally fine, but more compact, and the wood is easily wrought and polished. It is found strong and stiff enough for uses that require great solidity.

The heartwood, when separated from the sap and perfectly seasoned, long resists the influence of the air, and is said to be rarely attacked by insects. Its greatest defect, when employed in wide boards and exposed to the weather, is that it is liable to shrink and warp by the alternations of dryness and moisture; but this defect is in a great measure compensated for by its other properties, and may be, in part, owing to its not being allowed sufficient time to be properly seasoned.

The nature of the soil has so striking an influence upon the color and upon the quality of the wood, that the consumers distinguish it by the names of the white poplar and the yellow poplar. The trees show no outward signs of the special character of the wood they contain, and it is only made manifest by cutting it. The white variety is looked upon as inferior, the yellow being used for all the better purposes.

At New York and Philadelphia, and in the adjacent country, it is often employed in the construction of houses for rafters, and for the joists of upper stories. In the Middle States and in the Western States, it is more generally used in building, and is considered as the best substitute for the pine, the red cedar, and the cypress. Wherever it abounds, it serves for the interior work of houses, and sometimes for the exterior covering, the panels of doors and of wainscots, and the mouldings of chimney pieces.

Shingles about fifteen inches long are made of this tulip wood; for this purpose the wood is very suitable, as it is found to be proof against splitting by extreme heat or frost.

In all the large towns of the United States, tulip or poplar boards are used in widths of two feet to three feet. When dry, it takes the paint or polish remarkably well. The seats of the American Windsor chairs are invariably made of this wood. It is also used for trunk and box making, for furniture, agricultural implements, turnery, broom heads, etc. The farmers use it for troughs, which are hewn from the solid log. The Indians who inhabited the Middle States, and those who still remain in the Western country, prefer this tree for their canoes, which, consisting of a single

trunk, are very light and strong, and sometimes carry twenty persons.

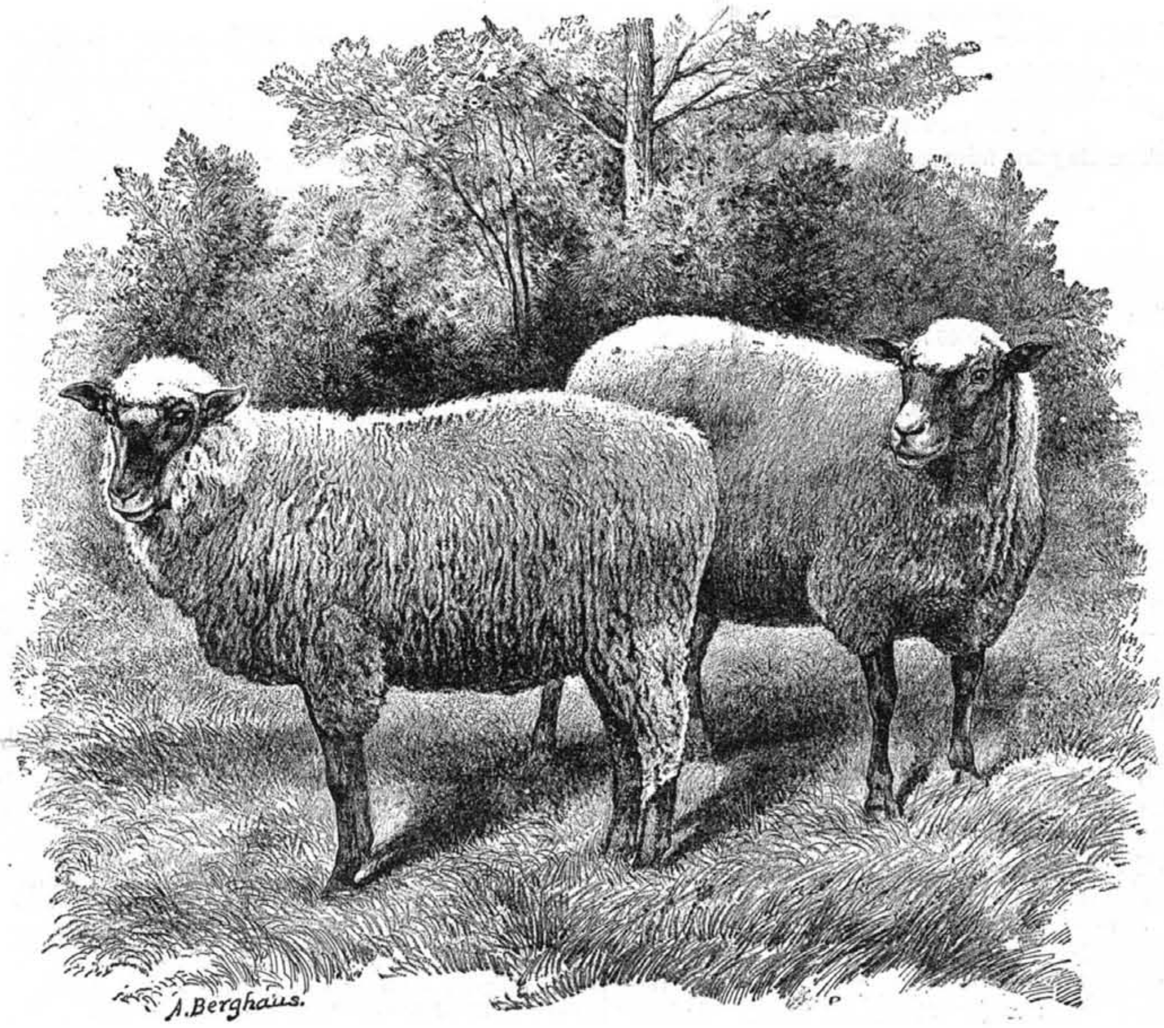
In the lumber yards of New York, Philadelphia, and Baltimore, a great quantity of this wood is found in converted sizes, and compared with black walnut, curly birch, etc., it is sold very cheap.

In the country watered by the River Monongahela, between thirty degrees and forty degrees of latitude, the tulip tree is so abundant that large rafts composed wholly of its logs are made to float down the stream.

Of late years a growing trade has been done in England in what is called American whitewood, or canary whitewood, for in the field of commerce we do not hear of it as tulip wood. This adoption of a popular trade name, merely descriptive of the wood itself, offers a real difficulty where the botanical name or character of the tree producing it is required. The writer, who is well acquainted with the imported wood, made inquiries among the Liverpool merchants, with the result that it was considered the produce of an American poplar, a statement negatived by the curator of museums at Kew and the botanical secretary attached to the Canadian section of the Indian and Colonial Exhibition, London, who class it as tulip wood.

The imported wood reaches this country, principally from New York, in waney logs, prepared after the manner of Quebec waney pine, associated with sawn planks of very fine dimensions.

The wood is remarkably clean and sound, and in the case of planks they are mostly cut clear of heart or fault, in which state they command a price fully equal to that of first quality Quebec yellow pine. The yellow or lemon-colored wood is the best, and it is only occasionally that the white variety, or real poplar, is shipped.



SHROPSHIRE SHEEP.

The uses to which this fine wood is applied are legion, and it is rapidly becoming a factor in the wood trade of this country.

It is freely used by the cabinet maker, the shop fitter, and the builder, or house fitter, the easy manner in which it is wrought or worked, its firm character when fully dried, and its suitability for staining or polishing rendering it a special favorite.

It is a favorite wood with coach and carriage builders, who have not been slow to discover its merits, and it is highly spoken of by agricultural implement makers and other consumers of wood.—*The Timber Trades Journal.*

SHROPSHIRE SHEEP.

WE show two beautiful Shropshires. These are the ewe Flossie (1019) and her ewe lamb Hazle (1791). These sheep are to be found in the Glynholm flock, owned by J. D. Stannard, Whitewater, Wisconsin. Mr. Stannard writes about the sheep as follows: "I have been interested in Shropshires for three years, first crossing a Shropshire ram on common merino ewes, and then using a Shropshire on the half-blood ewes. The half-blood bucks I have either sold as lambs or as yearling wethers. This year I sold in August, April lambs that averaged 63 pounds. I could have had them heavier but for the drought, which so completely burned up the pastures during the summer.

"The first cross produced ewes of large size, strong, hardy, always in good condition, and excellent mothers. They shear a fleece averaging about five pounds of washed wool, in which the good qualities of both breeds are combined, yielding a grade of wool which our local dealers think is the best in the market. The result of the second cross is a sheep more nearly approaching the pure Shropshire in style, markings, and character of fleece. Many individuals of this cross are very difficult to distinguish from pure breds. The rams of this cross are proving to be excellent stock-getters, transmitting their good qualities with a remarkable degree of certainty. The Shropshire is the object of much inquiry in this part of the country. The rams are picked up so closely as lambs that there is practically no supply of older sheep.

"I have written concerning the grades, because the question that is raised by flock masters throughout the country is: How will the Shropshires cross on the sheep that we already have? From my experience, I think they can safely be depended upon to produce a good mutton sheep, well covered with a fleece of medium wool; in short, a sheep that has the ability to yield a greater profit than the common sheep of our country now do."—*Rural New-Yorker.*

INFLAMMABLE BREATH.

THE note of Dr. F. E. Quimby, in the *Medical Record* of November 27, 1886, concerning the case of a man who, as he was blowing out a match, had an eructation from the stomach of gas, which ignited and burned his face, has called forth a number of communications from correspondents referring to reports of similar cases.

A gentleman of this city writes that Lauder Brunton, in his work on "Disorders of Digestion," quotes a case reported by C. Anton Ewald. The patient was surprised to find inflammable gas issuing from the mouth. Ewald collected the gas and analyzed it, finding it composed largely of marsh gas, though it was by no means identical in composition and physical characters with this gas. The source of the gas is chemical change in the food and mucus occurring in the intestinal tract in some forms of imperfect digestion, whence it passes through the open pyloric and cardiac orifices of the stomach.

Dr. F. C Clark, of Stillwater, Minn., suggests that the gas was similar in composition to that which escapes from the rectum, and which, as is well known, is inflammable. The phenomenon is due to the presence in small quantities, of hydrogen sulphide, which is produced by the decomposition of organic matters containing sulphur.

Dr. F. C. Shattuck, of Boston, mentions Ewald's case, and also one related by Senator, in which large quantities of sulphureted hydrogen were belched from the stomach. Lauder Brunton gives the details of these cases in an article published in the *Practitioner* for 1880, vol. ii., p. 267. According to the *Medical Times and Gazette* for 1875, Ewald's case was the third that had been reported up to that date.

Dr. William Graham, of Brussels, Canada, refers to the reports of a number of cases of this nature. One case is related by Dr. Beatson, in the *British Medical Journal* of February 13, 1886. The patient had been troubled with eructations having a very disagreeable odor, and one night, when blowing out a match, his breath caught fire, with a crack like the report of a pistol, which was so loud as to awaken his wife. Dr. Scott Orr reports, in the same journal, under date of February 27, a similar case, occurring in a man seventy years of age. The patient had been troubled for two years with dyspeptic symptoms, and had eructations of gas which had such an offensive odor as to make him miserable when in any one's company. One evening, while he was lighting his pipe, one of those involuntary eructations took place, and the gas became ignited, burning his mustache and lips, and frightening him greatly. The gas went off with a "puff," such as occurs when a match is applied to a pinch of gunpowder. The same thing has happened to the patient five or six times. Waldenburg, in 1864, published a case of dyspepsia in which there were eructations of gas which was inflammable, and exploded with a bluish flame. In a paper by Schultze (*Berliner Klinische Wochenschrift*, 1874), it is stated that Professor Friedreich, of Heidelberg, had a patient who belched up inflammable gases.

The writer refers also to the case related by Ewald in his work on indigestion. The analysis of the expired gas was as follows: Carbonic acid, 20·57; hydrogen, 20·57; carbureted hydrogen, 10·75; oxygen, 6·72; nitrogen, 41·38; sulphureted hydrogen, trace.

"The explanation, as given by Drs. Beatson and Saunby, is, no doubt, the correct one. The gas probably arises from the food remaining too long in the stomach, as in cases of dilatation, undergoing decomposition and generating gases such as carbureted hydrogen and free hydrogen, both of which are inflammable. . . . Professer Muller (*Deutsche Medicinische Wochenschrift*), who has investigated the formation of gases, ascribes their generation in the stomach and intestines to the action of certain forms of bacteria upon the carbohydrates of the food.

"For the relief of this condition, Ewald advises lavage of the stomach after Kussmaul's method. Heynsius says that chlorinated water gives more relief than anything else. Waldenburg obtained the best results from half-ounce doses of glycerine three times a day. Saunby suggests that these patients should take small quantities of solid food, without vegetables, every two or three hours."—*Medical Record.*

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