PROFESSOR TYNDALL'S SIXTH AND CONCLUDING LECTURE IN NEW YORK.

We have employed as our source of light the ends of two rods of coke rendered incandescent by electricity. Coke is particularly suitable for this purpose, because it can bear intense heat without fusion or vaporization. Still, refractory as carbon is, if we closely examined our voltaic arc or stream of light between the carbon points, we should find there incandescent carbon vapor. We might also detach the light of this vapor from the more dazzling light of the solid points, and obtain its spectrum; but instead of an unbroken succession of colors from red to violet, we should find but a few bands of color, with spaces of darkness between.

What is true of carbon is true of the metals, the most refractory of which can be fused, boiled and reduced to vapor by the electric current. Professor Tyndall then arranged two carbon points, the end of the lower one being hollowed out. In the cup thus formed, he placed a fragment of the metal thallium. On establishing the current, a flame of a vivid green color appeared upon the screen. On submitting this light to the action of a prism, the spectrum showed as a single green band. Therefore, the lecturer stated, light of one degree of refrangibility, and that corresponding to green, is emitted by the thallium vapor. A particle of silver was then substituted for the thallium. A bright green flame of precisely the same shade as that before obtained appeared, but the spectrum of the vapor exhibited two green bands. By adding to the silver in the camera a bit of thallium, the single band of the latter appeared in the spectrum between the two silver lines. But, continued the speaker, it should be noticed that the thallium band is much the brightest of the three. It is the resistance offered to the passage of the electric current from carbon to carbon that calls forth the power of the current to produce heat. Now thallium is a much more fusible and vaporizable metal than silver, and its vapor facilitates the passage of the current to such a degree as to render it almost incompetent to vaporize silver. As the thallium is gradually consumed, the silver lines increase in brightness until the three bands are of uniform brilliancy.

CHARACTERISTIC BANDS OF THE METALS.

We have in these bands a perfectly unalterable characteristic of these two metals. No other lines except the two green ones, are ever obtained from silver, or any other than the single green band from thallium. Every known metal has its bands, and in no known case are the bands of two different metals alike. Hence, these spectra may be made a test as to the presence or absence of any particular metal. If we pass off from the metals to their alloys, we find no confusion. The lecturer then showed the green bands of copper and the blue and red zinc lines; brass, an alloy of copper and zinc, gave the bands of both metals. But we are not confined to the metals; the salts of the metals yield also the bands. Chemical union is ruptured by a sufficiently high heat, and the vapor of the metal is set free. The chlorides of the metals are particularly suitable for experiments of this character. Common salt, a compound of chlorine and sodium, yields the spectrum of the latter element.

DISCOVERY OF NEW METALS.

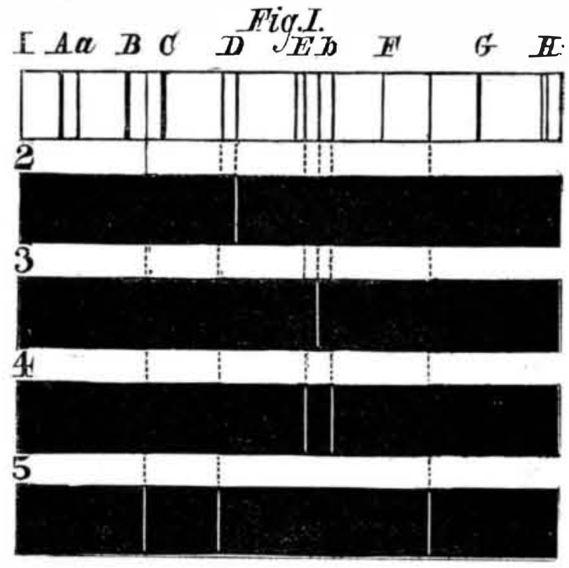
When Bunsen and Kirchoff, after having determined the spectra of all known substances, discovered a spectrum whose bands did not correspond to any known bands, they immediately inferred the existence of a new metal. By operating upon the mineral waters of Germany, evaporating immense quantities of the fluid, they discovered the metal rubidium, and afterwards a second metal which they named "cæsium;" subsequently Mr. Crookes, by the same method, added thallium to the list of metals.

APPLICATION OF SPECTRUM ANALYSIS.

Kirchoff showed how spectrum analysis might be applied to the investigation of the sun and stars. A spectrum is pure in which the colors do not overlap each other. We purify the spectrum by making our slits narrow and by augmenting the number of our prisms. When a pure spectrum of the sun has been obtained in this way, it is found furrowed by innumerable dark lines. Four of them were first seen by Dr. Wollaston, but they were afterward multiplied and measured by Fraunhofer with such masterly skill that they are now universally known as Fraunhofer's lines. Kirchoff had proved, for every ray of the spectrum, the doctrine that the body emitting a ray absorbed with special energy a ray of the same refrangibility. According to this principle, vapors of metals, if crossed by solar light, ought to absorb rays of the same refrangibility as those which they emit. Kirchoff proved this to be the case: he was able, by the interposition of a vapor, to cut out of the solar spectrum the band corresponding in color to that vapor. Now, the sun possesses a photosphere, or vaporous envelope, doubtless mixed with violently agitated clouds; and Kirchoff saw that the powerful rays, coming from the solid or the molten nucleus of the sun, must be intercepted by this vapor. One dark band of Fraunhofer, for example, occurs in the yellow of the spectrum. Sodium vapor is demonstrably competent to produce that dark band; hence Kirchoff inferred the existence of sodium vapor in the atmosphere of the sun. In the case of metals which emit a large number of bands, the absolute coincidence of every bright band of the metal with a dark Fraunhofer line raises to the highest degree of certainty the inference that the metal is present in the atmosphere of the sun. In this way solar chemistry was founded on spectrum analysis.

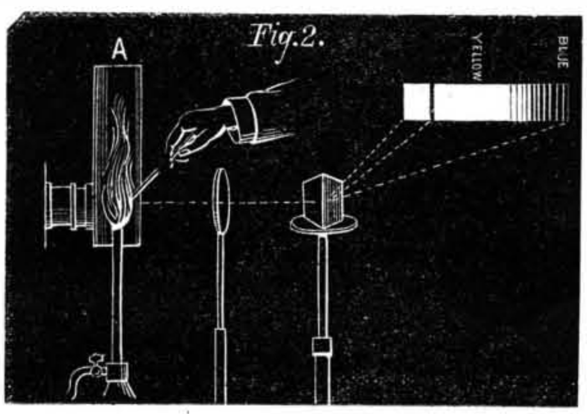
Fig. 1 shows a comparison of the bright lines in the spectra of terrestrial substances with the dark lines in the solar spectrum. The spectrum 1 in the engraving is that of the sun, 2, that of sodium, 3, of thallium, 4, of silver, and 5, of lithium.

Fig. I.



EMISSION AND ABSORPTION INTERPRETED.

Professor Tyndall then proceeded to explain the physical meaning of emission and absorption through the analogy of sound. Sounding a tuning fork, he showed that, out of a number of other forks, that of the same rate of vibration as the sounding one continued the sound even when the first was quenched. This is an instance of the absorption of the sound of one fork by the other. The speaker then exhibited on the screen the bright yellow band forming the spectrum of the sodium flame. He then arranged the apparatus shown in Fig. 2, in which A is the burning sodium, held in a shade



so as to screen the light. On sending the white light of the electric beam through this flame, the spectrum appeared on the screen with the yellow sodium light as it were cut out, and to all intents a dark Fraunhofer band was produced in its place.

THE CAREER OF OPTICS OUTLINED.

Professor Tyndall then proceeded to review the course of investigation as regards light, which had been passed over in the lectures delivered. Begun by the Arabian philosopher Alhazan in 1100, it was taken up in succession by Roger Bacon, Vitellio and Kepler. Then came the fundamental discovery of Snell, and its application by Descartes to the explanation of the rainbow. Newton followed with his experiments in the analysis and synthesis of white light, by which it was proved to be compounded of various kinds of light of different degrees of refrangibility. In 1676, Olaf Roemer, a Dane, determined, from the occultations of Jupiter's satellites, that light requires time to pass through space and that it moves with a velocity of 190,000 miles a second. Then an English astronomer, Bradley, determined that the rays from a star overhead are caused to slant by the motion of the earth through space. By knowing the speed of the earth in its orbit and the obliquity of the rays due to this course, he also calculated the velocity of light, with results identical to those obtained by Roemer. Dollond next proved that Newton's idea, that refraction and dispersion were inseparable and that one could not be abolished without abolishing the other, was wrong. By combining two different kinds of glass, he found that color might be abolished and a residue of refraction left, and this discovery he applied to the making of achromatic lenses. In 1808, Malus, by looking through Iceland spar at the sun reflected from the window of the Luxembourg Palace in Paris, discovered the polarization of light by reflection. In 1811, Arago discovered the splendid chromatic phenomena which we have had illustrated by plates of gypsum in polarized light; he also discovered the rotation of the plane of polarization by quartz crystals. In 1813, Seebeck discovered the polarization of light by tourmaline. The same year, Brewster discovered those magnificent bands of colors that surround the axes of bi axial crystals. In 1814, Wollaston discovered the ring of Iceland spar.

Professor Tyndall then reviewed the undulatory theory, as developed and asserted by Dr. Young, at considerable length. After Young came Fresnel, who grasped the theory in its entirety, and followed the ether into its eddies and estuaries in the hearts of crystals of the most complicated structure and into bodies subjected to strains and pressures.

CONCLUDING REMARKS.

Professor Tyndall then announced that he had reached the terminus of the course he had projected; and he concluded his lecture with an able disquisition on the study of science and its progress in America. Science, he said, must be cultivated for its own sake, for the pure love of truth, rather than for the applause and profit that it brings. Could we watch the true investigator in his laboratory, unless animated by his spirit, we could hardly understand what keeps him there. Many of the objects which met his attention might appear to us to be utterly trivial; and, if we were to step forward and ask him what is the use of his work, the chances are that we would confound him. He might not be able to assure us that it will put a dollar into the pocket of any human being, living or to come. That scientific discovery may not only put dollars into the pockets of individuals but millions into the exchequers of nations, the history of science amply proves; but the hope of its doing so is not the motive power of the investigator. The speaker then alluded to the need for original investigation in England and America. If the spirit of our great investigators die out, we shall find ourselves eventually in the condition of the Chinese, mentioned by De Tocqueville, who, having forgotten the scientific origin of what they did, were at length compelled to copy without variation the inventions of an ancestry who, wiser than themselves, had drawn their inspiration direct from Nature.

PRACTICAL APPLICATIONS DEPENDENT UPON ANTECEDENT DISCOVERY.

To keep society as regards science in healthy play, three classes of workers are necessary: First, the investigator of natural truth, whose vocation it is to pursue that truth, and extend the field of discovery for the truth's own sake, and without any reference to practical ends. Secondly, the teacher of natural truth, whose vocation is to give public diffusion to the knowledge already won by the discoverer. Thirdly, the applier of natural truth, whose vocation it is to make scientific knowledge available for the needs, comforts, and luxuries of life. These three classes ought to co-exist, and interact upon each other.

It is at our peril that we neglect to provide opportunity for those studies and pursuits which have no practical rewards and from which therefore the rising genius of the country is incessantly tempted away. If great scientific results are not achieved in America, continued Professor Tyndall, it is not to the small agitations of society that I should be disposed to ascribe the defect, but to the fact that men among you who possess the genius for scientific inquiry are laden with duties of administration or tuition so heavy as to be utterly incompatible with the continuous or tranquil meditation which original investigation demands. I do not think this state of things likely to last. I have seen in America willingness on the part of the individuals to devote their fortunes in the matter of education to the service of the commonwealth, for which I cannot find a parallel elsewhere.

This willingness of private men to devote fortunes to public purposes requires but wise direction to enable you to render null and void the prediction of De Tocqueville. Your most difficult problem will be not to build institutions, but to make men; not to form the body, but to find the spiritual embers which shall kindle within that body a living soul. You have scientific genius among you; not sown broadcast, believe me, but still scattered here and there. Take all unnecessary impediments out of its way. You have asked me to give these lectures, and I cannot turn them to better account than by asking you in turn to remember that the lecturer is usually the distributor of intellectual wealth amassed by better men. It is not as lecturers but as discoverers that you ought to employ your highest men. Keep your sympathetic eye upon the originator of knowledge. Give him the freedom necessary for his researches, not overloading him either with the duties of tuition or of administration, not demanding from him so-called practical results—above all things, avoiding that question which ignorance often addresses to genius: "What is the use of your work?" Let him make truth his object, however impractical for the time being that truth may appear. If you cast your bread thus upon the waters, then be assured it will return to you, though it may be after many days.

A Needy but Liberal Inventor.

The Commissioner of Patents lately received the following letter from an inventor who stands in need of one thousand dollars:

JANY THE SIXTH,
CINCINATTI, OHIO.

Commissioners Esqs of the patent office. Dere sirs—if you will send me one thousand dollars Cash i will invent a improved self acting operating automaton mechinery and one million—after the mechine proves satisfaction if i dont accomplish it i will refund the money in ten years.

Experiments with the Lay Torpedo at Newport.

A second trial of the Lay Torpedo was recently made at the United States torpedo station on Goat Island, Newport harbor. After being launched the boat started off in good order, but, after having run some five eighths of a mile, she became unmanageable. The wire of her cable parted so that she refused to mind her port helm, describing a series of circles until her motive power was shut off. The total distance run was about two miles, which she accomplished in twenty minutes and thirty seconds.

HARNESS DRESSING.—Long continued observations show that harness and other leather, exposed to the action of ammonia continually given off in stables, becomes weak and rotten sooner than other leather. Even when care is taken to protect it with grease, this takes place. Professor Artus recommends the addition of a small quantity of glycerin to the oil or fat employed in greasing such kind of leather, asserting that it keeps it always pliable and soft.

Air Power.

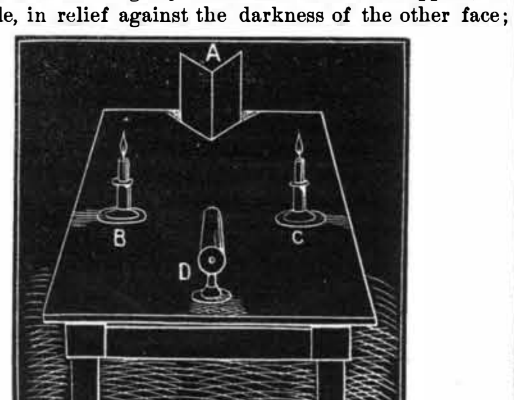
A letter from Brunswick, Me., to the Portland *Argus*, gives the following information relating to the use of air as a motive power in that village:

"On the Androscoggin River, some three fourths of a mile below the railroad station, is the site of a mill, long since burned, and the motive power which operates the condenser is a water wheel at the place. The wheel, it is said, is capable of driving four condensers of equal power with the one now in use. But it is only with results already accomplished, that we have to do. At the railroad station is an engine of ten horse power, running circular saws for sawing wood and various machinery in the blacksmith shop in the vicinity. Thence a small pipe passes on through the village, furnishing power to Worthly Brothers, jewelers, who are running a small engine of about one horse power. Parent and Dafriend also use an engine of two horse power in their blacksmith shop; Dennison & Co., box makers, an engine of two horse power, and Professor Brackett, of Bowdoin College, one of three horse power, for the manufacture of instruments, while the laboratory, of the College has one of six horse power. So that, nominally, this small condenser furnishes in all twenty-four horse power, and all unite in saying that the air power is much more efficient than steam in working the same engines; it does not drag, but recovers itself instantly from any strain or check, and is in every way a success."

REMARKS BY THE EDITOR.—The employment of pneumatic power for industrial purposes is constantly increasing. By its use the Mt. Cenis tunnel, through the Alps, seven miles in length, was bored. The Hoosic tunnel, in Massachusetts, five miles in length, now nearly finished, is being cut by the same means. The St. Gothard tunnel, in Switzerland, lately commenced, which is to be thirteen miles in length, will also be cut by means of compressed air. The Hell-Gate rocks, under the East River in this city, are in process of removal by the same agency. In planing mills, the pneumatic method is used to carry the shavings from the planers to the furnaces of the steam boilers; in grain and wool houses, to convey the stock. At the iron furnaces pneumatic elevators are used to lift the cars and their loads of ore from one point to another. In London the pneumatic method drives five ton freight cars in tubes under ground; the post office department of that city has now in use several miles of pneumatic tubes laid under the streets, in which letters are conveyed with great rapidity. In this country the largest scale on which the system has been applied is at the works of the Pneumatic Transit Company, on Broadway, where a railway passenger car, running in a nine foot tunnel under that street, is operated by compressed air. For an underground railway this pneumatic method is especially useful; cinders, gas, smoke, dust, noise and locomotives, all are avoided; the cars may be driven smoothly along with great rapidity. In England, some years ago, during the experimental trials of the pneumatic cars, the trains were driven by this method at a velocity of sixty miles per hour. The pneumatic car under Broadway has carried between two and three hundred thousand passengers, but, owing to the shortness of the tunnel, so high a speed cannot be reached. As soon as the Legislature grants the necessary authority, the works will be extended through the city from the Battery to Harlem river. New York will then be able to boast of having the safest, most agreeable and most rapid means of passenger conveyance of any city in the world.

A SIMPLE PHOTOMETER.

The photometer is an instrument used to compare the intensities of two lights. If, for instance, it is desired to determine whether the flame of one lamp is brighter than that of another, or if one kind of gas has greater illuminating power, according to M. Yoon the following simple and ingenious process may be employed: Bend an ordinary white card, as at A, in the accompanying illustration, so that the two faces will be at right angles, and stand it upright on a table. One of the faces is to be exposed to the light to be examined, and the other to the second light to which the first is to be compared. Let B and C be such lights, placed on lines perpendicular to the faces of the card. It is clear that if one is stronger than the other, one of the faces of the card will be more brightly illuminated and will appear, at the angle, in relief against the darkness of the other face;



but if the two lights are equal in intensity, the two sides of the card will be equally illuminated, and the appearance of relief will totally disappear. It is only necessary to practice moving the lights toward or from the faces until the relief at the angle becomes invisible, then to measure the distances from the lights to the corresponding faces on lines perpendicular to the latter. The intensity of each light will, of course, be inversely proportional to the square of its distance from the face of the card.

The experiment can be more satisfactorily performed by looking at the angle of the card through a small tube, as at D, or even through the hand partially closed.

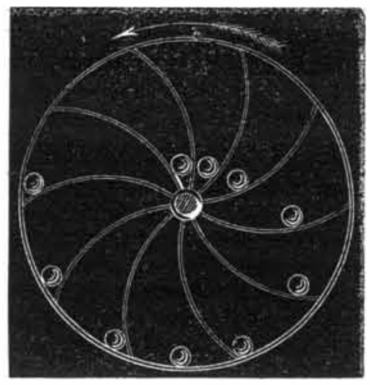
Correspondence.

Perpetual Motion.

To the Editor of the Scientific American:

In the SCIENTIFIC AMERICAN of January 18, I notice a question by A. J. S., respecting perpetual motion, and also the extremely simple experiment with the tub. Since valuable discoveries have been made by persons in search of such motion (Sir Richard Arkwright, for instance), I for one would like to encourage A. J. S. to persevere, as he might discover some motion, if not a "perpetual" one.

If, by reason of want of perseverance, muscular power, or moral influence, the experiment with the tub should fail, then let him make a wheel, as sketched, with spokes curved and with a groove on each side, so that a metal ball could run freely in it without falling out; let him place one of



these balls between each two spokes, and then, may be, he will see something move without the aid of either cog wheels or levers. If he does not, let him call upon

BRUMAGEM.

Williamsburgh, N. Y.

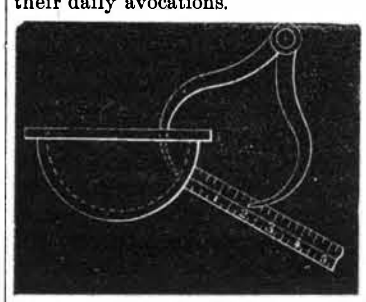
REMARKS BY THE EDITOR.—Our correspondent is evidently laboring under the impression that the example of perpetual motion which he presents differs in principle from the attempt of a man to lift himself in a tub. But a glance at his diagram ought to satisfy him that both plans are alike. One half of his balls pull up, the other half push down; just as the man in the tub pulls up with his hands and pushes down with his feet.

If our correspondent thinks that this wheel will move, why does he not try it? It is easily made. He will find that it stands still. He intimates that the plan he gives contains no levers. But every one of the curved spokes is a lever.

A Wrinkle.

To the Editor of the Scientific American:

A few days ago, having to get the thickness of a casting where the use of the calipers alone was impracticable, the idea here shown occurred to me, and I found it to be of great service. Pattern makers will doubtless find it useful in their daily avocations.



Hold a common rule, as shown, in line where it is required to know the thickness, and set calipers to some equal figure on the rule, say 2 inches; this allows the calipers to be removed without changing their distance. By measuring the calipers, the dimension above 2 inches will be the thickness. Various crooked bodies may be measured in this way, as well as the thickness of plates, etc., with flanges all round. JOHN WALKER.

Woodberry, Md.

An Invention Wanted.

To the Editor of the Scientific American:

I would pay a handsome sum for an invention (and it would be worth it) by which any music played on the piano could be reproduced. CHARLES T. SHELTON.

489 Chapel street, New Haven, Conn.

Bursting Cylindrical Boilers.

To the Editor of the Scientific American:

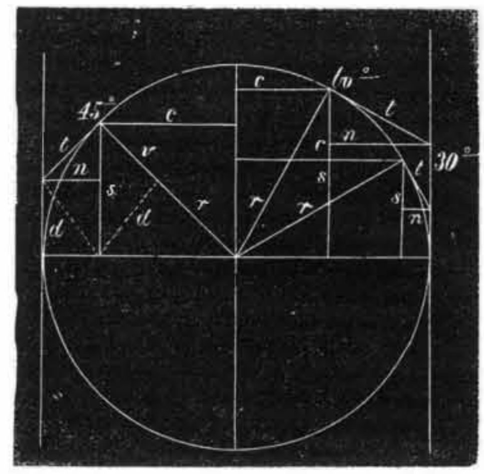
I was somewhat disappointed in the promised letter "to the point" by S. S., in the SCIENTIFIC AMERICAN of December 7.

The letter, however, with four formidable diagrams, is strong in proof of an undisputed point, namely, that the horizontal forces give the pressure, required to rupture, as the diameter. This singular oversight may be my excuse for repeating what I stated in your paper of October 19, to which S. S. refers. "Let the diameter be 1, the half circle 1·57, and the steam force 1 lb. per inch; then, by the resolution of the radial forces into horizontal and vertical, a steam force of ·637 lbs. will be the mean horizontal pressure on the half circle of 1·57, or $\cdot637 \times 1\cdot57 = 1$, being the diameter, and so far agreeing with the current error.

But, in the resolution of the vertical forces, we have a mean horizontal force from them of ·363 lbs. steam pressure on the half circle, or $\cdot363 \times 1\cdot57 = \cdot57$, in addition to the former, exclusively horizontal. I further repeat in substance, from my reply to Mr. Creuzbaur of December 14, that, without the action of the vertical forces, the ring would be elongated horizontally, unless arrested by the ignored vertical forces, to preserve the circle, and at the expense of increased strain on the said horizontal forces.

The direct horizontal pressure of ·637 lbs. is the mean of the cosines, and the additional derived from the vertical, of ·363 lbs., is the mean of the complement to the cosines. It is incumbent on the diameter advocates to dispose of the vertical forces in some way, and not evade or rule them out of existence by labored and fruitless efforts.

Some of my communicants are on the "anxious seat," and desire to know how I arrive at the mean additional force of ·363 from the vertical forces. For their information, I refer to the diagram:



REFERENCES TO DIAGRAM.—*r*, *r*, *r*, radii; *t*, *t*, *t*, tangents to radii; *s*, *s*, *s*, sines and vertical forces; *c*, *c*, *c*, cosines and horizontal forces; *n*, *n*, *n*, horizontal forces from the vertical.

VALUES.—At 30°, sin. ·500, cos. ·866, tangt. ·268, *n* ·134; at 45°, sin. ·707, cos. ·707, tangt. ·4144, *n* ·293; at 60°, sin. ·860, cos. ·500, tangt. ·5774, *n* ·500.

FORMULÆ.—At 30°, $r : s :: t = n$, ·134; at 45°, $r . s :: t = n$, ·293; at 60°, $r : s :: t = n$, ·500.

If the test of the parallelogram law be applied, we have for example the vertical force on sine at 45° resolved into the forces or lines *t* and *v*, the dotted lines completing the parallelogram. It is strange that so great a geometrical error as 57 per cent should so long have remained undiscovered or taken for granted. Its ramifications are numerous and important. The error assigns to a sphere the explosive pressure as the area of the bi-section, instead of the entire in-surface of the hemisphere.

I am aware of the responsibility of opposing an opinion hitherto considered invulnerably orthodox; but I am sustained by eminent scientists, both of England and this country; and by a recent letter from Professor Henry, of the Smithsonian Institute, I have his entire approval of my position. THOMAS W. BAKEWELL.

Pittsburgh, Pa.

The Superheated Steam Question.

To the Editor of the Scientific American:

If the discussion upon the superheated steam question is not closed, allow me to give your readers the following facts for their consideration:

The pumping engine of these works is supplied with steam from an ordinary tubular boiler, but, for the purpose of testing the comparative efficiency of the Miller boiler, the inventor was allowed to locate his boiler in the rear of the tubular boiler and connect with the same steam pipe. For the testing, a run of forty-eight successive hours with each boiler was contemplated, and was begun during the month of August last. We made and completed our first forty-eight hours run with the tubular boiler with no results that bear on this subject. The Miller boiler consists of a series of sections of tubes about three inches in diameter by ten feet long, arranged so as to give two in a horizontal row and five in a vertical row to each section, the size of the boiler being made up of the number of sections. Of these five vertically arranged tubes, four are inclined at an angle of about 30° with the horizon and the fifth is horizontal. The inclined tubes are water tubes, having interior circulating tubes of about an inch and a quarter diameter. One end of these water tubes is closed, the other connecting into a casting common to a section. The fifth or upper tube is for superheating, and it is so arranged interiorly that it is almost impossible for water to enter it. There are other pipes and connections which I need not describe here, my aim being to show that the same fire that reaches the water tubes also reaches the superheating tube. Unfortunately we had no thermometer in the steam pipe; but one in the steam chest indicated a temperature of 316°, when that due to saturated steam was about 236°, showing about 80° of superheat.

We commenced our run with the Miller boiler at 9.30 A. M. on August 22, 1872. The pressure of steam carried was about the same as on the other boilers, namely, 65 pounds. The temperature due to this pressure is 298°, and assuming that the superheating did not exceed 80° the temperature of the steam was about 378°. The steam cylinders are steam jacketed, and covered with felting and black walnut lagging. Pine ribs touch the cylinders, to which the lagging is fastened. At about 1.30 P. M., smoke began to creep through the crevices of the lagging near the steam chests, and it constantly increased from that time. I then had no apprehensions that it would actually set the lagging on fire, although the smoke continually increased in volume. At 3.20 P. M., while I was absent from the engine room for a few minutes, it increased very rapidly, so much so that it drove the men out of the