impossible to tell where it really comes to an end. "A linear thermopile, such as is commonly used, is liable under these circumstances to give deceptive results; and any error in its indications counts in a double manner; it not only diminishes the value of one spectrum, but adds that diminution to the value of the other." Thus an error of only two millimeters in estimating the position of the extreme red would have taken so much from the invisible and added it to the visible that the two would be brought to an equality; then the slightest turn of the screw, that carried the pile toward the dark space, would have given a preponderance to the visible. "It is obvious, therefore, that there cannot be certainty in such measures unless fixed lines are resorted to as standard points."

This done, the destruction of Tyndall's position is complete. The optical center of the spectrum is the ray which, according to Angstrom's determinations, has the wave length of 5,768. Now if the rays on two sides of this line be brought to seperate foci and their thermal effects carefully measured, it is obvious that any excess of heat at either end of the spectrum will be speedily detected. By an ingenious apparatus described at length in the memoir, Dr. Draper did so compare the heating power of all the less refrangible rays with that of all the more refrangible, using prisms of various material, and making some hundreds of observations on an unclouded sun. Taking 100 as the standard for the heating power of the entire spectrum, the mean of four sets of measures, with a prism of rock salt, gave 53 for the heat of the more refrangible region, and 47 for the less refrangible. Another series of three sets gave for the two regions 51 against 49. With a prism of flint glass, two series, one of ten sets of measures and the other of eight, gave respectively 49 to 51 and 52 to 48. Two series of the same number of experiments with a prism of bisulphide of carbon gave 52 to 48, and 49 to 51, respectively for the more refrangible and the less refrangible rays. With a quartz prism, twenty-seven experiments gave 49 to 51; while another set of twelve gave 53 as the mean for the more refrangible and 47 for the less. These are given as fair examples of results obtained by a multitude of experiments during several months, including winter and summer. The heating powers of the two halves of the spectrum show such close correspondence that we may safely follow Dr. Draper's lead and impute the differences to errors of experimentation.

The second memoir on chemical action of the spectrum, published in December, 1872, proves even conclusively that every part of the spectrum, no matter what its refrangibility may be, can produce chemical changes: and that the "actinic curve," so-called, does not represent any peculiarities of the spectrum, but simply the habitudes of certain compounds of silver. As a logical consequence, the supposed triple constitution of the sun ray must be dropped among the myriad other dead delusions that mark the onward course of Science, as the skulls of perished camels mark the course of a caravan. There is in the sun ray neither light nor heat nor chemical power, as such, but simply vibrations, which, when stopped, may manifest themselves in one or other or all of these phases of phenomena according to the nature of the extinguishing substance. "The evolution of heat, the sensation of light, the production of chemical changes, are merely effects, manifestations of the motions imparted to ponderable atoms."

It was a matter of surprise to many that, during his lectures here, Professor Tyndall did not so much as mention these important researches, not even to question the justness of Dr. Draper's conclusions. It is perhaps still more surprising that he has since as carefully refrained from publicly discussing them, yet still continues to teach the old doctrine.

It would be asking too much, perhaps, to expect Professor Tyndall to reconsider his subject in the face of the numerous and imperative engagements, that had been made for him here, but surely time enough has since elapsed to allow him to do so. The omission of any reference to Dr. Draper's later work, even in a foot note in the edition of the lectures published by the Appletons, might be excused for the same reason. But what can we think, when the English reprint retains the old teachings without the suggestion of a doubt in regard to their correctness? To put it in the mildest form, it places Professor Tyndall in a slightly equivocal position for one who boasts himself an unprejudiced seeker after truth, for the truth's sake.

It is reported that, when his attention was called to Dr. Draper's researches, Professor Tyndall—repeating his favorite Alpine figure—said that his investigations had raised such a Matterhorn of heat at the red end of the spectrum that it was impossible to get over it, short of a year at least. The year has passed; is there still a Matterhorn of pride to be surmounted?

WHITWORTH STEEL.

Sir Joseph Whitworth has recently published a valuable work, in which he gives an exhaustive account of his method of casting and rifling steel guns. It will be remembered that, some time ago, we published an account of the remarkable performances of the nine pounder cannon of the above inventor, and also referred to the crucial test caused by the explosion of $1\frac{1}{2}$ lbs. of powder in a cylinder of fluid compressed steel, in which no other opening was left save that of the vent. The cylinder was a copy of the breech of the nine pounder gun, and it was estimated that the strain would be six times greater than if the shot were allowed to leave the piece. The projectile was screwed in, and the charge fired. Although all the gas escaped through the vent, which was thereby enlarged from one to two tenths of an inch, no alteration could be detected in the external or internal dimensions of the cylinder.

In explaining the nature of his steel, the author states that it is impossible to cast a large gun of highly carbonized steel that can be relied upon as perfectly sound. With a small amount of carbon in its composition, however, the metal becomes so ductile that it will elongate under pressure from 30 to 50 per cent before breaking, and then will not fly in pieces, but only bulge and tear. To obviate the defect of honeycombing in steel of this description, recourse was had to extreme pressure upon the metal while in a fluid state, equal in some cases to twenty tons per square inch. As a measure of the quantity of air expelled by this process and the consequent improvement in density and soundness, it is stated that, within five minutes after the application of pressure, the fluid column will be shortened by an inch and a half per foot of length; and drawing out and forging develops, in a still higher degree, the strength of the material. It is cast in hollow cylinders, for reasons connected with rapid cooling and the more complete exclusion of air, and is manufactured in thirteen qualities, ranging from a tensile strength of 40 tuns per square inch to one of 72 tuns, the ductility at the two extremes being respectively 32 and 14 per cent.

The invention is of the highest importance, not only in its application to weapons of war, but to the more useful implements of peace. For steam boilers and railroad axles, it would seem that steel of such extreme strength must be invaluable.

A PAPER AND GLASS DEBATE.

A correspondent sends us a couple of interesting questions, which, he informs us, are to be the subject of a debate, relating to the merits of paper and glass. The first is: "Providing we had no paper, what other substances may be mentioned that would take its place?" and the second, "Providing we had no glass, what are its possible substitutes?" Of course the idea is to bring out, in the present connection, not names of substances which may be advantageously used instead of the above named almost indispensable materials, but of such as we probably would employ (and of many of which in fact our ancestors did avail themselves) did glass or paper cease to exist or become unattainable. The case is imaginary but leads to much instructive thought.

In lieu of glass, we can find materials suitable for window panes, for drinking vessels, and in some cases even superior to it for small lenses, but nothing that combines all its properties, or is capable of its ready manipulation into desired forms. For windows, perhaps the best substance other than glass is simple mica, which may be readily split from the rock in thin translucent sheets It is now used for doors of stoves, to protect paper shades around gas lights, and in other common employments. The Romans filled their windows with *lapis specularis*, a fossil of the class of mica, which is readily cloven into thin smooth laminæ. The same substance is found in the Island of Cyprus, in masses a foot in breadth and three inches in thickness. It is used for the construction of hot houses, and for the protection of delicate plants. Up to the present day it is also much employed in Russia, in place of glass for windows.

Horn cut into sheets is still used for lanterns, and for drinking vessels, and, if made sufficiently thin, would answer for illuminating purposes. Oiled linen or other fabric, similar to that now used by draftsmen for tracing, would also be available, and so would very delicate sheets of india rubber. Skins, prepared like parchment or vellum, would be translucent though not transparent. Gelatin, however, might be treated with bichromate of potash so as to be insoluble, and if it would stand the weather would give quite clear window lights. Collodion films, we should imagine, if made thick enough, could also be used for the purpose, as also animal membrane.

In addition of mica, the mineral kingdom offers a variety of substances. There is the Brazilian pebble, a species of quartz, now used in an immense extent for spectacles and other lenses. We have seen perfect spheres of this material three inches in diameter, without a single speck or flaw to blemish its complete transparency. Rock crystal and other varieties of quartz might also be employed, if means could devised to cut them properly; so could plates of selenite, of thin alabaster, or even of rock salt, though the latter would not be very durable. Some shells are sufficiently thin to be translucent, and ivory could be made into plates having the same property. Amber would be transparent enough but difficult to obtain while, like ivory it would be rather costly. Large leaves of trees, if chemically treated, might have their texture preserved and serve to cover windows if other means failed; or if the dwelling were located in polar latitudes, one might follow the example of the Esquimaux and use blocks of clear ice.

In recalling substitutes for paper, many of the materials, suggested in place of glass owing to their translucency, would, from their flexible nature, answer even more suitably for writing purposes. Such is evidently the case with parchment, membrane, cloth, horn, rubber, collodion, or gelatin sheets. We might go back to graven tablets, like the Moabite stone, or write with the stylus upon wax, as did the ancients; in fact, there are numberless modes of inscribing our thoughts on solid substances. But paper has a multitude of other uses, especially in these days of paper clothing, paper furniture, paper churches, and paper money. Hence materials are needed with more of its attributes than simply its use as a vehicle for the dissemination of our ideas. The same source of supply, open thousands of years ago, is still at hand, for the papyrus tree flourishes yet in Egypt and Sicily. The bark of the common white birch may also be employed; or by ingenious machines we can cut shavings of fine grained wood to serve in place of hangings for our walls. Sheets of metal, rolled to almost infinite attenuation, would, however, probably form the most favored substitute. About two years ago the Upper Forest Tin Works, in Wales, rolled the most delicate sheet of iron ever made. The metal was worked in a finery with charcoal and the usual blast, then forged into a bar, and finally passed through the tin rolling mills. When finished, the sheet was 10 inches by $5\frac{1}{2}$ inches in dimensions or 55 inches in surface, and weighed but 20 grains. It would require 4,800 such layers to make up a mass one inch in thickness. Letters have been sent across the Atlantic on iron thinner than ordinary paper, and nearly as light. Steel, iron, and copper could thus be pressed into service; and where flexibility was necessary, probably alloys could be made to answer the purpose.

SCIENTIFIC AND PRACTICAL INFORMATION.

A TEST OF THE AUTOMATIC TELEGRAPH.

A public test of the automatic system of telegraphy recently took place on a single wire between this city and Washington. The matter transmitted was the President's late message, with the Spanish protocol attached, numbering 11,130 words, it having been selected in consequence of the declaration that its transmission over eight wires by the Western Union Company, on December 2, 1873, was a fact unparalleled in telegraphy.

The President of the Automatic Telegraph Company submits a report, which is corroborated by the testimonials of various well known gentlemen who witnessed the trial, to the effect that the entire document was copied complete in New York in 58 minutes from the time of the beginning of the sending in Washington. Ten perforators, thirteen copyists, and two Morse operators were employed, as against sixteen expert Morse operators by the Western Union people. The average pay of perforators and copyists is $40 per month; of operators, $100.

A NEW ACOUSTIC PYROMETER.

It will be remembered that, some time ago, we gave an account of an acoustic pyrometer, devised by Professor Mayer, of the Stevens Institute. The principle on which the instrument is based is the variation of the length of a sonorous wave in air, when the temperature of the latter is changed.

Mr. Chautard states, in *Les Mondes*, that in his opinion the method proposed by Dr. Mayer is difficult in application, and he suggests the following arrangement as more suitable for practical requirements:

The sound is produced by the aid of an organ tube, Ut 4, for example, disposed with reference to a resonator which is put in relation with the two branches of a König improved interference apparatus. To the movable branch is attached a long tube of copper, which enters the furnace or other locality, the temperature of which it is desired to determine. This tube returns on itself and communicates with a small manometric capsule. The fixed branch of the apparatus is terminated by another capsule, which, like the first, is in relation with the same source of heat. The arrangement is completed by a revolving mirror, in which the state of the flame is seen.

Thus disposed, if the pipes which separate the resonator from the capsules each contain an equal number of half wave lengths, the flame will be edentulated; in the contrary case, the indentations will diminish, and this as much more as the difference of length of the tubes is more nearly equal to an unequal number of half wave lengths. In the latter event, the flame takes, in the mirror, the aspect of a ribbon; and by noting the changes in its appearance the calorific state of the air in the tube in the furnace is determined. If the temperature is elevated, the length of wave augments, and a clearly defined interference is shown by the flame in the mirror. If, during the continuance of the experiment, the movable tube be gradually elongated, it will be easy to bring the flame back to its primitive state, that is, to cause the indentations to re-appear. Then, by the aid of a scale previously determined and empirically translated into thermometric degrees, the degree of temperature in the tube can be easily noted.

TO NEW SUBSCRIBERS.

All subscriptions to the SCIENTIFIC AMERICAN will be commenced with the year, unless persons, at the time of remitting, request to the contrary. Nearly all subscribers preserve their numbers for binding; and in most cases where subscriptions are received during the first quarter of the year, if the back numbers are not sent, they are subsequently ordered. To save both the subscribers and ourselves trouble, the back numbers from January 1 will be forwarded, unless we are advised to the contrary. This course will be pursued till April 1, after which date the paper will be sent from the time of receipt of remittance; but subscription may commence at any time, at the request of the subscriber, The above regulation applies only to those who give no instructions, at the time of remitting, as to when they desire to commence.

G. D. says: "I think there is a great deal of humbug about the Troy chainmakers, in the paragraph from the Troy *Times*. Any good smith can make chain, and England is full of them; they would be glad to get one half of the wages mentioned."

A CORRESPONDENT, O. A. O., reports that in Sebastopol, Cal., from November 1, 1873, to January 14, 1874, the enormous quantity of 33 inches of water fell, in the form of rain and snow.