SCIENTIFIC USE OF THE IMAGINATION.

John Tyndall, LL.D., F.R.S., before the British Association.

I carried with me to the Alps this year the heavy burden of this evening's work. In the way of new investigation I had nothing complete enough to be brought before you; so all that remained to me was to fall back upon such residues as I could find in the depths of consciousness, and out of them to spin the fiber and weave the web of this discourse. Save from memory I had no direct aid upon the mountains; but to spur up the emotions, on which so much depends, as well as to nourish indirectly the intellect and will, I took with me two volumes of poetry, Goethe's "Farbenlehre," and the work on "Logic" recently published by Mr. Alexander Bain. The spur, I am sorry to say, was no match for the integument of dullness it had to pierce.

In Goethe, so glorious otherwise, I chiefly noticed the self-inflicted hurts of genius, as it broke itself in vain against the philosophy of Newton. For a time Mr. Bain became my principal companion. I found him learned and practical, shining generally with a dry light, but exhibiting at times a flush of emotional strength, which proved that even logicians share the common fire of humanity. He interested me most when he became the mirror of my own condition. Neither intellectually nor socially is it good for man to be alone, and the griefs of thought are more patiently borne when we find that they have been experienced by another. From certain passages in his book I could infer that Mr. Bain was no stranger to such sorrows. Take this passage as an illustration. Speaking of the ebb of intellectual force which we all from time to time experience, Mr. Bain says: "The uncertainty where to look for the next opening of discovery brings the pain of conflict and the debility of indecision." These words have in them the true ring of personal experience.

The action of the investigator is periodic. He grapples with a subject of inquiry, wrestles with it, overcomes it, exhausts, it may be, both himself and it for the time being. He breathes a space, and then renews the struggle in another field. Now this period of halting between two investigations is not always one of pure repose. It is often a period of doubt and discomfort, of gloom and ennui. "The uncertainty where to look for the next opening of discovery brings the pain of conflict and the debility of indecision." Such was my precise condition in the Alps this year; in a score of words Mr. Bain has here sketched my mental diagnosis; and it was under these evil circumstances that I had to equip myself for the hour and the ordeal that are now come.

Gladly, however, as I should have seen this duty in other hands, I could by no means shrink from it. Disloyalty would have been worse than failure. In some fashion or other—feebly or strongly, meanly or manfully, on the higher levels of thought, or on the flats of commonplace—the task had to be accomplished. I looked in various directions for help and furtherance; but without me for a time I saw only "antres vast," and within me "deserts idle." My case resembled that of a sick doctor who had forgotten his art, and sorely needed the prescription of a friend. Mr. Bain wrote one for me. He said: "Your present knowledge must forge the links of connection between what has been already achieved and what is now required."

In these words he admonished me to review the past and recover from it the broken ends of former investigations. I tried to do so. Previous to going to Switzerland I had been thinking much of light and heat, of magnetism and electricity, of organic germs, atoms, molecules, spontaneous generation, comets, and skies. With one or another of these I now sought to re-form an alliance, and finally succeeded in establishing a kind of cohesion between thought and light. The wish grew within me to trace, and to enable you to trace, some of the more occult operations of this agent. I wished, if possible, to take you behind the drop-scene of the senses, and to show you the hidden mechanism of optical action. For I take it to be well worth the while of the scientific teacher to take some pains, and even great pains, to make those whom he addresses copartners of his thoughts. To clear his own mind in the first place from all haze and vagueness, and then to project into language which shall leave no mistake as to his meaning—which shall leave even his errors naked—the definite ideas he has shaped.

A great deal is, I think, possible to scientific exposition conducted in this way. It is possible, I believe, even before an audience like the present, to uncover to some extent the unseen things of nature, and thus to give, not only to professed students, but to others with the necessary bias, industry, and capacity an intelligent interest in the operations of science. Time and labor are necessary to this result, but science is the gainer from the public sympathy thus created.

How then are those hidden things to be revealed? How, for example, are we to lay hold of the physical basis of light, since, like that of life itself, it lies entirely without the domain of the senses? Now, philosophers may be right in affirming that we cannot transcend experience. But we can, at all events, carry it a long way from its origin. We can also magnify, diminish, qualify, and combine experiences, so as to render them fit for purposes entirely new. We are gifted with the power of imagination, combining what the Germans called *Anschauungsgabe* and *Einbildungskraft*, and by this power we can lighten the darkness which surrounds the world of the senses.

There are tories even in science who regard imagination as a faculty to be feared and avoided rather than employed. They had observed its action in weak vessels and were unduly impressed by its disasters. But they might with equal justice point to exploded boilers as an argument against the use of steam. Bounded and conditioned by co-operant reason, imagination becomes the mightiest instrument of the physical discoverer. Newton's passage from a falling apple to a falling moon was a leap of the imagination. When William Thomson tries to place the ultimate particles of matter between his compass points, and to apply to them a scale of millimeters, it is an exercise of the imagination. And in much that has been recently said about protoplasm and life we have the outgoings of the imagination guided and controlled by the known analogies of science. In fact, without this power our knowledge of nature would be a mere tabulation of co-existences and sequences. We should still believe in the succession of day and night, of summer and winter; but the soul of force would be dislodged from our universe; casual relations would disappear, and with them that science which is now binding the parts of nature to an organic whole.

I should like to illustrate by a few simple instances the use that scientific men have already made of this power of imagination, and to indicate afterwards some of the further uses that they are likely to make of it. Let us begin with the rudimentary experiences. Observe the falling of heavy rain drops into a tranquil pond. Each drop as it strikes the water becomes a center of disturbance, from which a series of ring ripples expands outwards. Gravity and inertia are the agents by which this wave motion is produced, and a rough experiment will suffice to show that the rate of propagation does not amount to a foot a second.

A series of slight mechanical shocks is experienced by a body plunged in the water as the wavelets reach it in succession. But a finer motion is at the same time set up and propagated. If the head and ears be immersed in the water, as in an experiment of Franklin's, the shock of the drop is communicated to the auditory nerve—the *tick* of the drop is heard. Now this sonorous impulse is propagated, not at the rate of a foot a second, but at the rate of 4,700 feet a second. In this case it is not the gravity but the *elasticity* of the water that is the urging force. Every liquid particle pushed against its neighbor delivers up its motion with extreme rapidity, and the pulse is propagated as a thrill. The incompressibility of water, as illustrated by the famous Florentine experiment, is a measure of its elasticity, and to the possession of this property in so high a degree the rapid transmission of a sound-pulse through water is to be ascribed.

But water, as you know, is not necessary to the conduction of sound; air is its most common vehicle. And you know that when the air possesses the particular density and elasticity corresponding to the temperature of freezing water the velocity of sound in it is 1,090 feet a second. It is almost exactly one fourth of the velocity in water; the reason being that though the greater weight of the water tends to diminish the velocity, the enormous molecular elasticity of the liquid far more than atones for the disadvantage due to weight. By various contrivances we can compel the vibrations of the air to declare themselves; we know the length and frequency of sonorous waves, and we have also obtained great mastery over the various methods by which the air is thrown into vibration. We know the phenomena and laws of vibrating rods, of organ pipes, strings, membranes, plates, and bells. We can abolish one sound by another. We know the physical meaning of music and noise, of harmony and discord. In short, as regards sound we have a very clear notion of the external physical processes which correspond to our sensations.

In these phenomena of sound we travel a very little way from downright sensible experience. Still the imagination is to some extent exercised. The bodily eye, for example, cannot see the condensations and rarefactions of the waves of sound. We construct them in thought, and we believe as firmly in their existence as in that of the air itself. But now our experience has to be carried into a new region, where a new use is to be made of it.

Having mastered the cause and mechanism of sound, we desire to know the cause and mechanism of light. We wish to extend our inquiries from the auditory nerve to the optic nerve. Now there is in the human intellect a power of expansion—I might almost call it a power of creation—which is brought into play by the simple brooding upon facts. The legend of the Spirit brooding over chaos may have originated in a knowledge of this power. In the case now before us it has manifested itself by transplanting into space, for the purposes of light, an adequately modified form of the mechanism of sound. We know intimately whereon the velocity of sound depends. When we lessen the density of a medium and preserve its elasticity constant we augment the velocity. When we highten the elasticity and keep the density constant we also augment the velocity. A small density, therefore, and a great elasticity are the two things necessary to rapid propagation.

Now light is known to move with the astounding velocity of 185,000 miles a second. How is such a velocity to be obtained? By boldly diffusing in space a medium of the requisite tenuity and elasticity. Let us make such a medium our starting point, endowing it with one or two other necessary qualities; let us handle it in accordance with strict mechanical laws; give to every step of our deduction the surety of the syllogism; carry it thus forth from the world of imagination to the world of sense, and see whether the final outcrop of the deduction be not the very phenomena of light which ordinary knowledge and skilled experiment reveal. If in all the multiplied varieties of these phenomena, including those of the most remote and entangled description, this fundamental conception always brings us face to face with the truth; if no contradiction to our deductions from it be found in external nature; if, moreover, it has actually forced upon our attention phenomena which no eye had previously seen, and which no mind had previously imagined; if by it we are gifted with a power of prescience which has never failed when brought to an experimental test; such a conception, which never disappoints us, but always lands us on the solid shores of fact, must, we think, be something more than a mere figment of the scientific fancy. In forming it that composite and creative unity in which reason and imagination are together blent, has, we believe, led us into a world not less real than that of the senses, and of which the world of sense itself is the suggestion and justification.

Far be it from me, however, to wish to fix you immovably in this or in any other theoretic conception. With all our belief of it, it will be well to keep the theory plastic and capable of change. You may, moreover, urge that although the phenomena occur *as if* the medium existed, the absolute demonstration of its existence is still wanting. Far be it from me to deny to this reasoning such validity as it may fairly claim. Let us endeavor by means of analogy to form a fair estimate of its force.

You believe that in society you are surrounded by reasonable beings like yourself. You are perhaps as firmly convinced of this as of anything. What is your warrant for this conviction? Simply and solely this, your fellow-creatures behave as if they were reasonable; the hypothesis, for it is nothing more, accounts for the facts. To take an eminent example, you believe that our president is a reasonable being. Why? There is no known method of superposition by which any one of us can apply himself intellectually to another so as to demonstrate coincidence as regards the possession of reason. If, therefore, you hold our president to be reasonable, it is because he behaves *as if* he were reasonable. As in the case of the ether, beyond the "*as if*" you cannot go. Nay I should not wonder if a close comparison of the data on which both inferences rest caused many respectable persons to conclude that the ether had the best of it.

This universal medium, this light-ether as it is called, is a vehicle, not an origin of wave motion. It receives and transmits, but it does not create. Whence does it derive the motions it conveys? For the most part from luminous bodies. By this motion of a luminous body I do not mean its sensible motion, such as the flicker of a candle, or the shooting out of red prominences from the limb of the sun. I mean an intestine motion of the atoms or molecules of the luminous body. But here a certain reserve is necessary. Many chemists of the present day refuse to speak of atoms and molecules as real things. Their caution leads them to stop short of the clear, sharp, mechanically intelligible atomic theory enunciated by Dalton, or any form of that theory, and to make the doctrine of multiple proportions their intellectual bourne. I respect the caution, though I think it is here misplaced. The chemists who recoil from these notions of atoms and molecules accept without hesitation the undulatory theory of light. Like you and me they one and all believe in an ether and its light-producing waves. Let us consider what this belief involves.

Bring your imaginations once more into play and figure a series of sound waves passing through air. Follow them up to their origin, and what do you there find? A definite, tangible, vibrating body. It may be the vocal chords of a human being, it may be an organ-pipe, or it may be a stretched string. Follow in the same manner a train of ether waves to their source, remembering at the same time that your ether is matter, dense, elastic, and capable of motions subject to and determined by mechanical laws. What then do you expect to find as the source of a series of ether waves? Ask your imagination if it will accept a vibrating multiple proportion—a numerical ratio in a state of oscillation? I do not think it will. You cannot crown the edifice by this abstraction. The scientific imagination, which is here authoritative, demands as the origin and cause of a series of ether waves a particle of vibrating matter quite as definite, though it may be excessively minute, as that which gives origin to a musical sound. Such a particle we name an atom or a molecule. I think the imagination when focused so as to give definition without penumbral haze is sure to realize this image at last.

To preserve thought continuous throughout this discourse, to prevent either lack of knowledge or failure of memory from producing any rent in our picture, I here propose to run rapidly over a bit of ground which is probably familiar to most of you, but which I am anxious to make familiar to you all.

The waves generated in the ether by the swinging atoms of luminous bodies are of different lengths and amplitudes. The amplitude is the width of swing of the individual particles of the wave. In water waves it is the hight of the crest above the trough, while the length of the wave is the distance between two consecutive crests. The aggregate of waves emitted by the sun may be broadly divided into two classes, the one class competent, the other incompetent, to excite vision.

But the light-producing waves differ markedly among themselves in size, form, and force. The length of the largest of these waves is about twice that of the smallest, but the amplitude of the largest is probably a hundred times that of the smallest. Now the force or energy of the wave, which, expressed with reference to sensation, means the intensity of the light, is proportional to the square of the amplitude. Hence the amplitude being one hundred-fold, the energy of the largest light-giving waves would be ten thousand-fold that of the smallest. This is not improbable. I use these figures, not with a view to numerical accuracy, but to give you definite ideas of the differences that probably exist among the light-giving waves. And if we take the whole range of solar radiation into account—its non-visual as well as its visual waves—I think it probable that the force or energy of the largest wave is a million times that of the smallest.

Turned into their equivalents of sensation, the different light waves produce different colors. Red, for example, is produced by the largest waves, violet by the smallest, while green is produced by a wave of intermediate length and amplitude. On entering from air into more highly refracting substances, such as glass or water or the sulphide of carbon all the waves are retarded, but the smallest ones most. This furnishes a means of separating the different classes of waves from each other—in other words, of analyzing the light. Sent through a refracting prism, the waves of the sun are turned aside in different degrees from their direct course, the red least, the violet most. They are virtually pulled asunder, and they paint upon a white screen placed to receive them "the solar spectrum."

Strictly speaking, the spectrum embraces an infinity of colors, but the limits of language and of our powers of distinction cause it to be divided into seven segments: Red, orange, yellow, green, blue, indigo, violet. These are the seven primary or prismatic colors. Separately, or mixed in various proportions, the solar waves yield all the colors observed in nature and employed in art. Collectively they give us the impression of whiteness. Pure unsifted solar light is white; and if all the wave constituents of such light be reduced in the same proportion, the light, though diminished in intensity, will still be white. The whiteness of Alpine snow with the sun shining upon it is barely tolerable to the eye. The same snow under an overcast firmament is still white. Such a firmament enfeebles the light by reflection, and when we lift ourselves above a cloud-field—to an Alpine summit, for instance, or to the top of Snowdon—and see, in the proper direction, the sun shining on the clouds, they appear dazzlingly white. Ordinary clouds, in fact, divide the solar light impinging on them into two parts—a reflected part and a transmitted part, in each of which the proportions of wave motion which produce the impression of whiteness are sensibly preserved.

It will be understood that the conditions of whiteness would fail if all the waves were diminished *equally*, or by the same absolute quantity. They must be reduced *proportionately* instead of equally. If by the act of reflection the waves of red light are split into exact halves, then, to preserve the light white, the waves of yellow, orange, green, and blue must also be split into exact halves. In short, the reduction must take place, not by absolutely equal quantities, but by equal fractional parts. In white light the preponderance as regards energy of the larger over the smaller waves must always be immense. Were the case otherwise, the physiological correlative, *blue*, of the smaller waves would have the upper hand in our sensations.

My wish to render our mental images complete causes me to dwell briefly upon these known points, and the same wish will cause me to linger a little longer among others. But here I am disturbed by my reflections. When I consider the effect of dinner upon the nervous system, and the relation of that system to the intellectual powers I am now invoking; when I remember that the universal experience of mankind has fixed upon certain definite elements of perfection in an after dinner speech, and when I think how conspicuous by their absence these elements are on the present occasion, the thought is not comforting to a man who wishes to stand well with his fellow creatures in general, and with the members of the British Association in particular. My condition might well resemble that of the ether, which is scientifically defined as an assemblage of vibrations. And the worst of it is that unless you reverse the general verdict regarding the effect of dinner, and prove in your own persons that a uniform experience need not continue uniform—which will be a great point gained for some people—these tremors of mine are likely to become more and more painful. But I call to mind the comforting words of an inspired though uncanonical writer, who admonishes us in the Apocrypha that fear is a bad counsellor. Let me then cast him out, and let me trustfully assume that you will one and all postpone that balmy sleep, of which dinner might, under the circumstances, be regarded as the indissoluble antecedent, and that you will manfully and womanfully prolong your investigations of the ether and its waves into regions which have been hitherto crossed by the pioneers of science alone.

(To be continued.)

THE POWER OF MODERN SKILL IN THE MECHANIC ARTS.

The great camp of Chalons had just been completed, a whole city of soldiers spread over the rolling plain of Mourmelon, and all Paris, ever thirsting after "something new," was full of anxiety to enjoy the brilliant spectacle. The military authorities at the capital deplored the distance that separated them from the army; the contractors were often behind in their supplies, and the committees sent down to examine many important questions were seriously hampered by the remoteness of the camp from their books and their colleagues. The Emperor, aware of these inconveniences, determined to connect the camp with Paris by a railway, and never was imperial order executed more promptly and triumphantly.

Fortunately, the Great Eastern Company, which had a line of railways running from Paris to Strasbourg, and approached the camp at the station of Chalons within a distance of about sixteen miles, was one of the richest and best-organized companies of France. It owned already then (in 1860) more than five hundred locomotives and twenty thousand cars, and the central administration in Paris, which had spent over one hundred million dollars on the road, could well afford to gratify the Emperor when he expressed a wish to have a branch railway built not only in a short time, but more quickly than the like had ever been known before. The directors at a glance perceived the advantage that would accrue to them from such an addition to their great work; and although the Emperor allowed them only ten days for surveys and preparatory labors, they at once assumed the contract.

The difficulties were by no means trifling, although the railway was so short. It had to cross the valley of the Marne at a considerable hight above its level, then the river itself and a canal running parallel to it, and, after several very short curves, to span once more a deep valley in which the Vesle flows, till it reached in a straight line of about two miles the camp itself. All this involved necessarily very heavy works, three bridges, and high enbankments.

On the 10th of July, in the evening, the representatives of the company laid before the Emperor—who took a great personal interest in the matter—the complete plans for the work. They expected, of course, that not much time would be allowed them for the execution, but they were not a little taken aback when Napoleon asked them if they would undertake to have the railway ready in two months. They consulted a few minutes with each other, during which they were left alone, but soon the Emperor returned and demanded their answer. They claimed that the difficulties were very great and the time too short; nevertheless they engaged to do the Emperor's will, if he, on his part, would order the authorities, from the Minister of Public Works down to the district officials, to dispense with all but the most necessary formalities.

The promise was given, and on the very next day, early in the morning, they received the contract duly authenticated, thus giving an earnest on the part of the Government that everything should be done to aid them in their remarkable enterprise. At noon a meeting of the directors took place, at which matters were generally arranged, and when the sun set that evening the first spade had been struck in the ground near Chalons.

The first trouble—for troubles there were, many and grievous—was the want of laborers. The best and most experienced hands were sent for by telegraph from all the different works of the Great Eastern Company; they appeared in every express train from Loraine, Burgundy, and Alsatia—others were imported from Belgium, Westphalia, and Prussia; they received the highest wages, but were also required to do full work and in the best manner. Thus a force of twenty-four hundred first-class workmen was gathered in a few days around the first mile.

Next, all the powerful engines and machinery of the whole line were put into requisition; steam-rams, track-engines, circular saws set to work along the line, and torches, bonfires, and electric lights supplied the light of day during the short summer nights, so that relays of laborers could succeed each other without interruption. The company, moreover, provided for their food in the most careful manner. A famous Paris restaurateur, Chevet, was engaged to furnish cooked provisions for the little army of workmen, and a couple of days after the beginning of the marvelous work, his movable kitchens were seen along the line, furnishing a supply of excellent dinners, from six francs for the higher employes down to ten cents for the workmen.

All these interesting features—the almost magic rise of a railway in a heavy chalk soil, the wonderful activity of thousands of skillful laborers on so short a distance, and the almost fairy-like illumination at night—attracted immense numbers of Parisians, who came by day and by night to witness the strange sight, and brought a rich reward at once to the enterprising company.

High and large enbankments were of course out of the question under such circumstances, and the company adopted, therefore, our own system of trestle-work instead, planting immense piles by means of hundreds of steam-rams, which went to work at one and the same time, strengthening them simultaneously by heavy cross timbers, and laying the track without delay on the solid structure. One such trestle bridge, two thousand feet long, crossed the valley of the Marne, a second, of only five hundred feet, that of the Vesle, and a third, of six hundred feet, the lowlands of a smaller stream. When the whole line was completed, these trestle-works were filled up with earth, and at leisure changed into huge embankments. The principal bridge, however, was from the first placed upon solid béton foundations.

The construction began, of course, at Chalons, so as to remain constantly in direct communication with Paris, from which all the material and the supplies had to be obtained. An electric telegraph line was likewise erected along the route, with a station at every thousand yards, so that not a moment was lost by the sending of messages and orders, and directions could be issued at once to every part of the line. The track spun out like a ribbon, with all the necessary additions of crossings, turnouts, barriers, fencing on both sides, station buildings; in fact, everything that belongs to the most complete outfit of a first-class railway; and as soon as the rails were laid down, locomotives came up cautiously with new material and supplies for the workmen. The country through which the new line passed was fortunately not very rich, and hence the owners of land, struck by this unheard-of display of energy and capital combined, willingly ceded their rights and offered their assistance in every available shape.

It was said then, and it has since been confirmed by the Emperor's own admission, that he suggested this exploit in no wanton desire to prove his power and to excite wonder and admiration, but with a view to ascertaining what could be done under similar circumstances in time of war by the aid of the absolute power of a commanding general. He attained his end in the most satisfactory manner. On the fifty-sixth day after the first blow had been struck, the locomotive passed over the whole line from the station at Chalons to the terminus in the center of the camp; during the next five days the station buildings, restaurants, and waiting rooms were completely finished, and on the sixty-first day the Emperor opened the new railway in person, expressing his high satisfaction at the unexpected success in the most impressive words, and bestowing brilliant rewards upon the chief agents in the great enterprise.—*Lippincott's Magazine.*

Iron Plated Steamer "Captain."

The Naval Court appointed to investigate the causes which led to the loss of the iron-plated ship *Captain,* noticed on page 186 of this volume, have concluded their labors, and have returned a satisfactory verdict.

We, says *Engineering,* expressed plainly our opinion that the calamity which befel the *Captain* arose purely from the want of stability inherent in vessels of her particular class, while we further stated that the vessel "was built in opposition to all scientific principles, and in deference to a newspaper outcry, of which the loudest notes were uttered in the *Times;* and these views are fully corroborated by the verdict just returned, and by the evidence laid before the Court. Briefly stated, the plain facts of the case appear to have been these: Captain Coles advocated the construction of a sea-going turret ship, with a low freeboard, and he complained that in the *Monarch* and other turret ships built under the direction of the Admiralty, his plans had been by no means fairly carried out. Meeting with advocates of his plans in some members of Parliament, and in the conductors of certain newspapers, he was enabled, at length, to bring such an amount of pressure to bear upon the Admiralty that, in direct opposition to the advice of Mr. Reed and his department, an order was given for the construction of the *Captain* in strict accordance with Captain Cole's design. The contract for the construction of the *Captain* was taken by Messrs. Laird, and it appears to us to be proved, beyond all doubt, by the evidence offered at the court-martial, that on Messrs. Laird and Captain Coles, jointly, the entire responsibility of the non-success of the *Captain* rests. In saying this we have no desire to affirm that either Messrs. Laird or the late Captain Coles are alone responsible for the fearful loss of life to which the construction of the *Captain* has led. This responsibility we consider to have been shared by those under whose orders the ship was placed in commission. The *Captain* was acknowledged, on all hands, to be a purely experimental vessel, and, considering that she was built in direct opposition to the strongly-expressed opinions of Mr. Reed and his department, it would only have been reasonable to suppose that, before sending her on a cruise, experiments should have been made to determine what her stability really was, and, in fact, every practicable means taken to ascertain, as far as possible, what her performance at sea might be expected to be.

It has been hinted in some quarters that Mr. Reed was to blame in not having himself taken means to prove experimentally the unseaworthiness of the *Captain,* and in not having caused official information of her presumed want of stability to be conveyed to Captain Burgoyne. In this view we cannot agree. Mr. Reed opposed the construction of the *Captain* both publicly and privately, and when, in spite of his opposition, and that of Sir Spencer Robinson, it was resolved that the vessel should be built, he and the Controller considered that they ceased to be responsible. In fact Mr. Reed said in evidence, "so strongly did I feel that we were clear of all responsibility, that I forbade my assistants to ever use the word 'approved' even for the most minor details, and directed them never to use a stronger phrase, even with regard to the smallest details, than 'that no objection would be offered.'" Moreover, although Mr. Reed had many objections to the *Captain,* he does not appear to have apprehended any imminent danger from the vessel being sent to sea. To quote his own words, he thought "she would have the highest possible reports to begin with; that she would be very carefully nursed through her early career, admissions of her deficiencies being slowly made; and that before she got through her commission she would be utterly condemned as unfit for the naval service." His evident opinion was that the defects of the vessel would have been discovered by those in charge of her, before any danger resulted from them, and having freely expressed his opinions of her unseaworthiness, he felt that he could do nothing until the correctness of his opinions was acknowledged. Unfortunately the eyes of those under whose auspices the *Captain* was called into existence only became opened by the sad story of her having foundered; and thus in place of the nation having to sustain a mere monetary loss, as would have been the case had the Captain been condemned as unseaworthy, it has, in addition to this loss, to mourn the death of Captain Burgoyne and his gallant crew. The fate of the *Captain* conveys a lesson which we trust that the Admiralty will take to heart, and this lesson is that it is dangerous to disregard warnings founded on scientific knowledge. It is a false system which places the man on whom the whole responsibility of the designing of the vessels of our navy presumably rests in a position subservient to those who, however great their administrative powers may be, possess no knowledge whatever of naval construction; and we trust that some day a reform may be effected.

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Iron for ships is rapidly superseding wood in English ship yards. In 1865 there were 806 wooden ships built in England. In 1869 but 324. In 1868 the tunnage of iron ships built was 235,937, against 66,977 wooden, and 24,121 of composite. Iron ships are more durable, require less repairs and stand heavier storms than those of wood, and it will not be long till the latter must be entirely superseded.