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FLEXIBLE PROPELLERS.

BY JAMES REDDIE, Esq.

Member of the United Service Institution.

WHEN I had the honour of being offered the privilege of reading a paper in this Institution, on the subject of "Flexible Propellers for Boats and other Vessels," I ventured to accept that offer while I had every reason to believe that what I should have to communicate was perfectly new, and in hope that this novelty would go far to counterbalance all imperfections in my treatment of the subject; and I also hoped to have been able, not merely to propound a theory, but to communicate the result of complete and satisfactory experiments, establishing the usefulness of the invention. In both respects, I regret to say, I have been somewhat disappointed.

To find out that they have been anticipated is I fear the too common discovery of inventors; but it is equally a fact, that scarcely any of the most important and useful inventions have been brought to anything by those who first thought of them, but the same thing has had to be "invented" over and over again, before it has been adopted, or any practical results have been attained. Hence the national and individual claims and counter-claims, as regards the invention of the steam-engine, of steam vessels, the paddle and screw propeller, and even, at the present moment, as regards super-heated steam. With respect to the paddle-wheel, we generally associate it with the names of Miller, Taylor, and Symington, or Fulton, as the original inventors, and divide the honour between Britain and America; but about 100 years before, namely, in 1690, it appears that Denis Papin first proposed to use steam to work paddle-wheels, and it is asserted in a French work that Papin in 1707 actually propelled a vessel on the Fulda by an engine invented by Savery in 1702. The first patent granted for a steam-boat in England dates in 1736, to Jonathan Hulls, exactly 50 years before the successful experiments made with Miller, Taylor, and Symington's steam-engine, which is now deposited in the Patent Museum at South Kensington. I quote these facts from an interesting paper on the paddle and screw, read by Mr. MacGregor, barrister-at-law, before the Society of Arts on 14th April, 1858. I may observe, also, that it appears from the same paper, that, long before steam was applied to move paddle-wheels, the paddle-wheels themselves were used as a motive power for vessels, turned by means of manual or other labour, so far back as 1472, that is, 200 years before Papin; and a patent for such an invention was granted in 1618 to David Ramsey and Thomas Wild Gosse; but several modern writers are of opinion that the paddle-wheel was used by the ancient Egyptians, though Mr. MacGregor thinks this cannot be properly substantiated.

Few people, unless those who have given special attention to the subject, will be prepared to find, that what we generally consider the quite modern screw propeller is an old invention. The first name mentioned by Mr. MacGregor is again a Frenchman, — Duquet, who, in 1729, 50 years after

Papin's steam paddle-wheel, submerged an apparatus for propelling like a smoke-jack or windmill; and in 1746 Bouguer relates, that revolving vanes, like those of a windmill, had been tried for the propulsion of vessels. But it appears, besides, that in China the screw propeller is of indefinite antiquity. In 1780 a model of one was brought from that country. The first distinct description on record, however, of a screw propeller is that of D. Bernouilli, of Groningen, in 1752, which, it seems, was sufficiently matured to comprise the use of oblique vanes at the bow, sides, and stern, turned by a steam-engine, and capable of being hoisted out of the water. Mr. Macgregor (p 4) adds, "In 1768, Pauton proposed the pterophore, or screw thread on a cylinder, to be wholly or partly immersed. In 1770 James Watt suggested to Dr. Small the trial of a steam screw-propeller. Bramah in 1785 first patented a rotatory engine for this purpose; Ramsey (1792) put the screw between two hulls; and Lyttleton (1794) used a three-threaded screw; while Fulton (1798) tried one with four blades. Shorter's screw (1800), with a jointed shaft, and worked by men, was applied in 1802 to H. M. ships *Dragon* and *Superb*. The first screw steamer was tried by Stevens in America in 1804. In 1825 Brown used one on the *Thames*."

In art or science, or indeed any other human pursuit, it is scarcely ever wise to suppose we have arrived at perfection; and, before I quit the subject of the screw propeller, perhaps I may be allowed to state that within the last few weeks I have had an opportunity, through the kindness of a gentleman well-known in this place as the promoter of all, that tends to scientific advancement in respect of ships and vessels—I mean Captain Fishbourne—of witnessing a series of interesting and important experiments with a new screw propeller invented by Mr. Soëلمان, and which seems to possess many decided advantages over the ordinary screw propellers now in use. Strictly speaking, this new propeller is not a screw,—the blades not being twisted like the sections of a screw, but simply flat blades placed obliquely on their shaft, but of a peculiar shape, broader at the base than is usual, and, as a rule founded upon a proper theory, with the extreme corners cut off, and one corner of each blade more or less bent. With blades of this construction, which have this advantage, that they admit of being made of wrought instead of cast metal, Mr. Soëلمان finds he obtains greater speed with four blades, like Fulton's screw, than with two, contrary to experience with screws of the ordinary shape. I cannot, however, dwell longer upon this subject, but I may be allowed to add that it was stated in to-day's "*Times*" that the screw of the *Doris*, one of H.M. ships, has had its leading corners cut off, with increased speed as the result, and that further experiments are to be tried with both corners cut off.

After these allusions to the well-known paddle and screw propellers, the efficiency of both of which for marine propulsion is so well established, it requires some degree of boldness to call public attention to another class of propellers totally different. When, however, it is considered that from 1618, when the first patent was granted to Ramsey for his paddle propeller, to June 1857, no less than 803 English patents relating to marine propulsion have been sought or granted, it is not to be imagined that all these inventions relate to paddles and screws alone. Without doubt the great majority of them are adaptations of these two; and after these, the most

numerous class consists of collapsing propellers of various kinds, in imitation of ducks' feet, sometimes adapted to be used as oars, sometimes as paddle-floats, and some even as screws. These propellers are called duck's-foot, swan's-foot, hinged, jointed, collapsing, &c. and frequently compared to the opening and shutting of the leaves of a book. They are all, however, obviously imitations of the motion of aquatic birds; and I confess I see nothing in the particular operation of nature which they attempt to follow, to promise great results, even could art and science entirely come up to nature, as we know it never does. Few things certainly are more beautiful than the "majestic swan," especially when, its feathers distended, it sails before the wind; but it, as certainly, is not a fast sailer; and when it makes most haste, and relies most upon its collapsing propellers for its progress, its motion is far from steady, or even graceful. The jerky speed it then attains is neither very great, nor worthy of being imitated. It is difficult to understand, therefore, why so much time and money and ingenuity have been wasted upon this particular kind of flexible or collapsing propellers. They seem to me, besides, objectionable for this additional reason, that, of necessity, they are not continuous in the propulsive force they exercise, and every one knows that continuity of force or pressure is the grand essential to produce velocity. This is peculiarly exemplified in the operation of the screw: its first few turns produce little or no effect, but motion once produced, slight increments of force continuously operate and add to the previous velocity, till a maximum of speed is attained, which has only a limit because at a certain speed the obstruction of dragging the screw itself through the water balances its propulsive power, which, again, cannot be increased by making the revolutions of the screw more rapid, because then it would cut through the water, and its "slip" become fatal to its progress.

It is, then, with a full appreciation of the truth and importance of these principles, which govern propulsive power, that I venture to bring under your consideration another propeller, different from any of those yet mentioned. It, too, is borrowed from nature; and, as the problem is how best to produce a motive power in water, it must surely be admitted that we go to a legitimate source, when we set aquatic birds and even amphibious animals aside, when we neither attempt to copy from the swan, the beaver, or the frog, but go direct to the fish. Here, indeed, if art and science will enable us to attain but approximate results, we shall have all we can desire. Every one knows the grace and ease, and marvellous rapidity, at times, with which the finny tribes move in their native element. When they make a dart, it almost seems as if it were a mere exercise of will, (as when one waves his arm,) without the necessity for propulsive power obtained by mechanical means, *ab extra*, from pressure against the water. But it is not so. The fish cannot move an inch by mere will. It is, as it were, in a state of equilibrium in the water. By its volition it can move its fins and tail—parts of itself; but all the motions of its whole body, from place to place, are merely mechanical results, the effects of pressure and resistance, produced by the action of the admirable instruments nature has endowed it with. The fish is as truly propelled by the action of a material propeller as a paddle-wheel or screw steamer. All that, by its volition, life and instinct, the fish accomplishes, is merely

analogous to the motive power of the steam-engine inside a vessel, while the paddle-wheel or screw, acting upon the water, does what is accomplished by the fins and tail of the fish, or, more strictly speaking, by its tail alone. We know the results. Nature beats art: and from this point of view the question naturally arises, why have flexible propellers, in imitation of fishes' tails, not been tried, before paddle-wheels and screw propellers were thought of? The fact remains, unquestionably, that the most rapid motion of a fish is produced simply and merely by the vibratory motion of its tail, and the continuous pressure thus exerted against the water; and the *onus* seems, therefore, thrown upon the inventors of propellers, to explain why they have so generally disregarded this most common example of nature. Surely the first propeller ever tried ought to have been a flexible, or fish tail propeller; and to a certain extent, perhaps, this has been the case; for what is the paddle of the Indian but a rude imitation of the action of a fish's tail, only with a very imperfect instrument? Amongst ourselves, a single oar is frequently seen, adroitly manipulated with the figure eight movement called sculling, and many inventions have been tried to produce the same results by machinery. So far back as 1745 Masson describes an apparatus for this purpose.* A patent for a similar invention was granted to W. Taylor and H. Davies in 1836; † another in 1840 to William Mill; ‡ and another so recently as 1847 to Jean Charles Victor Coullon. § From the description of these patents, as one might have anticipated, the machinery is necessarily very complicated to produce so complicated a motion; and, after all, there is the same objection to them that was urged against the collapsing propellers, namely, the want of continuity in the pressure they produce, and the consequent loss of time between each effective stroke of the blade or paddle. Few attempts have, however, been made to follow nature—always perfect in its simplicity, and simple in its perfection—with greater closeness. Very few seem ever to have thought that by means of a flexible paddle the same, or rather a greater, effect would be produced than by sculling with a rigid blade, and that without the necessity for any such complicated movement. I say, few seem to have thought of this; and, for a whole month after the idea first occurred to myself, I was led to believe that there was no trace whatever of any patent for or other record of such an invention. ||

Do not suppose for a moment that I intend to inflict upon you the records

* Abridg. of Specif. of Patents for Mar. Propul, vol. i. p. 25.

† *Ib.* vol. ii. p. 126.

‡ *Ib.* p. 156.

§ *Ib.* p. 206.

|| A short notice of this paper having appeared in the *Mechanics' Magazine* of June 10, 1859, Captain Selwyn, R.N. wrote to the editor on the subject (*vide Mec. Mag.* 1 July, 1859), to the effect that it is "scarcely correct to assume that the 'fish-tail' form of propeller has been so much overlooked," and referred to the new edition of Tredgold's work, Appendix D. As to this I can only say I have noticed every instance in the Abridgment of Specifications, and indeed the fact that, except in the last edition of Tredgold's work, such propellers are not noticed at all, shows how very little attention has been given to this kind of propeller. Captain Selwyn also proposes a very ingenious mode of combining the screw and fish-tail, as to which reference is made to his interesting letter and the diagram which accompanies it; but I fear such a compound propeller would be still more liable to "foul" than a screw by itself, and could not be afterwards cleared without still greater difficulty.—J. R.

of a grievance. It is true I invested some ten pounds in securing provisional protection from the Commissioners of Patents for what I had then every reason to believe was really a new invention; but I never, from the first moment, arrogated to myself any merit in the matter, for I always regarded it as by a mere accident, which, indeed it was, that I had been led to think of it. I have, also, a most wholesome dread of an observation of Mr. Scott Russell's (made at the meeting of the Society of Arts at which the interesting paper from which I have quoted was read by Mr. MacGregor), "that the faculty of mechanical invention was not a very unusual faculty; that it belonged to nearly everybody, and that it was one of the greatest misfortunes that could fall upon a man when he took it into his head that he was endowed with a larger portion of that faculty than any one else." (p. 7.) I certainly do not go quite so far as Mr. Russell, when he adds, that "there were men in this country who could invent anything they were asked for, and all we had to do was to pay them for inventing." (p. 7.) This is surely decrying one's own art, and is a somewhat too mercenary view, if I may so say, of the motive power of the inventive faculty; still, every one will admit, that it is not to be expected that every private individual can afford to make expensive experiments, in order to mature some invention, without a reasonable hope of some return. But, in truth, instead of inventors being such mercenary beings, they are rather too much given to ride their hobby at all hazards, and so get involved in difficulties; and many a caution I have received from those experienced in such matters, "not to be too sanguine;" "not to incur much expense;" and even "not to ruin myself," in trying to carry out my invention. I am not likely to do so; in fact, I cannot afford it. If a reference to the Index of the "Abridgment of the Specifications of Patents relating to Marine Propulsion,"—an epitome of information most justly praised by Mr. MacGregor as a means for preventing ingenuity, time, energy, and private expenditure being needlessly thrown away by inventors discovering over again what had been already invented,—did not enable me, or the patent agents I employed, Messrs. Newton, of Chancery Lane, to discover that I had been forestalled; yet, by reading through the Abridgment itself, I discovered that such was the fact, in very good time, before my expenditure had been excessive; so my grievance is a comparatively slight one. I do not wish here to raise any question as to the propriety of granting "protection" when it is doubtful whether a patent could be maintained; and, at any rate, there is this to counterbalance any disadvantage I labour under in thus confessing my invention is not quite new, that I am no longer the mere exponent of my own views, but am able to place self aside, and speak in favour of the flexible propeller on more independent grounds.

It is a somewhat curious circumstance that the only propellers in the "Abridgment of Specifications" which are called "fish-tail" propellers, are indexed under the title "Propeller, Screw." The first is in 1841, to William Joest, called "the double fishes'-tail," "composed of a prismatical hollow solid," which is a "bent vane on a vertical axis, and which *revolves* under water" (p. 162). It will be admitted that no revolving propeller can be considered as having any resemblance to the action of a fish's tail. The next (also in 1841) is to John G. T. Campbell, and is called "a

whale-tail or fluke propeller." It is thus described in the Abridgment (vol. ii. p. 164):—"Two flap-like vanes, swinging fore and aft on horizontal axes, are so moved under water in an aperture through the dead-wood at a vessel's stern, as to imitate the motion of the tail of a fish, when the broad surface is nearly vertical and across the direction of the fish's length. This is done by an arrangement of levers and jointed 'knuckles,' the action of which is explained by the drawings."

This, it will be observed, is also rather complicated, and scarcely the fish-tail *au naturel*.

But, leaving the Index, and proceeding to the text of the Abridgment, at p. 16 we find that in 1688 Borelli of Rome describes a submarine vessel, "*navis urinatoria*," which he had invented, to move by fins or collapsing oars; but he adds that, instead of these, probably an easier mode of propulsion would be by one flexible oar acting like a fish's tail.

The next trace to be found in the Abridgment is at p. 61, Patent No. 3,909, 25 April, 1815, to Sam. J. Pauly and Durs Egg, for an aerial machine with feathery wings; to which is added, somewhat vaguely, "2. The patentees declare that the same principle is also applicable to the propelling of vessels through the water." I think we need not be surprised if this vague claim was not considered a proposition for a fish-tail propeller, or indexed as such. Neither would it be supposed by many that it was practicable either to move balloons by means of imitative fish-tails, or boats with imitative wings. And yet, upon reading these inventors' full specification in the Patent Office, I was astounded to find that, with this mere hint of such a possibility, he claimed such a universality of patent right, to apply to vessels, wings, feathers, fins, fans, and even tails, that I brought away with me a copy of his specification as a curiosity, and I beg to be allowed to read an extract from it, alike as an encouragement and warning to all inventors:

[*An extract from the Specification was here read.*]

It must be remembered that this sweeping privilege was granted; and certainly nothing can be easier than to be an inventor and obtain patent rights in this exclusive style, if only first in the field, and nothing more difficult, on the other hand, than to become an inventor and patent an improvement, if such exhaustive previous claims are meant to be sanctioned.

I may state that having often observed that percussion caps were stamped D. EGG, and remembering the same letters on fire-arms and the window-sill of a shop in the Opera Colonade, I was induced to call there and inquire whether anything was known of Durs Egg, the inventor of this flying balloon, and of the invention itself? I found that he was an ancestor (father or grandfather) of the present Mr. Egg, gun-manufacturer, and that the balloon in question, which cost a great deal of money, was sold for a song at the death of Durs Egg, the inventor. So far as I could learn, it had not been attempted by him to apply it to vessels in water, notwithstanding the terms of the patent.

The next propeller of the kind is patented by James Dawson, 14 March, 1816, No. 3,996, only a year after, and notwithstanding the sweeping patent last mentioned. It is in the first place, and chiefly for a station-

Abridgment it is merely described as "A paddle or screw propeller of elastic rods, covered with fan-like elastic pieces of canvas or similar material;" but upon obtaining the specification itself from the Patent Office, I found that it was veritably a fish-tail propeller, such as I imagined I had been the first to think of. We shall revert to Dawson's invention bye and bye; in the meantime I will shortly allude to the two only other inventions of the kind which appear in the Abridgment. In 1824, Nov. 11 (No. 5,053), p. 78, William Busk obtains a patent for "An elastic plate fixed to an axis at one end, which is caused to vibrate back and forward in the water. The axis may be horizontal or vertical." And so late as 1854 (June 2, No. 1,224), p. 263, the Earl of Aldborough patented "a vessel propelled by wing-like sails, urged by springs in conjunction with vacuum chambers and numerous other contrivances described at length; and in another form the propulsion is effected by an elastic propeller, acting in some manner like a rudder, and with or without valves, not particularly explained." He refers to a previous patent (1854, No. 224,) referring only to aerial locomotion, and I have therefore not thought it necessary to procure the specification of this invention.

Dawson may in fact be said to be the only person who has anticipated the invention, the claims of which to your consideration I venture to speak of. He patents three inventions: 1st. elastic floats for paddle-wheels; 2nd. elastic masts and sails; and 3rd. (with which we have to do,) an elastic lever or oar, with one end formed somewhat in imitation of the tail of a fish.

[*The Specification was here read.*]

I confess I do not understand what advantage he expects to gain either by the elastic plane, which he states he *sometimes* attaches to the handle, nor why he proposes that the handle, lever, or oar itself should be flexible like the backbone of a fish, with a vertebral action. The vertebrae of a fish are used to bend the body of the fish itself, and they have an elasticity and spring which no doubt greatly facilitates the various curvilinear motions of the fish in the water, but for a mere onward movement they are not required; and if a lever or rod to which an imitation fish-tail is attached were jointed and rendered elastic in this manner, it would only weaken its power for causing the tail part, in the water, to vibrate to and fro with sufficient force against the water's resistance. This being the case, I doubt very much whether Dawson ever made any experiments with such an elastic oar.

As regards the moving of his flexible propeller, Busk seems to have had a more practical view than Dawson. Busk's propeller is simply an elastic steel plate, which he proposes to attach to vessels like a rudder, and work it from side to side either with a tiller by the hand, or with the aid of machinery, without any complicated details for obtaining a closer imitation of the power of a fish's tail. Any one can at once perceive that to move such a propeller in the water an elastic or bending tiller would not give the helmsman greater power, but the reverse.

[*Busk's Specification was also read.*]

Let us now inquire what distinct advantages this mode of propulsion seems to promise, and what difficulties are attached to its adoption.

In the first place, I suppose it may be assumed, that the moving from side to side of a flexible paddle, or rudder, at the stern of a vessel, will propel the vessel. But not only so: this motion of a flexible propeller will be found to have little or no retarding influences to overcome; its every action is propulsive, partially, no doubt, (like the oar in sculling, or the screw propeller,) in an oblique direction, but also in a great degree directly in the direction of the vessel's onward motion. In the next place, from the position of such a propeller, submerged at the stern of the vessel, with the centre of the propulsive force level with the centre of gravity, the stable equilibrium of the vessel is not disturbed, and there is no waste of power, such as there is in sculling, which pulls the boat down against the water as well as onward; and as there also is in the paddle-wheel, unless when made to feather by complicated machinery; and as there is even in rowing, the action of the oars being chiefly oblique, except at the moment when at right angles to the boat, while even then a great part of the pressure tends to pull the boat downwards to the water, as may be observed by watching the rise and fall of a boat between each stroke of the rowers.

Before extending the comparison further to the screw, I would beg to point to some special advantages such propellers would have for boats. By means of crank machinery and multiplying power, I venture to anticipate that one or two men might do in a boat, to which steam machinery could not be applied, as much as is now accomplished by eight or ten rowers. Boats so propelled could also move up creeks and narrow rivers, where oars could not be used; and, for war purposes, it must be manifest that a boat with a crew of riflemen must be far more formidable than one encumbered and chiefly filled with a dozen rowers, with their backs exposed to the fire of the enemy. Such propellers could also be used in boats in aid of sails, which oars can scarcely conveniently be, both on account of the position of the rowers, and also the jerky and unsteady motion of rowing.

It was, indeed, almost solely as a substitute for oars that, in the first instance, I considered the fish-tail, or flexible propeller, would be found useful; and it has only been as such that I have as yet made any experiments. I had no models made. As the operation of such a propeller is very simple, I resolved, from the moment the idea struck me, to have one fitted to a boat, and prove the value of the invention by coming down the river. I have already expressed my regret that I had not been able to realize that idea. And, indeed, after I discovered that Dawson and Busk had anticipated the invention, I shrunk from appearing here this evening, with no very practical results to communicate. But the fact that these anticipations may probably prevent my laying any exclusive claim to the invention is, on the other hand, one of the most cogent reasons for making it more generally public, that others who have more time and money, and greater mechanical skill, may be induced, if so disposed, to undertake the task—which I think would be a most interesting one—of working it out to a practical result.

Those who are fortunate, or unfortunate, enough, as it often happens, to be inventors, have generally a difficulty as to the construction of their models, or mechanical contrivances. To whom to apply to make a fish-

tail was also my difficulty. For a first experiment, however, I did not hesitate. I went to a small gutta-percha shop, and had a fan or tail made, with a piece of wood for its narrow and rigid part; but this propeller turning out rather flabby, I strengthened it with additional pieces of gutta-percha in the middle, leaving spaces between these layers for inserting ribs of steel, should that be found necessary for further strength. (*Vide figure.*)

Fig. 1.

FLEXIBLE OR FISH-TAIL PROPELLER AND RUDDER.

- A. Wooden portion attached to ordinary rudder-stem.
 b. Fish-tail paddle of single thickness of gutta-percha.
 c, c, c. Portions of ditto, which are of double thickness.

The size of this propeller was—extreme length 2 feet, greatest width about 15 inches. Its narrow and rigid part was tapered down to an average breadth of about 4 inches. This part, made rigid with wood, I had nailed to the rudder of an ordinary four-oared boat, and the propeller extended beyond the rudder about 18 inches; but I confess when I saw the size of the boat, 24 feet long, and looked at the slightness of my propeller, I anticipated a total failure. But it was not so. Notwithstanding an inconvenience in working the iron tiller I had made, which was not quite suited to the stern of the boat, to give it free action, this slight, flexible propeller managed to keep the boat up against a strong tide and sharp head-wind, and to make a little way. I found it also a considerable auxiliary to the oars, when the boatmen rowed against stream; but the boat being out of proportion too large, I gave directions for the propeller being attached to the rudder of a smaller one, for another trial. This boat was what is called a funny, with an extremely raking stern-post, or, rather, no stern-post at all, but rather the keel continued, its bow and stern being shaped and sloped alike. With this boat, the action of the propeller being upwards, rather than onwards, it lost all the advantage of one of its special characteristics; and, if the tiller was moved three feet from side to side, the propeller was lifted obliquely out of the water, almost altogether. This necessitated me to confine my operations to a very limited vibratory motion, and so far an advantage was obtained by this trial; for, contrary to my expectation, I found that even a very slight movement of this kind, made with rapidity, gave considerable propulsive power, while I had hoped for the greatest results from the effective stroke at each turn of the propeller.

In making these trials it was further evident that attaching the propeller to the rudder was but a clumsy expedient, and that, of course, the obstructive effect of the flat rudder moving to and fro in the water was

considerable. I had, therefore, an iron skeleton-rudder formed, (fig. 2) with one fixed and one moveable pintle, in the hope of its fitting any boat, and of

Fig. 2.

a, a, a. Skeleton rudder substituted for the ordinary rudder of the boat.

giving my primitive propeller a fairer trial on a gig with a vertical stern-post. In this I found a decided advantage. The propeller was moved with a facility and effectiveness I had not before experienced. There was a drawback, however, in the moveable pintle, which allowed too much play at the hinge, or axis of the propeller, and the boatman being extremely fidgetty about the gudgeons and paint of his gig, I was induced, instead of endeavouring to prevent this play of the pintle, to shift the propeller to an old, but much larger, boat, which had also a nearly upright stern-post, full of confidence that now I could almost have propelled a barge! A few sweeps of the tiller, however, brought my experiments to a sudden close: the woodwork of the propeller had given way, and I was obliged to unship it, pull to the shore, and walk away, extremely chagrined, carrying my unfortunate tail behind me. An accident of this kind, it may be remembered, was a fortunate circumstance in perfecting the screw propeller; but I can boast of no such good chance.

I then resolved to have a boat of my own, and a new propeller, or rather propellers, of various shapes and degrees of strength and flexibility; but I will not take up your time, or abuse the indulgence you are so kindly and patiently according me, with the details of the delays and disappointments I then experienced, while in the meantime I made the discovery that others had preceded me, and that after all it was very questionable whether, even if I succeeded in overcoming every difficulty, I could reap any other reward for my pains. This consideration, however, would not have prevented me persevering; for, as I have said, I do not quite hold Mr. Scott Russell's doctrine of mercenary motive power, though I confess that it somewhat damped my zeal, and induced some caution as to expenditure. At the same time unexpected business engagements came upon me, followed by the war, which (as connected with one of the civil departments of the navy) created fresh and imperative demands upon my time; so that, though most willing, I have been utterly unable to attempt more as yet.*

* Since this paper was read, a friend—an officer of H.M.S. Formidable—who takes an interest in this matter, has had propellers made with steel ribs, separated at the stern-post, and joining at the extremities, like the bones of a fish's tail, the “flabby” part of the propeller being made of vulcanised india rubber, or canvas, and experiments are now being made with these propellers—J. R.

One word as to the application of flexible propellers to larger vessels, to be moved by steam machinery. Can it be expected that they would have advantages over the screw? In the first place, even if such a propeller were only a simple elastic steel plate, without any other contrivance to obtain the many wonderful powers of the fish's tail, its action would probably equal the screw in efficiency for ordinary speed; but, besides that, it promises almost an indefinite increase of velocity by means of more rapid vibrations, as it will have no slip, and presents no opposing surface, like the blades of the screw, to be dragged against the water. For the same reason, it will be a more efficient auxiliary to sails than the screw propeller can ever be; and, when not used as an auxiliary, it will not, like the screw, obstruct the course of the vessel when moving under sail alone. These appear to me to be no slight advantages, and they might, of themselves, well induce those who could afford it, who are interested in the progress of scientific navigation, at least to make experiments. I need scarcely add, that such propellers are at once propellers and rudders, and that the steering power of a vessel so propelled will be immense, and may be employed to turn a vessel when at rest, as one sweep of the propeller would put way on the vessel at once, and, if not reversed, would move the vessel to one side. It is obvious, however, that in all that has been said of this propeller, no means for going astern has been provided. That is quite true; but the point has not been overlooked, though it would add inconveniently to the length of this paper to deal completely with the subject now. I will, therefore, only observe that it is of secondary importance, compared with increased speed forwards, and that, even without any appliances for backing, the greater ease in turning a vessel with a flexible propeller, will, in a great measure, of itself counterbalance any such disadvantage.

But to conclude. It is a most natural question to ask, Can we hope, by artificial means, to attain, even approximately, so complete a propulsive instrument as nature has supplied to the fish, and thus rival its wonderful rapidity? I do not for a moment suppose that we ever could obtain a power like that of the salmon, by which it performs the most extraordinary feats, both in darting and leaping; but, for a steady, rapid, onward motion, we have every reason to expect we can. We cannot hope to rival the marvellous combination of flexibility and strength we find in the salmon's tail; but, if in that nature has the advantage, on the other hand it will be found that, in some respects, for such a propeller, science has the advantage even over nature. I trust this observation will not be misunderstood. Nature and true science are never antagonistic. I was alluding to the power of the steam-engine, by which our inferior propellers could be driven to and fro in the water, with a force and rapidity, and unflagging continuance, that not even the strongest and swiftest fish could ever exert. In this, science would have an advantage, which would compensate, and probably more than equal, the disadvantages of our inability to come up to the marvellous mechanism of nature in the construction of the fish's tail. And this is no foolish boast; for what is that science which accomplishes such results? It is merely the application by man, "as the minister and interpreter of nature" (as our greatest philosopher designates him), of other powers of nature, fulfilling the will of the Omnipotent. It is thus that

"knowledge is power." It is not art alone that drives the steam-engine; it is the expansive power of heat acting upon water, directed through man's knowledge and art, to do his will, but the power so potently exerted is after all a simple power of nature. And so with the still more powerful agency, which is frequently under the consideration of those connected with this Institution, and which, as we now speak, is carrying death and destruction elsewhere, and even thus affecting the present and future fate of nations. It is not art alone by which the ball from an Armstrong gun parts from its muzzle like a thunderbolt, and shatters all that would resist it: it is only art, after all, using and directing one of nature's most mighty agencies; and, in short, it should never be forgotten that, in all science, nature's power must be predominant, and that it is man's most legitimate province to render all the powers of nature subservient to his use by means of knowledge and art. True science ever and only exhibits the marvellous powers of nature, combined with art and skill, in harmonious co-operation.

MR. MACGREGOR.—With respect to the question of the fish-tail propeller, it is very difficult to speak of it unless one is in a boat in which it is tried: I think it is a mistake to compare it to any other mechanical arrangement for a similar purpose. Its action is of an exceedingly complicated kind; but I would give a word of encouragement to Mr. Reddie, not to be disheartened because others have been in the field before him. I must say that if they are able to give us as intelligent an account of their inventions as he has of his, they will produce significant results.

CHAIRMAN.—The subject is a very important one, since we all know or have experienced how numerous are the accidents which occur to the screw, and that, in some cases, there are no results commensurate to the enormous powers used. There is another disadvantage in the screw, viz., that it is scarcely applicable to light-draught vessels; yet we are going very much in the direction of light draught. Such vessels will be immediately necessary for the defence of our coasts in case of attack; and there is scarcely any part of the world where light vessels with such a propeller as this would not be of very great utility. We saw during the late operations at Canton that, while every one of our screw vessels broke down, an old paddle-wheel steamer, doing ten times the work, remained serviceable to the last. Mr. Reddie has read a very interesting paper, exceedingly well reasoned out, and it cannot fail to afford considerable instruction, especially to those experimenting on any similar contrivance. I must, therefore, return him our best thanks for his very interesting paper.

MR. AUSTIN exhibited and explained an apparatus of his invention for raising vessels sunk in deep water.