SCIENTIFIC AMERICAN

ESTABLISHED 1845

MUNN & CO. - - Editors and Proprietors

Published Weekly at

No. 361 Broadway, New York

TERMS TO SUBSCRIBERS

One copy, one year, for the United States, Canada, or Mexico	$3.00
One copy, one year, to any foreign country, postage prepaid, £0 16s. 5d.	4.00

THE SCIENTIFIC AMERICAN PUBLICATIONS

Scientific American (Established 1845)	$3.00 a year
Scientific American Supplement (Established 1876)	5.00 "
American Homes and Gardens	3.00 "
Scientific American Export Edition (Established 1878)	3.00 "

The combined subscription rates and rates to foreign countries will be furnished upon application.

Remit by postal or express money order, or by bank draft or check.

MUNN & CO., 361 Broadway, New York.

NEW YORK, SATURDAY, APRIL 20, 1907.

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

THE SCIENTIFIC AMERICAN AERONAUTIC TROPHY.

Despite the fact that very many inventors throughout the United States are wrestling with the problem of aerial navigation by means of a true dynamic flying machine, that is, a machine heavier than air, no public flight has been made in this country with such a machine up to the present time. The most advanced knowledge of heavier-than-air navigation seems to be held by two young western experimenters, of whom much has been written. These men have undoubtedly made flights with their aeroplane, and these flights have been witnessed by a considerable number of people. The general appearance of their machine is known, and other experimenters are making good progress along somewhat the same lines.

We feel, therefore, that the time is ripe for the offering of a suitable trophy commemorating the conquering of the air by a heavier-than-air machine. As the Scientific American is the oldest journal in this country treating of Science and the Arts, its proprietors feel that it is fitting that this journal should be the first to encourage the development of the latest great invention—a machine that shall conquer the air. The proprietors have, therefore, decided to offer a valuable trophy for competition for heavier-than-air flying machines. The trophy is to be given under a deed of gift to the Aero Club of America, to be competed for annually by both American and foreign inventors. The rules for the competition will be drawn up by a committee of the Aero Club, and it is expected that the first competition will occur at the Jamestown Exposition, September 14, and will be for a flight of one mile or less in a straight line. The competition is to be progressive in character, that is to say, if the flight of the predetermined distance is accomplished this year, next year a longer flight will be required, or a flight of a mile with turns. In other words, the conditions of the yearly contests will be such that they will be just ahead of the art, in order to induce inventors continually to strive to improve and perfect their machines. Should any one inventor win the prize three times, it will then become his property.

Further particulars regarding the first competition will be given from time to time in the columns of the Scientific American.

◆

BROKEN RAILS AND RAILROAD ACCIDENTS.

It is a significant fact that, side by side with the alarming growth in the number of railroad accidents which has been noticeable during the past winter, there has been an increasing frequency in the breakage of the steel rails, upon which, after all, the security of railroad travel immediately depends. There is evidence that not a few of the disasters have been caused directly by these broken rails; and there can be little doubt that many of the unexplained accidents have been due to a similar cause. According to one of our technical contemporaries, an engineer who was present at a recent railroad wreck stated that, within a distance of one mile in the vicinity of the wreck, he counted nineteen broken rails which had been removed from the track during the winter.

The writer was recently given an opportunity to examine an official report, made to the president of a certain trunk line, on the subject of broken rails; and he was dumbfounded to learn that, during two months of the present winter, there had occurred on this road over 600 cases of broken rails. When we remember that every such break puts the trains in immediate peril of derailment, we are filled with wonderment, not that there are so many, but that there are so few, disastrous accidents.

Time was when American rails, bought in the open market and rolled to the specifications of the engineers of the railroads, and by them held strictly to these specifications, were equal to any in the world. To-day the rails that are received from the one colossal concern which can furnish them, are of the very poorest quality—a constant and positively fearful menace to every passenger that rides over them.

The depreciation, rapid depreciation, in the quality of rails is due to the introduction by the makers of cheaper and quicker methods of manufacture.

These methods have been adopted with a single eye, not to the improvement of quality, but to the increase of profits on the output.

That the broken rail is a growing peril will be realized, when we state that, during the past few years, the rails supplied to the railroads by the concern which has the monopoly of their manufacture, have become so poor in quality, that breakages have gone up several hundred per cent.

And every broken rail is an invitation to a railroad disaster!

The blame for the present alarming conditions lies then at the door of the manufacturers. This fact will be fully appreciated, when we have made the American public familiar with certain astounding facts in the recent history of the relations between the railroads and the one concern upon which they are dependent for rails.

◆

THE CRUISER OF THE FUTURE.

The recent launch of the British first-class cruiser "Indomitable" marked the advent among the fleets of the world of the most notable warship of the day. In saying this, we do not exclude even the "Dreadnought," epoch-making vessel though she was.

The "Indomitable" is so entirely unlike any other warship as to be quite in a class by herself. She is swift enough to overtake, and powerful enough to sink, the fastest cruisers that are afloat on the high seas to-day. Were the most formidable battleship to attack her while she was destroying her quarry, she could swing her guns upon the ship, and overwhelm it by pouring in a long-range armor-piercing fire from her battery of eight 12-inch guns. Armed, as she will be, with a new pattern of 12-inch rifle, of considerably greater range and hitting power than any naval gun afloat to-day, she would be a fair match, if we except the Japanese "Kashima" and "Katori," for any two existing battleships that might be opposed to her; for with her high speed of 25 knots an hour at command, she could choose her own bearing and range, and place her shots in greater numbers, and with greater remaining energy at the range adopted, than could the enemy. By taking position where the shells of the enemy must strike her armor obliquely, her 7 inches of face-hardened Krupp steel protection would, at the long range selected, be proof against a vital penetration.

The leading particulars of the "Indomitable" and her sisters the "Inflexible" and "Invincible" are as follows: Length, 530 feet, or 30 feet more than that of the largest cruiser afloat; beam, 78 feet 6 inches; draft, 26 feet; displacement, 17,250 tons; horse-power, 41,000; and speed, 25 knots. Although the armor is not so heavy as that usually carried on the battleships (though it equals that of the "Duncan" class) it covers almost the whole of the hull, being carried nearly to the level of the upper deck. It has a maximum thickness of 7 inches amidships, and tapers to 4 inches at the ends.

Next to her speed, the most surprising feature of the "Indomitable" is her armament, which consists of eight 12-inch guns—twice the number carried in battleships—carried in four turrets, one forward, one aft, and one on either beam, the last-named turrets being placed *en echelon*, or diagonally to the center line of the ship. This renders all of the 12-inch guns available on either broadside, and enables the "Indomitable" to concentrate six 12-inch ahead, six astern, and eight on each broadside. The high freeboard of these vessels will enable them to fight their guns in heavy weather, since both the forward turrets and the two wing turrets are carried at a height of from 34 to 36 feet above the water line, the after pair of guns being about 26 feet above the water line.

The growth in power of the cruisers of the British navy in the past seven years has been very striking, the displacement having nearly doubled and the collective muzzle energy from one single round of all guns having increased over twelve times. Thus, the "County" cruisers of 1900 were of about 10,000 tons displacement, and the total muzzle energy of one round was about 30,000 foot-tons. The "Drake" of the following year, of 14,100 tons, has a collective muzzle energy of 64,000 foot-tons; the "Duke of Edinboro" of 1904 can deliver a total energy of 100,000 foot-tons; and the "Minotaur" of 1906, 137,000 foot-tons; while the "Indomitable" of 1907, displacing 17,250 tons, has a collective muzzle energy from one round of her guns of 381,000 foot-tons. Furthermore, while the 6-inch guns of the "County" class of 1900 have an effective fighting range of 3 miles, and the "Drake" can do effective work with two of her guns (the 9.2-inch) at 4 miles range, and the "Minotaur" class can use four guns at the same range, the "Indomitable" will be able to bring to bear the whole of her eight guns at 5 miles range, and engage at this range on equal terms of gun fire any two battleships, with the single exception of the Japanese ships, now afloat.

The *raison d'etre* of the remarkable combination of high speed and heavy armament in these three cruisers is to be found in the necessity of getting in touch with the enemy; breaking through his outer screen of scouts and cruisers; determining the exact strength of his battleship squadron; and returning with the information thus gleaned for the guidance of the admiral of the fleet. For such work the "Indomitable" class are perfectly suited, their power being sufficient to enable them to crumple up the scout and armored cruiser formation of the enemy, and their speed sufficient to bring them safely away, after drawing the fire and determining the numbers and power of the enemy's first line of battle.

◆

SUSTAINED ELECTRIC OSCILLATIONS.

The simplest method, and practically the only one hitherto employed, for obtaining currents of sufficiently high frequency to emit electric waves suitable for the transmission of wireless telegraph messages, is by means of a spark set up between the terminals of the secondary of an induction coil.

The opposite arms of an oscillator thus formed are the equivalent of a condenser, and hence when the pair of surfaces are discharged the circuit at the moment the spark passes has a negligible resistance and in consequence the negative and positive electric charges are permitted to equalize the difference of potential and the released energy to surge through the system in the form of high frequency currents or electric oscillations.

This phenomenon is due to the fact that a very small portion of the static, or stored-up, energy is required to burn out the air forming the insulating partition between the terminals or spark-balls, while the larger portion of the energy which is suddenly released and converted into kinetic electricity, and which is under a very high pressure, rushes first to one end of oscillation circuit, then back to the opposite end of the conductor, each time passing through the spark-gap, whose resistance is no longer of appreciable value, and so repeating the cycles of oscillation until the total energy is damped out by the emission of electric waves and other resisting influences.

If the oscillation circuit is an open one, that is if the opposite sides of the spark-gap are connected directly to conductors that end abruptly, or are open at both ends, the energy of the oscillations is very quickly converted into electric waves, the high frequency currents being damped out in two or three swings. Oppositely disposed, if the oscillation circuit is a closed one, that is if the circuit forms a loop and is continuous, the oscillations surging in it will be more persistent and the currents thus set up within it will swing thirty or forty times back and forth, depending on its electrical dimensions.

By the term electrical dimension is meant the capacity, inductance, and resistance of the circuit, and on these factors depends the frequency of the oscillations, which may surge at the rate of from thousands to millions of times per second. It must be borne in mind, however, that these high-frequency currents are by no means continuous in character, but are periodic, and decrease in geometric ratio reaching zero in a very small fraction of a second. By using a closed circuit instead of an open one, the decrement of the oscillations may be reduced, a shorter period of time will elapse between each successive series of swings. It is during this time that the oscillation system is recharged for the next succeeding discharge.

In wireless telegraphy the open circuit system possesses the advantage of sending out electric waves that are more penetrating than a closed circuit, while the latter is, in virtue of the persistence of its oscillations, which more nearly approach a sine wave form, much better adapted for producing sympathetic electrical resonance, so that an oscillating current set up in the first or transmitting circuit will start a series of oscillations of a similar frequency in a second or receiving circuit.

From the preceding it will be clear that both open and closed circuits possess certain commendable features for the emission and reception of wireless messages, and indeed these have been combined in what are termed compound systems which are well adapted for the production of resonance effects. By employing such compound circuits it is possible to receive at will one of two incoming messages of the same strength, but this is as near selectivity as can be obtained with periodic oscillations produced by a spark-gap, however feebly damped the former may be.

Fortunately there are other methods known by which high frequency currents can be set up, and in which the usual spark-gap plays no part, and yet more fortunately the oscillations thus produced are continuous and constant in amplitude. One of these methods for the conversion of direct currents into high frequency oscillations was described in a recent issue of the Scientific American, and as it was then pointed out, the system utilizing it gives much promise of solving the problem of selective wireless telegraphy.

Elihu Thomson was the first to discover that a direct current could be converted into an alternating current by shunting a suitable capacity and inductive around an arc light. Duddell then showed that by varying the coefficients of the shunt current the arc would emit a continuous musical note. The alternating currents thus produced represented a very small percentage of the direct current impressed upon the arc light and further, the currents thus obtained were of comparatively low frequency, being the equivalent of the musical note emitted, and these were, of course, much too low for the radiation of effective electric waves. Poulsen has recently found that if the arc is produced in an atmosphere of hydrogen or other gases, oscillations will surge through the circuit that are of the order of hundreds of thousands per second.

The object of inclosing the arc light in hydrogen—illuminating gas suffices very well—is due in a measure to its cooling effects, for the oxygen is excluded. It has been further ascertained that by placing the arc in a strong magnetic field the voltage drop in the arc is quite low considering its unit length, that is to say, it requires 440 volts to produce an arc ⅛ inch in length. Where these conditions prevail, it is possible to increase, within certain limitations, the inductance of the circuit without further increasing its capacity, and this permits the potential difference of the terminals of the circuit to be larger than would otherwise be possible.

The principles of resonance that have been so carefully and laboriously worked out in the past will not be lost in the commercial application of the new method, for without the knowledge of timing the circuits continuous oscillations would prove of but little worth. With a transmitter of the hydrogenic arc type and a receptor in which the oscillation circuits are arranged so that the damping factor is reduced to the least possible extent, the degree of accuracy of timing is said to be about one per cent, namely, that two stations equipped with this apparatus may communicate with each other with waves of 600 yards in length and two other stations at the same time in the same field of force with waves 606 yards in length and without any untoward result of interference. Since wave lengths varying from 300 to 3,000 yards may be used, several hundred stations may cover the same territory without suffering from the effects of the others.

There are methods other than the one cited by which continuous oscillations can be produced, but with the results already obtained there is sufficient encouragement to warrant a belief that the limitations which hedged in wireless telegraphy are to be greatly extended within the next few years, and its usefulness, now generally recognized, will prove a more potent factor than ever in the transmission of the world's intelligence.

* * *

ADVANTAGES OF TURBINE PROPULSION FOR BATTLESHIPS.

BY H. C. DINGER, LIEUTENANT UNITED STATES NAVY.

Repeated comments and the charges of uncalled-for unprogressive conservatism in the Navy Department for not requiring turbines for the propelling machinery of battleships, have caused me to think that the setting forth of some particulars of underlying information regarding the relative merits of turbines and reciprocating engines might be of interest. It must be granted that if turbines (a new and unfamiliar system of machinery) are to be adopted in place of reciprocating engines (an old and familiar system), they should have proven, beyond a reasonable doubt, one or more paramount advantages, which will warrant the making of the change.

What are the advantages of turbines for propelling battleships? The following are sometimes urged: Reduction in weight and space, greater simplicity, less attendance, greater economy, absence of vibration.

Reduction in Weight and Space.—This is a chimera, which may sometimes be found in theory, but has not been proven in practice. The actual marine turbine may weigh slightly less than the best type of reciprocating engine of the same power, but the increase in condensing apparatus and other auxiliaries necessary to the proper operation of the turbine will about balance this saving. Apropos of this, a somewhat misleading comparison has recently appeared in scientific magazines, where the reciprocating engine of a battleship, of a design six or seven years old and built to suit battleship practice, is compared with the turbine of a scout of four years later design and built on the weight schedule of a torpedo boat. A rather fairer comparison might be made by taking the reciprocating engine of the scout's sister ship, which is of same power. Had this been done, the startling advantage in weight for the turbine would have vanished, as would also the great discrepancy in size. For heavy fighting vessels, turbines have, thus far, not demonstrated that their use will produce a material reduction in weight. Neither is there any very material gain in floor space, if the machinery is installed with an idea of doing any overhauling. Head room is gained, but a great deal of space is necessary for lifting the casings. Large hatches are even more necessary than with reciprocating engines, so that the space that could be gained by the turbines in battleships is extremely slight.

Greater Simplicity.—While the turbine principle is of itself more simple than that of the reciprocating engine, the whole arrangement of the motive power of the type of turbines most in vogue, the Parsons, is not as simple as for an arrangement with reciprocating engines. In the Parsons system the power is developed upon four shafts in place of the two in ordinary use. This naturally leads to some complication and, it may also be remarked, will make it much more difficult to quickly change the direction and speed of these engines for maneuvering purposes. It will naturally be somewhat more of a problem to handle a vessel with four screws than one with only two; and this is something to consider, when quick and reliable maneuvering ability is one of the essential qualities that a battleship should have.

The adjustments of the turbine engine will require considerably greater accuracy than those for a reciprocating engine, and the ill-effect of mal-adjustment is much more serious. Due to slight inaccuracies in alignment, there is danger of many blades being torn out by striking the casing. A hot bearing becomes a very serious matter, since the melting of the white metal is liable to cause the ends of the blades to strike.

The turbine requires the same auxiliaries as the reciprocating engine and a few additional ones, besides larger condensers and air pumps.

There is practically no difference in the number of attendants required for a naval vessel. Though there may be some reduction in the work of oiling, this possible reduction is to a great extent counterbalanced by the fact that turbines are unfamiliar machines, and the engineering personnel will not, for years, understand their operation as well as they do that of the reciprocating engine.

Greater Economy.—At the designed speed, that is full speed, marine turbines are about as economical as the best reciprocating engines now being built. When the speed is decreased, the steam consumption of the turbine, per unit of power delivered, increases very rapidly, so that at one-half power and below, it is considerably more than that of the reciprocating engine, and at low powers, several times as great.

To show how this works out in practice, I will take the results of the "Dreadnought's" trial, as taken from the notes published in the November number of the Journal of the American Society of Naval Engineers, and compare these with some results obtained with the U. S. armored cruiser "Maryland" while in service. The engines of the "Maryland" are not up to what is now the best economical design of reciprocating engines; and they were designed about seven years ago. Reciprocating engines fully 10 per cent better in economy are now being built for large naval vessels. The results are taken from service runs with ordinary American coal and with an ordinary crew, made up largely by recruits.

The coal used on the "Dreadnought" was no doubt about the best in the English market, and probably contained 16,000 B.T.U. per pound. The coal used on the "Maryland" averaged about 14,000 B.T.U. per pound. Considering these differences (13.3 per cent in heating value of coal, and the fact that in one case the coal was in a measure at least picked, that a trial crew was used, and that efforts were made to obtain all possible economy to make a good showing for the turbines), an approximation to a fair comparison of results would be to take off 15 per cent from the "Maryland's" coal per I.H.P. and compare this with that of the "Dreadnought." (See last column under table of "Maryland's" performance.)

The boilers of the "Maryland" and of the "Dreadnought" are of the same type, Babcock & Wilcox, so that differences in boilers may well be left out, and the difference in coal per I. H. P. may be attributed to the engine installation.

By comparing the results, it will appear that the "Maryland's" reciprocating engines are, at designed full power, about as economical as the "Dreadnought's" turbines at full power. Below full power, down to ½ power, 22 to 18 knots, the difference is slightly in favor of the reciprocating engine; from ½ to ¼ power there is about 30 per cent in favor of the reciprocating engine; and below ¼ power the reciprocating engine uses 50 per cent and upward less coal.

The best reciprocating engines used in the merchant service are 10 to 20 per cent more economical than the full-speed performance of the "Dreadnought."

Avoidance of Vibration.—This the turbine accomplishes, and in this it has an important point of superiority. The vibrations of the reciprocating engines installed on battleships are, however, now so slight, due to improved balancing, that they offer no serious objection from a military point of view.

"DREADNOUGHT'S" PERFORMANCE.

Power.	I.H.P.	Approx. Speed.	I.H.P. per pound of coal.	Pounds of steam per I.H.P.
1/12	1,748	9.0 knots	4.16	41.6
1/9	2,771	10.8 "	4.97	49.7
1/7	3,423	11.4 "	3.23	32.3
1/4	5,000	13.1 "	2.59	25.9
1/2	11,301	17.3 "	1.99	19.9
3/5	13,748	18.1 "	1.89	18.9
4/5	15,875	19 "	1.66	16.6
4/5	16,950	19.3 "	1.7	17
Full	23,000	21 "	1.51	15.1

"MARYLAND'S" PERFORMANCE.

1/10	2,624	9.5 knots	†2.3	1.95‡
1/8	3,232	11.2 "	2.04	1.734‡
1/8	3,152	12 "	2.3	1.95‡
1/5	5,422	14 "	1.95	1.66‡
1/3	8,444	16 "	1.71	1.45‡
2/5	10,520	17 "	1.74	1.48‡
3/5	15,395	19 "	1.74	1.48‡
Full*	27,101	22.5 "	2.3	1.95‡

The advantage of economy of the turbine in marine work exists at a certain speed, which is the full speed for the turbine; when this speed is lowered, the economy drops rapidly. At ¾ speed and less the best types of reciprocating engines are more economical, and below ½ speed they are twice as economical. If turbines are to be placed in battleships on the ground of economy, they ought to be reasonably economical at the cruising speed. The cruising speed of battleships will be a little above half speed, 11 to 14 knots, 1/5 or 1/4 power. At this speed the turbine will use 50 to 100 per cent more coal per unit of power developed. If it is desired to go full speed, the turbine will show a slight superiority in economy, but hardly over 5 per cent. The question then is: Will this slight increase in economy at top speed be worth the sacrifice in economy of over 50 per cent at the speeds that the vessel will ordinarily run? In those ships where full maximum speed is the essential point of their being, the turbine will have an advantage; but where full speed is not to be used continuously, this advantage disappears. Battleships will not cruise at 20 knots, nor at 18 either. It is too costly, and they do not carry sufficient engineering personnel to maintain such a speed for any length of time.

In view of all this, it seems that the superior advantages of turbines for propelling battleships have not as yet been *conclusively* proven, nor should the Navy Department be considered extremely conservative in not definitely requiring them without alternative for the battleships whose contracts are about to be let. It may be that in time such increased economy will be developed for the turbine at the lower powers that it will remove this serious objection which is now present.

The turbine, however, has a place in naval vessels where its advantages are fully worth while, and that is in vessels that are built primarily for speed and for continuous steaming at full speed. Such vessels are the scout cruisers, torpedo boats, and destroyers. Here the turbine has more of an advantage, and it is here that its merits should be developed.

There is also another field where the turbine is peculiarly applicable, and that is for operating the dynamo engines on board ship. This is a field where a constant speed of revolution is necessary, and where the turbine system should show with advantage its points of superiority. The proper procedure would seem to be to develop the turbine for those places where its advantages are greatest, and not to place this new and apparently popular motor in a place where it has as yet not proven its superiority in an all-round manner.

* * *

The Army and Navy Journal says that though England appears to be taking the lead in turbines, she has copied America far more in her types of screw engines than America has copied England. The prevailing types of screw engines first used in the mercantile marine and the navies of both countries are what are known as the "back-action," "direct-action," and the "vertical overhead cylinder" engines; and these types all originated in America. The first ship in the English navy which had her entire steam machinery below the water line, and the first one whose engines were attached directly to the screw shaft, was the "Amphion," the design of whose machinery was made in New York and sent to England.

---

[*] On this trial steam was put in receivers, and safety valves were blowing part of the time. When all the steam passes through throttle, 25,000 I. H. P., which is 10 per cent above designed power, can be developed with about 1.8 pound per I. H. P., or with 15 per cent reduction, 1.53. The "Pennsylvania," a sister ship, has developed more than this on trial with an expenditure of 1.83 H. P. per pound of coal.

[†] Results obtained by dividing total coal used for main engines and all auxiliaries by the I. H. P. of main engines.

[‡] I. H. P. per pound of coal after taking off 15 per cent to equalize on account of difference in coal and conditions.