lever, and a similar engine is utilized to drive the conveyor. But this machine is controlled by a governor, and runs at a constant speed. The working parts are run in a bath of oil, and inclosed in an oil-type dust-proof casing. As with all of the other modern electrically-operated labor-saving devices, not only is a great deal of time saved, but the output is greatly increased as well, and the ovens are worked to their fullest capacity.

THE PRESENT STATUS OF THE TURBINE AS APPLIED TO MARINE WORK.*

By HERBERT C. SADLER.

THROUGHOUT the history of shipbuilding, the attainment of speed, whether high or low, has been one of the fundamental requisites of every design. Depending, as it does, upon so many other conditions, it may not be out of place to repeat, in a general way, the problem that the naval architect must solve.

A floating structure is to be designed which will carry besides its own weight, a certain weight of cargo, must move at a certain speed for a certain time, i. e., must have a certain weight of machinery and fuel, and, finally, must carry this total burden upon a certain draft of water, and do so with safety. It is evident, therefore, that the question of displacement or weight is one of the primary conditions of design.

A discussion upon the resistance of ships is beyond the scope of this paper, but it may be observed that, in general, the less the weight of a vessel the greater the speed obtained with a given horse-power. Attention may also be called to the fact that whereas, in high-speed vessels, the weight of machinery and coal may be from 30 per cent to 50 per cent of the total displacement in one of the cargo or intermediate type, this will range from 5 per cent to 20 per cent. This latter consideration has a very important bearing upon the type of propelling machinery that should be adopted in any given case, and, therefore, immediately affects the subject of this paper.

The requirements that should be fulfilled in any marine propelling instrument are necessarily diverse, depending upon the particular trade or occupation of the vessel. There are, however, certain broad conditions that should be fulfilled by all.

The first and most important is that of *reliability*; this term being taken to mean that the engine will run at its full power for long periods of time with minimum risk of breakdown. The modern marine engines of the ocean liners are prominent examples of what can be done in this respect; but it should be borne in mind that perfection is impossible of attainment, and occasional accidents necessarily unavoidable. In the merchant marine the failure of the machinery means a loss of time and, hence, money, sometimes a considerable amount, if the vessel is not under control. In war vessels the failure of the machinery at a critical time may turn what would otherwise have been a victory into defeat. Even in pleasure crafts an accident to the machinery may sometimes be accompanied by serious complications. In all, however, the danger of total loss is increased if the vessel be rendered helpless through the breakdown of her machinery.

The second requirement should be one of *economy*. This question is brought home to the naval architect and ship owner more forcibly than to any other designer or power user. From the naval architect's standpoint economy means that a smaller weight of fuel and water is required and hence a saving made in weight and power. To the owner economy not only means a reduction of running expenses, but also decreased first cost, because a smaller vessel may be designed to do the same work as a larger and less economical one.

In war vessels economy means many things, among which may be mentioned increased fighting power or protection, increased speed, or increased radius of action at the same speed.

The third condition should be one of *adaptability* to conditions of propulsion and maneuvering. The almost universal propelling instrument is now the screw, exception being made of the paddle wheel, the application of which is limited to special types of vessels. The marine engine, therefore, must be capable of running at fairly high speeds of revolution, but the screw propeller again sets an upper limit upon the revolutions beyond which it is undesirable to go. When the phenomenon of cavitation appears, the efficiency of the screw falls off rapidly, and hence very high speeds of revolution are inadmissible. High speed is also accompanied by small diameter of propeller, the diameter varying inversely as the revolutions. Small propellers are, in general, less efficient than large ones, but there are some compensations in the way of better immersion in cases of light draft and in a seaway, which, to a certain extent, counteract some of the disadvantages.

Another condition of importance is that of *maneuvering*. A marine engine should be capable of being stopped, started and reversed without difficulty, and by the simplest possible means. In certain cases where the service requires that the vessel should make a number of stops at short intervals, this condition is of primary importance.

In war vessels, also, maneuvering qualities require special attention; but in the case of the average merchant vessel whose trade requires long periods at full speeds and only short ones of backing and handling at each end of a voyage, the above condition does not occupy such a prominent place.

The fourth condition, and one to which attention has already been called, is one of *weight*. The weight per horse-power developed should be, in a marine engine, as small as possible consistent with good design. Here again the importance of this depends upon the conditions of service and type of ship; for in cases where the weight of engine is only, say, 5 per cent of that of the total vessel, a small percentage saving does not appreciably affect the result; whereas in those cases where this weight is in the neighborhood of 25 per cent of the total, even a small percentage saving may be accompanied with considerable advantages.

Closely connected with the above is the question of the space occupied and general dimensions of the engine. In a large majority of engines, any saving in space occupied by machinery is a distinct advantage; while in war vessels in particular, the necessity for protection demands an engine whose dimensions in the vertical direction are not excessive.

The final condition and one to which particular attention has been paid in the past few years, is that there should be no unbalanced force tending to produce vibrations when the engine is running.

With this brief résumé of the prominent conditions to be fulfilled by a marine engine, let us proceed to consider in what respects the steam turbine is suitable and wherein it falls short of the requirements.

There are two principal types of turbines, known respectively as the impulse and reaction turbine. These are distinguished by the pressure existing in the clearance spaces between the guide and rotating blades. If this pressure is greater than that of the steam as it leaves the rotating blades, the turbine is said to be of the reaction type, and if equal, the impulse type. There are many other classifications, but at present we need only consider those that have been used to any extent in practice.

As representing the two systems, the De Laval and the Parsons may be said to be typical. The De Laval turbine has one practically insurmountable difficulty, so far as its application to marine work is concerned, and that is its high speed of revolution. In order to bring this within reasonable limits it is necessary to introduce gearing. The high speed at which this gearing must run causes the marine engineer to pause before installing an engine of this type; in fact, high-speed gearing is a method of transmission of energy that should never be used in marine work.

In the Curtis turbine, which is practically a combination of the two systems, i. e., alternate pressure and velocity stages, the number of revolutions has been materially reduced. This turbine, although extensively used on land, has had, up to the present, only a limited application in marine work, so that experience with this particular type is somewhat lacking. There seems to be no reason why, with experience, the Curtis turbine should not be a success when applied to ships.

The success of the turbine in its application to marine work has so far been due entirely to Mr. Parsons, and, as the experience with this type of turbine is the greatest, the remainder of the discussion will be devoted to the application of this particular type.

Taking the conditions previously discussed, in order, the first requirement laid down was that of reliability. In any type of machine, one measure of the risk of breakdown is the number of moving parts. Other things being equal, a large number of joints, moving parts, rubbing surfaces, bearings, etc., is accompanied with a greater chance of stoppage of the whole machine through the failure of one, than where these are reduced in number. In the reciprocating engine the number of parts is unavoidably large, and sometimes an insignificant breakage or overheating may cause a temporary stop. From this point of view the turbine possesses a great advantage in that, so far as the engine itself is concerned, practically the two main bearings are all that require attention. With the present system of forced lubrication this difficulty has been almost eliminated.

The perfect balance and uniform twisting moment, possible with the turbine, also play a somewhat important part in this connection. Up to the present, experience with the turbine in marine work over very long periods has not been possible; but, judging from vessels already running, notably the "Turbinia," the first vessel to be installed with her present turbines in 1896, and also from the performances of similar land engines, there seems to be no reason for apprehension that the turbine should be inferior to any other type of engine. Certain difficulties have, no doubt, occurred, which with a new type of engine it was almost impossible to foresee, but once these are known their solution should not offer any serious difficulties. Attention has also been called to the gyroscopic effect upon the bearings, when a vessel is in a seaway or turning; but Mr. Parsons has pointed out that in the case of the "Cobra" at maximum speed and in the worst possible sea, these forces would not amount to more than one-half of the normal weight upon the bearings. In certain types of turbines, notably those of the impulse principle, the erosion of the blades is liable to cause trouble. In the Parsons type, where the steam velocities are comparatively low, the blades do not give any trouble on this score, at least so far as experience has demonstrated at present.

Closely associated with reliability is ease of repair. To some the multitude of small blades may seem somewhat complex, but in reality this is not so. In the case of one accident, where a number of blades were stripped, the turbine was stopped, the debris removed, and the turbine started again and run for the remainder of the day, apparently without appreciable decrease in power. In all, the accident caused a loss of about three hours.

The first commercial vessel to be fitted with Parsons turbines was the "King Edward," built in 1901. Since then this vessel has been run continuously during the summer months and has given entire satisfaction.

No doubt the cylinders of the larger turbines will require considerable attention in design, in order to take care of the expansion. They are apt to distort when heated, especially as the temperature along the cylinder may vary from about 400 deg. F. to 100 deg. F., thus causing a varying expansion radially. This may lead to increased clearance spaces, but immunity from possible stripping may demand a slight sacrifice of efficiency.

We now come to the second and, perhaps, the most important consideration, viz., economy. So far as direct comparison of turbines of different powers working under different conditions is concerned, we are met with the difficulty of being unable to determine the indicated horse power of this type of engine. Where it is possible to perform a brake test, such as in land practice, the economy with respect to brake horse power, or horse power delivered, may readily be determined. By making certain assumptions as to the efficiency of the reciprocating engine and applying these to the turbine, we may obtain a quasi-indicated horse-power.

It should be noticed, however, that this is not a satisfactory method, and, so far as ships are concerned, a better measure of economy would be the amount of water or coal consumed per mile or hour at different speeds. For definite information as to the amount of water consumed, we must refer, in the first place, to experiments upon land installations.

The results of a series of tests* upon a 400-kilowatt and a 1,250-kilowatt machine, built by the Westinghouse-Parsons Company, of Pittsburg, show that the consumption of dry saturated steam per indicated horse-power-hour at full load was about 14.5 pounds; and at 50 per cent and 100 per cent load the consumption was about 17 pounds and 15 pounds respectively. With 190 degrees of superheat, the consumption at full load fell to about 11½ pounds per indicated horse-power hour.

On the assumption of 94 per cent efficiency, these figures would give from 14 pounds to 13 pounds per indicated horse power hour under ordinary working conditions with dry saturated steam. For a good average triple expansion engine under similar conditions, the consumption in all probability would be from 12 pounds to 15 pounds, so that from this point of view the steam consumption of the turbine compares favorably with the best reciprocating engine practice.

It is, however, when we come to use superheated steam that the turbine appears in a more favorable light. The economy due to superheated steam is too well known to need any discussion here, but reference is made to the effect of superheating shown in the above figures.

From the results of tests made upon some Westinghouse-Parsons turbines,† the statement has been made that for every 100 degrees of superheat there is a corresponding decrease of 10 per cent in steam consumption.

No doubt there is a corresponding gain in the reciprocating type of engine, but this fact should be borne in mind, that the mechanical difficulties resulting from the use of highly superheated steam increase rapidly with the degree of superheat. The principal difficulty lies in the proper lubrication of the internal rubbing surfaces, such as valve faces, pistons and cylinders, where high-temperature steam is used.

In the turbine, however, there is no need of any internal lubrication, and high temperatures do not materially affect the working of this type, provided difficulties due to expansion do not occur.

In a similar manner the gain due to the use of higher vacuum may be represented as varying from 3.5 per cent to 4 per cent for each 1 inch, depending upon the load. In marine work, reduced power is generally accompanied by decreased revolutions, and as is generally known the efficiency of the turbine falls off considerably under these circumstances. Although data are somewhat lacking upon this point it seems reasonable to suppose that at, say, half power and half the usual number of revolutions the increase in consumption per horse-power-hour should not exceed from 40 per cent to 50 per cent of the normal amount.

In general, the amount of time at which a vessel is running at reduced speed is exceedingly small, except in special cases, such as war vessels. In these, special means for increasing economy have been devised and will be discussed under the next heading.

From the point of view of economy, therefore, the turbine should show as good results as any other type of engine, especially when its adaptability to the use of superheated steam is taken into consideration.

Before leaving this topic, reference should be made to experiments with exactly similar vessels whose only difference lay in the propelling machinery.

In 1904, the British Admiralty conducted an exhaustive set of trials upon the "Amethyst," a cruiser of 3,000 tons, fitted with Parsons turbines, and three exactly similar vessels fitted with reciprocating engines. A full report‡ appeared in Engineering, from which the following is taken: Originally up to a speed of 14½ knots, but since certain improvements in connection with the auxiliaries, to a speed of 10 knots, the reciprocating engine has the advantage so far as steam and hence coal consumption are concerned; but above this speed the turbine has the advantage. At 18 knots

* See paper by F. Hodgkinson, Am. Soc. Mech. Engineers, 1904.

† See paper by I. R. Bibbins, St. Louis Convention of the Am. St. Ry. Assn., October, 1904.

‡ See Engineering, London, November 18, 1904.

* Read before the Association of Engineering Societies.

the reciprocating engine required 24½ per cent, and at 20 knots 40 per cent more water than the turbine. Although some of this difference might be traced to the boilers, the actual amount cannot be great as the heating surface and grate surface were practically the same in all ships.

In the full-speed trials the advantage of the turbine became more apparent; the maximum speed obtained by the reciprocating engine being 22.1 knots, as against 23.63 by the turbine engined vessel, a gain of 1.53 knots, or 6.9 per cent. This is the more remarkable seeing that the boiler installation is the same in all, and the higher speed in the turbine vessel was obtained with slightly less air pressure in the stokehold.

One other case has occurred where direct comparison between reciprocating and turbine engines has been possible. The Midland Railway Company, of England, in 1904 built four vessels, two of which were fitted with four-cylinder triple-expansion engines and two with turbines. This experiment is all the more interesting seeing that one of the turbine vessels is practically the same in all details as the reciprocating type, while in the other full advantage has been taken of the saving in weight due to the turbine, of putting this extra weight into larger propelling machinery.

The vessels were designed for a speed of 20 knots, and the following figures confirm those previously quoted.

From 14 to 20 knots the turbine vessel shows an advantage in steam consumption; between 19 and 20 knots the decrease in consumption is about 8 per cent in favor of the turbine vessel exactly similar to the reciprocating type, while in the other case, where full advantage was taken of the turbine, this figure amounted to 14 per cent.*

From the speed point of view there was also a corresponding gain, the turbine vessels obtaining fully one knot higher speed. An analysis of the results of a number of actual runs under service conditions shows that for the same speed the saving in coal in favor of the turbine amounts to about 9 per cent; or for the same coal consumption the turbine vessel could be run at a speed of 20.3 knots as against 19.5 knots in the vessel with reciprocating engines.

The Cunard Company is about to carry out a similar set of experiments with two large ocean vessels, the "Caronia" and "Carmania." These vessels are 675 feet long, 72 feet broad, and 52 feet deep, and displace about 30,000 tons. The "Caronia" is already running and developed 22,000 indicated horse-power at 19½ knots speed on trial. The "Carmania" has already made several trips and another direct comparison on a large scale will soon be available.

We now come to the third requirement, viz., adaptability to conditions of propulsion. From the previous discussion, and from the number of vessels already equipped with turbines, the question of the general adaptability of this form of engine is beyond argument. There remain, however, certain conditions which need consideration. Compared with reciprocating engines turbines possess the quality of a relatively high speed of revolution, and it is this consideration which effectually bars certain types from marine work entirely, and places a limit upon the application of others. High speed of revolution is necessarily accompanied with small propellers, which in themselves are not so efficient as the larger ones. When we come to large vessels the actual size of the propeller plays an important part in the general handling and working of the vessel. Let us consider the principal types of vessels in the merchant service. These may be divided into the cargo boat of slow speed, the intermediate cargo and passenger with moderate speed, and the purely passenger or high-speed type. In the purely cargo boat not only is the power small relatively to the vessel, but also absolutely. For example, a large ocean freighter of, say, 500 feet in length, and say, 17,000 to 18,000 tons displacement, would not have engines of more than say 3,500 indicated horse-power, or about the same as that estimated for the "King Edward." The diameter of the center propeller in this case was 57 inches, and the two outside ones slightly less; the revolutions being 505 and 755 respectively. Such small propellers are evidently unsuited for the case in point, and, if the speed of revolution were reduced so that a propeller of larger diameter could be employed, the diameter of the turbines would have to be increased, with the result of little, if any, saving in weight and certainly decreased economy over the ordinary type of engine. We are forced, therefore, to this conclusion, that where the machinery installation or power is small relatively to the vessel, there is no advantage in the use of the turbine, but rather the opposite.

In the intermediate and fast passenger types the conditions just discussed do not hold, as in these cases large or fairly large powers are required, which naturally entail the use of large propellers, even though the revolutions be kept the same as in the smaller engines.

The one serious drawback that the turbine possesses is its inability to reverse. Although in most cases, in the merchant marine, an engine is moving ahead for about 99 per cent of its time, yet the condition of reversibility must be met. In all present arrangements a special reversing turbine is fitted, usually at the end of the low pressure, and runs *in vacuo* when the main turbine is running ahead.

The objection is sometimes heard that turbine vessels cannot be stopped as quickly as those of the ordinary type, and to a certain extent this is true with many vessels. The fact should be borne in mind, however, that the time required to bring a vessel to rest

depends largely upon the power exerted, and if sufficient backing power be supplied there is no reason why the turbine vessel should not be as handy as the ordinary type. The objection is, however, a real one, for while in the case of the reciprocating engine the full power is always available for backing, in the case of the turbine, full power in the astern direction would mean a large additional weight and the carriage of a useless engine for the greater part of the time.

Certain experiments upon this question have been performed which tend to show that even with moderate backing power the turbine vessel is fairly handy.

Torpedo boat No. 293 of the French navy, 130 feet long, displacement 94.6 tons, brought to rest from a speed of 20 knots in 4½ times her own length, or in 585 feet. Channel steamer "Queen," 323 feet long, brought to rest from a speed of over 19 knots in 2½ times her own length, in 1 minute 7 seconds. Steaming astern, she attained a speed of 13 knots. Channel steamer "Manxman," 330 feet, brought to rest from full speed (about 22½ knots) in 1½ minutes.

In war vessels the conditions as to operation at reduced powers and maneuvering are much more severe than those which obtain in the merchant marine. Except in special cases, a warship is seldom called upon to develop her full power after she has completed her official trials. Here the turbine as ordinarily fitted for full power would prove undesirable from reasons of economy.

One method of overcoming this difficulty was that adopted in the destroyer "Velox," where two small triple-expansion reciprocating engines were connected by detachable couplings to the low-pressure turbines. The steam after passing through these engines was led into the low-pressure turbines and thence to the condenser. This arrangement is undesirable both from an engineering and operative point of view and has since been discarded in favor of the entire turbine installation.

In the "Amethyst" two small cruising turbines are permanently attached to the main low-pressure turbines. At reduced powers the steam first passes through the cruising turbines and then through the main turbines to the condenser, thus giving a large range of expansion. For intermediate powers the steam is admitted first to the intermediate cruising turbine, then to the main high-pressure turbine and so on to the condenser. For full powers the auxiliary cruising turbines are cut out. This arrangement possesses all the flexibility that can be desired, and if reference be made to the steam consumption curves, it will be noticed that these compare favorably with those of the reciprocating engine.

The question of economy at reduced powers is therefore not such a serious matter as one would suppose at first sight; and, in this connection, it is interesting to note that similar arrangements have been made in the vessels of the Russian volunteer fleet: the reciprocating engines in these vessels working as quadruple at ordinary speeds and triple at the higher speeds required on government service.

In connection with the question of weight, there is no doubt that the turbine possesses an advantage over the reciprocating engine. In the case of the Midland Railway boats, referred to above, the reciprocating engines, shaft and propellers weighed 280 tons, on the turbines 195 tons, a difference of 85 tons, or 30 per cent. There was also a saving in hull construction weights of about 30 tons, making a total saving of 115 tons.

	Reciprocating.	Turbine.
Boilers	460	390
Engines	210	160
Shafting and propellers.....	60	25
Total	730	575
Speed	21.9 Knots	22.3 K.

Even in the foregoing figures full justice is not done to the turbine, when the speed is taken into consideration.

For the same weight of machinery in the case of the "King Edward" the speed of the turbine boat was 20.5 knots, as against 19.7 probable speed, if reciprocating engines had been fitted, or a gain in horse power of about 20 per cent.

In the case of the cruiser "Amethyst," the weight of machinery was practically the same as that of the reciprocating engined ships, viz., 530 tons. The speed of the "Amethyst" was, however, 23.63 knots against 22.1 for the other vessels.

	Reciprocating.	Turbine.
Engines and boilers....	537	535
I.H.P.	9,900	(14,000)?
Speed	22.1	23.63

For the same speed and displacement there would be a saving of about 155 tons, or nearly 30 per cent, on the weight of machinery alone. This would also be accompanied by less coal and water, or if these were increased so as to keep the total weights the same, there would be a corresponding increase in radius of action.

With regard to floor space occupied, there is nothing to choose between the reciprocating engine and the turbine. In space taken up in the vertical direction, the turbine has a distinct advantage, although in the merchant marine this may not always be an unmixed blessing on account of the tonnage laws.

The situation may, therefore, be summarized briefly as follows: So far as reliability is concerned, there seems to be no reason why the turbine should be inferior to the reciprocating engine; while from the point of view of economy and speed, the turbine has shown itself in many ways superior. At very low

speeds, however, the reciprocating engine is superior in economy of steam, but against this the turbine requires less oil and a slightly less engine-room staff. The turbine in its present state is not suitable for all classes of ships. Where the speed is high or fairly high, that is, in passenger and intermediate types, war vessels and yachts, it may be used to advantage; but in slow cargo vessels where the power is small relatively to the size of ships, and for those vessels which require to be started and stopped at frequent intervals, the turbine is not suitable. From the weight point of view the turbine is certainly superior to the reciprocating engine of the same power, especially in the case of ordinary high-speed vessels. It possesses also the advantage of being perfectly balanced, and hence the vibrations of the vessel may be considerably reduced. From figures available, the cost is slightly in excess in the case of the turbine, but as the speed of the vessel is usually greater, this is more apparent than real. So far as space occupied is concerned, there is little to choose between the two, the turbine having the advantage so far as height is concerned.

In conclusion, it may be interesting to note the number of vessels built and building, in which the turbine in some form, although mostly of the Parsons type, is employed. In the merchant marine there are some forty-three, ranging in size from small yachts to the new Cunard vessels which will have in the neighborhood of 65,000 indicated horse-power. Five naval vessels have been built and twenty-one are building, making a total of some sixty-nine vessels in all.

IMMIGRATION STATISTICS.

During the fiscal year 1,062,054 tourists and aliens passed through the immigration station. Of this number, 935,000 come under the head of alien newcomers who had emigrated to this country, the rest being composed of that conglomerate class which crosses and recrosses the Atlantic in 'tween-deck quarters, some being aliens who had obtained naturalization papers and who had gone abroad to revisit old haunts, some others being of that frugal type which crosses to Europe in steerage or second-cabin quarters, to return as third-class, and as such to come under the supervision of the Immigration Bureau.

Of the total million and odd that passed through Ellis Island during the fiscal year, 609,714 were males. Those under fourteen years old numbered 106,990; those over forty-five, 38,296. Of the entire number, 99,884 had been here before, these being largely the ones who had obtained a competence here and had utilized part of their savings to make trips to their old homes.

Italy furnished the largest proportion of the newcomers, that nation sending 221,696 of its population to this country during the year. Next in point of numbers are the Hebrews, of whom an army of 125,000 arrived, most of these being refugees from Russia. Germany sent 71,916 of her people. The Magyars came next, with 42,000. The rest are classed under the head of miscellaneous.

The total footing shows an increase of 99,075 actual immigrants over the number of aliens who passed through Ellis Island last year. The arriving horde brought, it is estimated, about \$19,000,000. For purposes of comparison it may be interesting to note that a former official of the Treasury Department has recently made a computation by which he figures that Americans who visit Europe this year will expend there the enormous sum of \$100,000,000. The comparison, of course, must be long drawn out, as the American tourist is one who usually goes abroad with all the consequence that wealth can give, while those who reach this country in steerage quarters are those of the laboring class.

There were 7,877 deportations during the year, of whom 195 were excluded on the proven charge that they were criminals. There has been much talk of anarchists being refused admission, but the records do not show that any one has been barred because of this charge.

The report of the Commissary Department of Ellis Island shows that there has been an average of 6,000 meals per day served to newcomers, which makes the dining room of the immigrant station one of the biggest in the country. In the report attention is called to numerous anonymous letters which had been sent to Washington and to newspapers of this city, alleging that employes of the Landing Bureau were overworked. It is shown that the inspectors worked on an average seven hours a day.

In trials to determine the physiological action of feeble radio-activity carried on by E. S. London, the results of which were published in Archives d'El. Médicale, a specimen consisting of 18 milligrammes of radium, applied to the skin of the forearm for brief intervals of time, was found to produce a reaction after a minimum exposure of 15 seconds duration. Three rabbits were confined in a cage 43 centimeters long, 41 broad, and 31 high. In the middle of the roof of the cage 260 milligrammes of radium bromide were placed. Redness of the ears was observed after sixteen days, and burns soon began to form on the skin of the back. After fourteen months the backs and heads of the animals were denuded of fur and covered with ulcers. The animals had become apathetic and slow in movement, the hind legs were partially paralyzed. Central retinitis was present in the eyes of all three and optic neuritis in one. The sexual instincts were abolished. Post-mortem examination revealed changes and degenerations in the muscles, liver, spleen, kidneys, and generative organs.

* See paper by William Gray, Inst. Naval Architects, London, July, 1905.