A NEW THEORY OF THE SCREW PROPELLER.

Prof. Oswald Flamm of the Technische Hochschule at Charlottenburg, the principal engineering school of Germany, very recently completed a remarkable investigation of the action of a ship's screw propeller. As a lecturer on naval architecture and engineering, he admitted that the theory of the marine screw had worked out very indifferently in practice. His investigation, which involved formidable complications, was reduced to a highly mathematical form; but on concluding his practical experiments, Flamm was nearly ready to deny that the theory had any real value. Propellers elaborately calculated on that theory were found, in practice, to require so much "cutting and trying" that calculation was simply wasted. The entire theory is now regarded by him as a mere dry abstraction. It gives no clear idea of the precise physical motion that a screw imparts to water.

Flamm finds that the most obvious features of a ship's screw were entirely overlooked by its originators, yet these very features indicate the real reasons for a propeller's action. One of these was the seething mass of water immediately behind a steamer's stern, and another, that familiar condition of any cast-off propeller, that when they have lost their usefulness they have a peculiar shape. The edges of the blades are always rough and irregular through erosion. Why are only the ends in that condition while the hub remains unimpaired? Prof. Flamm's experiments not only explain this paradox but also dispose of two very common notions; that a screw at the highest speed of its revolution, loses propelling effect through "cavitation" (a vacuum formed in the water behind the blades) and that the propelling effect may be increased

VELOCITY OF PROPELLER, 2 METERS PER SECOND.

by inclosing the propeller in a tube to prevent water that is being acted upon, from escaping at the sides.

Flamm's method of investigation meets the problem so clearly and fits the requirements so perfectly that it seems odd he should have been the first to try it. Much of our useful knowledge about screw propellers has been obtained at great expense by fitting propellers of various designs to a ship and in this way, measuring their efficiency. Flamm constructed a testing apparatus which reproduced similar conditions on a small scale at less cost, and at the same time permitted more complete and accurate observation and measurement.

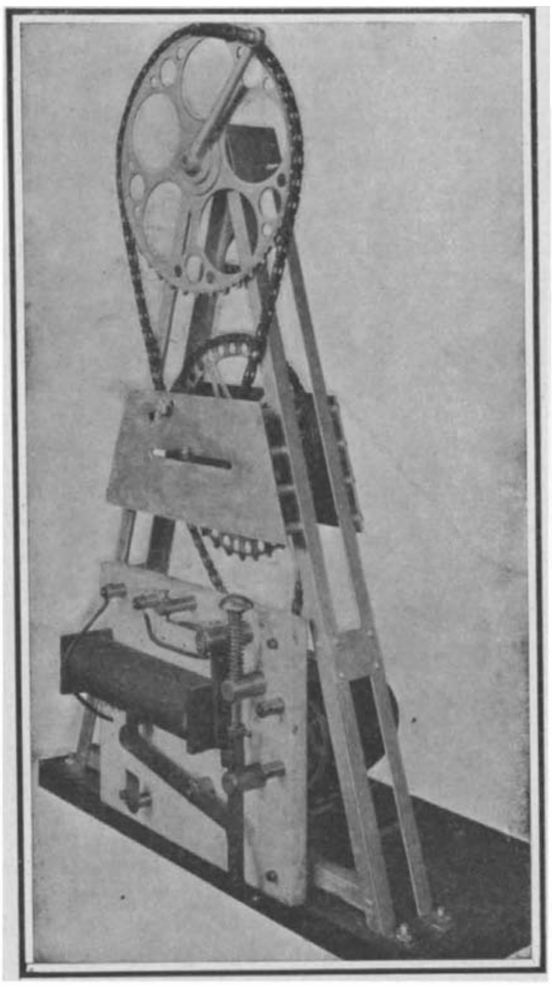
A screw was observed while it was propelling. The minutest features of the process, the water itself, were photographed by means of extremely sensitive plates that gave perfect pictures at exposures of only 1/1000 part of a second. It had been intended to make the stream lines visible by adding an opaque powdery substance to the water, as used successfully in photographing the stream lines around moving bodies. This was not necessary; enough air was mixed with the water by the propeller to make the screw's movement plainly visible. These pictures were stereoscopic and kinematographic views. The apparatus was very simple, a long glass tank filled with water, over which ran a small car along a railing; to the car was attached an electrically-driven screw propeller immersed in the water. There was no track resistance to the car, to which was fastened a cord running over a pulley at one end of the tank. This cord was attached to a cup for holding weights. The cup's range of fall was as long as the tank, therefore the resistance of the car to propulsion was measured with exactness. From one side of the tank two electric arc lights of 24,000 combined candle-power, sent their rays through the water on the level of the propeller, to the photographic lens on the opposite side. The tank was 32 feet and 9 inches long and 2 feet and 7 inches wide and deep; the diameter of the propeller was less than 4 inches. Fourteen different patterns were tested, including all the standard types. Accurate measurements were obtained of the number of the propeller's revolutions and of its push, but the amount of energy it consumed could not be determined with the same accuracy in this simple apparatus nor was it possible to ascertain the maximum push any certain propeller was capable of giving, except when the car was held stationary. Even so, many conclusions may be drawn. It is evident that a propeller's efficiency depends on the processes in the water, and that these processes obey definite laws. Flamm discovered a sucking action to be the real basis of the efficiency of all screw propellers. In naval practice, a ship's propeller is quite near the meeting line of water and air; this fact gives the sucking action a peculiar "by-effect" that is so incidental and variable, it has escaped much critical attention. As a result, all former theorizing was futile.

All the Flamm pictures show a positive dent in the water-level, immediately above the screw's periphery—the water is being sucked down to the screw's center with such force that it cannot flow in quickly enough from the sides to fill up the vortex. Flamm states that this dent exists even around a freight steamer's propeller when it is so far out of the water that the top blade projects above the surface. The water's quick turbulency on the slopes of this dent engulfs air, which is taken down to the blades; this peculiar ad-

PROPELLER SUCKING IN AIR FROM SURFACE.

hesion and attraction between air and water produces foam. Consequently, the screw does not work on water alone but on water mixed with more or less air. Thus is explained the paradox, how an implement placed as far below the surface as a ship's screw, whips the water into a frothing mass. Another fact, hitherto unsuspected, is presented by these experiments: What has been called the propeller's "slip," that difference between its pitch speed and the velocity with which it drives the ship, is variable for the same energy and size and shape of the screw. It depends on the volume of air that is sucked in; this in turn depends on various conditions.

Flamm found that the phenomenon attending any sudden loss of efficiency of a ship's propeller when it is driven above a certain number of revolutions a minute, was not one of "cavitation," as heretofore assumed. "Cavitation" has been explained as the hollowing out of water by the screw, meaning that the blades when passing too rapidly through the water, leave an instantaneous vacuum in their wake, thus losing their "grip" on the water, as a whip-lash leaves a vacuum in the air. On the contrary, it has been demonstrated that in all these cases of so-called "cavitation," the suction from the water's surface had become so strong that an immense volume of air rushed in from above, with the suddenness of an explosion. The water is instantly whipped into foam around the propeller, the blades lose all hold and the screw races away furiously as it does when lifted entirely out of the water when the ship pitches violently. In Flamm's experiment,

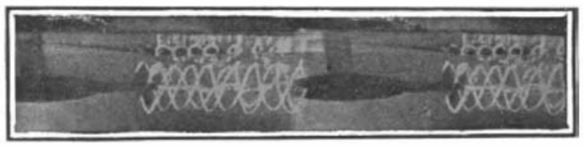


A MACHINE FOR FIRING BLASTS SIMULTANEOUSLY.

with the propeller working at very high speed, the car was dragged back by the weight in the cup.

There was an obvious remedy either under the experimental conditions or in water more or less smooth. When the car was fitted with a board that covered the water-level on top of the revolving screw, it permitted running the propeller even at higher speed; no "cavitation" occurred because the air was excluded. The efficiency of a ship's propeller may also be increased by a stern having a long overhang immediately below the surface. A screw's efficiency is impaired by any air screen too far below the surface because in that event it excludes the water as well as the air. A half-cylinder of sheet metal directly above the screw would be useless. Everything therefore urges placing the screw as far below the surface as possible. This seems to explain the efficiency that is obtained in fast motor boats by inclining the propeller's axis. Even a layer of water no deeper than the screw's diameter was not a very efficient shield against the entrainment of air. It was still more curious that when the revolving speed at which the board excluded "cavitation" was only slightly exceeded, "air tubes" were formed in the water. These traveled from the edge of the board to the propeller, again destroying efficiency. It was necessary to have the shielding board of ample size.

Observations of a worm-shaped air-space behind the hub of the experimental screws were not productive of much surprise. This was a neutral space without suction or pressure, as indicated by introducing a small tube. Air blown through that tube considerably increased the waterless space below the surface. Nevertheless, Flamm found that true "cavitation" exists, but that, quite contrary to established notions, it marks the very climax of a screw's efficiency. As this efficiency depends to its greatest extent on suction, it becomes evident that a screw is most efficient at the moment there is enough suction to actually create a vacuum. "Cavitation" is wasteful in that from the instant it begins, any increasing of the number of revolutions per minute does not increase the propeller's efficiency at the same rate that it costs power. It



VELOCITY OF PROPELLER, 3.7 METERS PER SECOND.

cannot increase a suction that is already at its maximum. These tests of real "cavitation" were conducted under a large protecting board. It was also found that starting a screw very suddenly increased the air-suction to a marked extent.

Prof. Flamm obtained a great number of excellent photographs. The air sucked in not only illustrates the stream lines next to the propeller but also reveals the wake of the blades for considerable distance behind the propeller. On examining these photographs, the reason propellers corrode at the edges of the blades, becomes very clear; especially upon considering that each little dent when first created by the erosion becomes a nest for air bubbles. Suction is strongest at the edges of the blades. Prof. Flamm also gave great attention to skin friction of the water. He advises running a propeller rapidly because the friction that forms an important part of its resistance to revolving, increases at a lower power of the speed than its push, and because "cavitation" may be obtained with a small screw. He found wide blades wasteful of power. He designed a very efficient screw with increasing pitch and narrow blades. These trials are to be resumed on a larger scale.

A MACHINE FOR SIMULTANEOUSLY FIRING MANY BLASTS.

BY FRANK C. PERKINS.

The electric machine for exploding blasts pictured in the accompanying illustration is said to effect a reduction of one-third in the amount of explosive used, on account of the simultaneous firing of the charges.

All the charges must be exploded at the same instant, this being far more effective than a number of intermittent explosions, separated even by only a fraction of a second.

The electric firing machine illustrated consists of a small dynamo of 12 volts pressure mounted on the base of the machine, and driven with a crank by means of sprocket wheels and chains, the best results being obtained from a dynamo 25 per cent over-compounded. By the use of the hand-operated machine, it is stated that one hundred casts have been fired at one time, all of the charges exploding precisely at the same instant.

An electro-magnetic switch, mounted on a marble slab on the front of the machine, accomplishes this desired end, and the current from the dynamo first passing around the coil of the electro-magnet, which has an iron core. The magnetic strength of the iron core increases as the current around the coil becomes stronger while the dynamo is being speeded up. When the electric generator is working at full speed, and the current is strong enough to explode all the fuses at once, a vertical armature is pulled over, and an iron core is sufficiently energized. A catch on the vertical shaft noted at the right of the coil in the illustration is thereby released, and a spring pulls the shaft up with a jerk. A switch beneath the coil is operated

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(*Concluded from page 496.*)

age cable, spaced at equal distances of 485 feet apart. These buckets are held to the runners by a one-half by two-inch steel frame, allowing it to swing freely on an axle between the flanged wheels. The seating capacity of each bucket is four.

In the entire distance there are fifty towers, built of eight by eight timbers, most of which were cut within a mile of the road. Over these towers run the cables. The stationary cable is the higher one, the haulage cable being two feet below and carried midway in the frame that supports the buckets. This haulage cable is endless, winding about a huge drum at either terminal. The towers are not placed an equal distance apart, but according to the slope and the contour of the ground. On the longer stretches they are frequently two hundred feet between, while at the base and summit they are within a few feet of one another. Perhaps the best example of the entire simple working plan may be found in the large stores of a city, where package carriers are in use. The little wire baskets that carry your purchases from the clerk to the wrapper are in miniature duplicates of these huge, man-carrying buckets, save where the former are operated by springs, the latter are moved by electric power.

The entire distance covered, from base to summit, is one and one-half miles, and in traveling this you are raised from nine thousand feet at Silver Plume to something greater than twelve thousand five hundred feet at the summit. This is, approximately, one foot lift for every two feet covered. In order to attain the same elevation, any road in the world—Pike's Peak cog road a possible exception—would have to traverse several times the distance. The time is thirty minutes each way.

The motive power is electric, the current being transmitted from Georgetown, four miles distant. Two motors are used, both of thirty-five horse-power each, and both located at the upper terminal. One motor is sufficient to operate the endless cables on an average haul, but on other occasions, where the buckets are filled, both are thrown in.

The entire road is equipped with electric signals and telephones. In its length are five stations, built about the towers, each with its watchman. The slightest accident is promptly telephoned to the engineer, and the buckets stopped.

The plans were first drawn up late in 1905, and the construction commenced the year following. It was not until the summer of 1908, however, that the road was in full running order. The total cost was slightly in excess of $70,000.

A MACHINE FOR SIMULTANEOUSLY FIRING MANY BLASTS.

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by the shaft. When the switch is thrown to the lower contact, the fuse circuit receives the whole current from the electric generator.

All of the fuses are melted instantly by the heavy rush of current accentuated by the inductive kick of the coil, thus producing a simultaneous firing of all the charges of explosives used. In deepening the river at Sault Ste. Marie for the United States government, the contracting firm used three similar machines, but larger and more powerful, operated by compressed-air engines. These machines were perfectly automatic and unfailing in operation. In all cases the fuses were arranged in parallel circuit between the two mains of the dynamos, the pressure being 12 volts. It is stated that these devices operated so simply that it required only the opening of an air valve to fire three hundred charges of dynamite at one time.

Oleat Maury.—A preparation for greasing wool, according to a French patent, is made by the saponification of mixtures of mineral oils and vegetable oils by alkaline carbonates.

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