a lever, and one by one the mines exploded without any visible agent. He declared that he had done it by a concentration of the power of F rays. He was next asked to blow up some powder magazines in an old hulk, which he also did successfully.

"The technical officers who had witnessed the tests next wanted to prepare mines in their own way and defied him to explode them. This he is alleged to have refused to do at one moment, and a discussion arose. Were the experiments sincere or not? The question was asked and sides were taken at the time; but the dispute was suddenly hushed up or dropped. The fact is that every subsequent move of Signor Ulivi has been shrouded in mystery."*

Self-Directing Torpedoes.

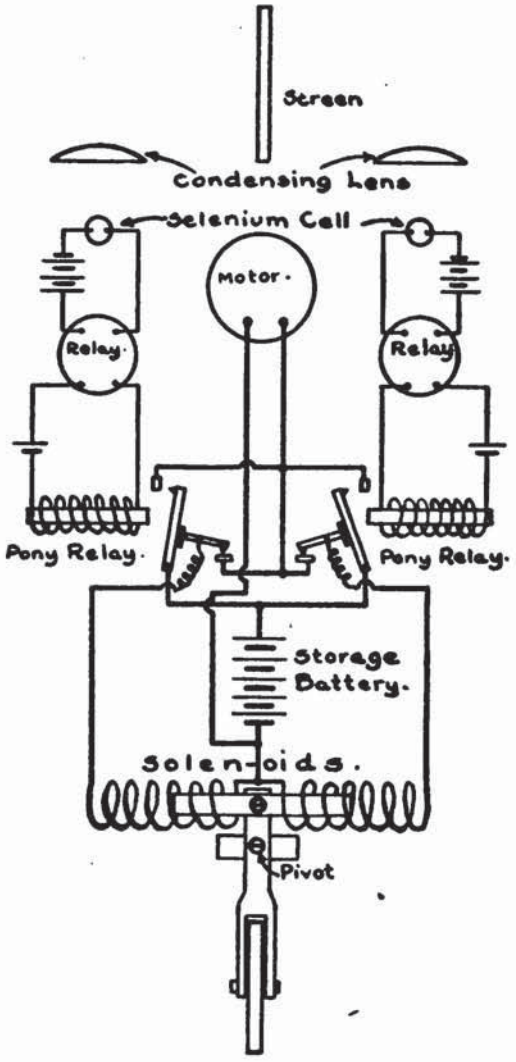
The latest tendencies along torpedo-control lines have been towards the development of apparatus which will give a torpedo the power of self-direction.

In 1912 the author, in collaboration with John Hays Hammond, Jr., developed such an apparatus, which was called an "orientation mechanism." It is more generally known now as the "electric dog." It is shown in Figs. 110, 111 and 112.

"This orientation mechanism in its present form, consists of a rectangular box about three feet long, one and a half feet wide, and one foot high. This box contains all the instruments and mechanism, and is mounted on three wheels, two of which are geared to a driving motor, and the third, on the rear end, is so mounted that its bearings can be turned by electromagnets in a horizontal plane. Two five inch condensing lenses on the forward end appear very much like large eyes.

* Extract from an article in the "London Times."

"If a portable electric light be turned on in front of the machine it will immediately begin to move toward the light, and, moreover, will follow that light all around the room in many complex manoeuvers at a speed of about three feet per



Wiring Diagram- Electric Dog.

FIG. 110.

second. The smallest circle in which it will turn is of about ten feet diameter; this is due to the limiting motion of the steering wheel.

Upon shading or switching off the light the dog can be stopped immediately but it will resume its course behind the

moving light so long as the light reaches the condensing lenses in sufficient intensity.

"The explanation is very similar to that given by Jaques Loeb, the biologist, of reasons responsible for the flight of moths into a flame. According to Mr. Loeb's conclusion, which is based on his researches, the moth possesses two minute cells, one on each side of the body. These cells are sensitive to light, and when one alone is illuminated a sensa-

FIG. 111.
Interior of Electric Dog.

tion similar to our sensation of pain is experienced by the moth; when both are equally illuminated, no unpleasant sensation is felt. The insect therefore keeps its body in such a position, by some manner of reflex action, as will insure no pains, and in this position the forward flying motion will carry it directly toward the source of light.

"The orientation mechanism possesses two selenium cells, corresponding to the two light sensitive organs of the moth, which, when influenced by light effect the control of sensitive relays, instead of controlling nervous apparatus for pain pro-

duction, as is done in the moth. The two relays controlled by the selenium cells in turn control electromagnetic switches which effect the following operations; when one cell or both are illuminated the current is switched onto the driving motor; when one cell alone is illuminated, an electromagnet is energized and effects the turning of the rear steering wheel. The resultant turning of the machine will be such as to bring the shaded cell into the light. As soon and as long as both

FIG. 112.
Electric Dog in Action.

cells are equally illuminated in sufficient intensity, the machine moves in a straight line toward the light source. By throwing a switch, which reverses the driving motors connections, the machine can be made to back away from the light in a most surprising manner. When the intensity of the illumination is so decreased by the increasing distance from the light source, that the resistances of the cells approach their dark resistances, the sensitive relays break their respective circuits, and the machine stops.

"The principle of this orientation mechanism has been

applied to the Hammond dirigible torpedo for demonstrating what is known as attraction by interference. That is, if the enemy tries to interfere with the guiding station's control, the torpedo will be attracted to it. The torpedo is fitted with apparatus similar to that of the electric dog, so that if the enemy turns their search light on it, it will immediately be guided toward that enemy automatically.

"In order that the search light used by the control operator may not have this same effect, use is made of a gyroscope to keep the turn table upon which the cells are mounted, in a fixed position relative to the earth. In this way no matter how much the torpedo turns, or in what direction it is traveling the selenium cells will always face from the shore and toward the attacking battleship in the open sea.

"By means of two directive antennae, instead of two selenium cells the same principle may be applied for attraction by interference when Hertzian, instead of light waves are used. Sound waves might also be utilized in a similar manner so that the sound reaching the torpedo (which would be equipped with two submerged microphones made sensitive and directive by megaphone attachments) from the pounding of the battleships engines and other machinery, would effect its attraction in a way analogous to the attraction of a source of light for the orientation mechanism. It is just possible, too, that similar apparatus could be used for the detection of submarines, or for defense against them." *

The electric dog operates in a single plane, the horizontal; the author has developed plans for extending its operations to both horizontal and vertical planes, by using two sets of the orientation apparatus operating at right angles to one another. These plans include the use of all forms of radiant energy.

* Extract from a paper on Torpedo Control by the author in the *Purdue Engineering Review*, 1914.

With such a double orientator a new defense against the submarine becomes possible. Captain K. O. Leon of the Swedish navy has already applied the electric dog principle to the automatic direction of torpedoes, the sound waves sent out through the water from the hull of a ship acting as the attracting stimulus; it is but a step to apply a double orientator of this type to torpedoes that will seek out and destroy any submarines within its range of hearing. This same type of automatic director is suitable for use with aerial torpedoes, explosive-laden mechanical moths, which will sweep down upon the ships of the air with a sting that will blow them into a thousand pieces. The electric dog which now is but an uncanny scientific curiosity may within the very near future become in truth a real "dog of war," without fear, without heart, without the human element so often susceptible to trickery, with but one purpose; to overtake and slay whatever comes within range of its senses at the will of its master.