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- The project of an automatic depth governor for submarines was completed by the Gema Firma, Berlin-Koepenick, in July 1949. As the ship designing office (KBS) was stalled on the construction of the four-cylinder pump, [Redacted] The first experimental device was finished as scheduled in early December 1949.
- The device proper was designed by Graduate Engineer Hoffmann, who was formerly with the Siemens Firm as an expert on anti-rolling devices in the shipbuilding field; he is now managing engineer with the Gema.
- The device is intended to automatically keep the submarine at a predesignated depth, particularly at the correct periscope depth for firing. Oscillations of the submarine, for instance in a seaway, are to be automatically counteracted by draining or letting water into the tanks prior to any change of depth or trim. This is caused by the piston pump which - and this is a new feature - works in two directions. The pump is started electrically. It also acts as a water meter, as a definite amount of water is forced up with each stroke of the pump. An essential requirement is that the gear meet the movements of the boat in sufficient time to prevent her from making any pendulum oscillations.
- Description of the submarine depth governor.

At low speeds the normal effects of diving planes would not suffice to keep the boat firmly in position. Until now depth was controlled by altering the weight of the boat, (by flooding or draining regulating water at low rates of speeds - snorkel speed and periscope depth). This procedure

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is of particular importance at "zero" speed, in other words, when the boat is to float at a definite depth.

Compressed air has been used up to now for driving the steering mechanism. In such cases regulating valves were actuated according to the deviation from the desired depth and the velocity of variation of the depth. If compressed air is used the amount of through-flowing regulating water is not only dependent on the sectional area of the valve but also on the difference of pressure existing between the compressed air and the water pressure outboard. It is difficult to clearly define the relation existing between the flowing velocity and the sectional area, and with simple means it is impossible. The determination of the velocity of the variation of the depth is also difficult.

The new depth governor is an integral steering gear. The steering components which are used for actuating the regulating valves are: The deviation from the desired depth, the integral of this deviation in relation to time and the conveyed amount of water.

As the flowing velocity of the regulating water is proportional to the opening of the valve, the velocity of the variation of depth is indirectly formed and is used as the amount of allowance for the steering.

The steering components can be made use of more or less, with the result that the submarine makes for the prescribed depth in a much damped oscillation. Oscillographic damping is obtained by appropriate choice of the interpolation values. In this case, the consumption of regulating water reaches its minimum. The shape of the movement curve of the submarine is shown by a differential equation of third degree; part of its constants depend on the difference of pressure between the compressed air and the outboard pressure. The existence of this interdependence means a handicap for the damping of the movements of the submarine, the stability and the consumption of water. For this reason the movement of the regulating water is no longer effected by compressed air, but by a piston pump. This piston pump, which is driven by the steering motor, secures a positive connection between the revolutions of the pump and the velocity of the regulating water independently of the difference of pressure which exists between the regulating water tank and the outboard pressure. The number of revolutions of the steering motor clearly indicates the amount of regulating water conveyed. The difference-of-depth pressure meter indicates the deviation of the actual depth of the boat from the prescribed depth. It works on the principle of a deflecting diaphragm. The deflection is transmitted to an electrical indicator which supplies an alternating voltage which is proportional to the deviation of depth.

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Differences of weight, such as those caused by the discharge of a torpedo, are eliminated by an isodrome which consists of a Ferraris integrating motor and a rotary current transformer. The Ferraris motor is steered by the electrical indicator of the difference-of-depth pressure meter and forms as a rotary angle the integral of the deviation of depth in relation to time which is transformed into the appropriate voltage by the rotary transformer. These two control components, multiplied by the corresponding interpolation values resulting from the stability conditions, correspond to the amount of water to be conveyed by the pump. The number of revolutions of the control motor and the piston pump, respectively, control the amount of regulating water to be moved. A rotary transformer, which is coupled to the motor shaft, furnished this amount in the form of voltage. This is the third control component. Thus it is a way control which ensures a more positive guidance of the boat at the prescribed depth. A characteristic feature of this new depth governor, intended to improve the stabilizing and damping qualities, is the flexible connection between the motor shaft and the counteracting transformer. It consists of a spring-controlled damping piston, which causes an advance of the control arrangement. This advance corresponds to a control component which is proportional to the velocity of variation of depth.

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 Comment:

- a. The designer of this device is a well-known expert in the field of anti-rolling devices for ships. In the case of the automatic depth governor the principle of such an anti-rolling mechanism has been applied. The construction of this design by the Soviets indicates the principles they adopt in submarine construction.
- b. The piston pump will presumably meet the requirements for noise-subdued running. The description, however, does not indicate the magnitude of the deflecting forces, the power required by the control device, and the respective dimensions.
- c. The whole device must undoubtedly cover comparatively wide fields. It would therefore be important to find out what type of submarine the device is intended for. A similar automatic depth governor was installed in the German midget submarine, type "Seehund" (seal), but was only meant for cruising.

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