United States Patent

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[54] **SHIPS' STABILIZER CONTROL SYSTEMS**
8 Claims, 1 Drawing Fig.

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[50] **Field of Search** ..... 114/122, 126, 144; 244/(Inquired), 77

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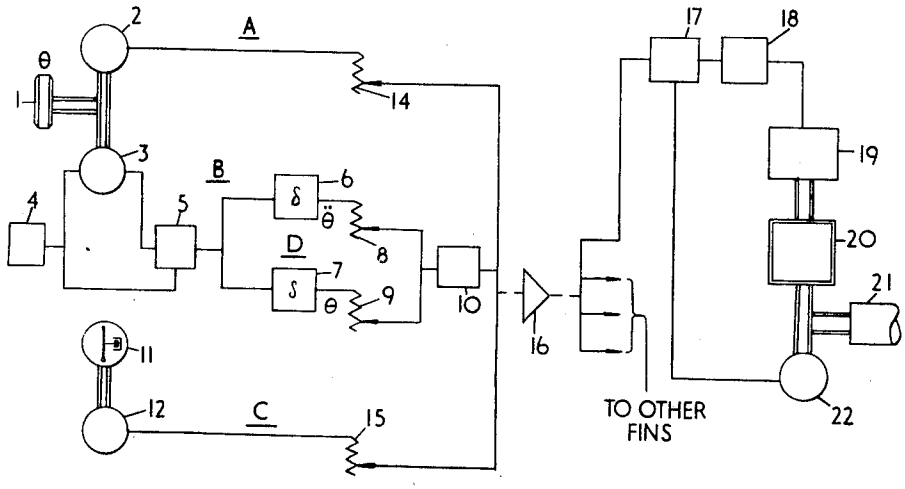
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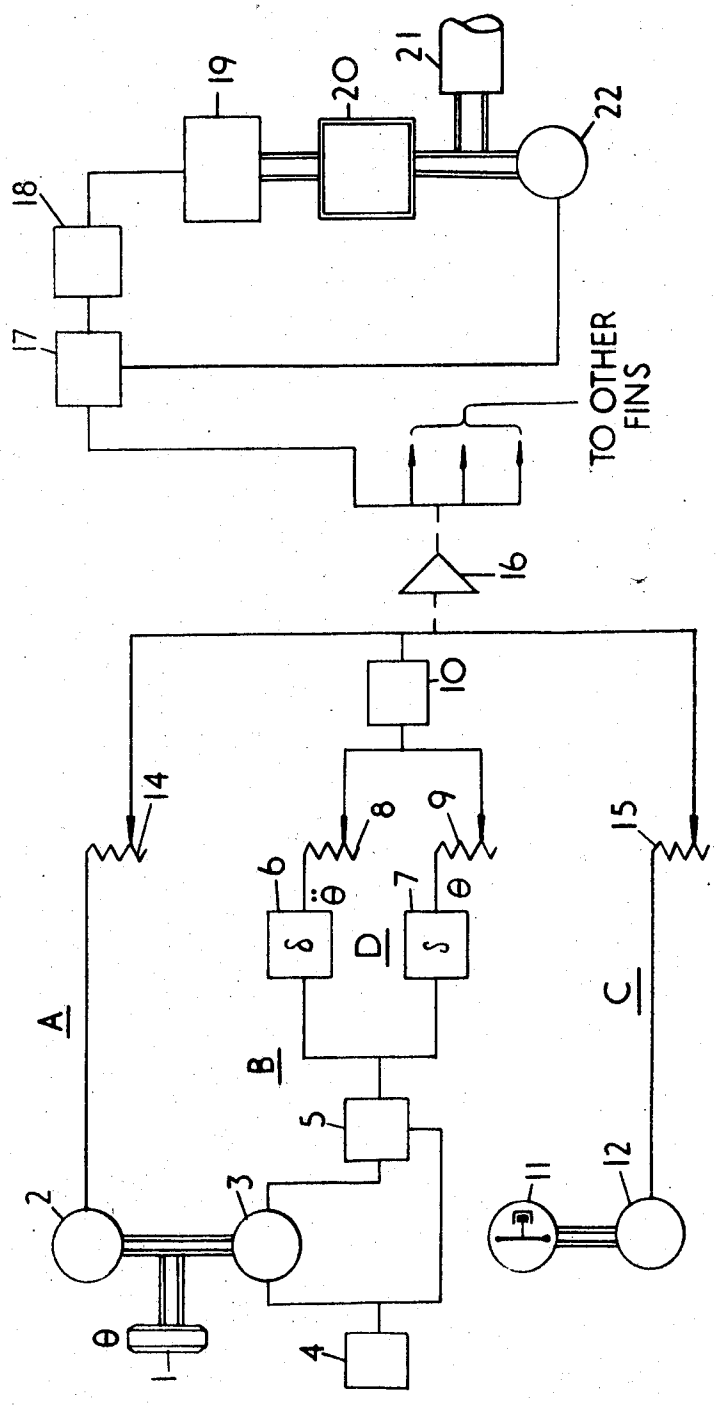
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ABSTRACT: To overcome the shortcomings of known ships' stabilizer control systems and to provide a variety of further desirable features, there is proposed a double-frequency ship's stabilizer control system whereby use is made of various design advantages of higher frequencies together with the convenience of drawing power at the supply frequency of the ship's mains. One of the features of such a system is that it makes possible the use of only a single roll sensing element, as opposed to the customary two. A specific arrangement is shown for the computation of further roll variables required for stabilization purposes from the output signal of the single roll sensing element. Allowance may be made for any steady list which may be present.





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SHIPS' STABILIZER CONTROL SYSTEMS

BACKGROUND OF THE INVENTION

This invention relates to the stabilizer control systems of ships, ores especially to control system in which modulation of an AC carrier frequency is employed.

In known AC carrier ship's control systems accepted practice has been to use a common carrier frequency throughout the entire control system. Sometimes this frequency is obtained at mains frequency from ship's electrical supplies, or else it is obtained at a higher frequency from a special auxiliary supply provided for the control system.

In the former case the comparatively low value of the mains frequency (usually 50 cps or 60 cps) gives rise to the following difficulties. In the various electrical circuits large-value capacitors are required, which leads, in turn, to a tendency for undesirable phase shifts to be produced. This limits the design possibilities of the control system circuits and may have an adverse effect on the operation of the stabilizer as a whole.

In the latter case, when a special generator is provided for the control system as a whole, the generator is necessarily large and expensive.

Further, in known stabilizers, with particular reference to fin stabilizers for stabilizing roll, it is common practice to employ two gyroscope elements as roll sensing means, one of which senses roll angle θ and the other roll velocity $\dot{\theta}$. In so far as gyroscope elements are comparatively complex pieces of apparatus, it is advantageous to employ a single gyroscopic element to yield one of the variables required for stabilization purposes and to obtain the remaining variables by effectuating on this variable the necessary integration and/or differentiation, as required. For instance, if the single gyroscopic element yields $\dot{\theta}$, the remaining variables θ and $\ddot{\theta}$ may be obtained by respective integration and differentiation thereof. Such computations are not readily and satisfactorily carried out in systems with a carrier at the frequency of the normal ship's supply, for the above-mentioned reasons.

An object of the present invention is to overcome the above-mentioned shortcomings of known stabilizer control systems employing only a single carrier frequency.

A further object of the present invention is to provide a stabilizer in which only a single gyroscopic element need be employed and in which use may be made of a low-power and, consequently, small and inexpensive auxiliary high-frequency supply to yield a stabilizer control system possessing a variety of desirable features.

SUMMARY OF THE INVENTION

In one aspect the invention provides a ship's stabilizer control system comprising a first channel adapted to operate with a carrier at the frequency of the ship's normal electrical supply for the production of a first control signal for the control of torque-producing means, a second channel comprising a modulator means adapted to operate with a carrier at a higher frequency for the production of a second control signal for the control of the torque-producing means, and means whereby the first and second control signals may be combined to form a composite control signal for the control of the torque-producing means.

The present system lends itself to adaptions incorporating: a single sensing means for producing a signal corresponding to a roll variable, and computing means for deriving from the given roll variable a signal corresponding to further roll variables which may be required to effectuate stabilization.

In accordance with a further aspect the invention provides a ship's stabilizer control system comprising a first channel adapted to operate at the frequency of the ship's normal electrical supply for the production of a first control signal for the control of torque-producing means, a sensing means for the production of a roll signal corresponding to a first roll variable, a second channel comprising a modulator means adapted to operate with a carrier at a higher frequency, the modulator means being coupled to the sensing means so that in use the output of the modulator means is a signal at the higher frequency modulated by the first roll variable, computing means for the computation from the first roll variable of a signal corresponding to at least one further roll variable, said computing means being coupled to said modulator means, the signal corresponding to at least one further roll variable constituting a second control signal for the control of the torque-producing means, and means whereby the first and second control signals may be combined to form a composite control signal for the control of the torque-producing means.

The sensing means may be a gryoscope element sensing, for example, $\dot{\theta}$. In this case the computing means may incorporate an integrator to produce θ, and a differentiator to produce $\ddot{\theta}$, the quantities θ, $\dot{\theta}$ and $\ddot{\theta}$ being the roll variables customarily employed for purposes of stabilization.

Use of a stabilizer with a channel operating at the normal ship's supply frequency and a channel operating at a higher frequency exploits both the design advantages of higher frequencies and the convenience of drawing power at the normal ship's supply frequency.

The higher frequency is conveniently obtained from a 400 cps oscillator.

For the situation where it is considered necessary to stabilize about the vertical, as opposed to stabilization about any direction of list which may be present, the present invention introduces a damped pendulum to detect an average roll angle. This average angle is incorporated into the stabilization system in the correct sense.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described with reference to the accompanying drawing, in which the sole figure shows a schematic diagram of a control system according to the invention.

In the embodiment shown, a sensing means **1** supplies a signal corresponding to a roll variable ($\dot{\theta}$ in the present embodiment) via a modulating means **2** adapted to operate with a carrier at the normal ship's supply frequency to a first channel A, and via a modulating means **3** adapted to operate with a carrier at a higher frequency to a second channel B.

Modulating means **2** and **3** may be synchro transmitters mechanically coupled to a velocity gyro **1**. Unit **4** is an oscillator for the supply of high frequency to synchro **3**.

Unit **5** is a demodulator, at the output of which is produced a slowly varying DC signal corresponding in this case to the roll velocity $\dot{\theta}$. This signal is fed to a computing means D comprising an integrator **7** for the production of roll angle θ and a differentiator for the production of roll acceleration $\ddot{\theta}$, the quantities θ and $\ddot{\theta}$ constituting further roll variables required to effectuate stabilization.

After suitable scaling by potentiometers **8** and **9**, signals θ and $\ddot{\theta}$ are combined and fed as an input to a modulator **10**, the output of which is a signal at the frequency of the normal ship's modulated by the DC input signal.

The output of modulator **10** is combined with the signal from channel A, suitably scaled by potentiometer **14**, in a means **16** for the production of a composite control signal, which means may be an AC summing amplifier.

The composite control signal from **16** controls torque-producing means **21** after being passed through a demodulator **17** and a buffer arrangement **18** (e.g. cathode follower, emitter follower) to a servo valve **19** for a pump system **20** controlling the torque producing means **21** (e.g. a fin shaft).

Demodulator **17** is also supplied with an input from a heavy-duty feedback synchrotransmitter **22** monitoring the angular position of fin shaft **21**.

Where it is desirable to stabilize about the vertical instead of about the natural list of the ship, a vertical reference must be provided and to this end a pendulum **11**, heavily damped by conventional dashpot means, is incorporated to mechanically control a synchro **12** energized from the ship's mains and thus provide the electrical equivalent of the pendulum motion.

The signal characterizes the average departure of the ship from the vertical since its oscillatory content is negligible. The signal representing the natural list is appropriately added to the other functions at the amplifier **16** after passing through the scaling potentiometer **15**.

In the foregoing the stabilization of ships by fins has been used as the basis for the description, but the method of control can apply also to any other form of stabilizer.

Various other modifications may be made within the scope of the invention.

We claim:

1. A ship's stabilizer control system comprising a first channel adapted to provide a first carrier at the frequency of the ship's normal electrical supply modulated with a first control signal for the control of torque-producing means; a second channel comprising a modulator means adapted to provide an intermediate carrier at a higher frequency modulated with the first control signal, and including means for providing from said intermediate carrier a second carrier at the frequency of the ship's normal electrical supply modulated with a second control signal for the control of the torque-producing means; and means whereby said first and second control signals may be combined to form a composite control signal for the control of the torque-producing means.

2. A ship's stabilizer control system comprising a first channel adapted to operate at the frequency of the ship's normal electrical supply for the production of a first control signal for the control of torque-producing means, a sensing means for the production of a roll signal corresponding to a first roll variable, a second channel comprising a modulator means adapted to operate with a carrier at a higher frequency, the modulate modulator means being coupled to the sensing means so that in use the output of the modulator means is a signal at the higher frequency modulated by the first roll variable, computing means for the computation from the first roll variable of a signal corresponding to at least one further roll variable, said computing means being coupled to said modulator means, the said signal corresponding to at least one further roll variable constituting a second control signal for the control of the torque-producing means, and means whereby the said first and second control signals may be combined to form a composite control signal for the control of the torque-producing means.

3. The ship's stabilizer control system as claimed in claim **2** in which the sensing means is such as to produce in use a signal in proportion to the angular velocity of roll $\dot{\theta}$, so that the first roll variable is $\dot{\theta}$, and in which the computing means comprises an integrator and a differentiator for the respective integration and differentiation of $\dot{\theta}$ to produce roll angle θ and roll acceleration $\ddot{\theta}$, the latter constituting second and third roll variables and being constituents of the composite signal for the control of the torque producing means.

4. The ship's stabilizer control system as claimed in claim **3** in which the sensing means comprises a gyroscope, the modulator means comprises a first synchrotransmitter mechanically coupled to the gyroscope, and in which a demodulator is provided via which the first synchrotransmitter is coupled to the integrator and the differentiator.

5. A ship's stabilizer control system; comprising a first channel adapted to operate with a carrier at the frequency of the ship's normal electrical supply for the production of a first control signal for the control of torque-producing means; a second channel comprising a modulator means adapted to operate with a carrier at a higher frequency for the production of a second control signal for the control of the torque-producing means; means whereby said first and second control signals may be combined to form a composite control signal for the control of the torque-producing means, and list correction means such that list of the ship which may be present may be balanced out.

6 A ship's stabilizer control system comprising a first channel adapted to operate at the frequency of the ship's normal electrical supply for the production of a first control signal for the control of torque-producing means, a sensing means for the production of a roll signal corresponding to a first roll a variable, a second channel comprising a modulator means adapted to operate with a carrier at a higher frequency, the modulator means being coupled to the sensing means so that in use the modulator means is a signal at the higher frequency modulated by the first roll variable, computing means for the computation from the first roll variable of a signal corresponding to at least one further roll variable, said computing means being coupled to said modulator means, said signal corresponding to at a least one further roll variable constituting a second control signal for the control of the torque-producing means, means whereby said first and second control signals may be combined to form a composite control signal for the control of the torque-producing means, said sensing means being such as to produce in use a signal in proportion to the angular velocity of roll $\dot{\theta}$ so that the first roll variable is $\dot{\theta}$, the computing means including an integrator and a differentiator for the respective integration and differentiation of $\dot{\theta}$ to produce roll angle θ and roll acceleration $\ddot{\theta}$ the latter constituting second and third roll variables and being constituents of the composite signal for the control of the torque-producing means, said sensing means including a gyroscope, the modulator means being defined by a first synchrotransmitter mechanically coupled to the gyroscope, a demodulator by which the first synchrotransmitter is coupled to the integrator and the differentiator, list correction means such that list of the ship which may be present may be balanced out, and the list correction means comprising a heavily damped pendulum and a second synchrotransmitter for operation at the frequency of the ship's normal electrical supply, the second synchrotransmitter being coupled to the pendulum so that in use the output of the second synchrotransmitter constitutes a list signal characterizing any list of the ship which may be present, the list signal being combined with the first and second control signals to constitute a component of the composite control signal for the control of the torque-producing means.

7. The ship's stabilizer control system as claimed in claim **6** in which said first channel for operation at the frequency of the ship's normal electrical supply comprises a third synchrotransmitter coupled to said gyroscope so that the output of the third synchrotransmitter is in use in proportion to $\dot{\theta}$, and in which the means whereby said first and second control signals may be combined comprises an AC amplifier with an input coupled to said third synchrotransmitter of the first channel, to the second synchrotransmitter of the pendulum, and to an electronic modulator with an input coupled to the differentiator and to the integrator.

8. A ship's stabilizer control system comprising: a first channel adapted to operate with a carrier at the frequency of a ship's normal electrical supply for the production of a first control signal for the control of torque-producing means, a second channel comprising a modulator means adapted to operate with a carrier at a higher frequency for the production of a second control signal for the control of the torque-producing means; means whereby said first and second control signals may be combined to form a composite control signal for the control of the torque-producing means; and list correction means such that list of the ship which may be present may be balanced out, said list correction means including a heavily damped pendulum and a synchrotransmitter for operation at the frequency of the ship's normal electrical supply, said synchotransmitter being coupled to the pendulum so that in use the output of said synchrotransmitter constitutes a list signal characterizing any list of the ship which may be present, the list signal being combined with the first and second control signals to constitute a component of a composite control signal for the control of the torque-producing means.