July 18, 1967 W. MÖLLER 3,331,971

MAGNETIC CONTROL STICK SYSTEM

Filed April 15, 1964

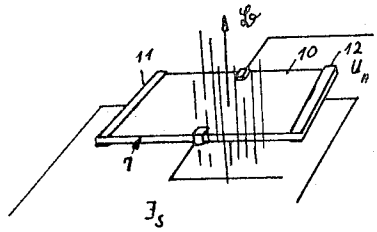

Fig.1

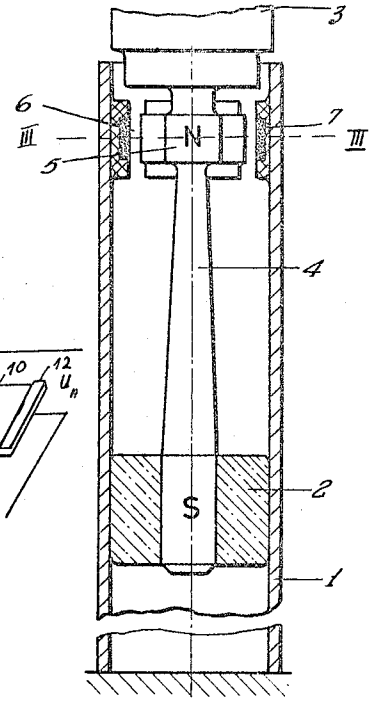

Fig.2

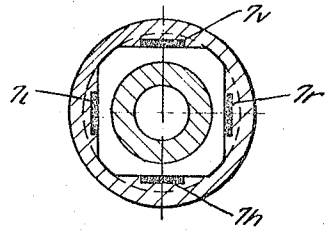

Fig.3

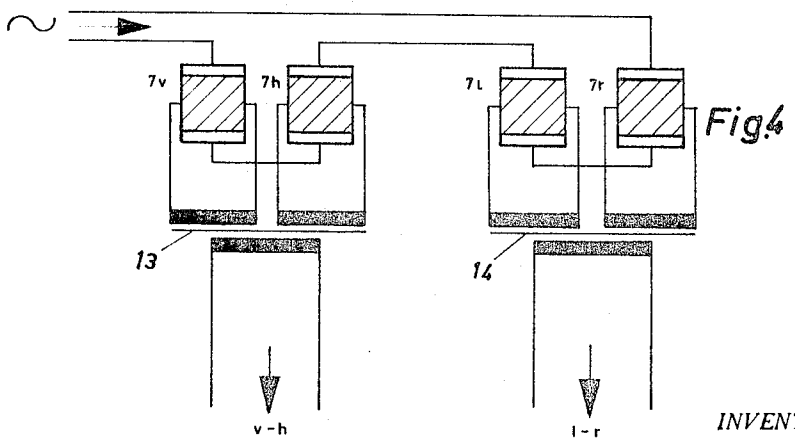

Fig.4

INVENTOR.
WALDEMAR MOLLER
BY
Andrew L. Frey

United States Patent Office 3,331,971 Patented July 18, 1967

3,331,971

MAGNETIC CONTROL STICK SYSTEM

Waldemar Möller, Heiligenberg, Baden, Germany, assignor to Bodenseewerk Perkin-Elmer & Co. G.m.b.H., Uberlingen am Bodensee, Germany

Filed Apr. 15, 1964, Ser. No. 360,004
Claims priority, application Germany, June 11, 1963, B 72,241
6 Claims. (Cl. 310—10)

General

The present invention relates to a control stick system particularly useful for steering airplanes and other types of vehicles. The invention is directed toward the "stiff stick" type of control wherein control signals are developed from the deflection of a stiff elongated member.

In "stiff stick" control systems, one end of the stick is tightly clamped to a fixed body while the other end of the stick is free to undergo resilient deflections in two directions. As the stick is deflected, the movement is sensed and control signals proportional to the deflection are developed. A very desirable feature of these systems is that the operator is able to sense the degree and direction of pressure exerted on the stick without requiring a visual check of the movement.

One known technique for sensing stick deflections utilizes inductive or capacitive members. As the stick moves the value of the inductance or capacitance of these members changes accordingly. While this sensing technique is advantageous in many respects, it has been found to be relatively expensive. In addition, such a system has been found to be somewhat susceptible to interference.

It is an object of the present invention to provide a new and improved control stick system.

It is another object of the present invention to provide a stiff stick control system which is simple in construction and inexpensive to fabricate.

It is a further object of the present invention to provide a new and improved stiff stick control system which is less susceptible to interference than control systems known to the prior art.

A control stick system constructed in accordance with the present invention comprises a longitudinally magnetized, elongated member and a tubular member surrounding the elongated member and concentric with the elongated member. The system also includes means for fixing one end of the elongated member rigidly to the tubular member and a plurality of pole faces positioned on the outer surface of the elongated member from which magnetic flux from the elongated member emanates. The control stick system further includes a plurality of Hall generators positioned on the inner surface of the tubular member and opposite the pole faces for receiving flux emanating from the pole faces.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawing:

FIGURE 1 illustrates the mode of operation of a Hall generator which is utilized in the present invention;

FIGURE 2 shows a control stick system constructed in accordance with the present invention;

FIGURE 3 is a cross-sectional view taken along line III—III of FIGURE 2; and

FIGURE 4 shows how four Hall generators utilized in the present invention are wired together.

Description and operation of control stick system

Referring to FIGURE 2, a control stick system constructed in accordance with the present invention includes

an elongated member **3**. Surrounding the elongated member **3** and concentric with the elongated member is a tubular member **1** of ferromagnetic material in the form of a sleeve. The elongated member **3** is tightly clamped at one end in a block **2** placed within sleeve **1** so that the elongated member is rigidly fixed to the sleeve. Like tubular member **1**, block **2** is of a ferromagnetic material. The clamped portion **4** of member **3** is somewhat thinner than the handle end so as to permit deflection of this member.

The control stick system further includes a plurality of pole faces positioned on the outer surface of the elongated member **3**. The pole faces **5** are preferably equally spaced and for the arrangement shown there are four such pole faces.

The control stick system additionally includes a plurality of Hall generators positioned on the inner surface of the tubular member **1** and opposite the pole faces **5**. One Hall generator is opposite each of the pole faces so that for the arrangement shown the Hall generators are equally spaced and there are four such Hall generators, **7L**, **7R**, **7H** and **7V**. Furthermore, as shown in FIGURE 3, the sleeve **1** has an inner square cross-section so that the four Hall generators **7** are arranged in the centers of the sides of a square.

Elongated member **3** is longitudinally magnetized so that magnetic flux emanates from the four pole faces **5**. Air gaps **6** exist between the pole faces **5** and the inner walls of sleeve **1**. The remainder of the magnetic circuit is completed through the sleeve **1** and the block **2**.

Referring to FIGURE 1, a Hall generator comprises a thin lamina **10** of semiconducting material to which are attached a pair of electrodes **11** and **12**. A control current is supplied to the lamina **10** by way of electrodes **11** and **12**. If a magnetic field extends through the lamina **10**, a Hall voltage is developed which is perpendicular to the direction of control current flow and is proportional to the magnitudes of the control current and the magnetic field.

The four Hall generators being positioned opposite the pole faces **5** receive the flux that emanates from the pole faces. The Hall generators are connected electrically, as shown in FIGURE 4, in such a way that the signals developed by oppositely disposed generators are effectively in phase opposition. In particular, the voltages developed by Hall generators **7V** and **7H** are so coupled to a transformer **13**, that a voltage is developed at the secondary of this transformer which is equal to the difference of the two voltages supplied to the primaries of this transformer. Hall generators **7L** and **7R** are connected similarly to a transformer **14**.

With the control stick in its central position all of the air gaps are of equal width and the magnetic flux branches out from the four pole faces **5** uniformly. When the control stick is moved even slightly from its central position the distribution of magnetic flux within the various air gaps changes. One air gap of an oppositely disposed pair is reduced in size, while the opposite air gap increases. The magnetic flux shifts to the side of the smaller air gap. Because of these changes in position of the elongated member **3**, the Hall voltages developed by the Hall generators also change. One Hall voltage of the pair increases while the other decreases so that the net output signal from a pair of Hall generators is representative of the resilient deflection of the elongated member **3** in one direction. Signals representative of the deflection in the second direction are developed from the other two Hall generators.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is therefore

aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A control stick system comprising:
a longitudinally magnetized, elongated member;
a tubular member surrounding said elongated member and concentric with said elongated member;
means for fixing one end of said elongated member rigidly to said tubular member;
a plurality of pole faces positioned on the outer surface of said elongated member from which magnetic flux from said elongated member emanates;
and a plurality of Hall generators positioned on the inner surface of said tubular member and opposite said pole faces for receiving flux emanating from said pole faces.

2. A control stick system according to claim 1 wherein the pole faces are equally spaced around the outer surface of the elongated member and the Hall generators are equally spaced around the inner surface of the tubular member.

3. A control stick system comprising:
a longitudinally magnetized, elongated member;
a tubular member formed of ferromagnetic material surrounding said elongated member and concentric with said elongated member;
means formed of a ferromagnetic material for fixing one end of said elongated member rigidly to said tubular member;
a plurality of pole faces positioed on the outer surface of said elongated member from which magnetic flux from said elongated member emanates;
and a plurality of Hall generators positioned on the inner surface of said tubular member and opposite said pole faces for receiving flux emanating from said pole faces.

4. A control stick arrangement comprising:
a longitudinally magnetized, elongated member;
a tubular member surrounding said elongated member and concentric with said elongated member;
means for fixing one end of said elongated member rigidly to said tubular member;
a plurality of equally spaced pole faces positioned about an outer surface of said elongated member from which a magnetic flux from said elongated member emanates;
a plurality of equally spaced Hall generators positioned on the inner surface of said tubular member and opposite said pole faces for receiving fluxes emanating therefrom;
said Hall generators being equal in number to the number of pole faces and having the outputs of oppositely disposed Hall generators coupled in opposition to each other.

5. A control stick system according to claim 4 wherein the equal number is four.

6. A control stick system according to claim 5 wherein the tubular member has an inner square cross-section and the four Hall generators are arranged in the centers of the sides of the square.

References Cited

UNITED STATES PATENTS

2,888,635 5/1959 Volk ---------- 323—51

FOREIGN PATENTS

1,100,305 2/1961 Germany.
938,705 10/1963 Great Britain.

MILTON O. HIRSHFIELD, *Primary Examiner.*
D. X. SLINEY, *Assistant Examiner.*