DESIGN OF AN ENDOSCOPIC CARRIER WITH COMPLETE DIRECTIONAL CONTROL

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An instrument is described in this article which will help flexible fiberoptic endoscopes negotiate the turns and loops in the large bowel, particularly those in sections that are only loosely suspended in the abdominal cavity and that are, therefore, difficult to pass. The principle of operation of this carrier as well as construction details are given and will demonstrate its advantages for gastro-enteroscopy.

INTRODUCTION

Bundles of glass fibers aligned in parallel can transmit images of a high resolution and brightness and are therefore widely used as endoscopes to examine body cavities. Several such instruments are available for the examination of the gastro-intestinal tract in particular, varying in length, caliber, and functional parameters according to the anatomical situation for which they are intended. Endoscopes for the lower digestive tract come in lengths of up to 2 m (approximately 6 ft) and their mean diameter is around 14 mm (about .55 in). They are used principally by physicians specialized in gastro-enterology to inspect the intestinal wall for inflammatory processes, lesions, or signs of abnormal growth. The disproportionate increase per annum in neoplastic degenerations of the bowel as compared to any other system is alarming (1). By far the greatest incidence of a cancerous degeneration of intestinal tissues is found in the descending colon and the next following sections, i.e., the sigmoid colon and the rectum (2, 3, 5). An examination with

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the fiberoptic endoscope of those parts of the bowel that are not accessible
to a rigid instrument is of great value for the early diagnosis of cancer.

The flexible endoscopes presently in practice are advanced through the
section to be examined by using its wall as a guide. Since the operator's thrust
to pass the instrument hardly ever acts in the direction of the intestine's
lumen, and since particularly the sigmoid colon is not tightly held by liga-
ments in the abdominal cavity, the advance of the endoscope can be difficult
or take an undue amount of time, even in the hands of an experienced phy-
sician. We have designed a carrier to facilitate the passage of an endoscope
including all probing and manipulating devices normally used with it. The
carrier advances the scope in all directions with ease to negotiate flexures or
pass constrictions in the intestinal canal since it is under the operator's com-
plete control and, with his guidance, the endoscope follows always the
lumen of the bowel. It does not have to be deflected off the intestine's wall
in order to assure its continued passage.

The carrier simulates the sequential activation of locomotor muscles en-
abling snakes to wind around an obstruction in their path. We give details on
the construction of a model which has the same diameter as a prototype
intended for clinical trials in veterinary medicine and which is about twice
the diameter of an instrument needed in human medicine. The model utilizes
exactly the same mechanisms also to be employed in the prototype, and it
functions to our complete satisfaction.

**DESIGN PRINCIPLES AND OPERATION**

The carrier is formed by a train of cylindrical segments with an outside
diameter of 30 mm. They are all identical and they are allowed to rotate
about diametric axes perpendicular to the carrier's long dimension. To this
end, the top and bottom surfaces are sloped such that the sector between
adjoining segments permits their approach through an angle of 12°. The
transverse axes of articulation are offset by 90° so that the top surface of a
segment can rotate with respect to the preceding one about an axis north-
south whereas the bottom surface of the same segment rotates with the
following one about an axis east-west (Fig. 1). Thus, a pair of succeeding
segments, odd- and even-numbered, constitute one directional unit. For
example, 5 articulations in the same direction (even-odd) would have to
close about axes E-W for the carrier to form a curve 60° south, involving 5
directional units or 10 succeeding segments. A photograph of the model
carrier is given in Fig. 2.

A central channel runs the entire length of the carrier to accept a fibero-
optic endoscope. This channel will be made wider in relation to the outside
diameter than in the model shown. In the prototype, the electronic leads
coming out of the central channel are replaced by slip-rings located on the
diametric edges of the segments' articulating surfaces. The physician directs
the carrier as is desired, under view through the fiberscope, by electrically