

## DESIGN CONSIDERATIONS FOR A PROSTHETIC PREHENSION DEVICE

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In choosing a prehensile hook for use with pneumatic power, a number of existing hooks were examined at Hendon. Each had its own good and bad features, but it was felt that it would be a good idea to design a new hook which would combine the desirable features of existing hooks, and perhaps to attempt to introduce new advantages. Attempting to build a motor onto an existing hook tends to result in a rather bulky design. It might therefore be an added advantage to design the hook and motor together. Phocomelic children and amputees are always short of control channels, so that it was decided to produce a hook that would give a reasonable variety of grips using only one degree of freedom. »One degree of freedom« here is used to mean the use of one independent channel of voluntary control without complicated automatic controls such as are used in the Yugoslav hand to change its mode of operation.

Prehensile devices are used in four different roles:

1. as a hook for lifting a suitcase, bucket, etc. (Fig. 1).
2. like the finger tips for picking up small objects (Fig. 2).
3. for cylindrical or round objects, balls, glasses, etc., like the hand with thumb opposed (Fig. 3).
4. for gripping long thin objects such as spoons, pencils, etc., in which case stable grip is achieved by a three-point hold (Fig. 4). This is a form of grip seldom used by the normal hand since it has so many degrees of freedom available. Interestingly enough one of the few times it is used is in handling chopsticks — a situation when even the normal hand is short of degrees of freedom!

### The Standard British Hook

The standard British hook consists of two complete hooks placed side by side, one of which is hinged so as to swing away from its partner (Fig. 5).

The grip is improved by increasing friction with rubber tubing forced over the blades. It functions well in role 1, but is not provided

with fingertips so that it is poor in role 2. In role 3, it may be criticised since, once it opens beyond a certain angle, there is a tendency for round objects to be squeezed out of its grasp rather as one may project



Figure 1. The Standard British hook used in role 1 (as a simple hook)

an orange pip. In role 4, it is again poor since no three-point grips are provided between the jaws. Some help is given with straight objects because their near end may be tucked over the cable lever.

#### The Dorrance Hook

An alternative is the Dorrance hook, manufactured in the U.S.A. This is fitted with «finger tips» at the end not unlike a pair of fine pliers (Fig. 2). The hooks have been considerably straightened so that these «finger tips» are not hidden under the hook.

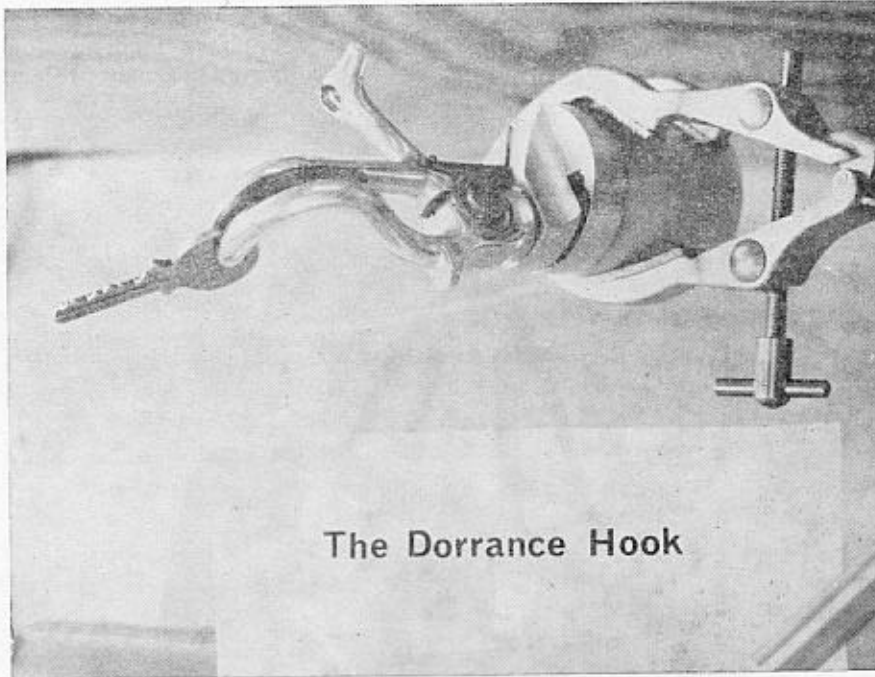


Figure 2. The «finger tip» grip (role 2) of the Dorrance hook being used to hold a key



Figure 3. A normal hand holding a glass with thumb opposed (role 3)

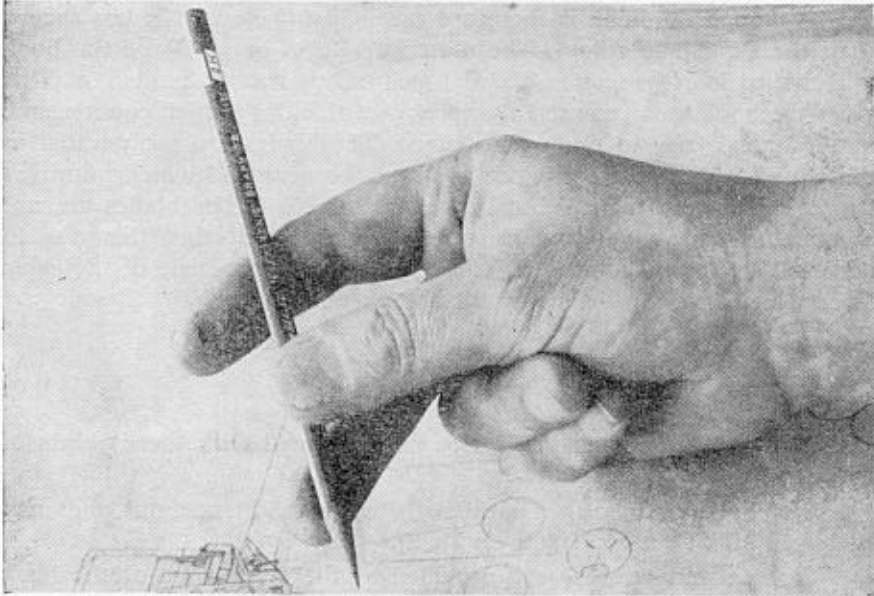


Figure 4. A normal hand showing the rarely used »three-point« grip (role 4)

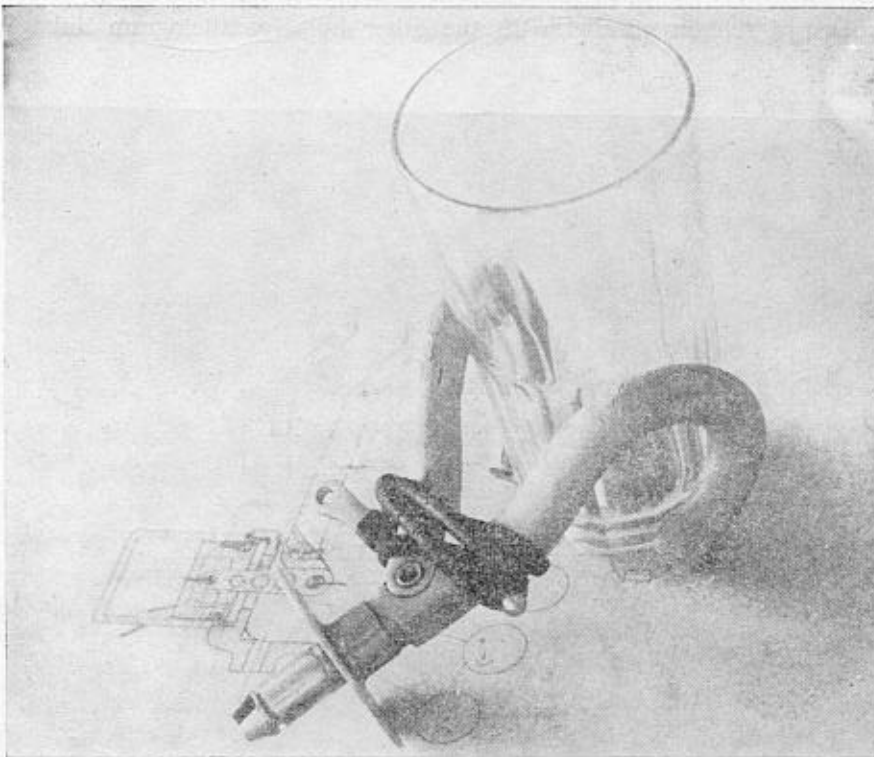


Figure 5. The Standard British hook in one of its less effective grips — widely opened and attempting to hold a smooth round object (role 3)

Although the hook is therefore excellent in role 2, it is less secure than the British in role 1. The material (Dural or steel) of the hook is D-shaped in cross-section, the flat side having rubber bonded on. This gives the hook a more graceful appearance than its British counterpart, but it is less easy to renew the facing. The blades are not parallel in the closed position, being wider apart at the near end which improves its performance in role 3, but impairs it in role 4. The blades are not identical in side view, and it was thought at first that this was to achieve three-point hold. This is not so. Use is again made of the cable lever which has an extension for the purpose.

### The Current Design

The current prehension device was designed with these points in view, and operates as follows:

*Role 1* (as a hook). The hook is not straightened out and may therefore still be used effectively in this role.

*Role 2*. »finger tips« are provided at the outer edge of the hook giving it the shape seen in Figure 6.

*Role 3*. the tip of one blade is articulated and may be arranged so as to remain parallel with the other by a parallelogram linkage (Fig. 7).

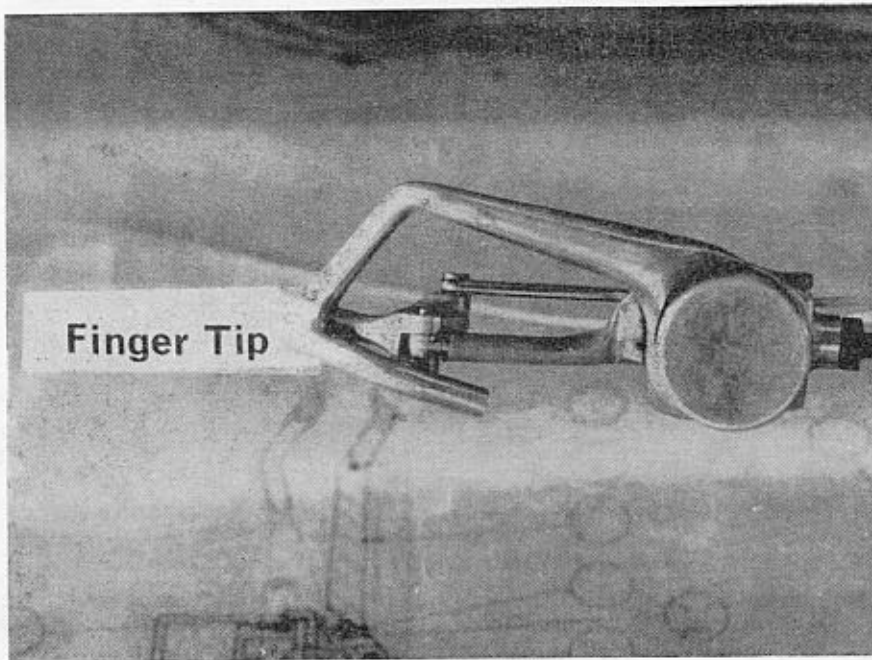


Figure 6. The current design in role 2 using its »finger tips«

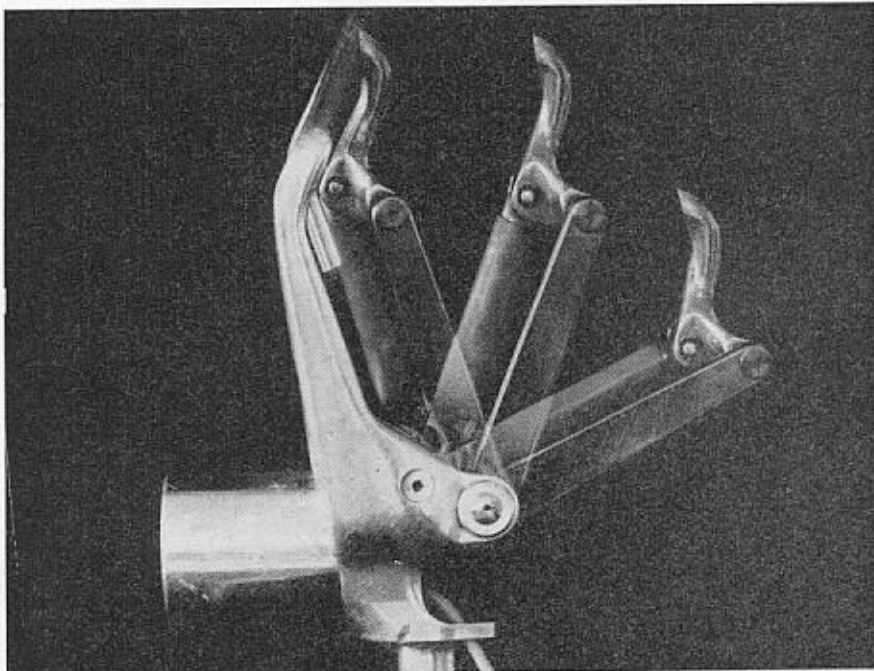


Figure 7. Triple exposure photograph of the current hook showing the effect of the linkage on the attitude of the moving blade

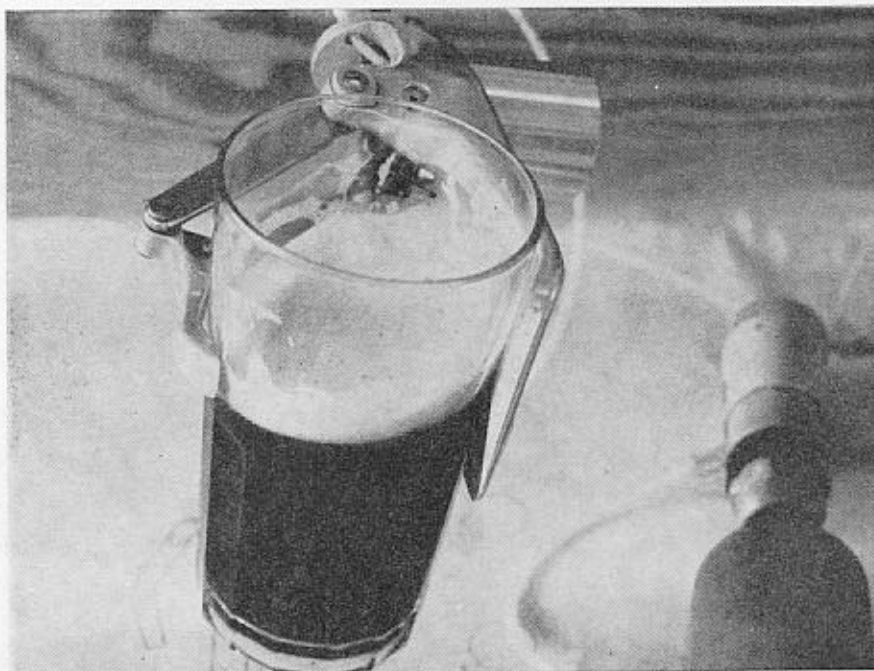


Figure 8. The current design in role 3 showing stable grasp of a half-pint (270 cc.) glass

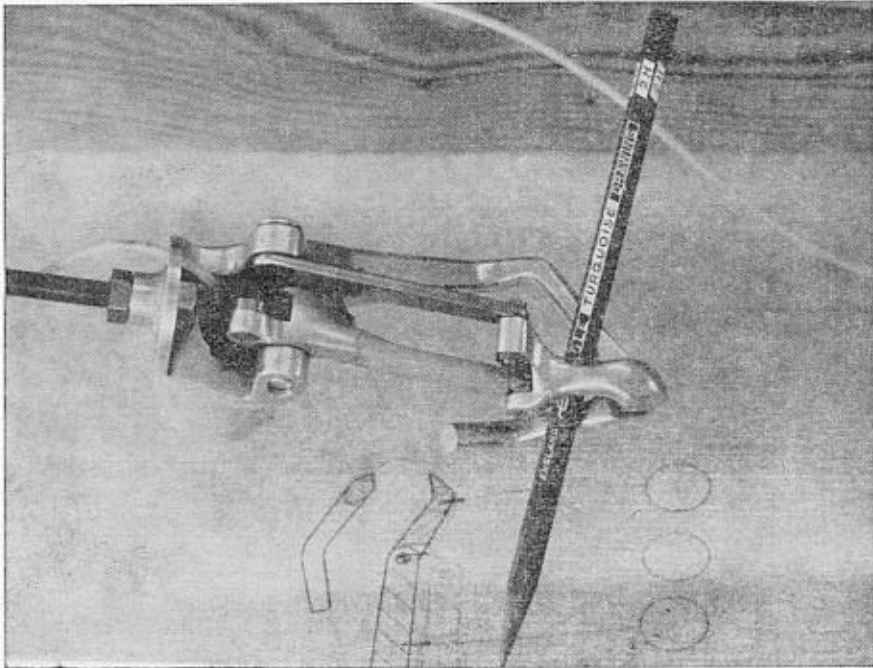


Figure 9. The current design showing one of the several possible »three-point« grips available at different angles to the axis of the arm.

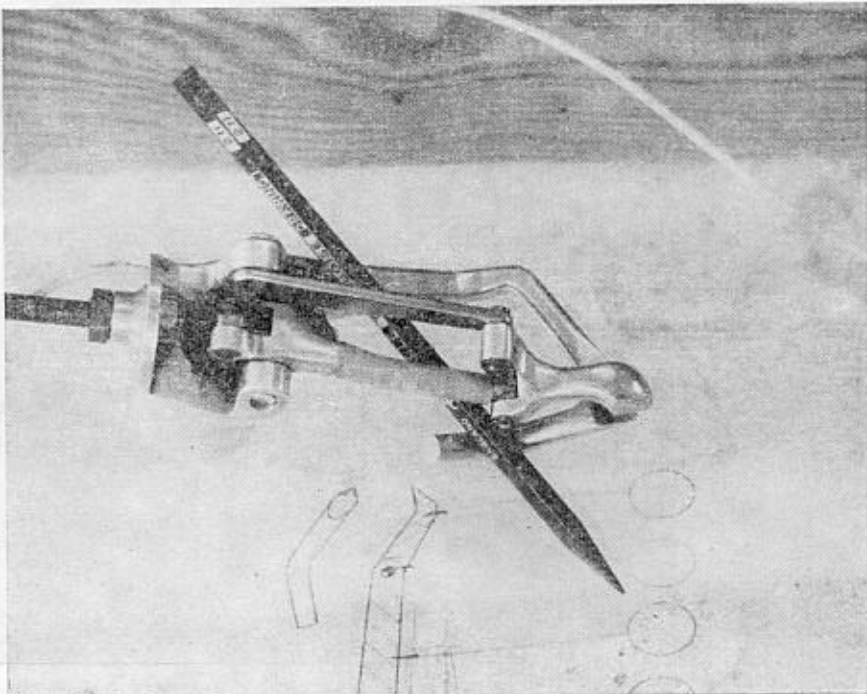


Figure 10. The current design showing another »three-point« grip

In the present version the distal bar of what is now a trapezium is made shorter than the proximal one so that the grasp of round objects is further improved since the distal phalanx tends to slope inwards behind them (the two longer sides are equal in length) (Fig. 8).

This does, of course, carry the penalty of reducing the size of the object that may be gripped. On the other hand, with any given length of lever or swept volume of pneumatic motor, the force exerted by any part of the hook is inversely proportional to the distance moved, so that force is improved by restricting excursion. It is, of course, an easy matter to vary this by adjustment of the geometry of the design. The hook shown is intended for a child of 6-7 years and will grasp a half pint (270 cc.) glass (though not a beer mug as found in the U.K.).

*Role 4.* In order to fulfil the needs of role 1, it is clearly only necessary to provide one complete hook, and several possible three-point grips can be achieved if the other articulated blade is taken straight from the proximal hinge to the «finger tip» as in Figs. 9 and 10. The user is not, therefore, committed to holding his pencil, fork, etc., at any particular angle.

Clearly it would be difficult to force rubber tubing over a complex shape like this. Probably, the most practical means of increasing friction would be to coat the blades with a resilient plastic by dipping and trimming away over the tips. Using 80 psi (5.5 kg/sq.cm.) the hook gives a gripping force of 10 lb. (4.5 kg.) at any point on the outer arm of the moving blade. The swept volume of the motor is .51 cu. ins. (8.2 cc.).