

REGNELL-HYDRAULIC SYSTEM FOR KNEE JOINTS

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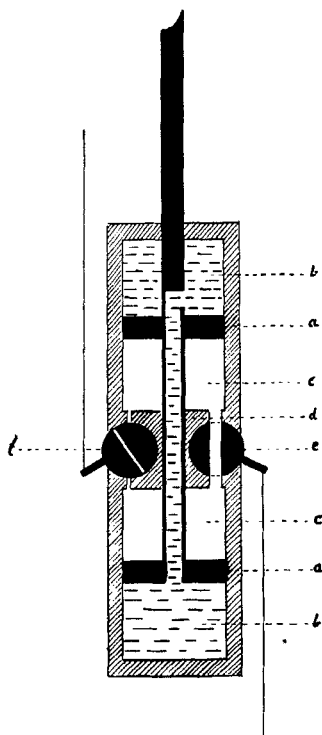
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One of the greatest problems in the construction of artificial limbs for above-knee amputees is the production of a mechanism permitting free movement of the knee joint in one phase of locomotion and retardation or rigidity in another, i.e. a mechanism securing a steady gait and facilitating the ascent and descent of stairs and hills.

The introduction of the eccentric knee joint (anatomic knee joint), which is far superior to the earlier concentric joint, implied an important advance. The later use of hydraulic systems in artificial limbs marked another stride ahead in the field of prosthetics. With such a system it is possible to secure automatic control of the movement of the knee joint by the excursions of the foot; the knee joint is alternately locked and released by certain weight-bearing positions of the foot. This principle has also been applied in a new Swedish design (Regnell prosthesis), which has been tried at the department of orthopaedics, University Hospital of Lund.

The hydraulic system in this prosthesis is briefly as follows.

A cylinder (Fig. 1) encloses two pistons *a* connected by a hollow piston-rod for the passage of oil *b* in either direction from one end of the cylinder to the other. Intermediate to the pistons the cylinder contains another oil system *c* divided by a fixed transverse arrangement *d*, through which the hollow piston-rod can move up and down. The transverse arrangement has two valves *e* and *f*. When the valve *e* is open oil can pass freely through it in either direction and thereby permit unhindered movement of the piston-rod; when it is closed the piston-rod is fixed in position. The other valve *f*, usually closed, is fairly narrow and, when opened, permits only a slow flow of the oil through it and thus allows retarded movement of the pistons. The hydraulic system is controlled by movements of the prosthetic foot which oscillates about the axis of the lower leg. As the heel is set to the ground it closes the valve *e*. With the valve closed the joint is rigid, and as the weight of the body is transferred to the anterior part of the sole, the valve is opened and the knee joint released, in other words, during the period of support the knee is rigid, during the



Regnell-hydraulic system.

Fig. 1.

period of swing, it is loose. The valve *f*, which is normally closed and which can be opened by hand, is provided for retarding the excursions of the pistons when the patient is walking down a hill or steps.

The first prosthesis of this type was delivered in October 1952, since when 14 patients have been provided with such an artificial leg, and a further 24 patients are on the waiting list. Of the 14 prostheses, 11 have been worn long enough for us to form an opinion of their value.

These cases are briefly accounted for below.

Case 1. Railway employe, aged 31. Amputation in June 1951. He first received an artificial leg with a concentric knee joint, which was replaced by a Regnell prosthesis in August 1953. He reported a marked improvement. He is standing all day long at his work and is able to walk on uneven ground without difficulty. As yet the prosthesis has functioned perfectly.

State at review.—Length of stump: 33 cm. Gait: good. Walking downstairs: excellent.

Case 2. Farmer, aged 48. Amputation in 1934. He first tried three different types of artificial leg with a concentric knee joint. In December 1953 he was provided with a Regnell-prosthesis, which he found

superior to the others, although the stump still gave him some trouble. In the beginning the knee joint was slightly loose, which was, however, remedied by exchanging the packings.

State at review.—Length of stump: 22 cm. Gait: good. Walking downstairs with help of hand-rail: good.

Case 3. Teacher, aged 39. Amputation in 1940. First he had a wooden prosthesis with a concentric joint, changed in 1947 to a metal prosthesis with an anatomic knee joint. In August 1954 he was provided with a Regnell-prosthesis, which he found better than the others; he attributed this especially to the feeling of safety it gave him. He has not practised walking downstairs. The joint functions perfectly.

State at review.—Length of stump: 23 cm. Gait: good. He must support himself on the hand-rail when walking downstairs (as mentioned above he had never tried to walk downstairs with this prosthesis).

Case 4. Student, aged 19. Amputation in June 1953. He was provided with a Regnell-prosthesis in September that year. The knee joint functioned well until August 1954, when the packings began to leak. The packings were exchanged and since then the joint has functioned well. Gait: good (he can even walk 2–3 miles without difficulty). He tried skiing. He does not find walking in the dark troublesome.

State at review.—Length of stump: 20 cm. Gait: good. Walking downstairs: good.

Case 5. Dentist, aged 83. Amputation in January 1954. In the beginning the patient fell once or twice when practising walking and since then he has preferred to walk with the knee joint rigid.

Case 6. Farmer, aged 59. Amputation in 1952. In February 1953 he was provided with a prosthesis with a concentric joint and with an inbuilt Regnell-appliance. In June 1954 the patient received a new Regnell-prosthesis. Both types functioned well. He can walk on uneven ground, he can work in the woods (as a lumber-jack) and can drive a car (taxi). The prosthesis gives him a feeling of safety, and he does not find walking in the dark troublesome. As yet the prosthesis has functioned perfectly.

State at review.—Length of stump: 30 cm. Gait: good. Walks downstairs with support of hand-rail.

Case 7. Factory worker, aged 33. Amputation in December 1953. He was provided with a Regnell-prosthesis in May 1954. Gait: good. At work he is often obliged to walk up and down stairs, which he manages well. As yet the prosthesis has functioned perfectly.

State at review.—Stump: 23 cm., slightly cyanotic and somewhat swollen. Gait: good. Walking downstairs: excellent.

Case 8. Farmer, aged 52. Amputation in 1949. That year he was provided with a prosthesis with a concentric joint, with which he felt satisfied. In February he received a Regnell-prosthesis, which he found superior, especially as it gave him a feeling of greater safety. He can take long walks, plough and walk over uneven ground in the dark. He is able to carry two buckets of water (12 kg. each) at a time. He has not practised walking up and down stairs. As yet, the prosthesis has functioned perfectly.

State at review.—Stump: 29 cm. long, slightly cyanotic and sore at the end. Gait: good. He can manage walking up and down stairs, though not very well, with the help of the handrail.

Case 9. Factory worker, aged 46. Amputation in 1949. He was first provided with a wooden prosthesis with a concentric joint, and in September with a Regnell-prosthesis, which has given him a feeling of greater safety. He can walk up and down hills without difficulty. He has not tried walking up and down stairs. As yet the prosthesis has functioned perfectly and does not disturb him at work.

State at review.—Length of stump: 20 cm. He walks with a limp. He would not try walking up and down stairs.

Case 10. Aged 47. Amputation in July 1952. He was provided with a prosthesis in September 1952. He walks long distances on level ground, even in the dark. He has even walked in deep snow and on icy ground and any stumbling never resulted in more than a partial fall. He has not tried walking up and down stairs. As yet the prosthesis has functioned perfectly.

State at review.—Length of stump: 23 cm. Gait: good. He could not (would not) demonstrate walking up and down stairs.

Case 11. Farmer, aged 41. From 1930 he walked with a stiff knee (osteomyelitis). Amputation in 1943. He was provided with a prosthesis with a concentric joint. In 1947 the prosthesis was replaced by another of the same type. He always walked with the joint locked. In August 1954 he received a Regnell-prosthesis. However, he became so used to walking with a stiff leg that he would not use the Regnell prosthesis for more than short periods at a time, although he thought he staggered less with the Regnell type. As yet the prosthesis has functioned well.

State at review.—Stump: 23 cm., cleft, with ugly skin. The patient walks with circumduction of the leg, evidently because of the years he had walked with a stiff knee. He can, however, walk much better when he tries.

COMMENTS

Of the cases briefly described above, 2 cannot be included in the evaluation of the Regnell-prosthesis, because the patients had only

worn the prosthesis with the knee joint locked. One of them was an elderly man who had fallen while he was exercising walking and therefore preferred always to walk with the leg rigid. The other patient was a man who had walked with a stiff ankylotic knee joint for 14 years and, after amputation, for 11 years with a stiff artificial leg. Neither would he dare to walk with an articulated prosthesis. Gradually in this case, however, the patient will probably try to walk with the knee joint released.

As to the remaining 9 patients, 7 had tried other types of prostheses before. All of them had formerly had an artificial leg with a concentric joint, and the Regnell type was considered superior by all with the exception of one, who thought that one was just as good as the other.

One of the patients had also tried an anatomic knee-joint, which he had not found so good as the Regnell type.

The patients reported that the greatest advantage of the Regnell-prosthesis was that it gave them not only a steadier gait, but also a better feeling of safety, especially when walking in the dark and on uneven ground, when they were otherwise liable to stumble. One of the patients remarked that on one occasion when he happened to stumble the fall was not more than partial because the sole of the foot was set on the ground in such a way that it locked the knee joint.

Many of the patients also stated that they could walk down steps and hills better with the Regnell-prosthesis than with any other type they had tried.

At the review all of the patients were found to have a steady gait and most of them, especially the younger ones, were able to walk down stairs really well with only slight support from a stick or the hand-rail.

In the Regnell-prosthesis the only imperfection deserving criticism is the occasionally less good locking of the knee joint owing to leakage of the rubber packings in the hydraulic system. This disadvantage also attends other types of hydraulic systems and has been stressed by American workers in this field. This has, however, received attention, and during the last six months the packings have been made according to a new manufacturing process.

Although the Regnell-prostheses in the present material have not been in use long enough to permit any definite statement about their wear and tear, and although we cannot say how they compare with other types of hydraulic prostheses, the reports of the patients and the observations made at the review do suggest that they are superior to the concentric and to the anatomic knee joint.

SUMMARY

Description of a new hydraulic system for knee-joints in artificial limbs. Judging by observations made on patients, who have worn such prostheses, the joint appears to be superior to the concentric joint and the anatomic knee joint.

RESUME

Description d'un nouveau système hydraulique pour les articulations du genou dans les membres artificiels. A en juger des observations faites chez les malades qui ont porté ce genre de prothèses, l'articulation semble d'être supérieure à celle de l'articulation concentrique et à celle de l'articulation anatomique du genou.

ZUSAMMENFASSUNG

Beschreibung eines neuen hydraulischen Systems für Kniegelenke in künstlichen Gliedmassen. Zufolge Beobachtungen an Patienten, die derartige Prothesen getragen haben, scheint das Gelenk dem konzentrischen und dem anatomischen Kniegelenk überlegen zu sein.