"Solvitur Ambulando"
“Solvitur Ambulando”

A Symposium on Prosthetic Achievement

Published by

J. E. HANGER & CO. LTD.
QUEEN MARY’S (ROEHAMPTON) HOSPITAL
FOR THE LIMBLESS
ROEHAMPTON, LONDON, S.W.15

Telephone: PUTNEY 3901
PRIVATE BRANCH EXCHANGE
in connection with all branches

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**A Nation-wide Service. Details will be found on page 71.**

**A complete Index will be found on page 72.**
INTRODUCTORY

The experience gained from the many thousands of amputations of limbs due to the Great War has led to a marked advance in surgical technique, and remarkable improvements in the design and mechanical efficiency of artificial limbs. In the production of modern artificial limbs highly specialised mechanical knowledge, up-to-date and costly equipment, and expert craftsmanship are necessary. Moreover, the qualifications and standard of efficiency now demanded from those engaged in fitting artificial limbs are of a very high order; only fitters with years of special training under medical supervision, and solely engaged in limb-fitting, are capable of fulfilling the exacting requirements imposed to-day.

To one who has lost a leg by amputation, or with a congenital deformity of the lower limb, and to the medical man to whom he looks for advice, it is of the utmost importance that the high standard of present-day technical efficiency should be readily at their disposal in any part of the country.

There is now available a nation-wide service, specialising solely in the provision and fitting of artificial limbs. Throughout the British Isles both surgeon and amputee have at their command to-day the best that modern science and technical skill can offer. Full details of this service will be found on page 71.

For a good many years before August, 1914, amputations of the limbs had become a comparatively rare operation in this country... at St. Thomas's Hospital, London, out of 5,483 major operations performed in 1913 there were only 34 amputations. In 1915 the Royal Surgical Aid Society had supplied 384 legs and arms among a total of 30,290 appliances... The War has drawn attention again to the importance of amputations and the experience gained in the treatment of some 40,000 amputees... has caused a revision of some of the opinions which were accepted formerly.1

From 1914 onwards the ravages of war made necessary the immediate provision in this country alone of artificial limbs for upwards of 40,000 limbless ex-Service men; the rising toll of amputations due to traffic accidents, particularly during the past few years, is now adding many civilian amputees to the number.

1 E. Muirhead Little, F.R.C.S., "Artificial Limbs and Amputation Stumps," page 22.
ADVANCES IN SCIENTIFIC KNOWLEDGE.

This situation has had its influence upon surgical and mechanical technique. It has resulted in great advances in scientific knowledge and remarkable mechanical improvements. The wide experience gained in dealing with many thousands of war amputations has convinced members of the medical profession of the serious effects upon the health of amputees caused by an improperly fitted prosthesis, or an artificial leg of unsuitable type. Special attention is now being given to this subject by an increasing number of the profession. The Ministry of Pensions has to-day a large body of surgeons specialising entirely in supervising the application of prostheses and the fitting of artificial limbs: special Hospitals have been opened, such as Queen Mary’s Hospital for the Limbless at Roehampton, where many hundreds of limbless civilians and Ex-Service men are provided with artificial limbs fitted under the direct supervision of Limb-Fitting Surgeons specialising in and giving their whole time to this work.

As the result of experience gained in these Hospitals and Limb-Fitting Centres, and improvements in the design and fitting of artificial limbs, it is not an exaggeration to say that to-day no amputee with a stump reasonably sound and free from painful nerve bulbs need suffer discomfort from the use of an artificial leg, if of the right type, correctly aligned and properly fitted.

THE DEVELOPMENT OF THE MODERN ARTIFICIAL LEG.

The amazing development of the modern light-metal and wooden artificial leg from the crude light-metal and wooden limbs of 20 years ago is entirely due to the Great War. Faced with the grave problem of rehabilitating over 40,000 limbless ex-Service men H.M. Ministry of Pensions enlisted the assistance of leading members of the medical profession and other technical advisers and organised special limb-fitting clinics throughout the country.

The Ministry had its own fully-equipped experimental department at Roehampton where a highly-trained technical staff was constantly engaged in research work in collaboration with the leading surgeons in this country. No effort or expense was spared in the endeavour to reduce to a minimum the disability of the thousands of limbless under their care. For over 20 years the Ministry of Pensions’ Medical
Services and technical experts have not ceased from intensive research into the surgical and mechanical problems involved.

"True to the spirit and tradition of the medical profession, the specialised knowledge and experience acquired by the Ministry of Pensions' Limb-Fitting Surgeons in their many years of service on this work have been freely communicated to the profession, and lectures and demonstrations on amputated stumps, and on the technicalities and the actual fitting of artificial limbs, have been given to nominated medical representatives of various public services and medical schools. During 1935 no fewer than 132 surgeons attended these lectures..."

No Government in the world has applied itself to this subject with such concentration, sympathy and marked success, as the British Government. In consequence, it has at its command a wealth of information and more highly-specialised knowledge, particularly regarding light-metal artificial legs, than has any other country. Its medical and technical advisers are in a pre-eminent position to judge the surgical and mechanical merits of artificial limbs and, what is of equal importance, the qualifications of those engaged in fitting them.

LIGHT-METAL LIMBS.

GOVERNMENT COMMITTEE OF ENQUIRY.

A Departmental Committee of Enquiry was appointed in 1925, by the then Minister of Pensions, to investigate the question of the supply of light-metal artificial limbs to limbless pensioners. The members of this influential Committee included:—

Colonel Sir GODFREY COLLINS, K.B.E., C.M.G., M.P. (Chairman).
Major J. BRUNEL COHEN, M.P., Disabled Officer.
Major MEURICE SINCLAIR, C.M.G., M.B., Ch.B., R.A.M.C. (Ret.),
late Orthopaedic and Limb-Fitting Surgeon, Royal Victoria Hospital, Netley.
Major M. P. LEAHY, B.A., M.B., B.Ch., Disabled (Limbless) Officer,
late R.A.M.C.
FRANK CECIL MEECH, Esq., Disabled (Limbless) ex-Corporal of Horse, Royal Horse Guards.
Major A. A. ATKINSON, M.B., Ch.B., Disabled (Limbless) Officer,
Surgeon-in-Charge of Limb-Fitting Section, Queen Mary’s (Roehampton) Hospital.
Professor A. F. C. POLLARD, A.R.C.S., F.Inst.P., A.M.I.E.E.,
Technical Adviser, Ministry of Pensions.

1 Extract from "The Times," 28th July, 1936.
A STRIKING TRIBUTE.

In its report the Committee states:

". . . 64 per cent. of the metal legs at present supplied are manufactured by two firms, viz.,

Messrs. Hanger and Messrs. Pedestros,

and the Limb-Fitting Surgeons and technical experts were unanimous that these two firms are producing limbs of outstanding design and workmanship, coupled with a standard of excellence in the matter of fitting which gives generally expressed satisfaction both to the surgeon and the pensioner."

The Committee of Enquiry included four representative Members of the Medical Profession—two of whom were, themselves, limbless. It heard the evidence of eminent orthopaedic surgeons and well-known technical experts. The unanimous opinion of such a distinguished body was, indeed, a striking tribute to the technical perfection and fitting of Hanger light-metal legs.

THE COMMITTEE’S RECOMMENDATION.

The Committee’s final recommendation was as follows:

"After full and careful consideration, and having regard to the special conditions already set out, your Committee recommend that the number of makers at present employed should be reduced to two, and that those two should be Messrs. Pedestros, Ltd., and Messrs. J. E. Hanger & Co., Ltd., as fulfilling most satisfactorily conditions (a), (b) and (c) set out above."

[ (a) Good design (b) durability and (c) correct fitting.]

Note.—In 1929, Messrs. Pedestros, Ltd., went out of business. The Managing Director and the whole of the executive staff of Pedestros, Ltd., together with the greater part of their trained limb-fitters and skilled craftsmen, are now a part of the Hanger organisation.
AERIAL VIEW OF THE WORKS OF J. E. HANGER & CO., LTD., AT ROEHAMPTON

THE LARGEST ARTIFICIAL LIMB WORKS IN THE WORLD.
DEVO TED SOLELY TO THE MANUFACTURE OF ARTIFICIAL LEGS AND
GIVING CONSTANT EMPLOYMENT TO NEARLY 400 SKILLED CRAFTSMEN.

See further illustrations on pages 8 and 54 and description of Works on page 15.
A GROUP OF SOME OF THE EMPLOYEES AT THE “HANGER” WORKS AND FITTING ROOMS AT ROEHAMPTON.

PART OF THE METAL DEPARTMENT.

A VIEW OF THE LEATHER DEPARTMENT.

Other departments illustrated on page 54.
HANGERS are now the sole Contractors to the Ministry of Pensions for light-metal artificial legs of every type. In 1935 we were appointed sole makers of wooden legs to the Ministry until 31st December, 1943, and our Contract for light-metal legs was extended until the same date. In a letter confirming this extension, signed by Sir George Chrystal, K.C.B., on behalf of the Minister and dated 26th February, 1935, the following words were used:

"I am to add that the Minister has read with interest and gratification your references to the assistance and co-operation extended to you by his staff, to which you are good enough to attribute in part the efficiency of your organisation and the many valuable improvements already effected in the limbs supplied during the past year. It is the Minister’s earnest desire that this spirit of mutual helpfulness shall continue so as to benefit not only yourselves and the Ministry but, especially, the large number of limbless pensioners whose comfort and well-being are so closely concerned with the efficient performance of the contract."

"HANGER" LIGHT-METAL LEGS.

In view of statements that have from time to time appeared relating to the numbers of light-metal artificial legs supplied to disabled ex-Service men through the Ministry of Pensions, the following statistics of such legs at present in use and now maintained by us are of interest.

<table>
<thead>
<tr>
<th>NAME OF MAKER</th>
<th>Number of Light-Metal Legs in use and maintained by us at 30th Sept., 1936.</th>
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<tr>
<td>J. E. Hanger &amp; Co., Ltd.</td>
<td>20,108 = 54%</td>
</tr>
<tr>
<td>Pedestros, Ltd. (see Note on page 6)</td>
<td>10,561 = 28%</td>
</tr>
<tr>
<td>All other Makers combined</td>
<td>6,690 = 18%</td>
</tr>
<tr>
<td>Total number of light-metal legs</td>
<td>37,359 = 100%</td>
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</tbody>
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47,790 ARTIFICIAL LEGS.

In addition to the 37,359 light-metal artificial legs enumerated above, on the 30th September, 1936, we were also responsible for the renewal and maintenance of 10,431 wooden legs for the Ministry, making a grand total of 47,790 artificial legs.

1 The terms "Hangers" and "Hanger organisation," include the associated companies of J. E. Hanger & Co. Ltd. and Artificial Limbmakers Ltd.
WOODEN LEGS.

DURING the past 21 years we have made and fitted many more wooden limbs than all other makers combined. Notwithstanding that the energies of our technical staff have been particularly directed to improvements in the design of light-metal limbs, the development of the wooden limb has not been neglected. In consequence, the history and the evolution of the wooden leg have followed a course almost identical with that of the light-metal limb. Many makers had been supplying wooden legs to the Ministry of Pensions for disabled ex-Service men, but in April, 1935, the Minister of Pensions gave further testimony to the outstanding merits of the Hanger leg and the satisfaction of Limb-Fitting Surgeons and pensioners with the Hanger organisation by also entrusting to us the sole contract for the supply of wooden artificial legs.

Whilst we may justifiably be proud of this evidence of the confidence reposed in us by the Minister of Pensions and Limb-Fitting Surgeons throughout the country, we are still more gratified by the appreciation expressed verbally or in writing by many thousands of civilian and ex-Service amputees to whom it has been our privilege to be of service.

QUEEN MARY’S (ROEHAMPTON) HOSPITAL FOR THE LIMBLESS.

THE unique work of this Hospital, under the patronage of Her Majesty Queen Mary, is too well-known to the medical profession to need comment. It is recognised throughout the world as the leading Hospital specialising in the work of providing artificial limbs.

The Governors and Committee of this hospital, with the concurrence of the medical officers engaged in this work, in 1935 appointed us sole contractors for light-metal and wooden artificial legs of all types for the civilian patients at this Hospital.

SOUTH AFRICA AND CANADA.

THE Hanger leg, after being supplied for many years, was adopted in 1935 by the Government of South Africa, for sole supply to limbless ex-Service men and civilians in the Union. The Hanger leg is also solely supplied by the Dominion of Canada to its disabled ex-service men.
A LIGHT-METAL LEG FOR AMPUTATION ABOVE THE KNEE

ILLUSTRATING THE "HANGER" PATENT COMPENSATING PELVIC BAND SUSPENSION. SEE ALSO ILLUSTRATION ON PAGE 12.

For details, see pages 29 and 36 to 38.

Page eleven
A LIGHT-METAL LEG FOR AMPUTATION ABOVE THE KNEE

ILLUSTRATING THE WIDE ANGLE AND FREEDOM OF MOVEMENT OBTAINABLE WITH THE "HANGER" PATENT COMPENSATING PELVIC BAND SUSPENSION. SEE ALSO PREVIOUS PAGE.

For details, see pages 29 and 36 to 38.

Page twelve
A LIGHT-METAL LEG FOR AMPUTATION ABOVE THE KNEE

ILLUSTRATING THE "HANGER" IMPROVED DOUBLE SWIVEL PELVIC BAND SUSPENSION. SEE ALSO ILLUSTRATION ON PAGE 14.

For details, see pages 28 and 36 to 38.
A LIGHT-METAL LEG FOR AMPUTATION ABOVE THE KNEE

ILLUSTRATING THE ANGLE AND FREEDOM OF MOVEMENT OBTAINABLE WITH THE "HANGER" IMPROVED DOUBLE SWIVEL PELVIC BAND SUSPENSION. SEE ALSO PREVIOUS PAGE.

For details, see pages 28 and 36 to 38.

Page fourteen
A NATION-WIDE SERVICE.

THE difficulty of obtaining the latest and best types of artificial leg and the services of expert limb-fitters in the smaller centres of population has been overcome by the Hanger nation-wide service. Details of this are set out on page 71 where a list of the present Hanger branch establishments is given. At any town within the area served by the branch, Hospitals, Surgeons, and Amputees may be assured of the same efficient service as at our principal establishment in London.

AN UNIQUE ORGANISATION.

FEW people realise the vast extent of the Works required to fulfil the demand for Hanger light-metal and wooden artificial legs, or that such an organisation exists for this purpose alone.

The Hanger Works are many times larger than any other works in the world devoted to the manufacture of artificial limbs, and have no counterpart in regard to size, equipment or the number of men employed. Some idea of their magnitude will be gained from the aerial view on page 7 and the illustrations of a few of the Departments on pages 8 and 54.

The area of our main Works is over 40,000 square feet, occupying five acres of land, in addition to our Branches throughout the country. Nearly 400 skilled craftsmen are constantly employed, and no effort is spared to maintain the high standard of efficiency which has become a Hanger tradition, and to improve and perfect our productions down to the smallest detail in manufacture.

Arrangements can be made at any convenient time for visits of inspection by members of the medical profession and others who are interested.

IMPROVEMENTS IN LIGHT-METAL LIMBS.

THE illustrations of Hanger legs in this brochure only convey in part the extraordinary improvements in design and construction made by us during recent years. The early light-metal legs were a mass of riveted parts and Hangers were the first to form the shin of the leg in one piece without seam or rivets; to-day, the Hanger shin is made in a one-piece seamless pressing drawn from a flat sheet. This results in a much lighter and stronger production.

The material used in the shin, as in the knee, thigh-piece and socket, is Alclad 17S., one of the strongest light-metal alloys known to science,
which has the additional advantage of exceptional powers of resistance to corrosion. The quality used is known as A.I.D., this being the highest standard required by the exacting tests of the Air Ministry Inspection Department for use in aircraft.

Elsewhere in this brochure will be found details of some of the many patented and exclusive features which have made the Hanger light-metal leg famous throughout the world.

100,000 WEARERS OF “HANGER” LEGS.

There are over 100,000 satisfied wearers of Hanger artificial legs to-day and the Hanger organisation has become of national importance; there is not a city or town, in fact, scarcely a village, in the United Kingdom without its quota of those who are wearing Hanger artificial legs. The place of honour held by the Hanger leg is undoubtedly due to our consistent policy of specialising in making and fitting artificial legs and prostheses for the lower limb, and to our research on this problem alone.

It is strange, but none the less true, that in this age of specialisation Hangers is the sole organisation confining its work to the provision of such prostheses only. The supply of an artificial leg is usually carried out in connection with the sale of other surgical appliances or some other business. From time to time we have been asked to extend our activities in other directions, but after careful consideration we have preferred to concentrate our efforts entirely to the improvement of artificial legs and prostheses for the lower limbs alone and the training, under medical supervision, of a fully-qualified staff specialising in limb-fitting only. Notwithstanding many inducements offered to us, we have declined, so far, to deviate from this sole object.

The result of this intensive specialisation is that, in the considered opinion of those best qualified to judge, we are producing artificial legs which surpass anything available elsewhere either in this country or abroad, coupled with a standard of fitting which is beyond comparison.

TECHNICAL RESEARCH.

Our Research Department is continually engaged in research work on the improvement of artificial legs. Its activities, although limited to one particular subject, cover a wide field. Its usefulness has been amply proved by the many remarkable advances made in prostheses for the lower extremity.
A LIGHT METAL LEG FOR AMPUTATION ABOVE THE KNEE

SHIN AND KNEE MADE FROM ONE-PIECE PRESSINGS WITHOUT SEAM OR RIVETS; PRECISION-MADE BALL-BEARING KNEE JOINT; AND "HANGER" ROLLER-BEARING ANKLE JOINT (SEE PAGE 46).

This leg may be fitted with any method of suspension and any type of control.

Page seventeen
ILLUSTRATING WAIST-BELT SUSPENSION SUITABLE FOR LADIES. GENERAL SPECIFICATION AS FOR LEG ILLUSTRATED ON PREVIOUS PAGE. See also pages 30 and 36 to 38.
It has needed courage to concentrate on one form of prosthesis alone and has entailed the expenditure of many thousands of pounds on perfecting new ideas and introducing new plant, materials and methods. With regard to out-of-date methods, plant or equipment, we have never hesitated to "scrap the lot" ruthlessly, irrespective of cost.

Due to this consistent policy, the mechanical design and the high fitting standard of Hanger legs have shown uninterrupted progress, and scarcely a year passes without producing outstanding improvements in the design or details of one or other types of artificial leg. It is impossible, within the scope of this book, to deal with more than a few of the most notable recent improvements.

**PRACTICAL EXPERIENCE.**

Results of technical research must of necessity be proved in the field of practical experience and under the most stringent conditions. However carefully the Technical Department may work out a new idea and however free from faults it may seem in theory, unsuspected 'snags' and small defects manifest themselves in practical use. Hangers are in the unique position of having among their staff of nearly 400, a great number of limbless employees by whom all new ideas are put to critical tests in normal use.

Many of the thousands of wearers of Hanger limbs are kind enough to co-operate with us in this respect whereby we have the advantage of testing out new inventions under varying conditions of use by wearers in every kind of occupation. Our large number of wearers living abroad gives us the advantage of collective experience under every climatic condition from the Tropics to the Frigid Zones.

For these reasons the Hanger Technical Organisation has a wealth of information at its disposal quite unavailable to other makers; this is an inestimable help to continued progress and improvement.

**SURGICAL AND PSYCHOLOGICAL ASPECT.**

The provision of a prosthesis, such as an artificial leg, has a surgical and psychological side which can be fully appreciated and properly dealt with only by members of the medical profession, and upon which they alone are qualified to advise. Our research and experimental work has for years past had the great
advantage of being carried out in the closest co-operation with Orthopedic and other Surgeons throughout the country, and with the Limb-Fitting Surgeons of the Ministry of Pensions and its Technical Research Staff, to all of whom we are deeply indebted for valuable advice, assistance and co-operation, the resultant benefits of which cannot be over-estimated.

HOSPITALS AND MEDICAL SCHOOLS.

In the case of many Hospitals and Medical Schools a visit to our Works is now included in their post-graduate course, and we are at all times happy to welcome members of the medical profession and others who are interested in this subject. The following letter from a well-known Fellow of the Royal College of Surgeons is typical of many acknowledgments received by us:

Dear Sirs,

Post-Graduate Lecture at—

I wish to express my own appreciation and also that of the Doctors who were present at my lecture on Wednesday, 4th instant, of the excellent demonstration of Artificial Limbs and of the working parts, provided by your firm. I wish to thank you also for arranging the presence of Amputees who showed the merits of the limbs your firm has supplied to them.

This demonstration rounded off in a very practical and convincing way my lecture on Amputations, and showed how excellent are the results of a close and understanding association of Surgeon with the maker of the most improved types of Artificial Limbs.

The Doctors who attended the Lecture-Demonstration come from all over the Empire. Many of them expressed to me their great appreciation of this opportunity of seeing modern artificial limbs of various types, and especially of seeing them in use by Amputees.

I also had my own most recent patient there— ——- who suffered double amputation below the knee on November 23rd, 1935, and who has been supplied with Artificial Limbs by your firm. He is now walking well and is going to be a credit to you as well as to me.

I wish to take the opportunity of thanking your representative for his unfailing help and skill in fitting my patients who are in need of Artificial Limbs and other Surgical Appliances, and also for the interest he takes in arranging Demonstrations for my lectures on Amputations. I have also to thank you for the excellent illustrations of Artificial Limbs which you have placed at my service, and concerning which I shall be communicating with you shortly.

I am,

Yours faithfully,

M.A., M.Ch., F.R.C.S.
A LIGHT-METAL LEG FOR AMPUTATION BELOW THE KNEE

WITH LEATHER THIGH CORSET AND "HANGER" OR POLYCENTRIC BALL-BEARING KNEE JOINTS.

For details, see pages 15, 30, 40, 42 and 66.
A LIGHT-METAL LEG FOR AMPUTATION THROUGH THE KNEE

WITH BLOCKED LEATHER SOCKET; BALL-BEARING "HANGER" KNEE-PAN JOINTS; AND ONE-PIECE SEAMLESS SHIN-PRESSING.

For details, see pages 15 and 30.
WORLD-WIDE INTEREST.

The world-wide interest in Hanger limbs is an outstanding tribute to their reliability and efficiency. Evidence of this is found in the fact that we are constantly receiving Delegations from Dominion and Foreign Governments specially sent to this country to investigate our methods with a view to improving their own; almost invariably we are asked by these Missions to train men for them, and there are usually a number of such trainees going through an intensive course of instruction in our works and fitting rooms.

FITTING AN ARTIFICIAL LEG.

The importance of correct fitting to the health and comfort of the wearer of an artificial leg cannot be exaggerated. Wearers of an artificial leg, unless they have had the benefit of experience by comparison, obviously cannot appreciate the immense difference a properly fitted leg makes in their health and well-being.

The wearer of a badly fitted artificial leg with no previous experience is apt to think that any discomfort and harmful effects are the inevitable consequence of his or her disability. In recent years, the importance of a correctly fitted prosthesis has been more generally recognised, and increasing attention is being given to this subject by the medical profession.

THE HANGER FITTING STAFF.

The Hanger Fitting Staff numbers over 40 fully trained limb-fitters solely engaged in fitting artificial legs. Not one has been permitted to take charge of the fitting of a limb until he has had at least ten years’ experience as an assistant-fitter under the direct supervision of a Limb-Fitting Surgeon. The average experience of our limb-fitters is over 15 years, and each of them has fitted many hundreds of cases. Owing to the many thousands of cases we deal with every year, Hangers is the only organisation in which it is possible to have fitters specialising in one type of leg amputation.
OVER 20 Royal Letters Patent have been granted in respect to essential details of Hanger artificial legs, of which the following may be mentioned:—

Compensating Pelvic Band for securing an artificial leg to the body allowing unrestricted movement in all directions, without any metal attachments. (Patent No. 351,821.) See pages 11, 12 and 29.

"Hanger" Double Swivel Pelvic Band. For preventing undue rotation of the leg, providing perfect flexibility round the body whilst firmly supporting the leg vertically. (Patent Nos. 434,304 and 448,828.) See pages 13, 14 and 28.


Control of the Knee for amputations above the knee. A means of instantaneously adjusting the tension of the knee whereby the swing of the shin is automatically controlled to synchronise with that of the natural leg. (Patent No. 416,341.) See pages 36 and 37.

Improved Knee Spring for amputations above the knee. A means for automatically bringing the shin of the artificial leg forward with a natural gait in walking, whilst holding the leg backward when in a sitting position. (Patent No. 454,142.) See pages 36 and 37.


A Knee Joint Locking Device. (Patent No. 370,700.)


MASS PRODUCTION IMPRACTICABLE.

ENOUGH has been said regarding fitting to demonstrate that methods of mass production in the supply of artificial limbs are utterly impracticable if anything but the lowest standard of fitting is expected. The making and fitting of an artificial limb requires, in every stage, the closest attention to the distinctive
A "KNEELING" LEG FOR AMPUTATION BELOW THE KNEE

FOR VERY SHORT BELOW-KNEE STUMPS. BLOCKED LEATHER SOCKET; BALL-BEARING "HANGER" KNEE-PAN JOINTS AND LIGHT-METAL ONE-PIECE SEAMLESS SHIN.

For details, see pages 15 and 30.
(1). A WOODEN LEG FOR AMPUTATION ABOVE THE KNEE
(2). A WOODEN LEG FOR AMPUTATION BELOW THE KNEE

(1). WILLOW LEG WITH ROLLER-BEARING ANKLE JOINT. MAY BE FITTED WITH ANY METHOD OF SUSPENSION AND ANY TYPE OF CONTROL.

(2). ANGLESEY TYPE LEG. WITH "HANGER" OR POLYCENTRIC BALL-BEARING KNEE JOINTS. SEE ALSO PAGES 31, 40 AND 42.

For details, see pages 40 and 42.
anatomical characteristics of each individual in order to ensure that it conforms, with meticulous precision, to the shape and any peculiarities of the stump; and that the positions of joints and the length, alignment and balance are correct in every detail.

No two cases are alike; not only the type of limb but also the method of attachment which suits one patient may be most unsuitable for another with a similar amputation, as stump condition, age, occupation, sex, physique and general health, all need careful consideration. In the Hanger establishment, the whole process is individual from the first measurement or cast to the final setting-up and finishing-off of the leg and is carried out under the personal supervision of the actual limb-fitter dealing with the case. The final shape of an artificial limb is, of course, modelled, as far as a correct fitting permits, in all details to the shape of the sound limb.

We probably fit ten times as many artificial legs as any other limb-makers in the world, and three times as many as all other makers in this country put together. We are satisfied that mass-production methods and attempts to standardise limbs in different sizes—even if they run into thousands—are wrong in practice, definitely harmful to the unfortunate wearers, and much to be deplored. Making an artificial limb is considerably more than a mere engineering problem.

MEANS OF SUSPENSION.

The indiscriminate use of one method of suspending an artificial leg from the body for each type of amputation or stump length, without giving proper consideration to the many other factors which should be taken into account, is open to grave objection; this particularly applies where the amputation is at or above the knee.

The same care needs to be used in selecting the means of suspension from the body as is required in the selection of the type of limb itself. It is not sufficient to adopt one or other type of suspension, such as a pelvic band, according to the length of stump alone; experience shows, if the best results are to be achieved, that every factor requiring consideration in deciding the type of limb must also be taken into account in selecting the form of suspension to be used.

For many years we have given close attention to devising more efficient methods of suspension and perfecting improvements in all known means of suspending an artificial leg from the body; as a
result, we have a very wide range of patents protecting a number of vital improvements in methods of suspension which are exclusive to Hanger limbs.

Suspension for amputations above the knee falls into two main classes; suspension from the pelvis by means of a pelvic band or other form of belt or from the shoulder by means of suspenders, or a combination of both. Each of these classes is sub-divided by variations and modifications too numerous to detail within the scope of this book. The necessity for such wide variations in method will be obvious if full consideration is given to the diverse requirements and characteristics peculiar to each individual; no artificial limb can be fitted to the best advantage unless all these factors are properly appreciated and the means of suspension selected or modified accordingly. Some of the many types of suspension used by us are described below.

"HANGER" IMPROVED DOUBLE SWIVEL PELVIC BAND.

(Patents Nos. 412,527; 434,304; and 448,828.)

The Hanger Improved Double Swivel Pelvic Band, illustrated on pages 13 and 14, is a remarkably efficient means of suspension of an artificial leg in many cases of amputation above the knee, and on account of its advantages is deservedly popular. It holds the leg rigidly to the body, at the same time giving wide lateral movement, and allows the leg complete freedom to follow the natural movements of the body in walking, bending or sitting.

The old type of Double Swivel Pelvic Band, in its earlier method of construction, permitted far too much rotatory movement, allowing the leg to turn on the stump and to assume an unnatural position, particularly when sitting; the excessive rotatory movement also gave a sense of insecurity when walking on uneven ground. To ensure vertical rigidity a rigid strip of steel shaped to the pelvis was inserted in the soft leather band. However accurately fitted, this sometimes caused discomfort by pressure on the back or abdomen, when movement of the body took place in bending or sitting.

These two defects are now completely eliminated and other definite improvements have been effected in the Hanger Improved Double Swivel Pelvic Band by recent inventions.
which are fully protected by Letters Patent Nos. 412,527, 434,304 and 448,828.

These valuable improvements entirely overcome the undesired excessive rotational movement inherent in the old type of Double Swivel Pelvic Band by a novel method of hinging the steel strip; this gives flexibility round the body whilst still retaining the leg in definite relation to the body in a vertical direction. The artificial leg is thus held firmly to the body whilst the Pelvic Band itself is as supple and flexible as a soft body-belt. When sitting, bending, or changing position there is no tendency for the ends of the steel strip to press into the back or the abdomen as, being hinged, they automatically follow every movement of the body. A new type of precision-made ball-bearing hip joint has recently been perfected by us and adds considerably to the comfort of the wearer.

The exclusive advantages and patented features of the Hanger Improved Double Swivel Pelvic Band give greater efficiency, reliability and comfort than hitherto it has been possible to attain with this type of Pelvic Band.

“HANGER” COMPENSATING PELVIC BAND.

(Patent No. 351,821.)

THE Hanger Compensating Pelvic Band which is illustrated on pages 11 and 12, has many excellent advantages. It gives complete and unrestricted freedom of movement in every direction; it responds to and reciprocates every movement of the body, whilst holding the artificial leg firmly to the stump no matter what position the body may assume. Among other strong points in its favour are a complete absence of metal parts and joints likely to damage the clothing, and its extreme lightness—being less than half the weight of the Double Swivel Pelvic Band.

The Hanger Compensating Pelvic Band gives a feeling of security under all conditions of use, owing to the leg being held in equal tension from both sides of the thigh. Suspension from each side of the socket, in place of pivotal suspension from the centre of the front and back, prevents any tendency for the outer edge of the socket to press into the hip when standing astride or bending sideways. This will be seen from the illustration on page 12, and is due to the fact that the range of movement is such as to permit the whole of the socket to move in unison and perfect alignment with
the stump in any direction. Since its introduction by us in 1934 it has been fitted with great success to a large number of cases of amputation above the knee, and is, in the opinion of those best qualified to judge, an ideal method of suspension for a very large proportion of above-knee amputations.

Being fully covered by patents, the Hanger Compensating Pelvic Band is a distinctive and exclusive feature of Hanger artificial legs.

OTHER METHODS OF SUSPENSION.

ABOVE-KNEE AMPUTATION.

OTHER means of suspension for amputation above the knee that may be briefly referred to are the ordinary rigid type of Pelvic Band with or without lateral hip joint; shoulder braces attached to the leg itself or to the Central Knee Control; Moore’s control, a means of suspension from the shoulder by braces with cord control through rollers; a waist-belt with three or four points of suspension (see illustration on page 18)—this is especially suitable for ladies; a fitted corset or light waistcoat with suspending straps.

THROUGH-KNEE AMPUTATION.

(Illustrated on page 22.)

For amputations through the knee joint, most forms of above-knee suspension are applicable; they are usually associated with a forked patella and elastic or other type of control.

BELOW-KNEE AMPUTATION.

(Illustrated on pages 21, 25, 26, 31 and 32.)

For this type of amputation, in cases where the stump is suitable and of sufficient length, an ordinary knee strap, as illustrated on page 32, is suitable, otherwise a thigh corset, illustrated on page 31, is generally used, with or without shoulder brace. Very short or unhealthy stumps or those unable to take pressure at the condyles are usually fitted with a blocked leather Ischial-bearing thigh corset; this corset relieves part or all of the pressure from the condyles of the femur, the weight being taken at the thigh and ischium. The usual method of control is by means of a forked patella and elastic.

In certain cases of below-knee amputation where the stump is too short or cannot take the weight on the condyles a kneeling leg is used, as illustrated on page 25.
A LIGHT WOODEN LEG FOR AMPUTATION BELOW THE KNEE

WITH LEATHER THIGH CORSET AND "HANGER" OR POLYCENTRIC BALL-BEARING KNEE JOINTS.
For details, see pages 10, 30, 40 and 42.
A LIGHT-METAL LEG FOR AMPUTATION BELOW THE KNEE

WITH KNEE STRAP IN PLACE OF THIGH CORSET, ONE-PIECE SEAMLESS SHIN-PRESSING AND "HANGER" ROLLER-BEARING ANKLE JOINT.

For details, see pages 30 and 39.
SYMÉ’S AMPUTATION.
(Illustrated on page 35.)

Generally speaking, a leather gaiter fitting the calf, as illustrated on page 35, is sufficient. In some cases the addition of a strap above the knee is found to give extra comfort in control of the limb. Where no weight can be taken on the end of the stump it is necessary to take the pressure on the condyles of the knee with or without the addition of a thigh corset.

AMPUTATION AT, OR THROUGH THE HIP-JOINT.
(Illustrated on pages 49 and 50.)

In this type of amputation, the Pelvic Band is an integral part of the socket of the leg, as will be seen from the illustration. The methods of control are usually either the Central Knee Control with roller cords, as illustrated, a forked patella and elastic attachment between the shin and the socket, or the Hanger spring knee.

ARTIFICIAL LEGS WITHOUT BODY ATTACHMENTS OF ANY KIND.

It is necessary to give a definite warning regarding the use of suction as a means of holding an artificial leg to the stump. Over 50 years ago, the Suction Socket as a method of attaching an artificial leg to the body without other assistance was invented by Beacock and Sparham, who were granted a patent in A.D. 1885, for a socket provided with an air valve, which was described in the following words:

"When the stump of the natural limb is inserted in the chamber (socket) into which it accurately fits, the valve will yield to allow egress of air displaced by the stump, and when the stump is full inserted the pressure of air on the valve will keep it closed and the pressure of air around the chamber (socket) will keep the stump firmly therein . . . ."

After a lapse of half a century much-advertised attempts have been made recently to resurrect this long discarded theory. In only a very few cases can the method be even attempted, and the risks attendant upon its use, and other objectionable features, more than outweigh its somewhat doubtful advantages.

Obviously, a socket will not hold to the stump by suction unless it is air-tight; this is not possible unless the bare skin is kept in close contact with the interior of the socket. By pressing the naked stump into the socket the air is expelled through a valve; on closing
the valve a partial vacuum is created which holds the socket to the stump.

Owing to the drag on the flesh created by the semi-vacuum and the complete lack of ventilation there is serious danger of oedema and congestion of the blood vessels, and inflamed and sore stumps often accompanied by severe pain. A stump sock cannot be worn as the suction effect depends upon maintaining air-tight contact between the flesh and the socket. The complete lack of ventilation causes profuse perspiration which condenses and drains to the bottom of the socket; in the case of a wooden socket, this perspiration is absorbed by the wood; the hygienic condition of the limb at the end of a day’s wear can better be imagined than described.

If a healthy condition of the stump is to be maintained perfect ventilation of the socket is a sine qua non. With a socket held by suction, obviously, this is impossible. The use of a stump sock is also essential to maintain the stump in good condition and to protect it from changes in temperature; the non-use of a stump sock is unhygienic and definitely harmful to the stump. (See page 65.)

There is a grave risk of irremediable harm being done to the stump by the use of suction as a means of attaching an artificial leg. Methods of suspension have to-day been so perfected that a Suction Socket can hardly be said to have any advantages, certainly not such as to warrant the danger incurred in its use.

In view of the risks referred to, we fit a Suction Socket, in the very few cases to which it can be applied, only under the direct instructions of a qualified medical practitioner. We cannot too strongly recommend that medical advice should be sought by anyone contemplating its use.

**CONTROL OF AN ARTIFICIAL LEG.**

Some wearers of an artificial leg, particularly those with a healthy, muscular stump, are able to control the leg by the stump alone without other help; this applies more particularly to amputations below the knee. Generally, however, especially for amputations above the knee, some form of control is required for the purpose of assisting the leg forward in walking.

All Hanger legs are so designed that any suitable method of control may be used, irrespective of the type of leg or means of attachment to the body. A further advantage in Hanger legs is that the various types of control are easily interchangeable, according to which is found most suitable in the particular case.
A “HANGER” APPLIANCE FOR SYME’S AMPUTATION

LEATHER SOCKET WITH GAITER LACING IN ANY POSITION. FRONT BIFURCATED AND LATERAL SUPPORTS OF FIRTH’S RUSTLESS STEEL. “HANGER” ROLLER-BEARING ANKLE JOINT.

For details, see page 51 and also page 33.
SHOWING THE REMARKABLE CONSTRUCTION OF THIS METHOD OF
“BUTTON” CONTROL, AND THE DETAILS OF THE BRAKE
DRUM, KNEE SPRING AND BALL-BEARING KNEE JOINT.
For description, see opposite page.
Quite apart from the question of assisting the leg forward, it is also necessary that the movement should be a natural one. This point is often overlooked.

**NATURAL SWING IN AN ARTIFICIAL LEG.**

*(For Amputation above-the-Knee.)*

For many years past a characteristic of Hanger light-metal limbs for amputation above the knee has been an adjustable frictional knee action whereby the swing of the artificial leg in walking is made to correspond to the swing of the natural leg. Frictional devices for controlling the movement of the shin of an artificial leg have long been in use, even in wooden legs, and the general principle is well-known. The advent of the ball-bearing knee joint in light-metal limbs, another important innovation the credit for which is entirely due to the Hanger organisation, has led to renewed interest in methods of controlling the action of the knee and such devices have been recently the subject of articles in the medical press.

**THE “HANGER” ADJUSTABLE KNEE CONTROL.**

*(See illustration on opposite page.)*

The latest, and certainly the most efficient, means of controlling the swinging speed of the shin and the action of the knee of an artificial leg is undoubtedly the Hanger Patent Adjustable Knee Action, the subject of Royal Letters Patent Nos. 416,341 and 454,142.

This improvement is due to the initiative of the Hanger Technical Research department and is the outcome of an experience over a period of 20 years of the use of such devices. By its means the control is so perfect that the movement of the limb may be instantly adjusted so that the swing of the artificial leg is indistinguishable from that of the natural limb. Whether walking quickly or quietly strolling, the gait of the artificial limb corresponds precisely to that of the natural leg.

A natural swing of the leg is obtained by means of a spring enclosed in the knee, which brings the shin forward in walking, and a frictional device which controls the speed of the swing. Both are
adjustable to suit the requirements of the individual, and, in combination, result in a perfectly natural gait.

The frictional means used is the usual Hanger method of an adjustable Brake Band and Drum on the knee bolt, the novelty consisting of an ingenious but simple cam arrangement. Adjustment is made instantly, unnoticeably and almost automatically by slight pressure through the clothing on a button on the thigh; this may be done whilst walking, without any change in position. The necessity of awkwardly bending down to make adjustments at the knee is entirely obviated. It is instantaneous in operation and may be set at precisely the amount of knee resistance required in each individual case, from an entirely free frictionless knee-swing to a practically locked knee, if such is required.

Another important advantage of the Hanger patent adjustable knee control is that it is so designed that, when sitting, the action of the spring is reversed and it holds the shin back, thus keeping the foot well under the knee without any tendency to swing forward.

The construction of some forms of control causes a constant pull forward on the shin in all positions of the leg, making it difficult to keep the leg under the knee when sitting; this is a great disadvantage and annoyance when sitting in a confined space such as a theatre or public vehicle.

The simplicity of the Hanger Knee Control is seen in the section illustrated on page 36. It is without question the lightest and most efficient device of its kind and may be used with every type of light-metal artificial leg for above-knee amputation. No similar device has been so successful in meeting the exacting surgical demands and the high mechanical standards required to-day.

CENTRAL KNEE CONTROL.

This alternative method of control for artificial legs for amputation above the knee was first introduced by Hangers in 1915, and is now in general use by most limbmakers throughout the country. Since we introduced the Central Knee Control we have considerably improved it in many points of detail for which several Patents have been granted. It is operated by means of cords from the shoulder brace which pass over a lever in the knee joint; the movement of the shoulder in walking automatically brings the lower part of the leg forward. It is useful in some cases of amputation above the knee where the stump lacks muscular strength, and also in certain occupations where heavy work and much standing are necessary.
A full description of the "Hanger" foot and ankle joint will be found on pages 46 and 47.

The lower illustration shows its application to a rubber foot.
THE “HANGER” POLYCENTRIC KNEE JOINT

THE UNIQUE ADVANTAGES OF THE “HANGER” POLYCENTRIC KNEE JOINT ARE FULLY EXPLAINED ON PAGE 42.
FORKED PATELLA AND ELASTIC CONTROL.

This type of control consists of a forked leather or thong; the two ends are attached to the top of the shin and terminate in an elastic webbing, fastened either to the socket, Pelvic Band or shoulder brace. Flexion of the leg causes the elastic to stretch and bring the shin forward at the end of each step. The elastic is adjustable to any tension according to the requirements of the wearer. This form of control may be used with practically any method of suspension of artificial legs, both for above- and below-knee amputations.

OTHER METHODS OF CONTROL.

There are many other methods of control, most of which are variations or modifications of the three principal methods outlined in the preceding paragraphs.

PROVISIONAL PROSTHESES.

When is a stump ready for fitting? No categorical answer can be given to this question, each case must be taken on its merits. Some limb-makers are inclined to suggest the fitting of an artificial limb at too early a date and before the stump is ready for fitting.

"The scar should be well consolidated and quite painless. The collateral circulation must have re-established itself, and there must be no consolidation of the tissues with oedema at the stump extremity. The stump must permit of being roughly handled without pain, the presence of sensitivity indicates that the nerves have not yet settled down, but the complaint of occasional 'shooting' in the stump or perhaps slight jactitation may be ignored in this connection. Full or nearly full extension at the hip should be obtained. When the stump comes up to these requirements it can be said that it is ready for fitting and it will usually be found in normal cases that this stage is arrived at about 2½ to 3 months after amputation in above knee stumps. Cases in which there has been much prior sepsis, diabetics, gangrene, vascular conditions such as Thromboangitis obliterans, Raynaud's disease, etc., will require a much longer recovery period."

A provisional prosthesis, such as a Plaster Pylon, is sometimes used for economic reasons. A stump shrinks rapidly during the early stages of limb-wearing and new sockets are required which, in a permanent limb, are more costly than in a provisional prosthesis. The cost of altering a provisional prosthesis, as shrinkage of the stump progresses, is small.

1 Extract from a Lecture given by a Surgeon on "Amputation Stumps."
AN IMPORTANT “HANGER” INVENTION
of exceptional merit relating to artificial legs for amputations below-the-knee.

THE “HANGER” POLYCENTRIC KNEE JOINT.
(Patent No. 414,317.)
(See Illustration on page 40.)

The invention of the Hanger Polycentric Knee Joint is one of the most outstanding achievements of recent years; it marks a new epoch in prostheses for amputations below the knee.

For the first time a solution has been found of the problem of providing a satisfactory joint with a movement coinciding with that of the natural knee joint.

The natural knee joint has a very complicated action, the two articular surfaces of the femur (thigh bone) and tibia (shin bone) partly rolling and partly sliding over each other during flexion and extension of the knee in walking, sitting or standing. The axis of the natural joint constantly changes during the action of bending the knee; the shin does not swing in the arc of a true circle as would be the case if the knee joint had a fixed axis—therefore, no artificial joint having a fixed point of axis can possibly move in unison with the natural knee joint with its continually changing axis.

Mr. E. Muirhead Little, F.R.C.S., says:—

“In the case of the knee which is a combination of a hinge joint with a sliding joint, it is not practicable to fit an artificial joint of which the movements shall exactly coincide with those of the natural joint . . . .”

Mr. Muirhead Little was, of course, referring to the usual type of artificial joint with a fixed point of axis, the Hanger Polycentric Knee Joint at that time not having been invented.

The subject of the movement of the natural knee joint has been exhaustively dealt with by Dr. Ducroquet, an eminent French Orthopaedic surgeon, who has closely studied this problem. In his well-known text book he demonstrates conclusively the

1 E. Muirhead Little, F.R.C.S., “Artificial Limbs and Amputation Stumps.”
2 Dr. Ducroquet, “La Prothèse Fonctionnelle des Blessés de Guerre.” A translation of the article appears at the end of this book, pages 66 to 69.
impossibility of the ordinary type of artificial joint, with a fixed point of axis, reproducing the movement of the natural knee joint. We are indebted to Dr. Robert Ducroquet and the publishers, Messrs. Masson et Cie, of Paris, for permission to print a translation of the article dealing with this subject. (See Appendix, page 66.)

With the usual type of artificial knee joint having a fixed point of axis there is bound to be a disparity between the movements of the natural and artificial joints at various points when bending the knee. This causes displacement of the stump in the socket when flexing the knee in walking and the bunching up of the gastrocnemius muscle and soft flesh of the calf on the back of the artificial leg socket when the wearer assumes a sitting position. It is this pressure behind the calf and under the knee which causes discomfort to many wearers of an artificial leg for below-knee amputation after sitting for any length of time.

The introduction of the Hanger Polycentric Knee Joint has eliminated this trouble as its movement coincides with that of the natural knee.

THE PERFECT KNEE JOINT.

For below-knee amputation.

In this invention, which is fully protected by Royal Letters Patent (No. 414,317), the moving axis of the Polycentric joint follows the downward movement of the axis of the natural knee joint. As the axis of the Hanger Polycentric Joint moves in correlation with the natural knee joint, the socket of the artificial leg is displaced downward and backward, reciprocating the downward thrust and backward movement of the shin which takes place during the action of bending the natural knee. The chafing caused by the pumping movement of the stump in the socket with the ordinary type of knee joint with a fixed point of axis is entirely avoided, and there is no constriction of the gastrocnemius muscle and soft flesh of the calf when the knee is fully flexed in a sitting or kneeling position. In consequence of the freedom from strain at the back of the calf and the absence of pressure on the stump at any point of movement of the knee, the Hanger Polycentric Joint allows one to walk faster with less exertion and to sit without discomfort.

As will be seen from the illustration on page 40 the movement of the natural knee joint is obtained by connecting the two parts of the artificial joint by a link, their pivoted ends being arcuate in shape and formed with teeth which intermesh. The effect of this
arrangement is progressively to move the shin of the artificial leg downward and backward in an involute curve as the knee is flexed; this allows room for the expansion of the muscle and soft flesh behind the shin and thigh.

AN EXCELLENT TEST.

C YCLING involves a considerably greater angle or amplitude of movement in the knee than is required in walking. Not only is the angle of flexion greater, but it is accompanied by forward, downward and backward thrusts of the foot, all of which, of course, have to be impelled by the stump itself. For this reason cycling is an excellent test of the relative movements of the polycentric and natural knee joints.

The writer of the letter printed below cycles 17 miles daily to and from his work and his remarks are typical of the many favourable opinions we have received in regard to this exceptional invention.

"All the difference in the world."

HOUNSLOW, 7th April, 1936.

DEAR SIRS,

I think my experience of the Hanger Polycentric Knee Joint will interest you. My amputation is below the knee—a 4½ in. stump—and during the past 20 years I have had legs made by four different makers. With every previous leg, however well-fitted, there has always been a feeling of strain at the knee when sitting down or cycling. This I find to be a common trouble with others who have below-knee amputations.

The improvement made by your new knee joint is astonishing; it makes all the difference in the world. It moves as if it were part of one's own knee, and from the day I first wore it I have never experienced the slightest strain or pressure behind the knee.

The tremendous difference in this knee joint is particularly noticeable in cycling. I cycle to and from my work every day, a distance of 17 miles. Previously my artificial legs had a tendency to slip on the pedal; this has entirely disappeared and I find myself using my artificial leg equally with my good one. I can now cycle with my artificial leg alone, without assistance from my good leg.

Chafing of the stump has completely gone as it does not slip up and down in the socket. Although I stand at my work all day and have a great deal of walking about, I have never found a mark on my stump at night since I had the leg.

All this is entirely due to your really remarkable joint, and I sincerely congratulate you on an improvement which no wearer of a below-knee leg can afford to be without.

You may make use of this letter in any way you wish.

Yours faithfully,

J. . . . C. . . .
MOTOR DRIVING.

Motor driving with a below-knee amputation, particularly in commercial vehicles where space is limited, causes great discomfort to the wearer of ordinary joints, owing to the strain at the back of the calf and knee due to the leg being for long periods in a constantly flexed position.

The writer of the letter printed below is engaged all day in driving a commercial motor delivery van.

“A tremendous improvement.”

13th August, 1936.

Dear Sirs,

I have now been wearing your artificial leg with the new knee joint for about five months, and would not under any circumstances go back to the old joint. I drive a motor van all day, and with my other legs I have always found that the socket pinched up the flesh and caused it to ache through sitting for long periods driving the van. With the new knee joint this has completely disappeared, and however long my day there is not the slightest feeling of strain.

In the cinema I find a great difference. Before I had this joint, I used to have to get an end seat in order to stretch my leg out on account of the cramped position, but I do not have to do that now.

I walk very much faster than I did before, although I do not quite know why.

In every way the new joint is a tremendous improvement.

Yours truly,

W. A. A. . . .

Without exception, all wearers speak in terms of the highest commendation of this joint.

The Hanger Polycentric Knee Joint has the additional advantage of four precision-made ball races, giving an almost frictionless movement which is unique in prosthetic practice.

The Polycentric Knee Joint is, without doubt, a very definite advance in prosthesis for amputations below-the-knee and an unqualified boon to every such amputee. We are prepared to substitute this knee joint on other makes of leg at a moderate charge according to the work involved.

The translation from Dr. Ducroquet’s text book, “La Prothèse Fonctionnelle des Blessés de Guerre,” (See Appendix, pages 66 to 69), and the accompanying illustrations of the movements of the natural knee joint in relation to artificial joints, may be of interest to members of the medical profession. We take this opportunity to tender our thanks to the owner of the copyright, Dr. Robert Ducroquet, and the publishers, Messrs. Masson et Cie, who have been good enough to allow us to translate and publish the article.
THE "HANGER" IMPROVED FOOT AND ANKLE.

(Illustrated on page 39.)

Strength and correct design at the foot and ankle joint of an artificial leg are of material importance. It is here that the most severe strain is applied, yet it is at this point that any saving of weight gives the greatest advantage. Ample strength and lightness of weight are essential, and in order to ensure a natural gait the action of the artificial joint must be smooth and flexible. Like other noteworthy inventions, the Hanger foot is the outcome of many stages of development and has been evolved as the result of years of patient experiment and wide experience in practice.

The Hanger Improved Foot is so constructed as to reproduce almost precisely the action of the 'tendo Achillis' and its opposing flexors: thus, the movement of the Hanger artificial foot approaches more closely to that of the natural foot than was possible previous to its introduction. After exhaustive tests it has proved itself to be of ample strength and free from the mechanical troubles so often due to faulty design and consequent inability to withstand the stresses this part of an artificial leg has to bear. Although stronger, it is considerably lighter than any other type of foot giving satisfactory service and efficiency.

THE "HANGER" ROLLER-BEARING ANKLE JOINT.

The Hanger Roller-Bearing Ankle Joint is a masterpiece of engineering design. Being totally enclosed, with automatic lubrication, it will give years of the hardest wear without requiring lubrication, adjustment or other attention. Due to the special design of its anti-friction roller-bearing ankle joint the foot has an easy life-like movement and a smooth effortless action.

In the Hanger foot there is a complete absence of torsional strain at the ankle joint itself. It has been claimed that a torsional ankle joint approximates to the action of the muscles of the natural foot; any book on Anatomy will show that the muscles of the foot have nothing to do with ankle movement. Torsional strain at the artificial ankle joint is definitely undesirable and should be avoided.

An ideal ankle joint would be frictionless with the opposing stresses acting upon the foot, as far as possible, at the same point and in the same direction as the 'tendo Achillis' and its opposing flexors.

The illustration, page 39, shows that the Hanger foot approaches this ideal. Friction at the ankle joint itself is reduced to a minimum;
therefore, the free action of the foot is in no way impeded. The opposing forces are applied at the correct points, the carefully designed heel buffer compressing under the weight of the heel when placing the foot on the ground, the compression being transferred to the instep buffer as the foot comes over on to the toes in walking. The "slap" of the foot, which is typical of most artificial legs, is thus overcome and the compression of the heel buffer, together with the padding under the heel, prevents any jar or concussion being transferred to the stump when the heel is brought to the ground.

The Hanger Improved Foot and Ankle Joint is now fitted without extra charge to all Hanger light-metal and wooden artificial legs, and can be fitted by us to other makes of limb.

RUBBER FEET.

As will be seen from the illustration on page 39, the principle of the Hanger Improved Foot and Roller-Bearing Ankle is also applied to a rubber foot. For those who prefer a rubber foot and do not object to the additional weight entailed, the combination is ideal.

CONGENITAL DEFORMITIES OF THE LOWER EXTREMITY.

For a number of years we have given particular attention to the provision of prostheses for congenital deformities of the lower limbs. In consequence of the very gratifying results we have obtained our work in this connection has developed to a considerable extent. Each case requires special consideration and treatment as no two are alike. However difficult a case may appear to be we welcome the opportunity to design a useful prosthesis.

The more difficult cases are discussed at meetings of our limb-fitting staff, numbering upwards of 40 fully trained limb-fitters, or the details are submitted to them for consideration and report. This team-work and co-ordination of effort results in a practical prosthesis if such is at all possible; often a thoroughly satisfactory appliance has been evolved when, at first, the problem appeared to be unsolvable.

On pages 58, 59, 60 and 64 we illustrate a few examples of successful prostheses designed by us for congenital and other deformities.
AMPUTATIONS AT THE HIP-JOINT.

The latest prosthesis devised by us for amputations involving disarticulation at the hip-joint, or so close thereto as to leave no useful stump, will be found illustrated on pages 49 and 50.

At one time the fitting of an artificial leg for this type of amputation was looked upon as almost useless except to conceal the disability. To-day, we have a large number, in fact, six or seven hundred through-hip amputees rehabilitated and restored to normal employment; this is due to the many improvements made by us in the mechanical details and design of prostheses for this type of amputation, to a further reduction in weight and to the Hanger patented improved automatic hip-locking device (Patent No. 188592).

In our own works there are numbers of through-hip amputees pursuing their work at the bench under ordinary working conditions; so well do they walk that it would be impossible for the uninitiated to say where they are amputated or, in some cases, whether they are amputees at all.

Mr. E. Muirhead Little, F.R.C.S., whose well-known work Artificial Limbs and Amputation Stumps is, at present, the standard text-book upon this subject, says on page 241:

"The light-metal No. 1 limb made by J. E. Hanger & Co. at Roehampton is at present the lightest and most satisfactory limb for disarticulations at the hip-joint."

A letter from Mr. C. Shelton, who climbed Snowdon in three hours wearing an artificial limb for amputation at the hip-joint appears on page 56.

The letter printed on page 51 from Miss Tenniswood is of interest. After 38 operations for osteomyelitis this lady was finally amputated in 1931 by disarticulation at the hip-joint. She was told that an artificial leg would never be of any use to her except as an ornament. She came to us in 1936 and, with the consent of the surgeon who performed the operation, we fitted her with an artificial leg in light-metal of the type illustrated on pages 49 and 50 on the 26th June, 1936. It should be noted that this limb was fitted without her having had any previous experience of even a provisional prosthesis to accustom the stump to pressure.
A LIGHT-METAL LEG FOR AMPUTATION AT THE HIP-JOINT

THIS LEG IS FULLY DESCRIBED ON PAGES 48 AND 51 AND ON PAGE 33. SEE ALSO ILLUSTRATION ON PAGE 50.

Page forty-nine
A LIGHT-METAL LEG FOR AMPUTATION AT THE HIP-JOINT

THIS IS THE LEG ILLUSTRATED ON THE PREVIOUS PAGE WHEN IN A SITTING POSITION.

Page fifty
On the 4th September, 1936, just ten weeks after being fitted, she writes to us as follows:

"I never had a hope of walking again."

Dear Sirs,

After nine years on crutches it is wonderful to walk again and look like others. I have had my artificial leg exactly ten weeks to the day. For the first fortnight I only used it for an hour or two each day but for the last eight weeks I have worn it continuously and have never once taken it off except to go to bed. I walk about in the house and go for walks of about a mile and a half now without feeling tired. I go up and down stairs and on and off buses without the slightest difficulty. I wondered about the escalators on the "Underground" and was a little nervous of using them but found them no trouble at all. I have only used the knee lock once, at Guildford Station, where there is a steep slope. I am still using a light walking stick because after all it is only ten weeks since I had my leg, but I can do without a stick and have carried a large tray of crockery using both hands. It is all too wonderful—I never had a hope of walking again . . .

Yours sincerely,

(Signed) Olive Tenniswood.

SYME'S AMPUTATION.

The chief considerations in fitting a prosthesis for Syme's amputation are strength, a neat appearance and ample ventilation of the stump. In order to obtain a neat appearance appliances are made in which the stump is totally enclosed in a light-metal shin piece: this gives a close-fitting appliance but the results are, otherwise, disappointing. The lack of ventilation causes an unhealthy condition of the stump and the danger of early breakdown.

We prefer to fit the type of appliance illustrated on page 35. As the illustration shows, the aesthetic objections have been overcome and its appearance compares favourably with the totally enclosed metal type. It will be seen that the stump is freely ventilated at the site of amputation.

There are, unfortunately, some Syme's amputation stumps unable to tolerate end-bearing: for such the appliance is modified to take the weight partially on the condyles or, in exceptional cases, at the thigh, under the tuberosity of the ischium.

AMPUBTATIONS AT THE FOOT.

These cases mostly comprise Chopart's, Pirogoff's and Lisfranc's amputations. They are few in number—particularly the two latter—and owing to their peculiar nature the prosthesis
usually has to be modified or specially designed for each case. The descriptions given below must, therefore, be considered as subject to wide modification.

CHOPART'S AMPUTATION.
This prosthesis usually consists of a strengthened sole-piece with a moulded block shaped to the stump and fitted with a toe-joint. The foot and ankle are given support by a soft-leather upper portion. In some cases a steel joint is required: here a corset is necessary for the calf, the corset and foot sometimes being connected with an elastic dorsiflexion strap. In other cases a leather ‘tendo Achillis’ is also provided.

PIROGOFF’S AMPUTATION.
For these cases the prosthesis usually consists of a leather shin corset, side ankle joint, light-metal sole plate with hinged toe and metatarsal joints.

LISFRANC’S AMPUTATION.
For these amputations, and others involving less extensive mutilation of the foot, we usually provide a special boot with moulded forepart and sponge rubber cushion at the site of amputation.

CRUTCHES.
It is remarkable how little attention is given to the selection of the correct type of crutch. During the period between the amputation of a lower extremity and the provision of a temporary prosthesis, or the permanent artificial leg, the use of crutches is essential: at this time the amputee is going through a stage when getting about imposes an undue physical strain. It is necessary, therefore, that crutches should be selected with care to ensure that they are of correct design and length, and as light as possible consistent with ample strength. Many amputees, after being supplied with a limb, use crutches in the early morning before they are fully dressed: for such use the lightest type of crutch is required. These considerations equally apply to the temporary use of crutches in the case of injuries to the lower limb and other causes.

We have effected a number of improvements, particularly in light-metal elbow crutches. A few of the types made by us are illustrated on the opposite page.
“HANGER” CRUTCHES.

Fig. 1.—Wantage crutch. Unpolished split ash, shaped arm rest with best quality chrome leather stretched across. Hand-grip adjustable to any position.

Fig. 2.—As Figure 1 but black enamelled or French polished.

Fig. 3.—As Figure 2 but with leather covered and padded arm rest. Black enamelled or French polished.

Fig. 4.—French type crutch. Made from unsplit round beech. With adjustable hand-grip and leather covered padded arm rest. Black enamelled or French polished.

Fig. 5.—Made from a solid piece of ash. Padded and leather covered arm rest. Black enamelled or French polished.

Fig. 6.—Elbow stick crutch. With metal forearm support and hand-grip. Padded forearm stirrup. Hand-grip rubber cushioned or smooth. Ash stick. Black enamelled.

Fig. 7.—As Figure 6 but with light steel tubular stick.

Page fifty-three
THE "HANGER" ARTIFICIAL LIMB WORKS AT ROEHAMPTON

A VIEW OF THE ASSEMBLING AND FINISHING DEPARTMENT.

A MACHINE SECTION IN THE ENGINEERING SHOP.
SPORTING RECORDS ON ARTIFICIAL LEGS.

SOME fourteen years ago newspapers and others organised sporting events for wearers of artificial limbs, and most of these and other records were won by wearers of light-metal artificial legs made and fitted by Pedestros, Ltd. (see note on page 6). Such competitions have now been discontinued. It is significant, however, that practically every winner of these records is now wearing a Hanger light-metal leg and has expressed his appreciation of its outstanding merits.

London to Brighton Walk—52 Miles.

Actual Walking Time ... ... 14 hrs., 31 mins.

Mr. V. F. Bell’s amputation is above the knee. He is now wearing a Hanger light-metal limb, with the Hanger Roller-bearing Ankle Joint, and the following letter received from him will be of interest.

"I have never before had such comfort."

HARROW, MIDDLESEX.
28th February, 1936.

DEAR SIRS,

I am writing to express my delight at the general excellence of the new light-metal leg you have made for me.

In 1922, when I walked to Brighton, I thought the leg I then wore was the last word in artificial limbs, but your new leg is a revelation. In spite of the lapse of years I am confident that on this new leg I could put up an even better performance than I did then.

The fit is perfect, it is lighter than ever and walking is a pleasure. The smooth movement of your Roller-Bearing Ankle Joint is a great improvement on anything I have ever had.

Since 1917 I have worn six different makes of leg, including the Pedestros leg on which I walked to Brighton, but I have never before had such comfort and satisfaction as my new Hanger is giving me.

Wishing you every success,
Yours faithfully,
(Signed) V. F. BELL.

Climbing Snowdon.

In 1923 Mr. Charles Shelton and Mr. Ernest Riddles climbed Snowdon, wearing light-metal limbs. Mr. Shelton has the most serious disablement, being amputated at the hip joint. Mr. Riddles
is amputated through the thigh, his stump being less than 6 ins. long. Mr. Riddles covered the 5 miles of ascent in 2 hours 3 minutes; Mr. Shelton’s time was just under 3 hours. Both Mr. Shelton and Mr. Riddles are now wearing Hanger light-metal legs and their testimony is contained in the letters printed below.

“I can never thank you enough.”

6th July, 1936.

Dear Sirs,

The new leg you supplied to me early this year is wonderful; I am sorry I did not have it when climbing Snowdon. Although I had heard good reports of your new knee control for adjusting the swing of the leg it has exceeded all my expectations. As for your new roller-bearing ankle joint I cannot speak too highly of it. It makes all the difference to comfort in walking, and the movement is much more natural than anything I have ever had before. Everybody remarks upon it. The fit of the leg is perfect.

As you know, my left leg is amputated above the knee and my stump is less than 6 ins. long. Also my foot of my right leg has dropped owing to a wound in the shin, and I wear an iron. In my job I have to be either standing or walking from 8.30 in the morning until 6 o’clock at night. I have worn light-metal artificial legs since they were first introduced, but your leg feels lighter than ever. It has made a new man of me, and I can never thank you enough.

Yours faithfully,

(Signed) E. R. Riddles.

P.S.—You may make use of this letter in any way you like.

“I am at last absolutely comfortable.”

London, S.W.15.
2nd March, 1936.

Dear Sirs,

Certainly I will tell you what I think about my Hanger light-metal leg. It is the best I have had. I am at last absolutely comfortable and walk better than ever I have done before. My amputation is at the hip joint and with my previous legs I was always thankful to take them off at the end of a day’s work. I now wear my Hanger leg from early morning until last thing at night without any discomfort, as there is no strain in walking, and it is lighter and in every way better.

From my point of view, the greatest improvement is in the roller-bearing ankle joint which allows much more angle of movement in the foot. This would have been an immense advantage to me in my Snowdon climb as the increased movement is particularly useful in walking up and down hill.

Owing to the wide angle of movement I have no fear of the knee shooting forward when walking down hill which has always worried me in all my previous legs.

The ball-bearing knee movement is perfect and enables me to walk
"HANGER" PEG LEGS

(1). For through-knee amputation, with leather socket and light-metal post.
(2). For above-knee amputation, in light metal, with "Hanger" automatic knee lock.
(3). For above-knee amputation, wooden, with "Hanger" automatic knee lock.

Page fifty-seven
FOR A CONGENITAL DEFORMITY OF THE RIGHT LEG

THE ILLUSTRATION SHOWS THE FRONT AND SIDE VIEW OF THIS APPLIANCE. THE DEFORMED LIMB LACES INTO A LEATHER CORSET AND BOOT. THIS PATIENT IS ABLE TO WALK IN COMFORT WITH A NORMAL GAIT.
FOR A BI-LATERAL CONGENITAL DEFORMITY

THE DEFORMED LIMBS LACE INTO THE SOCKETS PROVIDED, THE FEET RESTING IN LEATHER STIRRUPS; WITH NORMAL HIP, KNEE AND ANKLE MOVEMENT. THIS PATIENT HAD NEVER WALKED AND IS NOW ABLE TO DO SO WITHOUT DIFFICULTY.
(1). A LIGHT-METAL LEG FOR ANKYLOSED HIP-JOINT
(2). A CONGENITAL DEFORMITY OF THE LEFT LEG

1. In this case the femur is flexed and abducted.
2. Light-metal and leather leg, providing normal movement at the hip, knee and ankle.
with a very easy and natural stride. The press-button hip lock is a great improvement and never fails.

I have now had this leg nearly 12 months and it has not given me a moment’s trouble or discomfort, and for the first time I have been completely free from any trouble with my stump.

With grateful thanks to you,

Yours truly,

(Signed) C. Shelton.

8½ MILES AN HOUR!!

One of the most outstanding records made on an artificial limb was that of Mr. E. Clarke, who, at the time, was amputated below the knee. At the British Legion Third Annual Sports Rally at Stamford Bridge he completed the 220 yards walking race in 53 secs., creating the amazing record of 8½ miles per hour. Owing to a motoring accident, his leg was re-amputated above the knee, and he has worn two light-metal legs of another make for his above-knee amputation. Recently, he was fitted with a Hanger light-metal leg and permits us to publish the following letter of appreciation.

"The best I have ever had."

14th August, 1936.

Dear Sirs,

You may remember that I held the “Star” Walk record for 10 miles in 1 hr. 46 mins. 41 secs. At that time I was amputated below the knee, but owing to an accident I have had my leg re-amputated above the knee, for which I have had two light-metal limbs of another make.

Recently I have been fitted by you with one of your light-metal limbs with the Hanger Double Swivel Pelvic Band. I am writing to say that my Hanger leg is certainly in every respect the best I have ever had, and by far the most comfortable fitting. The controlled knee action is a definite advantage, as also is the roller-bearing ankle joint.

Yours faithfully,

(Signed) E. Clarke.

MR. STACEY’S RECORD.

Mr. William Stacey is amputated above the knee and created a record in each Star Walk for Limbless; his records are:

1922 ... 15 miles in 3 hrs. 33 mins.
1923 ... 10 " " 2 " 8 "
1924 ... 10 " " 2 " 2 " 29 secs.
British Legion Sports Rally (Stamford Bridge).
220 yards in 1 min. 7 secs. = 6¾ miles per hour.
Mr. Stacey writes as follows:

"I have given up breaking records, but could certainly better them on this limb."

Sawbridgeworth, Herts.
15th July, 1936.

Dear Sirs,

I am anxious to congratulate you on the artificial leg you supplied to me. I have always been a naturally fast walker and a hard wearer. I have had four different makes of artificial leg, two of which were willow and two light-metal, but the one you have recently supplied to me is undoubtedly far in advance of the others.

Your new gadget for instantly controlling the friction on the knee gives me a most natural gait, and is a tremendous advantage as it allows me to adjust the tension of the knee exactly to my walking speed which I have not been able to do in my previous legs.

As an instance of this, I may tell you that on the parallel bars with your leg I am able to do "the scissors," which I have never been able to before.

The ankle action also is a great improvement and its advantages are particularly noticeable when walking down a slope, as the foot takes a firm grip in a natural position. In wet weather this gives a great sense of security.

I have not weighed my new light-metal limb but it certainly feels very much lighter than my previous one, and the fit is the best I have ever had.

I have given up breaking records, but could certainly better them on this limb.

Yours very truly,

(Signed) WM. STACEY.

P.S.—You may publish this letter, and I shall be very pleased to answer any enquiries.

LETTERS OF APPRECIATION.

A LETTER of appreciation is of far greater value if the writer has had experience of other makes of artificial limb. With one exception, only letters from wearers with experience of other types of limb are printed herein. A number of such letters are reproduced in the pages of this book in places where they happen to be appropriate: in addition, a few selected from many hundreds of similar letters are printed on page 70.
DOUBLE AMPUTATIONS
Above the Knee.

THIS lady was run over by an omnibus and lost both legs by amputation above the knee. The right stump is 9\(\frac{1}{2}\) inches long and the left stump is 9\(\frac{1}{2}\) inches. Her height is 5 ft. 7 ins. Successfully fitted with her artificial limbs approximately four months after the date of amputation, this lady’s normal appearance has been completely restored and she walks exceedingly well. She has been good enough to give us permission to publish this photograph. Whilst not wishing her name to be published, she would be very glad to answer any enquiries addressed to her through us.

Motoring. Both legs amputated above the knee.

"To the best of my recollection I have never expressed in letter form my very great satisfaction of the artificial limbs you have made for me, and I take this opportunity of tendering my thanks for the services you have rendered in the past. I still feel indebted to you for your attitude back in, I think, 1920, when I came to you after being turned down by two other makers, because of the difficulties my particular case presented, and how I awaited the result of a conference to decide whether or not you would undertake the fitting of my ‘far from standard’ double amputation. To my great relief you accepted me as a case, with the ultimate result that I have since been able to carry on a normal life. In the course of my business I do a considerable amount of motoring, and you may be interested to know that I have never had the slightest trouble in controlling a car satisfactorily, provided slight alterations are carried out to the car."

Bromley, Kent.

F. H. Grain.
A fractured femur stump with marked angular deformity due to mal-union of the femur, resulting in 7½" of shortening.

The site of amputation is through the knee-joint, but owing to the shortening, the position of the condyles is about mid-thigh. This patient was satisfactorily fitted with the specially constructed light-metal leg illustrated above.

Page sixty-four
STUMP SOCKS.

It is not always realised how much the comfort of the wearer and a healthy condition of the stump depend on a right choice of stump sock and proper care in its washing. We have given a great deal of attention to this subject and stump socks supplied by us have the following advantages:

They are made from the finest quality soft, white natural wool; they are seamless, being knitted in fine continuous strands, and correctly shaped. They are supplied in the correct fitting from the most comprehensive stock of stump socks in the world. We stock hundreds of different sizes and are thus in a position to select the correct form and shape to individual measurements.

The Hanger Stump Sock gives perfect ventilation and, if it is properly washed, will continue to do so throughout its life. This is of vital importance in retaining a healthy condition of the stump. The material, texture and knit of each type of Hanger Stump Sock have been selected after many years experience of the essentials required in an ideal stump sock; they have been produced in collaboration with the technical experts of the leading makers of soft woollen underwear.

CARE OF THE STUMP SOCK.

Reference has already been made to the necessity of proper ventilation through the texture of a stump sock if the stump is to be maintained in a healthy condition. Whatever care may be given to the manufacture and selection of materials of a stump sock, improper washing will result in discomfort. The chief difficulties are wrinkling, change in shape, shrinkage and, particularly, the thickening or closing up of the fabric which causes the sock to lose its properties of ventilation.

All these difficulties may be avoided by the use of the Hanger Shaping and Drying Board, an inexpensive device made to the exact measurements of the individual stump. By drying the sock on this board shrinkage and wrinkling are prevented; it keeps to its exact shape and the fabric remains in its open condition as originally woven, thus assuring the perfect ventilation which is so necessary to retain a healthy condition of the stump. A Hanger Shaping and Drying Board of the correct stump measurement is supplied free with each order of one dozen stump socks. It may be separately purchased at from 1s. 6d. upwards, according to size and quality.

WASHING STUMP SOCKS.

Stump socks should never be washed in hot water nor rubbed. The best method of washing is to use “Lux” in lukewarm water. Squeeze the sock in this water by hand and then rinse in lukewarm water, squeezing out the soap by hand only. DO NOT WRING.

To keep the stump in a healthy condition the stump sock should be changed as often as possible. A clean stump sock should be used at least every day; changing the stump sock in the evening, as well as in the morning, will be found to be very refreshing.
APPENDIX.

THE KNEE JOINT.

Translation from "La Prothèse Fonctionnelle des Blessés de Guerre" par le Dr. Ducroquet, Chirurgien Orthopédiste de l’hôpital H. de Rothschild, Paris.

Since the researches of F. Martin it is the rule for the axis of the artificial knee joint to be placed at a point corresponding to the junction of the anterior three-fourths with the posterior fourth of the condyles. This position of the artificial joint is physiological, as it corresponds to the insertion of the two lateral ligaments into the condyles and Martin has shown that the cruciate ligaments B and C are inserted at an imaginary line joining the superior ends of the external and internal lateral ligaments A and D (fig. 22).

He showed this in a very simple manner. By driving a pin across the condyles and thus effectively showing the line of union between the superior ends of the insertion of the two lateral ligaments, it has been demonstrated that this pin does, in fact, cross in its path the superior insertion of the two cruciate ligaments.

Fig. 22—Illustrating level of axis of artificial knee joint corresponding with upper points of insertion of the lateral and cruciate ligaments.

Fig. 23—Good position for axis of artificial joint situated at the mid-patella line at the junction of the anterior three-fourths with the posterior fourth on the lateral surface. In both arms of the joint are curved backwards; in it the lower joint is straight.

Since that time it has been the practice to place the axis of the artificial joint in the position designated by Martin on a level corresponding to the centre of the patella. In an adult of muscular build one can bend the femoral artificial joint backwards, leaving the leg joint straight; in fact, on viewing the lower limb sideways one can see that a line along the middle of the thigh lies in front of the corresponding line of the leg (fig. 23").

Remarks on the Mechanism of the Knee Joint.

The point of the axis which we have agreed to accept is the best, but not perfect as we shall demonstrate.

Let us recall that according to the researches of the brothers Weber the movement of flexion and extension of the tibia on the femur is, in reality, a simultaneous rolling and gliding movement of the articular surfaces on one another.

(i) F. Martin "Essai sur les appareils prothétiques." Paris, 1850.

Page sixty-six
Now if we imagine tibia and femur both extended and then allow the femur to perform a movement of flexion, we shall see that during this movement the femur has gone through a gliding movement which has carried it forward from behind. If we imagine the tibia immobile, we must admit that quite independently of its rotatory movement the femur has performed a gliding movement from behind forwards (figs. 25 and 26).

H. Meyer has shown that the curve of the articular end of the femur is formed by two arcs of circles $BC$ and $CD$ of different radii and centres $O$ and $O'$ (fig. 26\textsuperscript{2}). The lateral ligaments are inserted exactly into the centre $O$ of the small posterior circumference, \textit{i.e.}, into that of the smaller radius.

Let us imagine a movement of flexion of the femur on the tibia. At the beginning of flexion the different points of the arc $CD$—those nearest $C$—move in a circle.
APPENDIX—continued.

around the axis O, in such a way that we are, in fact, witnessing a purely rotatory movement. During this movement of the femur, which is purely rotatory, these points on the circumference leave the tibia and are carried upwards.

As long as the range of movement does not exceed 15° to 20°, the movement does not change its character, and it would never do so if the lateral ligament EO always remained taut (fig. 26'). But as soon as the range of movement increases, the ligament slackens; for when the points from B to D come in contact with the tibia they lower the axis O, the place of insertion of the lateral ligaments: These having lost their tension, the weight of the femur tends to push the condyle forward and a gliding movement is initiated which is not arrested till the lateral ligament has taken a new position E'O which stretches it once more and counteracts all further forward movement. The axis O is then immobilised at O' and a purely rotatory movement again takes place around O'. Flexion of the knee can therefore be split up as follows—at the beginning a rotatory and gliding movement and in extreme flexion a purely rotatory movement again.

In the movement of flexion as the points of contact of the femur move from B to D, there is a continual lowering and forward movement of the axis, 1, 2 and 3, the last of which is the final position around which the femur moves (fig. 26'); to these the positions 1, 2 and 3 of the femur correspond. In short, and to keep to the viewpoint which interests us, the gliding movement of the femur combined with its rotatory movement results, as the femur rotates, in a displacement of the mechanical axis of rotation.

The tibia does not describe a movement around the condylar insertion of the ligaments; the curve which it describes is, in reality, much more complex, as it is constituted by portions of circumferences whose axis moves nearer and nearer to the anterior part of the femoral condyle in proportion as the femur becomes more and more flexed.

It is easy to demonstrate experimentally the truth of these somewhat complex deductions. On a prepared articulation in which the superior insertion of the lateral ligament has been laid bare, let us fix two rods, one to the tibia and the other to the femur, but in such a fashion that the ends touch each other and are at the level

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Tillaux “Anatomie Topographique.”
of the insertion of the ligament (fig. 27\textsuperscript{14}). If we bend the knee to 45° the points overlap by 0.079 inches; on flexing to 90° the femoral end is lowered 0.394 inches and moved forward 0.315 inches (fig. 25 and fig. 27\textsuperscript{18}). However, this is the point we have chosen as the centre or axis of the articulation and rightly so, for at any other point the differences will be still more marked. Here is, in fact, the result of three other experiments:

In fig. 27\textsuperscript{14} the ends are placed at the junction of the posterior with the anterior three-fourths of the knee at the level of the articulation; we notice on flexion to 90° an advance of 1.181 inches of the femoral end which is at the same time elevated 1.181 inches (fig. 27\textsuperscript{18}). If the ends are placed in the middle of the external surface of the femur (fig. 27\textsuperscript{1B} & B) there is a divergence of the ends on flexion to 90° and we notice an elevation of 1.181 inches and an advance of 1.197 inches if the end is at the level of the articulation; if it is at the mid-patella level the elevation is 1.787 inches and the advance 1.472 inches (fig. 27\textsuperscript{1A} & B).

The Disadvantage of Incorrect Position of Axis.

The experiments which we have just described show that in certain cases the femoral end rises 1.181 inches and in others advances more than 3.94 inches. These two facts are accompanied by two very different undesirable results. If the axis is placed at a point where the femoral end rises we see on flexion to 90° that the corset rises on the upper surface of the thigh and compresses the back of the thigh (fig. 28\textsuperscript{1}). This is easy to understand; the fixed point of axis of the artificial joint which unites the femoral and tibial portions of the leg makes them dependent upon one another and the femoral portion cannot follow the movement of the thigh. If, on the other hand, the axis is at the level which corresponds to the middle of the condyles, it causes compression of the back of the shin on the top of the socket (fig. 28\textsuperscript{1}).

![Fig. 28.—The disadvantage of an incorrect point of axis. In I, the axis is placed in the centre of the articulation; when the knee is flexed the stump recedes from the front of the socket and pressure is applied to the back of the calf. In II the axis is placed at a point where the femoral end rises, causing the thigh corset to lift and compress the back of the thigh.](See page 42)

If the axis is placed at the level indicated by Martin, there is also an advance of the femoral portion of the leg, but as it is situated at the anterior end of the last quarter of the knee it does not bulge beyond it as happens when the axis is placed in its middle part.

The “Hanger” Polycentric Knee Joint has solved this problem.

(See page 42).
A FEW MORE APPRECIATIONS.

BADMINTON, TENNIS, DANCING, MOTORING.

"You will no doubt be pleased to hear that I managed to win the First Prize in the Mixed Doubles Badminton Tournament at the Club. The final game was a terrific struggle but the new Hanger Leg stood the strain admirably. I have played in several different makes of legs and can assure you that I have never had one that has been so comfortable and easy to move about in. In addition to Badminton I occasionally play tennis, cycle and dance. I drive a car anything from ten to fifteen thousand miles a year.

"Thanking you for the attention you gave me when fitting the leg and the interest you have taken since supplying the limb."

Bristol.  F. H. BALLINGER.

CRICKET, TENNIS, SQUASH RACKETS, GOLF.

Both legs amputated.

"I have used Hanger artificial legs for about one year now, having lost both my legs by amputation, one above- and one below-knee. I have found them very suitable substitutes for what I have lost, both of them fitting very well. The below-knee leg has your Polycentric knee joint which I have found a great advance on the old type of joint, since it lessens the piston action between the stump and the leg and therefore stops chafing.

"As regards the above-knee leg, the new Hanger Flexible Double Swivel Pelvic Band is, I think an improvement, and, of course, the adjustable knee brake, operated by a button on one side of the leg, is a definite advantage since it can be controlled without any effort while one is actually walking. It is invaluable for games. I can play cricket, tennis, squash rackets and golf, and as far as tennis and squash are concerned the controllable knee is almost a necessity. I can manage two rounds (36 holes) of golf a day comfortably, my present handicap is 12.

"I also find the Hanger foot action is very smooth and satisfactory."


NURSING 24 HOURS ON END.

"I've done it! Have just come in from a 10 mile walk! The best I've done yet. Time 2 hrs. 40 mins.—not racing time, I am afraid, but I hope to improve on it. My Hanger is doing very good service—was it 24 hours on end twice last week, while nursing a case.

"I can never be too grateful to Hangers for the skill and patient care with which they fitted me, and also for the sympathy and kindness shown to me. The loss of a limb can never be exactly a joke, and it makes a wonderful difference when your fitters realise that their work has a human as well as a technical aspect."

Lincoln.  (Miss) G. G. VAUGHAN.

RIDING.

Amputation above the knee.

"Now that I have my two new limbs and have tried them out thoroughly I should like to say how pleased I am with them, and how much I appreciate all the care and trouble you have taken in their construction, and particularly in their fitting.

"The leg which you have adapted for riding is in every way a success and I should only be too pleased to recommend it to anyone else who might be interested."

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There is now provided by the Hanger organization a nation-wide service to hospitals, surgeons and amputees at every town in the British Isles, Northern Ireland and the Irish Free State. The services of fully trained limb-fitters are available, solely engaged in fitting artificial limbs, whose qualifications are set out on page 23. A list of the centres of population where permanent Hanger branches are at present established is given below. These branches, as will be seen, cover the whole country. Arrangements are made for attendance at hospitals, and upon surgeons and amputees, at any town within the area served by the branch.

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SOME TYPICAL AMPUTATION STUMPS IN RELATION TO SUBSEQUENT PROSTHESSES (Lower Extremity)

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NOTES.

Fig. 1a. Disarticulation of the head of femur. Indicating lack of prominence upon lateral contour. Posterior view, left pelvis.

Fig. 1b. Disarticulation of the head of femur. Indicating lack of anterior prominence. Lateral view, left pelvis.

Lack of prominence upon contours results in diminished control of the artificial leg.

Fig. 2a. Sub-trochanteric amputation. Indicating marked prominence upon lateral contour to which artificial limb socket can be moulded. Posterior view, left pelvis.

Fig. 2b. Sub-trochanteric amputation. Indicating presence of marked anterior prominence. Lateral view, left pelvis.

*If the head, neck and great trochanter of the femur can be retained, the resultant prominences upon the contours are of the utmost value in the control of the artificial limb.*

Fig. 3. Sub-trochanteric amputation. Posterior view, left pelvis with stump dependent.

The relative horizontal levels of the Ischial Tuberosity and the stump extremity require the fitting of a Tilting Table type of limb, which is worn with the femur stump flexed at an angle of 90 degrees. (See Figs. 2a and b.)

Fig. 4. Amputation above the knee. Posterior view, right side, showing position of scar in relation to the nerve bulb and subsequent spur.

*The ideal above-knee stump measures 10" to 12" from the tip of the great trochanter.*

Fig. 5. Amputation below the knee. Posterior view, left leg.

*The ideal below-knee stump measures from 5" to 6" from the inner articular head of the tibia. The Fibula is shorter than the tibia by 1". The small figure shows position of scar resulting from a short posterior flap, i.e. the scar is anterior but becomes retracted to the posterior aspect by the time the stump is ready for fitting.*

Fig. 6. Disarticulation at the knee. Posterior view, right leg.

*The bulbous extremity of the resultant stump necessitates an adjustable leather socket for the artificial limb and external knee joints and controls.*
CARE OF THE STUMP
FOLLOWING AMPUTATION
OF THE LOWER
EXTREMITY

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For many years past the British Government has entrusted to our sole care the whole of the work of supplying every type of light-metal and willow artificial leg for Officers and men disabled in the Great War, an example followed by most of the Dominions and many foreign countries. A visit to our Roehampton establishment is a feature of the Post-Graduate and Fellowship Courses of many of the Medical Schools and Post-Graduate Institutions, and practically every nation of importance has sent representatives to study our methods and technique of fitting, and to be trained in our Workshops, where a highly skilled staff and nearly 400 men are employed solely in making artificial legs.

We are pardonably proud that our intensive research work has effected improvements in the design of light-metal artificial legs without parallel in the history of prosthesis.

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CARE OF THE STUMP
FOLLOWING AMPUTATION

MOST of the initial difficulties experienced by the amputee when first wearing an artificial leg may be obviated if, during the period that must elapse between amputation and the fitting of the artificial limb, the following simple directions are carried out.

Owing to the severance of muscles and nerves certain muscular contractions and changes take place in the amputation stump. It may become flexed, that is to say, it may incline in a forward direction in the case of an amputation above the knee; or in a backward direction when the amputation is below the knee. Less frequently the stump may become abducted (inclined outwards) or adducted (inclined inwards). These conditions inevitably create difficulties at the limb-fitting stage: they may be prevented, or corrected, by proper exercise of the stump. Following amputation the stump is soft and flabby, but after wearing an artificial leg shrinkage invariably takes place; this necessitates refitting the socket and often remodelling the artificial leg, with consequent expense. By correct bandaging following the amputation, the normal shrinkage of the stump may be hastened and, to a large extent, completed before the leg is fitted. (see Figs. 1 and 2.)
Unfortunately, too often a visit to the limbmaker is delayed until the time approaches for fitting an artificial limb; this is a mistake as during the waiting period, before the stump is ready for fitting, much may be done to ensure a successful prosthesis.

The factors necessary to produce a sound, healthy and firm stump may be summed up in two words—bandaging and exercise. Provided the stump has properly healed to the satisfaction of the surgeon, the patient, during the transition period between amputation and being fitted with an artificial leg, can do much for himself to facilitate his early return to normal activity with a minimum of discomfort and expense. By bandaging the stump, and a few simple routine exercises, the conditions referred to may be avoided.

Bandaging will assist the normal shrinkage of the stump and help to form it to a satisfactory shape for limbfitting. Exercising the stump will help to restore the tone of the severed muscles, assist the new blood circulation and keep the joint mobile and active until the stump is ready to be fitted with an artificial limb.

**BANDAGING**

The main object of bandaging is to reduce the swelling and hasten shrinkage. It should not be commenced until the stump has soundly healed, dressings discontinued, the stitches removed and the approval obtained of the surgeon in charge of the case. A crepe bandage about 3 to 3½ inches wide will be found to be the most satisfactory.
It is most important that the bandage should be applied in the right direction, namely, by binding from the end of the stump in an **upward direction** towards the hip or the knee, as the case may be. Bathe and powder the stump with a good talcum powder, then, commencing at the extremity of the stump, apply the turns of the bandage firmly, making several turns round and then under the end of the stump. (see Fig. 3). Working in an upward direction, continue the turns of bandage firmly but with gradually reduced pressure so that the compression of the stump by the bandage is progressively reduced as the bandage travels upwards towards the top of the stump. (see Fig. 4.)

In the case of amputations above the knee the bandaging should be continued as high as it will go, well up into the crotch and as far as possible towards the hip joint. Finish with several turns of bandage and fix with a safety pin.

For amputations below the knee, bandage well up to, but not above, the knee-joint. The bandage should be worn continuously until the artificial limb is in use.

**EXERCISING**

The stump should be exercised at least twice a day for short periods of about 15 minutes as soon as it has healed and is ready for bandaging. At first, exercising should be confined to simple movements of the stump in all directions. Do not continue the movements to

*It is necessary to stress the fact that the correct method of bandaging is to commence at the terminal end of the stump and bandage upwards. It has been suggested that the bandaging should be from above downwards but this method is generally condemned by surgeons specialising in amputations and limb-fitting on the ground that it may obstruct the circulation of blood in the stump and increase the swelling (oedema) at the end; based on our own experience of many thousands of amputations, bandaging from above downwards also has definite disadvantages from the limb-fitting point of view.*
the extent that the stump muscles become tired. Later, these movements should be performed against resistance. For this purpose, we supply the “Hanger” Stump Exerciser which is quite inexpensive and is an improved design of the well-known Roehampton type stump exerciser. It consists of a sling with a spring extension to a hook fixed at, or a little below, the level of the middle of the stump when standing erect (see Fig 5). Place the stump in the sling and exercise it in a forward and backward direction against the resistance of the spring with the back to the Exerciser (as in Fig. 5) then reverse the position and repeat facing the Exerciser. Particular attention should be given to extending the stump to the limit in a backward direction for an above-knee and forwards for a below-knee stump; this assists in preventing stump flexion. Exercise gently and never overtire the stump.

If the few simple rules given above are carefully observed a strong and healthy stump will result; extensive readjustment or remodelling of the artificial leg a few months after fitting will be avoided, and the patient will be saved unnecessary expense. In addition, the stump condition will ensure immediate complete control of the limb and the initial discomfort of wearing an artificial leg will be reduced to a minimum.

A PRELIMINARY VISIT

An early visit to a Hanger establishment is recommended as soon as the stump has healed, in order that a preliminary examination may be made in relation to the subsequent artificial limb and the correct method of bandaging and exercising demonstrated. This entails no charge or obligation whatever. A full list of our Branches is given overleaf.

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