AMPUTATIONS AND ARTIFICIAL LIMBS

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The treatment of the amputated should not be considered a pure surgical problem. It requires in addition to operative skill, orthopædic training for the after-treatment and a knowledge of the construction and application of artificial limbs. The practice heretofore, commonly in vogue, of amputating and then turning over the patient to the manufacturer of artificial limbs, cannot be too strongly condemned. It is only through the coöperation of surgeon and bracemaker that the best results can be secured. No matter how well the operation has been performed, if a contracture is allowed to develop subsequently, it will be impossible to apply the artificial limb correctly, nor is it possible to determine what type of operation should be performed, unless the surgeon is well versed in the type of artificial limb demanded by the patient in question.

I shall first describe the type of amputation, second, the after-treatment, and third, the application of the artificial limb. I shall deal particularly with conditions, as they present themselves to the military surgeon.

Amputation at the front or the emergency amputations of civil practice must be performed rapidly and with as much conservation of tissue as possible. The simple guillotine method or oval amputations are the best; no attempt should be made to suture the wound tightly. It is well, however, to prevent marked retraction of the skin, to insert a few superficial sutures which are tied loosely. The wound should be considered infected and treated accordingly, either by dry packing or by one of the newer antiseptic methods (Carrel-Dakin, Dichloramine-T, etc.).

The posture subsequent to the operation must be such as to prevent the development of contractures. The mistake most frequently made is flexing the thigh stump at the hip. This posture is usually adopted, so as to prevent pressure over the raw wound surface. It leads, however, invariably to a shortening of the flexor muscles, which renders the application of the artificial limb impossible. To overcome it, months of tedious mechano-therapy are frequently necessary. The surgeon must see to it that the thigh is kept fully extended. This is best done by placing a pillow under the buttocks and allowing the weight of the thigh to keep the flexor muscles on the stretch.

Abduction at the hip, too, is a frequent mistake, which leads to unpleasant sequelæ. At the knee the flexed position must be avoided also, since, owing to the preponderance of the flexor muscles over the extensors, a contracture in the flexed position is prone to develop. This holds good of the elbow joint also. At the shoulder I have seldom seen a contracture develop, no matter what the posture, unless there be a concomitant injury of the shoulder muscles. In that event the treatment corresponds to the rules governing the prevention of contracture for muscle injuries. (See Mayer: "Orthopædic Treatment of Gun-Shot Injuries," pages 54 *et seq.*)

To prevent the retraction of the skin, which tends to occur, a piece of stockinette of appropriate size can be glued to the skin above the wound and traction thus exerted. A suitable gluing mixture is a solution of mastic.[1] A slight weight of two to three pounds usually suffices for purposes of traction. When the wound is dressed, the projecting cuff is turned back, so as to expose the granulating area.

REAMPUTATION

Reamputation should not be undertaken too quickly, since it frequently occurs that, what at first sight seems a hopelessly large granulating area, eventually heals, producing a serviceable limb. This warning applies chiefly to the short thigh stumps, where every inch is of value to the patient and to those cases of amputation just below the elbow or the knee in which reamputation would mean sacrifice of the joint. The indications for reamputation are: (1) projection of the bone beyond the granulation tissue, (2) persistent ulceration of the stump owing to the thinness of the epithelial covering, (3) a fixed contraction of a short stump in such a position as to render application of the artificial limb impossible, (4) in rare instances for painful neuromata which yield to no other form of treatment. A conical

[1] Mastic 20
Chloroform 50
Linseed oil .... gtt. xx.

stump is in itself no indication for reamputation since it may, if properly exercised, develop excellent functional capacity. A discharging sinus, due to the presence of a sequestrum or foreign body, necessitates operative removal (easily accomplished through a small incision), but this operation is in no way analogous to a reamputation.

SITE OF AMPUTATION

The general principle of maintaining the maximum length of stump, like all rules, has exceptions. The exceptions apply particularly to the foot. The partial amputations (Chopart and Lisfranc) do not give satisfactory functional results; the patient and brace-maker almost invariably complain, and the brace-maker usually tells the surgeon he could have saved much trouble if he had amputated above the ankle. Whether this site or the Pirogoff amputation is the more advisable is largely a matter of which particular brace-maker can be secured for the construction of the artificial limb. The Pirogoff operation in itself is an excellent surgical procedure, giving a weight-bearing stump. The stump is, however, slightly too long for the application of the usual artificial foot and therefore requires a different type of construction. The calf amputation, although seldom resulting in a weight-bearing stump, has the advantage of allowing the brace-maker to work in a field which is familiar to him. In the case of calf amputations there is no site of election, since it matters little whether the stump is six inches long or ten inches. It is of far greater importance that it should be weight-bearing rather than the maximum length. When the stump, however, is short, then every fraction of an inch is of the utmost importance, since, once the stump becomes so short, as to render the fitting of the socket impossible, the patient has no control of the artificial limb and is unable to use the calf. In thigh amputations, the longer the stump, the more effective the control. An almost impossible problem is presented by a very short stump, particularly when there is a contracture. It is then advisable to disarticulate at the hip. In injuries of the upper extremity, it is important to save every possible joint. If even a single finger can be saved or a part of a finger, this should be done. At the elbow every attempt should be made to conserve even a small stump of the forearm, since this will give the patient a marked advantage over the man who has lost the use of the elbow joint. At the shoulder, too, even a short stump is a distinct advantage, since cases of disarticulation at the shoulder present the most difficult of all prosthetic problems.

TYPE OF AMPUTATION

Whenever amputation can be performed aseptically, it is advisable to adopt some plastic procedure, which will render the stump weight-bearing. The Pirogoff and Gritti amputations are excellent osteoplastic procedures, which in almost every instance result in excellent function. For calf amputations the Bier technic is excellent, provided the stump is long enough to sacrifice two or three inches without impairing its power as a lever. For thigh amputations, it is, I find, less applicable. For the upper extremity, of course, the principle of weight-bearing does not come into play.

KINETIC STUMPS

Vanghetti, Ceci and more recently Sauerbruch, have developed methods, by means of which the inherent muscular power of the stump can be utilized to manipulate the artificial hand. The Sauerbruch technic is simple. After preliminary muscle training, which enables the patient to contract the muscles of the stump, a canal is bored through one or more muscles, a pedunculated tube of skin is drawn through the canal, and sutured in such way as to line it (see Figs. 1-4). The opening is kept patent by a drainage tube or ivory peg. When healing has occurred, the patient is able, by the contraction of the muscle, to move the peg some two or three inches against a weight of ten or twenty pounds (see Fig. 5). Excellent though the surgical technic is, the practical advantage of these kinetic operations has as yet been extremely slight, owing to the difficulty of devising a suitable artificial hand. Thus far the procedure has not been applied to the lower limb. Here, however, I think it could be utilized to great advantage in cases of thigh amputations, since the quadriceps extensor could thus be employed to extend the artificial calf.

TRAINING THE STUMP

Even before the wound has closed, it is advisable to allow the patient to move the stump, so as to prevent excessive muscular atrophy. As soon as healing has occurred, the process of hardening should be

Fig. 1.

The Sauerbruch method of producing a kinetic stump. First step of operation. A tunnel has been bored through the biceps muscle. A skin flap has been freed and is being sewed about a piece of rubber tubing with the epithelial surface turned inward.

Fig. 2.

The Sauerbruch method of producing a kinetic stump. Second step of operation. The epithelial-lined tube is being drawn through the channel in the muscle.

Fig. 3.

The Sauerbruch method of producing a kinetic stump. Third step of the operation. The sutures are being taken to unite the edges of the skin flap to the skin of the arm near the point of emergence from the muscular channel.

Fig. 4.

The Sauerbruch method of producing a kinetic stump. Fourth step of operation. The operation is completed by uniting the skin edges as shown in the illustration. The canal is kept patent by running a piece of rubber tubing or an ivory peg through it.

begun. In every instance an attempt should be made to render the stump capable of weight-bearing. Just exactly as in a case of a club-foot, the cuboid bone becomes capable of supporting the body weight, so in the case of the amputated, the bone can frequently be rendered suitable for weight-bearing. At first the patient is taught to rest the stump lightly against a soft pillow. Later a harder pillow is substituted, then a wooden disk; finally, the patient is allowed to hammer with the end of the stump against some hard object. The entire process should be done gradually and with great care, since if not carefully graduated the stump may become irritated instead of hardened.

The majority of stumps, particularly those of the thigh, are œdematous and have an excess of adipose tissue. The muscles, which can no longer function, are flabby. To help get rid of this useless tissue, massage and firm bandaging are important procedures. The most important educator of the stump is the artificial limb itself. Therefore, it should be applied as soon as possible. The use of a crutch for the amputated is an indication of inadequate treatment. The early use of an artificial limb presents one great difficulty; the stump is still swollen, a large amount of fatty tissue is still present, and the muscles are usually flabby. With time, the stump changes its shape so markedly that the artificial limb, which fitted accurately when first applied, is no longer suitable. If this has been made of leather or wood, great expense has been involved, and the value of early training of the stump seems to be outbalanced by the economic waste of time and material involved in the construction of an artificial limb whose period of usefulness is so short-lived. Owing to this difficulty, the provisional or temporary prosthesis has been evolved. The evolution of these provisional limbs has been most interesting. At first they were constructed in the crudest way of a broom-stick or a piece of bamboo incorporated in a plaster shell fitting the patient's stump (see Fig. 6). Later, an iron framework was substituted for the broom-stick, terminating in a flat metal plate which could be rivetted into the empty shoe of the patient. A still later development was the use of a hinged joint corresponding to the knee, in cases of amputation of the thigh, so that the patient could learn early to utilize the joint of the artificial limb instead of striding with a stiff leg. All of these contrivances served their purpose in helping to educate the stump and in teaching the patient how to walk.

To Mommsen belongs the credit of evolving what is, in my experience, the most practical and efficient provisional artificial limb. Assume that the patient has been amputated six inches below the knee. An exact plaster impression is taken of the stump by enveloping it with a plaster-of-Paris bandage. The plaster should not be thicker than 1/16 inch. While it is hardening, the operator should carefully mould the tuberosity of the tibia, since this bony projection forms the chief weight-bearing area (see Fig. 7). The head of the fibula and the condyles of the tibia are not subjected to pressure, since experience has shown that they are not adapted to weight-bearing. The plaster negative is then turned over to the brace-maker, who makes the corresponding foot, steel supports, knee-joint, and thigh-piece, just as though he were making an artificial limb for a patient whose stump has assumed its final definite form. The one difference between the final prosthesis and this provisional one, lies in the fact that the plaster shell has been substituted for the usual leather socket. The steel uprights are firmly fixed to the plaster by means of two rivets, and a series of bandages soaked in a mixture of plaster-of-Paris and bone glue.[3] In other words, the patient is given at once the same type of artificial limb which he is to wear after the stump has attained its constant shape (see Fig. 8). During the stump's transition period, the plaster negative can be changed whenever necessary, since the cost is minimal and the labor involved comparatively slight. For amputations of the thigh, the technic is similar. In these cases, the surgeon must lay stress upon an accurate moulding of the tuberosity of the ischium, since this bone is to bear the weight of the patient's body (see Fig. 9).

When the stump has, after many months, assumed a form which no longer changes, then leather is substituted for the plaster-of-Paris, and the patient is equipped with a finished prosthesis.

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[3] This mixture, which, though light, is extremely hard, is prepared as follows: 400 grams of bone glue, broken into small chips, are dissolved in half a liter of water, heated over a water-bath. When boiling, 400 grams of alabaster plaster-of-Paris in the form of a thin plaster cream are added slowly to the glue. The mixture is constantly stirred during the process, and the preparation kept as near 100° C. as possible. When thoroughly mixed and boiled, the requisite number of starched bandages of appropriate width are immersed in the fluid, and when saturated are wound about the plaster shell, so as to strengthen it and hold the steel upright of the artificial limb firmly in place. Complete by a few turns of a plain gauze bandage. Dry in a warm room one to two days.

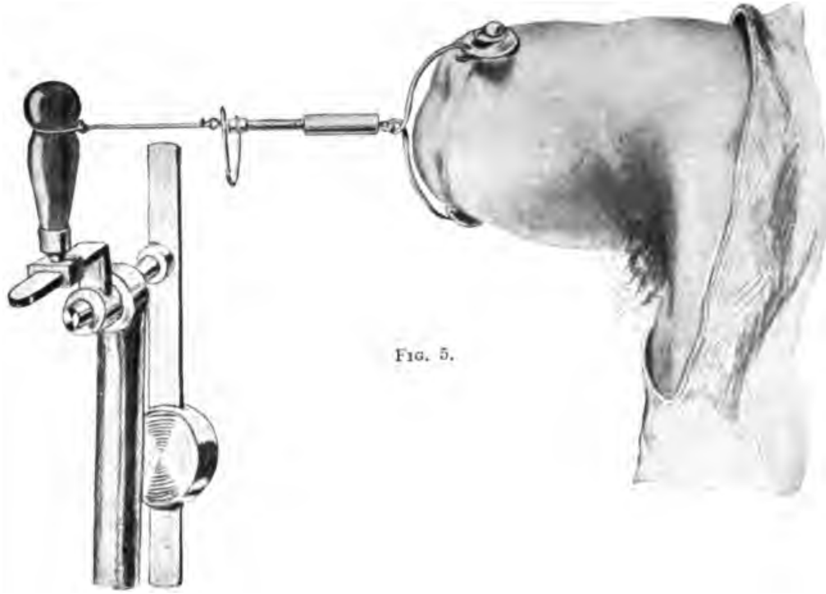


FIG. 5.

The Sauerbruch method of producing a kinetic stump. The after-treatment. To exercise the muscle through which the channel has been bored, the ivory peg running through it is attached to a pendulum apparatus. The patient can by a voluntary contraction of the muscle cause the ivory peg to move upward and thus move the lever of the apparatus. By regulating the length of the pendulum the exercises can be graduated to meet the increasing muscular power of the patient.

FIG. 6.

A simple type of provisional artificial limb, consisting of a broom stick incorporated into the plaster dressing which envelopes the stump.

FIG. 7.

Making a provisional artificial limb for an amputation of the calf. (Mommsen.) The figure illustrates the first step in the process when the exact plaster impression is taken of the patient's stump. Note that the surgeon is bringing pressure to bear on each side of the tuberosity of the tibia. The condyles and the head of the fibula should not be exposed to pressure.

Fig. 8.

The provisional artificial limb for an amputation of the calf. It is exactly like the finished prosthesis, except that the socket into which the stump fits is of plaster-of-Paris instead of leather.

Fig. 9.

Making the provisional artificial limb for an amputation of the thigh. (Mommsen.) An exact plaster impression is taken of the stump. The surgeon's fist brings pressure to bear just below the tuberosity of the ischium, so as to mold the support for the weight of the body.

TYPES OF ARTIFICIAL LIMBS FOR THE LOWER EXTREMITIES

I want to emphasize certain general principles, since it is impossible even to mention the numerous different types. First, for amputations of the thigh: In almost all cases the success of fitting the artificial limb depends upon an accurate adjustment to the pelvis, since most of the weight is usually carried by the tuberosity of the ischium and the adductor muscles. The tuberosity slants from below upward and forward, not in the reverse direction, as most brace-makers seem to think. If the artificial limb at this point slants downward, instead of upward, the patient is bound to slip forward, a rotation of the stump will occur and a proper fit will be rendered impossible. Care must be taken to exclude pressure from the ramus of the pubis, because this bone cannot stand pressure. The adductor muscles, however, when properly trained, are almost as important as the tuberosity of the ischium. When the stump is short, there should be a trochanter joint attached to the artificial limb; that is, a joint at the level of the trochanter, which allows flexion and extension, but prevents abduction and adduction. This joint is attached to a pelvic band or girdle. Were it not for some such device, the patient would not feel sufficiently secure.

In attaching the calf-piece to the thigh-piece, greatest stability is secured by slight knock-knee position. The type of knee joint is of comparatively little importance. The simpler it is, the better. Spring devices for aiding extensions are, in my experience, unnecessary, and prevent the patient from acquiring a natural stride. The essential in the construction of the joint is the location of its axis posterior to the centre of gravity of the anatomical joint. This is necessary, because if it lay anterior the patient's weight would cause the joint of the artificial limb to flex, as is readily seen by reference to Fig. 10.

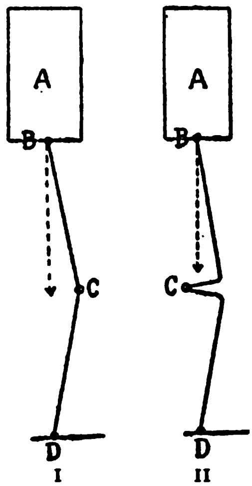
For amputations of the calf, the type of limb depends upon the length of the stump. If it is short—less than one-half the length of the calf—there must invariably be a thigh-piece and a knee-joint. If it is long, these may be dispensed with, provided the stump is capable of weight-bearing.

As already indicated, when the stump is not capable of weight-bearing, the artificial limb must be so moulded as to grasp the tuberosity of the tibia firmly, not the condyles, as is usually taught. The patella-tendon also is capable of weight-bearing, as can be learned by observing any patient who has worn an artificial limb for many years.

Some difficulty is frequently experienced in bringing the leather socket of the artificial limb over the gastrocnemeii. This can be obviated by slitting the socket posteriorly and inserting eyes so as to lace it up when once it is in proper position.

The ankle-joint, like the knee, should be of the simplest type, allowing merely flexion and extension. In addition to the ankle-joint, there should be one corresponding to the metatarso-phalangeal junction.

FIG. 10.



Diagrams illustrating the importance of posterior displacement of the knee joint of the artificial limb. A, Body, B, Hip, C, Knee joint, D, Ankle. In FIG. I, the axis of the artificial joint corresponds in position to the anatomical. A slight degree of flexion brings the body weight posterior to the axis and, as is evident from the figure, further flexion must result. For the patient this position of the axis causes insecurity since the least degree of flexion is almost certain to cause him to fall. In FIG. II the axis of the artificial limb has been displaced posteriorly. The body weight represented by the dotted line now falls anterior to *C* (the axis) and tends to lock the knee instead of producing further flexion.

TYPES OF ARTIFICIAL LIMBS FOR AMPUTATIONS OF THE UPPER EXTREMITIES

Of all the medical problems arising out of the war, none should attract more attention than the method of dealing with patients who have lost a hand or an arm. The difficulty of replacing the missing member is far greater than in a case of the lower extremities; these merely have to support the body-weight, the hand, however, has an infinite number of delicate tasks to perform. We cannot hope to replace it completely, nor can any one device be regarded as best for all types and conditions. There are, however, a large number of appliances which, when properly adjusted to the suitable case, are of inestimable service to the wearer. The artificial appliance, however, is not to be regarded as the most important element in the treatment of these patients. Of far greater significance is the educational element. The patient's will must be trained to overcome the loss which he has suffered. He must be made to feel that the amputated can be rendered as useful a member of the community as the normal individual. Only by this attitude of mind can he be brought to use the artificial appliances effectively and permanently. In hundreds of instances artificial limbs constructed at enormous expense have been discarded at once by the amputated, simply because of lack of proper education. It is as illogical to expect a patient, equipped with an artificial limb to be able to use it at once and without instruction, as it would be to expect a man to play a complicated musical instrument as soon as this is given to him. All institutions, therefore, dealing with the treatment of the amputated, must have adequate facilities, not merely for the proper application of the protheses, but for teaching the patients how to use them.

As already stated, there is no universal type of artificial limb suitable to all patients. Two factors play a deciding rôle in determining the type of appliance: (1) The site of the amputation and whether it is a unilateral or bilateral, (2) the occupation of the patient. For the farmer or mechanic the appliance must be radically different from that used by the lawyer or business man. For those with single amputation a suitable prosthesis is of value, which for the double amputated would be entirely useless. Nor, of course, can any one solution of the problem be considered the only correct method.

Let us start with the simplest type: Loss of one hand with retention of a useful stump of the forearm. In many instances, as far as the work of an artisan is concerned, no artificial limb whatever is needed, since the stump can be trained to do the work of the missing hand. Figures 11 and 12 show a one-arm apprentice who did all the work required of a brace-maker, without any artificial contrivance. With practice, the stump had become sufficiently hardened, so that he could use it for filing as well as the normal mechanic uses his hand. For hammering, the handle of the hammer was gripped between the upper arm and the chest wall. The blow was delivered by a rapid movement of the body. At the turning-lathe the stump was used to turn the screws. This boy did his work as accurately and almost as rapidly, as any other man in the shop, and naturally received the same pay. He served as instructor to soldiers having a similar amputation, and it was most gratifying to see how rapidly they acquired a dexterity almost equal to his.

For the farmer, a simple prosthesis is of great advantage, since the unaided stump cannot cope with such work as pitching hay, using the scythe, chopping with a heavy axe, etc. Of all the devices I know, the most effective is that designed by a German peasant, August Keller, eight years before the war began (see Figs. 13–20). This consists of a wooden hand-piece, into which three strong steel claws are inserted. These claws are not movable. They serve as levers in manipulating various tools. To hold the farm implements in place, a leather strap passes from the front to the back of the wrist, where it is held in place by means of a pin. When the strap is made to take two turns about the handle of an axe, the force of three men is insufficient to pull it away from the wearer. The hand-piece is fastened to the stump by means of a leather socket, attached at the elbow by a broad strap, which makes a figure-of-eight turn about the joint. The hand-piece can be removed and in its place a hammer, hatchet or other small implement inserted. With this eminently simple contrivance Keller did all the work of a twenty-five acre farm. His speed and dexterity were more than the equal of the average farmer.

For the business or professional man, a device is to be preferred which is more æsthetic. Although one of the cardinal principles in dealing with the amputated is the development of a healthy disregard for squeamishness on the part of hypersensitive observers, it is only fair to the amputated, as well as to his surroundings, to hide the defect as far as possible. A prosthesis which looks like a hand is, therefore, a reasonable demand. Those designed by the Carnes Artificial Limb Company and by Judge Corley are effective as well as æsthetic. Both enable the wearer to control the movements of the fingers by means of a lever, operated by motion at the elbow. The Carnes arm enables the wearer to move all the fingers and the wrist (see Figs. 21–23). Not only flexion, but also pro- and supination

FIG. 11.

Bracemaker's apprentice shown in the act of filing. The stump had become so hardened that he was able to use it exactly as the ordinary mechanic uses his left hand.

FIG. 12.

The one-armed bracemaker's apprentice already pictured in Fig. 11. This illustration shows his method of gripping the hammer between the stump, upper arm and chest.

FIG. 13.

The Keller artificial hand. The picture illustrates Keller's method of inserting a small knife, with which he is sharpening his pencil. Note also the piece of cork attached to the pencil. This enables him to grip the pencil between the claws and to write with it. The lower arm socket is held firmly in place by a broad strap which makes a figure-of-eight turn about the elbow.

FIG. 14.

The Keller hand. To make the pencil fit between the claws, a piece of cork is used.

Fig. 15.

Keller splitting wood. Note the double turn of the leather strap around the handle of the axe. This gave Keller so strong a grip on the handle that the united strength of three men was unable to pull the axe away. Keller's dexterity equalled that of an expert woodsman.

Fig. 16.

Keller pitching hay. The strap takes a double turn around the handle of the pitch fork.

Fig. 17.

The Keller artificial hand. Keller pruning a small tree.

Fig. 18.

The Keller artificial hand. Keller at work with his spade.

Fig. 19.

The Keller artificial hand. The hand attachment can be removed, permitting the insertion of various instruments. In this instance a hammer has been inserted, which Keller is able to use with the same dexterity as a normal individual.

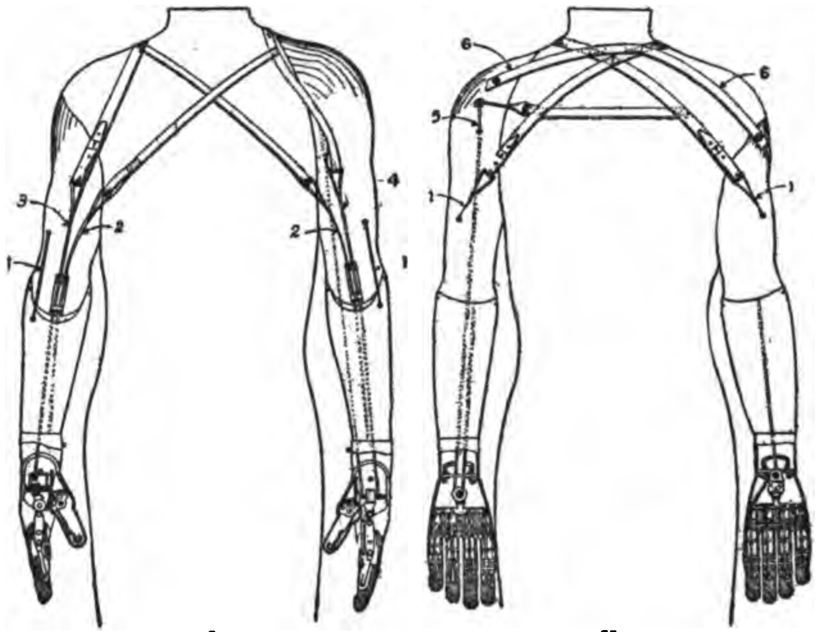
Fig. 20.

The Keller artificial hand. For æsthetic purposes Keller draws a glove over the hooks. This he terms his "Sunday" hand.

are possible. The Corley hand is of much simpler construction and utilizes only the index finger and thumb for grasping purposes. It has the advantage of being much less expensive.

For amputations at the elbow or above, the problem becomes more

FIG. 21.



Two diagrams illustrating the principle of the Carnes arm for a double amputation, with one arm amputated between the elbow and the shoulder, and the other arm disarticulated at the shoulder. I. View from in front. II. View behind. The functions of the different straps are as follows:

Strap No. 1. Bends or operates the elbow. This strap coming from the back, passing over pulleys in the upper arm, and being anchored to the forearm, enables the wearer to get the elbow movement, simply by moving his stump forward a little.

Strap No. 2. Locks the rotating wrist. To unlock the wrist, the elbow is bent up to the extreme. When the wrist is not locked, it turns or rotates as the elbow is bent, but can be locked in any position desired, by first bending the elbow until the wrist and hand are rotated to the position desired, then hold it in this position while pulling on strap No. 2, to lock it there.

Strap No. 3. Opens and closes the fingers. On the amputation above the elbow, by throwing the shoulder down, a sufficient tension is had on this strap to open or close the fingers; then, by raising the shoulder, the cord is pulled back into the hand, allowing the mechanism to reverse, and then, by again pushing the shoulder down, the opposite movement of opening and closing the hand is obtained.

Straps Nos. 4 and 5. Opens and closes the hand on the shoulder or disarticulated amputation.

Strap No. 6. Simply an elastic support to hold the arm in place. For a single amputation on either side, the harness will be as shown, excepting that on the opposite side, it would simply be looped up under the good arm.

Straps No. 2. are the only ones which come across the chest and these are not tight, it being necessary to throw the arm out to the side, in order to lock the wrist.

For the diagrams and explanatory text I am indebted to the Carnes Artificial Limb Co., Kansas City, Mo.

complicated. A home-made prosthesis, depicted in Figs. 24 and 25, was designed by the fourteen-year old carpenter apprentice, who is shown wearing it. This lad's ingenuity marks a distinct advance in artificial limbs for this type of amputation. Instead of the usual hinge joint, he constructed a ball-and-socket joint, using a wooden sphere, fitting between the concavities of the upper and lower arm pieces, the three being held together by a spiral spring. In this way, not only flexion and extension, but pro- and supination were made possible. By means of this simple device, the boy became an expert carpenter and constructed a table, chair and bookcase for me of as perfect workmanship as any I have ever seen. Of course, the artificial limb serves merely as an adjuvant; the main work has to be done by the sound arm. It is, therefore, of little or no use to those with a double amputation.

A somewhat more complicated apparatus is that shown in Fig. 26. This arm is worn over the clothing. It, too, is particularly adopted to carpentry. It is suspended at the shoulder by a broad leather ring, in which there is a metal gutter, in which a second ring runs on ball-bearings. There is thus perfect freedom of motion. Two lateral uprights, to which the stump is securely fastened, end in a circular disk, into which various working appliances can be fitted. (For further details and drawings of this arm see McDill's "Lessons from the Enemy," published by Lea and Febiger.)

An interesting modification of the working arm, suitable for amputations above the elbow, is the utilization of a spring at the elbow-joint, which permits a springy motion of distinct value in hammering, filing, etc., work in which absolute fixation at the elbow takes away from the freedom of the stroke. Fig. 27 elucidates the principle of this arm. By fastening screws *A* and *B*, the arm can be absolutely fixed at any desired angle. By releasing screw *A*, which controls the springs, the plunger is allowed to move backward and forward, allowing about 10° motion, but not beyond the limit set by screw *B*. Pronation and supination are not possible in this type of arm except by rotating the tool, which is inserted into the hollow barrel corresponding to the forearm.

Two types of working arm have been constructed after the pattern of the ball-and-socket joint devised by the young carpenter's apprentice already mentioned. To render the fixation at the elbow firmer, a screw is attached to the elbow articulation which locks the upper and lower arm against the spherical surface of the intervening steel ball. Although these two arms are capable of withstanding great strain, they are not, so far as I have been able to judge, as advantageous as

Fig. 22.

The Carnes artificial arm for the patient shown in Fig. 23.

Fig. 23.

A case of double amputation—on the right side through the elbow, on the left 4″ below the shoulder. In a case of this kind, unlike that pictured in Fig. 28, an artificial limb is necessary, since the two stumps cannot be approximated. The Carnes artificial arms are seen lying on the table. The patient can put these on without assistance and is then able to eat alone, dress, shave and use many tools. (See also Fig. 25.)

Fig. 24.

The carpenter's apprentice shown in Fig. 25 guiding the plane with his artificial arm.

Fig. 25.

The carpenter's apprentice already pictured in the preceding figure, at work with the saw. The artificial limb is used to steady the board.

Fig. 26.

The Siemens-Schuckert arm for amputations above the elbow.

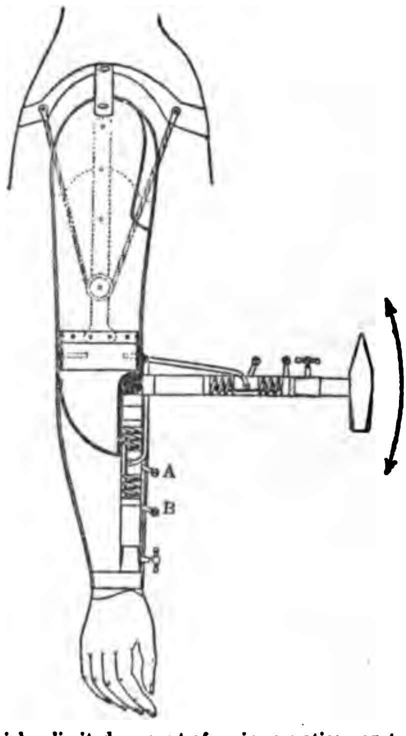
Fig 28.

Patient of Riedinger with very short upper arm stump.

that pictured in Fig. 26, because the tool is not brought into sufficiently intimate contact with the stump. As a rule, with practically no exceptions, the nearer the stump can be brought to the instrument which it is to control, the more effective is the amputated's use of the implement.

The Carnes arm, already described in speaking of amputations of the forearm, is also applicable to amputations of the upper arm. The

FIG. 27.



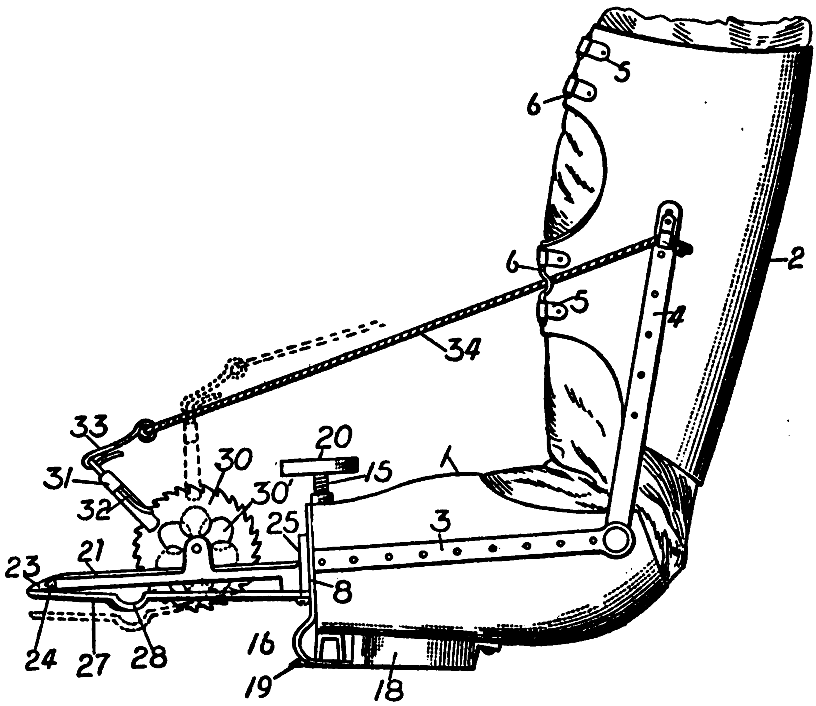
Artificial arm in which a limited amount of springy motion can take place at the elbow by adjusting the screws A and B. (Model of Biesalski).

motor power is then derived by the movements of the shoulders (see Fig. 22). The difficulty in learning to use the arm is increased when the amputation lies above the elbow, nor is it particularly well suited to the use of the artisan.

The Corley arm has recently been adopted to this type of amputation and is an unusually ingenious construction. The elbow joint is moved by means of a shoulder strap, working on a double lever which locks the joint at any desired angle. A device of this kind is of particular value to the double amputated.

In case of very short upper arm stumps, the difficulties of applying a suitable artificial limb become still more marked. Figs. 28–32 show how the difficult problem has been overcome by Riedinger. Despite the very short conical stump, the patient was able to do excellent

FIG. 34.



Side view of Judge Corley's device for the double amputated. Extension at the elbow produces traction on the cord (34), pulling the lever (32) and thus causing a rotation of the cog wheel (30). This wheel is equipped with 4 small arms (30') so shaped that, as they revolve, they force the bar (28) downward into the position shown by the dotted lines. This opens the tip, so that articles can be grasped simply by allowing the wheel again to revolve and the arm (28) to snap back into place. The screw (20) can be twisted by the teeth and serves to tighten a clamp (19), into which knife, fork, spoon or pencil can be readily inserted (see also Fig. 3).

work in the mechanic's shop. Even for disarticulations at the shoulder an artificial limb can be applied. Thus far they have been of comparatively slight assistance, but there is excellent prospect of development in this direction.

For the double amputated, the question assumes an altogether different complexion. With them the stump or the artificial limb has to do everything. At first thought, it seems impossible to get

Fig. 29.

The same patient equipped with a Riedinger prosthesis. Note the broad circular pad which closely surrounds the shoulder and serves as support for the leather socket which is attached to it by a strong joint, permitting motion in all directions.

Fig. 30.

The same patient as in Fig. 29. Illustrating the method of using hammer and chisel.

Fig. 31.

The same patient as in Fig. 29 at work at the turning-lathe.

Fig. 32.

The mechanic's tools employed by the patient shown in Fig. 29. These are inserted into the slot at the lower end of the forearm piece and fastened firmly in place by a turn of the screw.

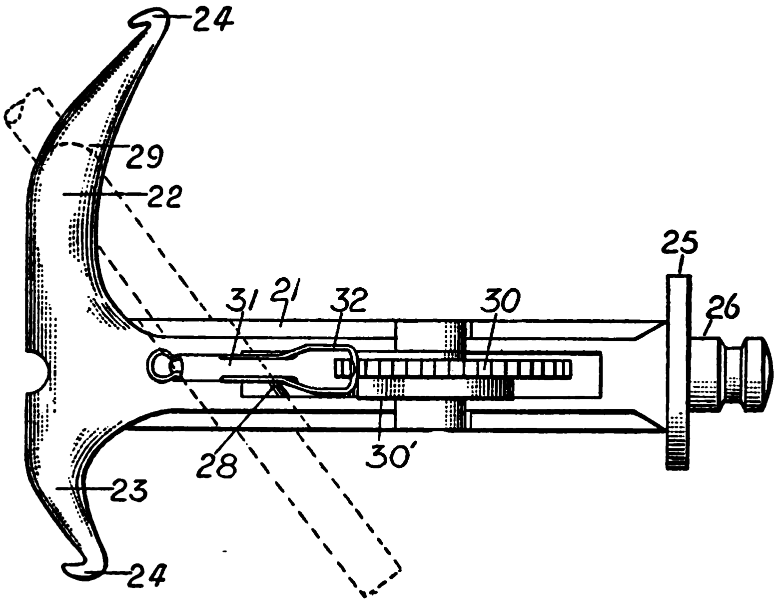
Fig. 33.

A teacher, both of whose hands had been amputated when six years old. He had learned to be absolutely independent and had passed his examination entitling him to a teacher's license. Without artificial limbs he could dress himself (the illustration shows him in the act of buttoning his collar), shave, eat with grace and assurance, write an unusually legible hand with more than normal rapidity, travel long distances alone, carry a suit case and pay his fares, just as the normal individual would. All this was done by careful education of the stump, which in his case had acquired almost the same sensitiveness as the tips of the fingers.

Fig. 37.

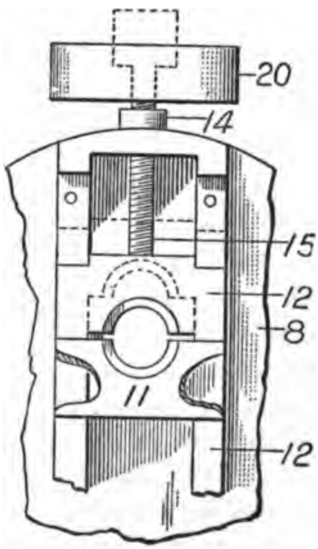
Judge Corley's apparatus for helping the man who has lost both hands to button his own collar.

Fig. 35.



Judge Corley's device for the double amputated. Enlarged view of the hook seen from above. For lateral view see Fig. 1, parts labelled 21-30. The hooks (24) are extremely important in buttoning the clothes, opening doors, etc.

Fig. 36.



Judge Corley's device for the double amputated. Enlarged view of the clamp and screw (20). By turning the screw the clamp (11) is made to grasp any object desired.

along without both hands, using the stumps only, and yet, in at least three instances, known to me personally, the patients have acquired complete independence despite this handicap. One of them is pictured in Fig. 33. There he is shown buttoning his necktie by means of a buttonhook held between the two stumps. In writing, the pencil or pen was grasped in a similar way. The patient was able not only to dress himself in fifteen minutes, but to shave, ride, travel alone, light his own cigarettes and do everything which you or I can do. Of course, such dexterity is not to be acquired in a short time. This patient, for instance, had been amputated when six years old and only by dint of years of patient effort had he acquired his power.

The two other patients utilized the same method of grasping objects between the stumps. The one, a young lady, now holds an important business position, the other is a school teacher. A requisite in the utilization of the stumps is that they be long enough to be brought together. If this is impossible, an artificial device must be used. Under these conditions one artificial arm stands in a class by itself—that designed by Judge Corley (see Figs. 34–37). The Judge himself was amputated when nineteen years old, losing the right arm at the shoulder and the left arm three inches below the elbow. As he was unable to find any artificial device which seemed satisfactory to him, he constructed his own. With it he dresses himself, writes, eats, runs an auto, bowls, works in his garden, etc. The device is a kind of pincers, one of whose jaws ends in a small hook. The jaws are opened and closed by a slight motion at the elbow joint. It is applicable also to amputations above the elbow joint by the utilization of a special self-locking elbow-joint. In one instance Corley has equipped a patient with double amputation above the elbow with this type arm and rendered the man independent.

In all work dealing with cripples of any kind, healthy optimism combined with a sane sympathy is necessary. No case is to be considered hopeless. At present I am engaged in the task of helping a man, both of whose arms, from the shoulder down, are completely paralyzed. In his case, arthrodesis at the shoulder will give the stump the motive power transferred through the scapula muscles, and thus enable him to use a modified Corley arm.