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METHOD OF AND APPARATUS FOR REPAIRING FRACTURED BONES

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Fig. 1.

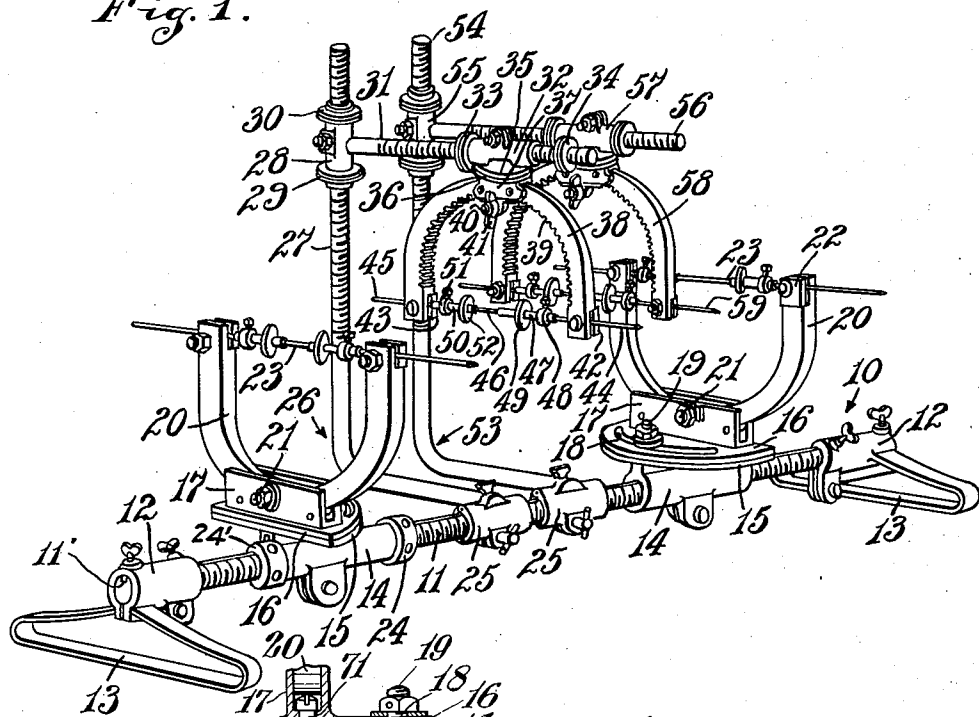


Fig. 4.

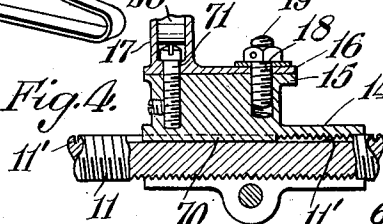


Fig. 2.

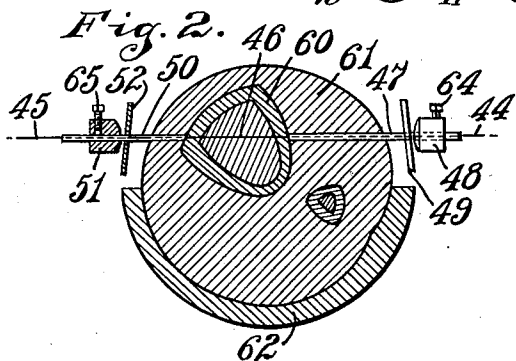
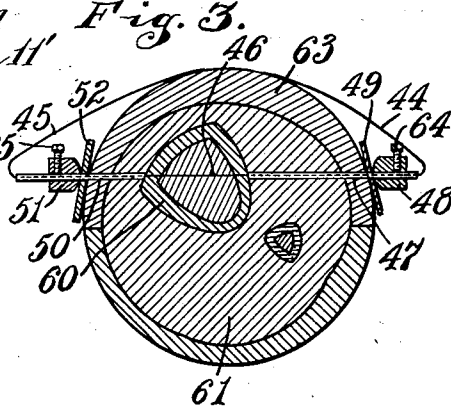


Fig. 3.



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METHOD OF AND APPARATUS FOR RE-PAIRING FRACTURED BONES

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21 Claims. (Cl. 128—84)

The present application relates to a method of, and apparatus for, repairing fractured bones. The invention is particularly adapted to the repairing of fractured bones in the lower leg and in the arm.

The primary object of the invention is to provide a method of and apparatus for manipulating the sections of the fractured bone to bring them into closely abutting proper registry; holding the bone sections in such registry throughout a knitting period, and throughout the period required for complete reduction of swelling in the soft parts surrounding the bone; and holding the bone sections against possible displacement during the ambulatory period of repair, all without impressing upon the soft parts surrounding the bone any bone controlling pressure. A further object of the invention is to provide a method of and apparatus for direct skeletal control of the sections of a fractured bone during the period of repair of the bone. A further object of the invention is to provide apparatus whereby the fractured ends of the sections of a broken bone may be manipulated and returned into normal registry with a nice degree of accuracy in all cases, heretofore impossible of accomplishment. A further object of the invention is to provide mechanical means through the medium of which all bone manipulation necessary to bring the bone sections into proper registry may be accomplished. A further object of the invention is to provide means of the character just described which shall be capable of an extremely fine adjustment exactly to a predetermined optimum point. A further object of the invention is to provide means of the character just described wherein the mechanical manipulating means directly engages the bone sections to be manipulated, and does not depend to any extent upon control of the positions of the bone sections through the medium of the surrounding soft parts.

A further object of the invention is to provide a method of and apparatus for holding the bone sections in place during a period of ambulation of the patient in such a manner as to permit continued accurate retention of the bone sections in place during removal of the cast for treatment of the soft parts surrounding the bone, for supplementary manipulation of the bone sections, and/or simply for substitution of a new cast. A further object of the invention is to provide a method of and apparatus for performing the above functions without dependence upon the surrounding soft parts for any bone controlling effort.

A further object of the invention is to provide for direct skeletal control of the injured bone from a cast surrounding the soft parts, during ambulation of the patient, and without dependence upon the soft parts for any bone controlling function. Still further objects of the invention will appear as the description proceeds.

To the accomplishment of the above and related objects, my invention may be embodied in the form illustrated in the accompanying drawing, attention being called to the fact, however, that the drawing is illustrative only, and that change may be made in the specific construction illustrated and described, or in the specific steps stated, so long as the scope of the appended claims is not violated.

Fig. 1 is a perspective view of apparatus constructed in accordance with the present invention;

Fig. 2 is a section through a leg showing a part of the apparatus of the present invention associated therewith, and showing a posterior cast in place;

Fig. 3 is a view similar to Fig. 2 but showing a completed cast in place on the leg, and showing the relation of a part of the apparatus of the present invention to such cast; and

Fig. 4 is an enlarged sectional fragmental view taken substantially on the vertical plane including the axis of the threaded base element.

Prior to the present invention, the general practice of bone surgery in setting fractured limbs has been attended by many apparently insuperable problems from a mechanical standpoint. The most serious of these problems have been encountered in the setting and holding of broken bones in the lower leg. In such cases, the general practice has been to take an X-ray to determine the location of the ends of the sections of the broken bone. Supplementing the information given by the X-ray photograph, the surgeon probes with his fingers attempting to determine, by feeling through the surrounding soft parts, the positions of the bone ends. In most instances, the reflex contraction of muscles causes the ends of the fractured bone to overlap. Before the bone can be set, of course this overlapping must be overcome. In most instances, an interne is entrusted with the duty of pulling upon the foot of the patient to elongate the muscles of the injured leg and overcome the overlapping of the fractured bone ends. In many instances, a force of about sixty pounds must be exerted to accomplish this purpose.

As the leg is pulled by the interne, the surgeon

keeps in touch with the bone ends by feeling through the soft parts, and, when the elongation has been carried to a suitable point, the surgeon presses and manipulates the soft parts with his fingers to force the bone ends back into proper registry. It will be obvious that this is a very delicate operation, particularly when, as in most cases, the bone ends are jagged. During this manipulation of the bone ends, the tractive effort of the interne must be continued. It is obvious that such tractive effort cannot be continued with entire uniformity throughout the period necessary to realign the bone sections. Thus, one feature of inaccuracy enters into the operation.

It is also obvious that, no matter how skillful the surgeon may be, it is not possible for him always to bring the bone ends into exactly proper registry simply through the use of the sense of touch, and through the exertion of bone controlling pressure through the soft parts. Here enters, of course, another feature of inaccuracy.

After the bone ends are brought into approximately accurate registry, they must be permitted to slip back into substantial abutment and, since the force which is holding them out of abutment is exerted by the interne, it is obvious that it is impossible to bring the bone ends carefully and accurately into abutment by the gradual release of tractive effort.

After the setting has been completed, it is necessary to hold the bone against the reflex tendency of the muscles to bend the limb and, perhaps, to slip the ends of the sections out of position. In the past, this function has usually been roughly accomplished by the use of counterweights exerting tractive effort on the free end of the limb. It is obvious that such counterweights cannot be entirely accurate in overcoming the tendency of the muscles at all times.

It will also be clearly seen that, while the interne can, with some degree of accuracy, overcome the tendency of the muscles, he cannot with any substantial degree of accuracy, control the tendency of gravity to cause the ends of the fractured sections to bow downwardly. Neither can the tendency of gravity be at all accurately overcome by the counterweights above mentioned; and consequently there have been many instances in which fractured leg bones have knitted with a decided bow therein.

Most injuries which result in fractures of the lower leg result also in abrasions and contusions of the soft parts surrounding the bone. Such injuries must be treated during the period of knitting of the bone. The injuries also almost universally cause a more or less serious swelling of the soft parts surrounding the bone. For those two reasons, it is highly impractical to mold a cast on the injured member until the injuries to the soft parts have healed and until the swelling in the soft parts has been completely reduced. During that period, according to established practice, there is substantially nothing to prevent bending of the injured member at the point of fracture.

It is sometimes necessary, after a cast has been applied, to remove the cast for one purpose or another. Obviously, it would be highly desirable to hold the injured member against possible displacement of the fractured bone sections during the removal of the cast, during the period while the cast is off of the injured member, and during the application of a new cast. So far as I am advised, there has been, prior to the present in-

vention, no entirely effective means for so holding the bone sections during such periods.

The method and apparatus of the present invention solve all of the above problems and provide means for accomplishing all of the above-mentioned desiderata.

Referring more particularly to the drawing, it will be seen that my apparatus comprises a base, indicated generally at 10, and consisting of a threaded rod 11 formed with a longitudinal key slot 11', to the opposite ends of which are secured a pair of clamps 12, each of said clamps carrying a foot piece 13, whereby said rod 11 is supported above a surface upon which the foot pieces 13 rest.

Slidably mounted upon said rod 11 are two clamps 14, either or both of which may be clamped in place upon said rod. Each clamp 14 is provided with a key 70 entering the slot 11' to hold said clamp against turning about the axis of the rod 11, and each of said clamps supports a plate 15 upon which is oscillably mounted a plate 16 carrying a guideway 17. The plate 16 is provided, within the guideway 17, with an aperture through which snugly extends a threaded screw 71 which is threaded into the member 14 to provide a swivel mounting for said plate 16 on the plate 15. The plate 16 is further provided with an arcuate slot 18 centered on the screw 17, in which slot is received a clamping bolt 19 carried by the plate 15 and operable to clamp the plate 16 in adjusted position. A U-shaped saddle 20 is adjustably received in the guideway 17 and may be clamped in adjusted position by a clamping bolt 21. At the extremities of its arms, each U-shaped member carries clamping means 22 for engaging the opposite ends of a bone-penetrating drill 23. A nut 24 mounted on the threaded rod 11 comprises mechanical means for shifting one clamp member 14 away from the other clamp 14, and a second nut 24' is operable to shift said member 14 in the opposite direction.

Between the two clamps 14 there are slidably mounted on the rod 11 two other clamps 25, each of which may be clamped in adjusted position on the rod 11. One of the clamps 25 carries an L-shaped member indicated generally at 26, said L-shaped member comprising a substantially vertical threaded stem 27 spaced laterally from the base 10. A sleeve 28 is slidably mounted upon the stem 27, and two nuts 29 and 30 are threaded on said stem 27, respectively below and above the sleeve 28. It will be obvious that, by manipulation of the nuts 29 and 30, the sleeve 28 may be moved upwardly or downwardly upon the stem 27 with a nice degree of accuracy.

The sleeve 28 carries a laterally projecting arm 31 which overlies the base 10 and which is provided with screw threads. A sleeve 32 is slidably mounted upon the arm 31, and nuts 33 and 34 are threaded on the arm 31 at opposite ends of the sleeve 32. As will be clear, the sleeve 32 may be adjusted axially of the arm 31 by manipulation of the nuts 33 and 34.

A plate 35 depends from the sleeve 32, and a second plate 36 is suitably secured to said plate 35, said plate 36 being rotatable upon a vertical axis. Carried by the plate 36 is a guideway 37 for an inverted U-shaped member 38. Said member 38 is provided on its inner surface with teeth 39 for cooperation with a pinion carried upon a shaft 40 operable by a key 41. It will be obvious that, as the key 41 is operated, the member 38 will be oscillated about an axis lying perpendicular to the plane of the element 38 and substan-

tially at the center of curvature of said element.

At the extremities of its arms, said U-shaped member is provided with clamping elements 42 and 43 for engaging respectively the ends 44 and 45 of a bone-penetrating drill 46; and it will be seen that said drill 46, when in position, substantially intersects said axis of oscillation.

Sleeved on the drill 46 adjacent the end 44 thereof but between the arms of the U-shaped member 38 is a tube 47, said tube having associated therewith a collar 48 and having sleeved thereon a relatively large-diameter disc 49, said disc being positioned between the collar 48 and the inner end of the tube 47. Sleeved on the drill 46 adjacent the end 45 thereof, but between the arms of the U-shaped member 38, is a tube 50 having associated therewith a collar 51, and having sleeved thereon a relatively large-diameter disc 52, said disc being positioned between the collar 51 and the inner end of the tube 50.

The other clamp 25 carries an L-shaped member 53 comprising a threaded stem 54 upon which is slidably mounted a sleeve 55 controlled by nuts similar to the nuts 29 and 30; and said sleeve 55 carries a threaded arm 56 overlying the base 10 upon which is slidably mounted a sleeve 57 controlled by nuts similar to the nuts 33 and 34. A U-shaped member 58 is carried by a guideway similar to the guideway 37 and is provided with means for clampingly engaging the ends of a bone-penetrating drill 59 with which are associated tubes, collars, and discs similar to those associated with the drill 46. Similar tubes, collars, and discs are associated with the drills 23.

The apparatus above-described may be used in carrying out the method of the present application. If it be assumed that, upon examination, it has been determined that there is a fracture of the lower leg, the following procedure will be pursued. A local, regional or spinal anesthetic is administered, and an X-ray examination of the leg is made to determine the exact site and the nature of the fracture and the relative positions of the fragments. Of course, the X-ray examination could be made before administration of the anesthetic, but I prefer to anesthetize before making the examination both for humane reasons and because anesthesia leaves the patient comparatively relaxed and permits a more thorough examination.

A drill 23 is now placed through the most proximal end of the fractured bone, passing through the soft parts and through the bone itself, and another drill 23 is driven through the most distal end of the fractured bone or segment of the injured limb. In practice, I prefer to insert one of the tubes 47 or 50 through the soft parts and into abutment with the bone, and then drive the drill through that tube, whereby the drill is guided in its passage through the soft parts and through the bone. The drills will project at both ends beyond the soft parts, and one of the tubes 47 or 50 will be sleeved over each projecting end and forced into the soft parts into contact with the bone. The discs 49 and 52 are then sleeved over the tubes 47 and 50; and thereafter the collars 48 and 51 are associated with the tubes. The projecting ends of the drills 23 are then clamped in place in the arms of the U-shaped members 20, whereafter the tubes and drills are finally adjusted in proper relation and the set screws 64 and 65 are turned down to compress the tubes on the drills to clamp the drills against movement with respect to the tubes. It will be

seen that the bone sections are thus firmly held against movement axially of the drills.

The U-shaped member 20 adjacent the right-hand end of the mechanism as shown in Fig. 1 is now adjusted so that the proximal fragment 5 of the injured limb is in proper position as compared with the uninjured limb, whereby the patient will be subjected to the least possible discomfort. The nut 21 is now tightened to prevent further rotation of the proximal fragment 10 about the axis of the bone, but the nut or clamping bolt 19 is left loose to permit oscillation of the plate 16 on the plate 15, whereby the proximal fragment may be adjusted angularly. With the clamp member 14 adjacent the left-hand end of the mechanism as viewed in Fig. 1 free to slide on the rod 11, the plate 16 free to oscillate on the plate 15, and the U-shaped member 20 associated with said plate free to move in the guideway 17, the screw 24 is manipulated to extend the injured limb to overcome shortening and overriding of the fractured bone ends. Any deformity of rotation or gross deformity of angulation at the site of fracture is then corrected by movement of the U-shaped member 20 in the guideway 17 and by movement of the plate 16 on the plate 15, and thereafter the various elements carried by said clamp member 14 are locked in adjusted position.

The drill 46 is now driven through the fractured bone immediately below the site of fracture and the drill 59 is driven through the bone immediately above the site of the fracture, and the tubes 47 and 50 with their various associated parts are associated with the drills 46 and 59.

It is to be understood that the work heretofore described has been done with the clamp members 25 and all of their associated parts entirely removed from the organization. Said clamp members 25 and their associated elements are now positioned on the rod 11, and suitable adjustments are made to bring the U-shaped elements 38 and 58 into position to be clamped to the projecting ends of the drills 46 and 59 as said drills are positioned in the injured leg. After said drills 46 and 59 are clamped in position in the members 38 and 58, the tubes 47 and 50 on said drills are finally adjusted, and the set screws 64 and 65 are turned down to clamp said tubes in place on said drills, thereby preventing all lateral displacement of the bone ends with respect to the drills.

It will readily be seen that, with the mechanism so assembled, means is provided for universal skeletal manipulation of the two bone sections through purely mechanical means, without placing any dependence for bone controlling functions upon the soft parts surrounding the fractured bone. The two sections of the fractured bone can be independently manipulated in any direction or directions to bring them into proper registry, and thereafter, through the use of purely mechanical means, the various elements associated with the base 10 may be shifted to bring the ends of the bone into intimate abutment with any desired degree of pressure. It will also be seen that, without bringing any bone controlling duty upon the soft parts, the bone sections will be absolutely and mechanically controlled against the distorting tendency not only of the muscles, but also of gravity. In short, the bones are absolutely under control of mechanical means, and no bone-controlling duty devolves upon the surrounding soft parts.

According to the present method, which may

be carried out through the use of the herein-disclosed mechanism, the injured member may be left entirely open for treatment of any kind during the period of reduction of swelling or healing of the soft parts, and as long as desired during the period of knitting, it being understood that the drills are held in the illustrated machine during such periods. If desired, a posterior cast or other supporting splint may be applied and changed as often as changes in the condition of the limb may require. Of course, if a complete plaster of Paris supporting splint were applied at a time when there existed a risk of future swelling of the limb or further shrinkage, which might interfere with the circulation and damage the limb, or which might interfere with the supporting function of the cast, considerable damage might be done. According to the present method, the limb is subject to skeletal support during that period of possible shrinkage or swelling.

It is well understood in the profession that, particularly in cases of fracture of the lower leg, it is highly desirable to get the patient as early as possible into an ambulatory condition, since ambulation stimulates circulation and stimulates callus growth to accelerate permanent knitting. It is desirable to make it feasible for the patient to use the injured member as early as possible. After observation over a period sufficient to be sure that the limb will not swell or shrink further, the limb being supported in a posterior cast, the cast is completed by application of an anterior molded plaster of Paris cast, and a sufficient number of circular turns of a plaster of Paris bandage to hold the two cast elements firmly together.

In accordance with the present invention, after swelling has disappeared and a check up X-ray examination of the limb in the apparatus shows the position of the bone fragments to be satisfactory, the complete cast, illustrated at 63 in Fig. 3, is applied to the leg in the manner above outlined. Such cast is molded about the protruding ends of the tubes on the various drills, and the discs 49 and 52 are adjusted to positions either within the newly molded soft plaster or in intimate contact therewith and held firmly in such contact by the collars 48 and 51 so that, when the plaster becomes hard, the discs will assist in holding the drills and their associated elements against any movement with respect to the cast, whereby the bone sections are directly supported in adjusted positions from the cast, without dependence upon the surrounding soft parts for any bone-controlling function.

When the cast is hard and dry, the positions of the bone fragments are preferably checked by X-ray examination.

After the cast has hardened, and if the X-ray examination shows the position of the bone fragments to be satisfactory and the absence of pain or discomfort shows that no harmful or unbearable pressure is being produced by the cast, the various drills may be removed from the U-shaped elements 20, 38, and 58, and the protruding ends of the drills are bent around to lie flat against the outer surface of the cast, as indicated in Fig. 3. The patient may now be permitted to use the injured limb to some extent without fear of any displacement of the bone sections, since such sections are held in proper relation by direct skeletal connection to the cast 63.

If, for any reason, it should be found desirable to remove the cast 63, the various drills may be

reassociated with the respective U-shaped members before the cast is removed. The bone sections will thus be rigidly held, by skeletal control, against any possible displacement during the removal of the cast, during any desired treatment, and during substitution of a new cast.

Very occasionally, there arises the necessity for shifting the bone sections after a relatively extended period of treatment. Even after the application of a cast, it is sometimes necessary to relocate the ends of the bone sections. It will be quite obvious that such relocation can be accomplished, according to the present invention, by simply reassociating the ends of the drills 23, 46, and 59 with their respective U-shaped members, removing the cast, and manipulating mechanically the various adjustment means associated with the U-shaped members 38 and 58.

In the use of the herein-disclosed mechanism for carrying out the herein-disclosed method, one of the features which makes for extreme accuracy of registration of the bone ends lies in the fact that it is possible to gauge, upon tangible, visible, touchable means, the amount of adjustment which is necessary to bring the bone ends into exact registration. An apparently accurate setting of the bone having been completed, and the injured member being, of course, still in the illustrated machine, a series of X-ray pictures may be taken from various angles. If there is any slight defect in the accuracy of registration, that fact, and the degree of inaccuracy, will be shown by the photographs. If the photographs show, for instance, that the end of the lower section should be lifted one-sixteenth of an inch, and shifted toward the patient's right-hand one-eighth of an inch, the surgeon, or even a relatively inexperienced interne, can make the adjustment with absolute accuracy. For instance, under the circumstances above outlined, a strip of adhesive might be placed about the stem exactly one-sixteenth of an inch above the upper surface of the nut 30; and a second strip might be placed about the arm 31 exactly one-eighth of an inch from the left-hand face of the nut 33, as viewed in Fig. 1. The nut 30 will then be turned up to a point at which its upper surface just engages the lower edge of the adhesive strip. The nut 29 will then be shifted to lift the sleeve 28 until the sleeve 28 binds against the lower surface of the nut 30. Similarly, the nut 33 will be shifted into contact with the adjacent edge of the adhesive strip on the arm 31, and the nut 34 will be manipulated to bring the sleeve 32 into binding engagement with the adjacent face of the nut 33; thereby bringing the lower section of the patient's bone into exact registry with the upper section thereof. It will be obvious that a skilled operator need not use the adhesive strip as above suggested, but may move the various nuts proper distances, as gauged by his eye; or he may make the adjustments in the supporting mechanism while the limb is under the fluoroscope.

The use of the skeletal control herein-described overcomes a problem frequently met by surgeons in past practice. It has been found that, where it is attempted to hold the bones of the lower leg, or of the arm, in proper registry by bone-controlling pressure exerted upon the surface of the surrounding soft parts, such pressure will, in a very great many instances, so hinder blood circulation and so injure the fibers of the soft parts as to cause actual sloughing of those parts against which the pressure is exerted.

In many instances, such sloughing has extended to such a degree as to compound the fracture. In other instances, pressure upon the soft parts sufficient to be effective in holding the bone fragments suitably in position may produce pain and discomfort that is unbearable to the patient. Of course, such difficulties are never encountered in the use of the present device.

While I have illustrated certain arrangements of the elements of the present invention, it is to be understood that there is a substantially illimitable possibility of variations in those arrangements. For example, any of the rods used in the invention may be plain or threaded, may be formed with or without one or more kerfs, and may or may not have associated therewith one or more shifting nuts. Any of the saddle support units may or may not be constructed to permit adjustment of the saddle or the supporting platform manually or by any desired mechanical means. In other words, modifications of the arrangement of the elements is contemplated by the applicant. And it is to be understood that the exigencies of the particular case which confronts a surgeon will determine the manner in which the surgeon will combine the various units of the disclosed organization to provide a satisfactory structure to perform the operation which appears to be necessary; and that only the skill of the surgeon who is operating can determine the proper steps to be taken and the proper sequence of those steps. I have provided, however, mechanism which, in the hands of the skillful surgeon, will materially facilitate the operations necessary to bring badly fractured bone fragments into proper coaptation, and to hold them there with a minimum of deleterious effect upon the soft parts surrounding the fractured bones.

I claim as my invention:

1. The method of setting a fractured bone which includes the steps of piercing the soft parts surrounding the bone and piercing the bone above the fracture with a drill and causing said drill to project at both ends beyond the soft parts, piercing the soft parts and the bone below the fracture with a second drill and causing said drill to project at both ends beyond the soft parts, photographing the fractured ends of the bone sections, measuring exactly the displacement of said fractured ends with respect to each other, applying mechanical shifting means to said drills, providing means for automatically stopping movement of at least one of said mechanical shifting means at a point exactly measured in accordance with the previously measured displacement, and operating said mechanical shifting means until the same is stopped by said stop means, whereby said fractured ends are returned exactly to their normal positions.

2. In combination, a base, a plurality of L-shaped members adjustably mounted on said base; the stems of said members projecting substantially vertically above said base and being threaded, sleeves slidably mounted on said stems, each of said sleeves carrying a laterally projecting screw-threaded arm projecting over said base, threaded means cooperating with said stems for mechanically shifting said sleeves axially of said stems, sleeves slidably mounted on said arms, threaded means cooperating with said arms for mechanically shifting said arm sleeves axially of said arms, a guide member swivelly depending from each of said arm sleeves, an inverted U-shaped member adjustably received in each of said guide members, means for mechanically oscillating each

of said U-shaped members in its guide member about an axis perpendicular to the plane of such U-shaped member and substantially at the center of curvature of said U-shaped member, and a bone-penetrating drill having its ends rigidly engaged by the arms of each U-shaped member and substantially intersecting the axis of oscillation of its U-shaped member.

3. In combination, a base, a plurality of L-shaped members adjustably mounted on said base, the stems of said members projecting substantially vertically above said base and being threaded, sleeves slidably mounted on said stems, each of said sleeves carrying a laterally projecting screw-threaded arm projecting over said base, threaded means cooperating with said stems for mechanically shifting said sleeves axially of said stems, sleeves slidably mounted on said arms, threaded means cooperating with said arms for mechanically shifting said arm sleeves axially of said arms, a guide member swivelly depending from each of said arm sleeves, an inverted U-shaped member adjustably received in each of said guide members, means for mechanically oscillating each of said U-shaped members in its guide member about an axis perpendicular to the plane of such U-shaped member and substantially at the center of curvature of said U-shaped member, and a bone-penetrating drill having its ends rigidly engaged by the arms of each U-shaped member and substantially intersecting the axis of oscillation of its U-shaped member, and two bone-engaging tubes sleeved on each drill intermediate the arms of its U-shaped member.

4. In combination, a base, a plurality of L-shaped members adjustably mounted on said base, the stems of said members projecting upwardly above said base and being threaded, sleeves slidably mounted on said stems, each of said sleeves carrying a screw-threaded arm overlying said base, threaded means cooperating with said stems for mechanically shifting said sleeves axially of said stems, sleeves slidably mounted on said arms, threaded means cooperating with said arms for mechanically shifting said arm sleeves axially of said arms, a guide member carried by each of said arm sleeves and mounted for rotational adjustment about an axis perpendicular to the axis of its arm, a U-shaped member adjustably received in each of said guide members, means for mechanically shifting said U-shaped members substantially about their respective centers of curvature, and a plurality of bone-penetrating drills, each drill having its opposite ends rigidly engaged with the arms of one of said U-shaped members.

5. In combination, a base, a plurality of L-shaped members adjustably mounted on said base, the stems of said members projecting upwardly above said base and being threaded, sleeves slidably mounted on said stems, each of said sleeves carrying a screw-threaded arm overlying said base, threaded means cooperating with said stems for mechanically shifting said sleeves axially of said stems, sleeves slidably mounted on said arms, threaded means cooperating with said arms for mechanically shifting said arm sleeves axially of said arms, a guide member carried by each of said arm sleeves and mounted for rotational adjustment about an axis perpendicular to the axis of its arm, a U-shaped member adjustably received in each of said guide members, means for mechanically shifting said U-shaped members substantially about their respective centers of curvature, a plurality of bone-

penetrating drills, each drill having its opposite ends rigidly engaged with the arms of one of said U-shaped members, two tubes sleeved on each of said drills between the arms of its U-shaped member, each of said tubes being positionable with its inner end in abutment with the bone penetrated by its drill, and means for securing each drill and its tubes against relative movement.

6. In combination, a base, a plurality of L-shaped members adjustably mounted on said base, the stems of said members projecting upwardly above said base and being threaded, sleeves slidably mounted on said stems, each of said sleeves carrying a screw-threaded arm overlying said base, threaded means cooperating with said stems for mechanically shifting said sleeves axially of said stems, sleeves slidably mounted on said arms, threaded means cooperating with said arms for mechanically shifting said arm sleeves axially of said arms, a guide member carried by each of said arm sleeves and mounted for rotational adjustment about an axis perpendicular to the axis of its arm, a U-shaped member adjustably received in each of said guide members, means for mechanically shifting said U-shaped members substantially about their respective centers of curvature, a plurality of bone-penetrating drills, each drill having its opposite ends rigidly engaged with the arms of one of said U-shaped members, two tubes sleeved on each of said drills between the arms of its U-shaped member, each of said tubes being positionable with its inner end in abutment with the bone penetrated by its drill, a collar carried by each of said tubes adjacent its outer end, a set-screw associated with each of said collars and operable to lock its tube against movement with respect to its drill, and a disc of relatively large diameter sleeved on each tube and spaced from the adjacent arm of the U-shaped member by the collar on said tube.

7. The method of repairing fractured bones which includes the steps of piercing the bone and the soft parts surrounding the same above the fracture with a drill and causing the drill to protrude at both ends from the soft parts, piercing the bone and the soft parts surrounding the same below the fracture with a drill and causing the drill to protrude at both ends from the soft parts, sleeving on each end of each drill a tube and forcing each tube to pierce the soft parts and penetrate into intimate abutment with the bone, securing said tubes to said respective drills to prevent relative movement between said drills and said tubes, securing both ends of said first drill to a universally adjustable member, securing both ends of said second drill to a second universally adjustable member, mechanically manipulating said members to bring the fractured ends of the sections of the bone into intimately abutting proper registry, and mechanically holding said members in such adjusted positions during a knitting period.

8. The method of repairing fractured bones which includes the steps of piercing the bone and the soft parts surrounding the same above the fracture with a drill and causing the drill to protrude at both ends from the soft parts, piercing the bone and the soft parts surrounding the same below the fracture with a drill and causing the drill to protrude at both ends from the soft parts, sleeving on each end of each drill a tube and forcing each tube to pierce the soft parts and penetrate into intimate abutment with the

bone, securing said tubes to said respective drills to prevent relative movement between said drills and said tubes, securing both ends of said first drill to a universally adjustable member, securing both ends of said second drill to a second universally adjustable member, mechanically manipulating said members to bring the fractured ends of the sections of the bone into intimately abutting proper registry, mechanically holding said members in such adjusted positions during a knitting period and during partial reduction of the swelling in the soft parts, applying a posterior cast to the soft parts while mechanically holding said members in such adjusted positions, and, after complete reduction of the swelling in the soft parts, applying a complete cast to the soft parts, said cast being molded about portions of the protruding ends of said drills and said tubes, and, after hardening of said cast, disengaging said drill ends from said members to permit ambulation of the patient.

9. The method recited in claim 8 modified by the steps of subsequently reengaging said protruding drill ends with said universally adjustable members, and mechanically holding said members and said drills in constant relative positions while removing said cast and replacing the same with a new cast.

10. The method recited in claim 8 modified by the steps of subsequently reengaging said protruding drill ends with said universally adjustable members, mechanically holding said members and said drills against movement while removing said cast, readjusting the sections of said bone by mechanical manipulation of said members, and applying a new cast to the soft parts, said new cast rigidly holding said drills against relative movement.

11. Means for applying traction to fractured bones in limbs of patients comprising a pair of members adapted to be passed entirely through the bone on opposite sides of the break, means associated with the ends of said members for supporting said members and for moving the same relative to each other, means adapted to be sleeved over each of said members, after a bone has been pierced, and adapted to be slid along such members to pierce the soft parts surrounding said bone and to engage the opposite sides of said bones directly, and means associated with said last-named means for securing the same against movement with respect to said members.

12. In a traction splint, a yoke mounting member, a traction yoke operatively supported thereby, a traction wire mounted across the yoke arms; said yoke having a base portion formed with gear teeth, and an adjusting gear rotatably mounted in said yoke mounting member and meshing with the said gear teeth of the yoke base.

13. The method of repairing a fractured bone which includes the steps of piercing the soft parts surrounding the fractured bone with a plurality of drills and driving said drills through the bone and the soft parts at points on opposite sides of the fracture so that said drills protrude from the soft parts at both ends, sliding onto each end of each drill a closely-fitting sleeve-like element and forcing said sleeve-like elements into abutment with the bone, securing said sleeve-like elements, while so in abutment, to their respective drills to prevent axial slipping of said drills through the bone in either direction, manipulating said drills to bring the sections of the fractured bone into abutting registry, and mechanically holding said

drills in adjusted positions to hold said bone sections in such abutting registry throughout a knitting period.

14. The method of repairing a fractured bone 5 which includes the steps of piercing the soft parts surrounding the fractured bone with a plurality of drills and driving said drills through the bone and the soft parts at points on opposite sides of the fracture so that said drills protrude from the 10 soft parts at both ends, sliding onto each end of each drill a closely-fitting sleeve-like element and forcing said sleeve-like elements into abutment with the bone, securing said sleeve-like elements, while so in abutment, to their respective drills to 15 prevent axial slipping of said drills through the bone in either direction, mechanically manipulating said drills to bring the sections of the fractured bone into abutting registry, and mechanically holding said drills in adjusted positions to 20 hold said bone sections in such abutting registry throughout a knitting period.

15. Apparatus for assisting in the repair of a fractured bone comprising a drill adapted to be 25 driven through the bone and the surrounding soft parts above the fracture, a second drill adapted to be driven through the bone and the surrounding soft parts below the fracture, means directly engaging each of said drills on each side of said bone and adapted directly to engage said bone, 30 means for securing said last named means to said drills in adjusted position and in abutment with said bone to prevent movement of said drills axially in either direction with respect to said bone, means for gripping the protruding ends of 35 said drills, and mechanical means for controllably universally adjusting said gripping means.

16. Means for applying traction to fractured bones in limbs of patients comprising a pair of 40 members adapted to be passed entirely through the bone on opposite sides of the break, means for supporting the members and the limb of the patient, means on the ends of the members for moving the members relative to each other, two elements snugly sleeved on each drill and respec- 45 tively adapted to penetrate the soft parts of the limb into abutting relation with opposite sides of the bone penetrated by such drill, and means for securing each of said elements in adjusted position on its drill whereby relative movement 50 of said bone and drills in either direction axially of the drills is prevented.

17. Means for applying traction to fractured bones in limbs of patients comprising a pair of 55 members adapted to be passed entirely through the bone on opposite sides of the break, means for supporting the members and the limb of the patient, means associated with the ends of said members for moving the same relative to each other, means adapted to be sleeved over each end 60 of each of said members and adapted to pierce the soft parts surrounding said bone and to en-

gage the bone directly, and means for securing each of said last-named means in adjusted position against movement with respect to the member on which it is sleeved.

18. Apparatus for assisting in the repair of a 5 fractured bone comprising a drill adapted to be driven through the bone and the surrounding soft parts above the fracture, a second drill adapted to be driven through the bone and the surround- 10 ing soft parts below the fracture, two tubes sleeved on at least one of said drills and normally shiftable axially with respect thereto, said tubes being respectively adapted to engage the bone through which said drill is driven on opposite sides of the 15 bone, means for securing said tubes to said drill to prevent relative movement between the drill and bone in the direction of the axis of the drill, in either direction, and manipulable means for 20 gripping the protruding ends of said drills.

19. In a splint of the character described, a 20 yoke housing fixedly mounted to rotate about a vertical axis, a traction yoke having spaced arms and an arcuate connecting base member mounted in said housing, and a taut traction wire mounted 25 by said arms across the mouth of the yoke and within the vertical plane of the said vertical axis; said base member of the yoke being arcuately curved about a center at the point of intersection 30 of the wire and said vertical axis, and being slidably movable in the yoke housing to change the position of the wire without change of relative position of the yoke and said center point, the 35 curved base member of the yoke being formed with rack teeth, and an adjusting means for the yoke comprising a gear meshing with the toothed 40 portion of the yoke, and means for rotating the gear.

20. In a method of repairing fractured limbs through skeletal control, the art of passing a 45 drill through the bone and through the surrounding soft parts, which comprises the steps of forcing a sharp-ended tube through the soft parts and into abutment with the bone, inserting a snugly- 50 fitting drill through the bore of said tube and into contact with the bone, rotating the drill, while the same is sheathed from the soft parts by said tube, to drive said drill through the bone, and 55 forcing the drill through the soft parts on the opposite side of the bone.

21. In a method of repairing fractured bones 60 the steps of providing for skeletal fixation which consists in passing at least one drill through the bone and the surrounding soft parts, sliding a sharpened sleeve-like element over one protruding end of said drill to penetrate the soft 55 parts and into abutment with the bone, securing said sleeve-like element, while so in abutment, against movement with respect to the drill, and securing the opposite end of the drill against 60 movement with respect to the bone.

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