formalin into *warts* with a stick, and these shrink and come off without leaving a scar.

As a vaginal douche Crawford recommends formalin in *obstetrics*, and Van Winckel uses ʒ i. (4 c.c.) to a quart (1 litre) for *endometritis* or for *vaginitis*, especially gonorrhœal. It may be used in full strength in the treatment of *chancroids*.

Surgically it is an antiseptic of great power (see *Disinfectants* and *Disinfection*), and is used for sterilizing the hands, dressings, sutures, and instruments. Hoffmeister, Hirst, and others recommend it highly for catgut. Hoffmeister's method is to harden the catgut on glass spools in four per cent. formaldehyde for twenty-four hours, then boil in water for ten minutes and keep in alcohol containing five per cent. of glycerin and 0.1 per cent. of corrosive sublimate. Vandermarker states that it should not be used directly in wounds, as one-per-cent. solutions will destroy fresh granulations, and two-per-cent. will produce sloughs. Its combination with gelatin (glutol), however, is used thus by Schleich and others. Inoperable epitheliomata and sarcomata have been treated with injections of one-half-per-cent. solution (about twenty minims) followed by curetting of the hardened tissue. The bleeding has been slight, and the growths have practically disappeared after a few treatments (Mitchell, Thompson). Ravogli claims to obtain the same results from the application of a paste of rice powder, oxide of zinc, and formalin. In chronic tuberculous joints, tuberculous abscesses, and empyema, Hahn considers a one-per-cent. glycerin solution to be more efficient than the much used iodoform-glycerin.

In dentistry, paraformaldehyde is preferred, as, being in solid form, it can be placed in cavities, disinfecting them by slowly evolving formaldehyde gas.

The more common preparations and compounds of formaldehyde are:

Aminoform, Ammonio-formaldehyde—synonyms for hexamethylene-tetramine.

Amyloform—starch and formaldehyde (see Vol. I.).

Bismal—the bismuth salt of methylene digallic acid, formed by the action of gallic acid on formaldehyde. Used as intestinal antiseptic and astringent.

Creoform, Creosoform, Kreoform—a non-toxic, tasteless, and odorless compound of creosote and formaldehyde. A strong antiseptic.

Cystamine, Cystogen—synonyms for hexamethylene-tetramine.

Dextroform—formaldehyde and dextrin (see *Amyloform*, Vol. I.).

Eka-iodoform—iodoform and paraformaldehyde (see Vol. III.).

Euformol is a mixture of oil of eucalyptus, formaldehyde, thymol, menthol, etc.

Formacoll—synonym for glutol.

Formaldehyd-bisulphite (HCOH, $Na_2S_2O_5$) is a crystalline mixture resulting from the action of formaldehyde on sodium bisulphite in solution. It is claimed to possess the antiseptic properties of both constituents.

Formaldehyde-casein (Formalbumin) is an odorless, tasteless, coarse yellow powder, used in surgery as an antiseptic.

Formaldehyde-gelatin—used in photography and in surgery (see *Glutol*).

Formaldehyde-sulpho-carbolic acid [$(CH_2OH)_2.C_6H_3.OH$] is used as an antiseptic dressing for wounds.

Formaldehyde tannalbuminate—tannalbumin subjected to the action of formaldehyde to render it more resistant to the action of the gastric juice. The compound passes unchanged through the stomach, and as it is split up but slowly in the intestines, it gets well down in the bowel before it separates into its components. Used as an intestinal antiseptic and astringent.

Formaldehyde-urea is an amorphous, white condensation product of urea and formaldehyde in alkaline solution. It is insoluble in water. Used as disinfectant.

Formalin, Formol—a saturated aqueous solution of formaldehyde.

Formatol is a proprietary dusting powder containing formaldehyde.

Formin—synonym for hexamethylene-tetramine.

Formo-chloral is an oily compound formed by the action of formaldehyde on chloral in the presence of concentrated sulphuric acid. It is used as an antiseptic.

Another compound of this name, used by Trillat as a deodorizer, is made by acting with calcium chloride on formaldehyde in solution in methyl alcohol.

Formoforin consists of formaldehyde 0.18, thymol 0.10, zinc oxide 34.44, and starch 65.28 per cent., and is used for sweating of the feet.

Formopyrin occurs in white crystals formed by the action of formalin on a solution of antipyrin. It is insoluble in cold water or ether, but fairly soluble in boiling water, alcohol, chloroform, and acids, with the latter forming stable salts.

Fortoin—cotoin acted upon by formaldehyde (see *Fortoin*).

Galloformin is prepared by acting on hexamethylene tetramine with gallic acid (see *Galloformin*).

Geoform—guaiacol and formaldehyde (see *Geoform*).

Glyco-formol is a mixture of formalin, water, and glycerin.

Glycero-formol is said to be formed by the prolonged action of formaldehyde on glycerin. It is claimed to be more toxic than formaldehyde, but the writer could find no evidence for this statement.

Hexamethylene-tetramine—the chemical name for aminoform, cystamine, cystogen, formin, and urotropin (see Urotropin).

Holzin is a sixty-per-cent. solution of formaldehyde in methyl alcohol used by Oppermann as a deodorizer.

Holzinol is a mixture containing formaldehyde and menthol.

Krameroform is prepared like tannoform, but from rhatany-tannin.

Lanoform is lanolin containing one per cent. of formaldehyde.

Lysoform is a soapy disinfectant containing formaldehyde (see *Lysoform*).

Naphthoformin is made from paraformaldehyde and the alpha and beta compounds of naphthol. It is used both externally and internally as an antiseptic.

Paraform is paraformaldehyde.

Polyformin Soluble and Insoluble—used in skin diseases (see *Polyformin*).

Preservalin—a mixture used by dairymen.

Protogen is an albuminous food obtained by acting on serum or egg albumen with formaldehyde. It is not coagulated by heat.

Quebrachoform, Quinoform, Querciform are prepared like tannoform (which see), but from the tannins of quebracho, cinchona, and oak.

Saligenin, also yielded by salicin, may be obtained by the interaction of phenol and formaldehyde.

Steriform Chloride and *Iodide*—formaldehyde 5, pepsin 20, lactose 65, and ammonium chloride or iodide 10.

Tannoform—an antiseptic in skin diseases (see *Tannoform*).

Tannopin or *Tannon* consists of tannin and hexamethylene-tetramine, and is used in diarrhœa (see *Tannopin*).

Thymoform is thymol-formaldehyde (see *Thymoform*).

Triformol, Trioxymethylene—synonyms for paraformaldehyde.

Urotropin—hexamethylene-tetramine (see *Urotropin*).

W. A. Bastedo.

FORMANILID ($C_6H_5NH.COH$) occurs in long, colorless prismatic needles obtained by digesting aniline with formic acid, or by rapidly heating aniline and oxalic acid together. It melts at 46° C. (115° F.), and is soluble in water, alcohol, glycerin, and oils. In dose of 0.13–0.3 gm. (gr. ij.–v.) it is antipyretic and analgesic, but is said to depress the heart and produce cyanosis. Its chief employment is as a local anæsthetic in two-per-cent.

solution, as in genito-urinary inflammation, or subcutaneously, or in powder form, mixed with chalk, starch, or talcum, or as a snuff in nasal troubles. *W. A. Bastedo.*

FORMIC ACID.—$HCHO_2$. Formic acid is a heavy, colorless fluid of a sharp, sour odor and taste, soluble in all proportions in water, alcohol, and glycerin. It is exceedingly irritating, producing, when applied to the skin, redness, blistering, and even sloughing, and, taken internally, gastro-enteritis and bloody urine. It has been used occasionally, locally, as a counter-irritant, applied diluted with an equal measure of water.

Edward Curtis.

FORT CRAWFORD MINERAL WELL.—Crawford County, Wisconsin.

Post-Office.—Prairie Du Chien. Hotel.

Access.—Viâ Chicago, Burlington and Quincy, and Chicago, Milwaukee and St. Paul Railroads. Prairie du Chien contains about 4,000 inhabitants, and is one of the oldest towns in the State. The well from which the mineral water is obtained was bored in 1876. At a depth of 960 feet a strong flow of water was encountered, and ever since there has been a continuous stream, six inches in diameter and having a pressure of twenty pounds to the square inch. The well yields about 40,000 gallons per hour. By means of mains and hydrants it furnishes the city fire department, and affords an abundance of water for domestic purposes. It was soon learned that the water possessed medicinal qualities. An analysis by Professor Bode, of Milwaukee, showed the following results:

One United States Gallon Contains:

Solids.	Grains.
Calcium bicarbonate	0.62
Magnesium bicarbonate	10.97
Sodium chloride	90.20
Potassium chloride	3.80
Sodium bromide	.13
Sodium sulphate	12.80
Calcium sulphate	15.38
Iron bicarbonate	.23
Sodium phosphate	Trace.
Sodium bicarbonate	Trace.
Alumina	.66
Silica	3.84
Organic matter	None.
Total	138.63

This is a valuable member of the widely useful alkaline-saline class of waters. It closely resembles some of the Saratoga waters in its mineral constituents, being, however, somewhat milder than those waters. Its chief effects are antacid, laxative, diuretic, and tonic. It is well adapted for the class of diseases to which such waters are applicable. It is also an excellent table water. A well-equipped sanitarium with ample bathing facilities is conducted in connection with the well. The water is used commercially. *James K. Crook.*

FORTOIN, or methylene-dicotoin [$CH_2(C_{14}H_{11}O_4)_2$] is obtained by allowing formaldehyde to act on cotoin, and occurs in yellow, tasteless crystals or powder having a cinnamon-like odor. It melts at 211°–213° C. (412°–415° F.), is insoluble in water, soluble with difficulty in alcohol, ether, and benzol, and readily soluble in chloroform, acetone, glacial acetic acid, and alkalies. Overlach reports thirty cases of diarrhœa in which it was used in dose of 0.25 gm. (gr. iv.) three times a day as an intestinal astringent. He believes it preferable in cases with sloughs of the mucous membrane of the intestine, as, unlike the tannin preparations, it stimulates tissue growth and causes regeneration of the mucous membrane. Its advantages over cotoin are that it is free from pungent taste and is a more powerful bactericide. *W. A. Bastedo.*

FOUNTAIN PARK MAGNETIC SPRINGS.—Champaign County, Ohio.

Post-Office.—Fountain Park. Hotel and cottages.

Access.—Viâ Pennsylvania Railroad (P., C., C. and St. L., Indianapolis Division). The hotel is within five minutes' drive of the Fountain Park Station. The location is 34 miles west of Columbus and 12 miles east of Urbana. Fountain Park village was laid out in 1882 soon after the discovery of the springs. The resort came under the present management in 1894. The site of the village is one of great natural attractiveness. The elevation is 1,200 feet above the sea-level and the surrounding country is gently undulating. The hotel and cottages are located in a beautiful tract of 43 acres in which are numerous hills surmounted by groves of deciduous trees. New acme stone walks and driveways have recently been laid around the hotel grounds, and an artificial lake of sufficient size for boating constructed. The large lawn is adapted for all kinds of outdoor sports and games. Brush Lake, one mile east of the Park, affords rare attractions to the piscatorially inclined visitor. The waters at Fountain Park proceed from five flowing wells. The largest is 2,200 feet in depth and fills a ten-inch pipe at about twenty-one pounds' pressure. Following is an analysis of this spring, made in 1892 by Prof. E. S. Wayne, of Cincinnati:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	13.64
Calcium chloride	4.22
Magnesium chloride	2.12
Potassium sulphate	2.61
Calcium carbonate	26.24
Magnesium carbonate	11.41
Iron carbonate	.16
Silica	.24
Organic matter	.39
Total	61.03

This is an excellent water of the alkaline-saline-calcic variety. The presence of a small quantity of carbonate of iron will prevent debilitating effects on continuous use. The water has been found valuable in acute and chronic rheumatism, gout, dyspepsia, and diabetes. Two of the remaining four wells were analyzed in 1895 by Prof. H. A. Weber of the Ohio State University. They show the same general characteristics as Spring No. 1 (above). There is an excellent modern hotel in the Park. It contains twenty well-equipped bath-rooms, under the charge of an experienced physician. *James K. Crook.*

FOXGLOVE. See *Digitalis*.

FRACTURES.—A fracture is the breaking of a bone or of a cartilage. The sudden forcible destruction of the continuity of a bone in whole or in part, except when done with a cutting instrument, is called a fracture (Stimson). The gradual undermining of the strength of a bone, whether by tumor or by inflammation, does not produce a fracture until a trauma, however slight, snaps the diseased bone. The so-called *pathological* fractures are of this class. The trauma may be so slight as to pass unrecognized, but, nevertheless, this "sudden, forcible destruction of continuity" constitutes the fracture. The only etiological difference between pathological and traumatic fractures is that in the former the disease of the bone predisposes it to fracture and the violence required to produce the fracture is comparatively insignificant.

Varieties.—Fractures are commonly classified as complete and incomplete.

A Complete Fracture is a break traversing the whole thickness of a bone. In a long bone, this implies that the extremities of the bone are separated by the line of fracture. In a flat bone a complete fracture may simply break off a fragment.

Incomplete Fractures may be: (1) Fissured; (2) "Green-stick"; (3) Depressed; (4) Separation of a splinter or of an apophysis.

By a "depressed" fracture is here meant a depression of only part of the thickness of a flat or long bone. It is not an uncommon fracture of the cranial bones.

The commonest of all incomplete fractures is the *green-*

stick fracture (infraction). It usually occurs in the forearm or clavicle, and is rarely seen in adults. The condition of the bone is exactly that of a green stick broken over the knee (Fig. 2200). The bone is bent and on its

FIG. 2200.—Green-stick Fracture.

convexity broken, the line of fracture running inward, transversely or obliquely, and then longitudinally in either or both directions.

Fractures are usually described according to—

(*a*) Their direction, as tranverse, oblique, longitudinal, toothed (dentate), etc. (Figs. 2201, 2202, 2203).

(*b*) The seat of fracture—of the shaft, neck, epiphysis, condyle, epiphyseal separation, etc.

(*c*) Special features—simple, compound, comminuted, impacted, multiple, gunshot, pathological, intra-articular, etc.

A *simple* fracture is one neither compound nor comminuted. A *compound* fracture is one in which the external wound runs down to the seat of fracture. A *comminuted* (Fig. 2204) fracture is one in which the bone is splintered into a number of small fragments. By *multiple* fracture is meant the fracture of several bones or of the same bone in several distinct places. Simple fracture of both bones of the forearm or leg, however, is not spoken of as a multiple fracture. An *impacted* fracture is one in which the broken bone ends are crushed into each other and thus fixed more or less firmly.

FIG. 2201.—Toothed Fracture of the Femur.

ETIOLOGY.—*Frequency.*—Men are more subject to fractures than women (three to one), by the nature of their occupations, and their habits of life. Stimson disagrees with the accepted belief that fractures are most frequent during the winter months on account of the ice and snow, the increased frequency of fracture of the lower extremity in winter (seventy-six to fifty-three) being more than offset by the increased frequency of fractures of the upper extremity in summer (one hundred and seven to sixty-seven.)

Fractures are relatively more frequent in the aged than in the adolescent (Malgaigne, Gurlt), and this in spite of the greater exposure of the latter class to various injuries. This increasing liability to fracture with age is due to a progressive decrease in agility and strength of muscle with which to ward off or minimize an injury, and also to certain changes that take place in the bones themselves.

FIG. 2202.—Oblique Fracture.

Predisposing Causes.—In infancy the structure of the bones is in great part cartilaginous, the bones are elastic, and fracture is rare. In adult life the cartilage is replaced by bone; hence a loss in elasticity and an increase in strength; fractures are more frequent. Later still, when senile changes occur in the body, the bones become thinned by an actual diminution in the amount of bone tissue and a corresponding increase in the contained fatty and connective tissue. The bonc becomes weak and brittle, and in spite of the lessened exposure to injury, fractures are most frequent. The luxations of elbow and hip, for example, are in great part replaced by fracture of the humerus, and neck of the femur, the latter being, *par excellence*, the fracture of old age.

Pathological predisposing causes of fracture are disease of the bone, such as gumma, sarcoma, osteomyelitis, and necrosis. The condition known as osteoporosis is a rare cause of fracture. In this disease the bones appear to have undergone in early life the rarefying process natural in old age. Diabetes, paralysis, locomotor ataxia, osteomalacia, and pregnancy have been noted as causes of this condition. The resulting brittleness of bone is often so marked that many fractures occur almost simultaneously. Such fractures usually heal perfectly well. Prolonged disuse may apparently cause osteoporosis, and some cases are congenital.

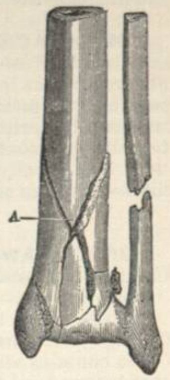

FIG. 2203.—V-shaped Fracture.

Immediate Causes.—A fracture is always caused by some force, external or internal. (1) Fracture by external violence. (2) Fracture by muscular action.

The mechanism of fracture by external violence is usually simple enough. The bone is crushed, broken or twisted, or a fragment is torn away from it. The fracture may be *direct* or *indirect*. A direct fracture occurs at the point of impact, an indirect one by transmission of the force to some more or less distant point. Thus a fall upon the outstretched hand may result in a direct fracture of the carpus, metacarpus, or phalanges, or an indirect fracture of radius, ulna, humerus, or clavicle. This distinction is most important only in compound fractures.

Muscular action is concerned in almost every fracture. Indeed the drunken man who uses his muscles little or not at all is notoriously shielded by a special Providence in this matter. But by "fracture by muscular action" is meant those fractures caused solely by muscular action. The commonest of these is fracture of the patella.

Spontaneous and *pathological* fractures have already been considered.

PATHOLOGY.—When a bone is broken the condition is a laceration of the bone itself, the periosteum, and, to a greater or less degree, of the surrounding tissues.

The bone is broken more or less completely, splintered or comminuted (see Varieties). The periosteum is usually torn in one or more places, and is elsewhere stripped up from one or both fragments, while remaining attached to each and forming a bridge between them. This *periosteal bridge* is of great service in the process of repair.

The damage to the soft parts, if caused by the broken ends of the bone ploughing through them, constitutes a complication of the fracture, while if the fracture is simply one of a number of lesions due to a trauma, the condition of the bone is relatively unimportant. This distinction has no weight in fractures of the extremities where bone lesions are always of primary importance; but in injuries of the skull and thorax an undue prominence is often ascribed to the bone lesion and injuries of the contained viscera are classed as complications of fracture; whereas the presence or absence of fracture has often little or nothing to do with the etiology, prognosis, or treatment of the visceral injury.

The laceration of the skin may, like that of other soft parts, be caused directly by the trauma or indirectly by the protrusion of a fragment of bone either by laceration or sloughing. Here, again, the distinction is of importance. If the fracture is compounded at the seat of injury the wound is usually large and plentifully befouled, while if indirectly compounded by puncture or sloughing over a sharp point of bone,

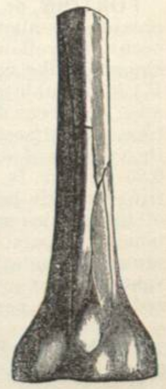

FIG. 2204.—Comminuted Fracture.

the skin wound is comparatively small and clean; the probability is that it will escape infection, and as a compound fracture it is comparatively unimportant.

PROCESS OF REPAIR.—Within the first few hours after a fracture has been received the contusion and laceration of the various tissues produce a hæmatoma and then œdema. This œdema increases for twenty-four or forty-eight hours and then gradually subsides. The application of moist heat and pressure to the limb minimizes the œdematous reaction and hastens its resorption. During this period, the periosteum like the other tissues is boggy and thickened, and the bone ends lie in a cavity of greater or less size, full of semi-coagulated blood. As the œdema disappears, granulations spring from the periosteum, the surrounding soft parts, the marrow, and the bone itself. At the same time the blood collection disappears, partly by absorption and partly by making its way along the various fascial planes whence it may finally reach the surface, forming an ecchymosis some days after the injury and thus constituting one of the signs of fracture.

Thus the process of repair begins by simple granulation of all the lacerated structures, and it may be said to have completed its *first stage* when these granulations, spreading along the periosteal bridge or simply filling the cavity between the bone ends, completely envelop the region of fracture in a mass of granulation tissue. This mass is called the provisional callus. Its shape and size, as well as its relation to the bone ends, depend on the amount and nature of the displacement. If this is slight the callus is small; if considerable, it is large and irregular. This callus is formed chiefly by granulations springing from the periosteum (Fig. 2206), and in a less degree from the marrow, and also by a thickening of the periosteum and by granulations from the soft parts and the bone ends. The greater part of the callus, that arising from the periosteum, first changes to cartilaginous tissue and then to bone; the callus formed from the marrow goes through no cartilaginous formation, but becomes bone directly, the osseous formation beginning around the inner surface of the bony shell and extending inward until it entirely occludes the medullary canal (medullary plug), and outward to meet the periosteal callus and the medullary plug of the other fragment.

By this time, toward the end of the third or fourth week, the healing of the soft parts is complete, the ecchymoses are disappearing, and the callus, composed of bone within and cartilage and bone without, is quite firm everywhere except over the broken edges of the fragments. The delay here is due to the very slow progress of bone granulation, partly because of the comparatively poor circulation of that tissue and partly because a thin shell along the surface of the bone is cut off from the circulation and has to be absorbed, as have also the splinters which must inevitably be torn away at the time of fracture, before the callus can unite firmly to the bone itself. This concludes the *second stage* of the process of repair.

The osseous callus now unites the bone ends very much as a mass of solder connects two ends of pipe, with this important difference, however, that the callus is a solid mass obstructing the lumen of the "pipe" as well as extending beyond its circumference. In the *third and final stage* of repair the superabundant callus is gradually absorbed. The lumen of the bone is cleared, the callus between the bone ends becomes firmer and more compact, approaching in structure very nearly to that of the bone ends which it connects, and the external callus is absorbed until in some cases, when the bone has been accurately "set," there remains no trace of the fracture. Thus the reparative process is completed months after the receipt of injury. In most cases, however, the reduction of the fracture is not and cannot be absolutely accurate, and in these cases the displaced bone is fortified by a permanent exuberance of callus which persists during the life of the subject. At the same time projecting edges of displaced bone are rounded off in the process of callus absorption. If the exuberant callus invades a joint cavity or surrounds a nerve, ligament, or tendon, the chisel may be required to reduce it.

The fate of completely detached fragments of bone is interesting. Small splinters are probably always absorbed, but, judging from the appearance of old fractures, it is probable that fairly large fragments may become embedded in the granulations, derive new circulation from them, and end by forming an important element in the reconstructive process. On the other hand, fragments may remain embedded but unattached to the callus for years, and their presence be first suspected when, on account of debility or inflammation elsewhere in the organism, they become centres of suppuration which go on to abscess and fistulization and persist until the offending fragment is removed.

In fractures of the skull the repair is chiefly effected by the diploë which is not capable of producing exuberant callus or of closing in large defects, such as those left by a trephine opening.

Fracture of spongy bones or of the spongy ends of long bones is repaired chiefly by the bone itself. Fracture of cartilage is slow to heal and the union is chiefly fibrous. Hence old fractures crossing a joint surface are usually marked by a line of fibrous tissue or bare bone where the cartilage has been lacerated, though in exceptional instances the callus is exuberant.

The histological processes of callus and bone formation and resorption are quite the same as take place in the normal growth of a bone.

The repair of a compound fracture differs in several ways from that of a simple fracture. In the first place the primitive œdema and hæmatoma are less on account of the free escape allowed to the blood and serum. A more important difference, however, lies in the result of infection. If the wound suppurates, healing is delayed by the casting off of all fragments, by the death of a layer of some thickness along the broken edge, and especially by the destruction of the periosteum. The bone is reformed entirely by the medullary plug which grows slowly (and does not undergo immediate cartilaginous formation). The callus is large and irregular and fragments of dead bone caught within it may prolong the suppuration indefinitely.

SYMPTOMS AND DIAGNOSIS.—The symptoms of fracture are subjective and objective. The subjective symptoms are the history, pain, tenderness, and loss of function. The objective signs are deformity, abnormal mobility, crepitus. It is usually one or more of the subjective symptoms that lead to the suspicion of fracture, while it is upon the objective signs that the diagnosis is based.

SUBJECTIVE SIGNS.—The *history* of the patient may relate to previous fractures which have left a deformity that might otherwise be misleading. A history of active syphilis affects the prognosis and treatment. In old fractures the history may be of valuable assistance, though in recent cases it is usually indefinite and unreliable.

Pain and tenderness are constant symptoms of fracture unless the patient is intoxicated, comatose, or suffering from some grave lesion of the central nervous system. Spontaneous pain is usually diffuse and referred rather to the point of greatest contusion than to the point of fracture. Thus in Pott's fracture, the pain is often greatest over the inner side of the joint, though the chief lesion of the bone is in the other side. Tenderness is, however, a more definite symptom. It is usually localized over the point of fracture and may be a great aid in establishing this point accurately. This is especially the case in fracture of the ribs and fibula (*q. v.*). It is a universal rule that *when pressure applied laterally or in the long axis of a bone evokes pain at a distance from the point where the pressure is applied there is a fracture at the painful point.*

Loss of function may be considerable or slight. When the shaft of a long bone is broken function is lost in most instances. Yet the loss of function is in part due to pain and fright, and hence varies with the nervous quality of the patient.

Objective Signs.—Without the objective signs the diagnosis of fracture is never certain. They are essential. The objective signs of contusion or laceration of the soft parts, always present in greater or less degree, sometimes (*e.g.*, compound fractures) facilitate the diagnosis, but more often only obscure the objective signs of the fracture itself.

Fig. 2205.—Fracture of the Shaft of the Femur. Overriding and angular displacement; faulty union.

Deformity.—The deformity caused by fracture is the result of injury to the soft parts as well as of displacement of the broken bone. In some fractures the bone deformity is characteristic and unmistakable, but it is too often obscured by the effusion of blood and consecutive œdema to be a symptom readily determined by simple inspection. Hence the four methods of determining the existence of deformity, *viz.*, inspection, palpation, mensuration, and the *x*-rays.

The deformity is caused by displacements of the broken ends of the bone. The displacement may be slight or great, characteristic or obscure; hence the variety of means adopted to recognize it. Malgaigne has classified displacements as transverse, angular, rotary, overriding, impaction or crushing, and rarest of all, direct longitudinal separation. Clinically the displacement may come under two or more of these classes (*e.g.*, overriding and angular) (Figs. 2205, 2206).

Inspection may suffice to determine the existence of displacement. *Palpation* may determine the angular deformity of a bone or the protrusion of sharp fragments close under the skin; but abnormal motility and crepitus (*q. v.*) are *par excellence* the data sought by palpation.

Mensuration, on the other hand, is often of great service in the estimation of deformity, for whether impacted or overriding, the broken bone is usually shortened by muscular tension and swelling, the increase in circumference of the member being compensated for partly by shortening and partly by the elasticity of the integument. However obscured the deformity at the point of fracture, the shortening of the bone may be estimated by comparing its length with that of its fellow of the opposite side. In applying mensuration, however, two most important facts must be borne in mind:

1. There may be a previous difference in length, either congenital or acquired, of the two bones.

2. In comparing the length of the long bones of a limb it is often necessary to measure from bony points not on the same bone. In this case the bones to be compared must be in the same relative position.

In other words, if the injured limb is measured in the abducted or flexed position, the measurements of the uninjured member must be taken with it *at the same angle* of abduction or flexion. Neglect of this simple precaution is often a grave source of error in estimating shortening from fracture of the neck of the femur. The measurements are usually taken from the anterior superior spine of the ilium to the external malleolus, and the injured limb, whether fractured or not, usually lies slightly abducted and flexed, while the patient instinctively protects it by adduction of the sound limb. The relative positions of the limbs cannot be appreciated unless the patient is laid flat on his back and stripped so that the two anterior superior spines can be distinctly felt. A string drawn tightly from one to the other marks the horizontal plane of the body, and a perpendicular dropped from the centre of this marks the sagittal plane with which the abducted thighs should make equal angles.

Measurements of the diameter or the perimeter of the limb are entirely fallacious.

Abnormal Mobility and Crepitus.—These two symptoms might be termed the accessory symptoms of fracture. When obtainable there is nothing more characteristic of fracture than abnormal mobility along what should be the firm shaft of a bone, especially if accompanied by a grating sensation of crepitus imparted to the fingers rather than to the ear of the surgeon as the rough bone ends are made to rub against each other. But while these two signs are more frequently sought for than any other of the signs of fracture, they may be misleading and non-essential to a complete diagnosis, and the search for them is often the occasion of rough and painful manipulations injurious both to the patient's tissues and to his mental attitude toward the surgeon. In this matter gentleness is far more successful than force, for force assures the resistance of the patient's muscles at the same time as it blunts the sensitiveness of the surgeon's fingers. The methods of eliciting abnormal mobility and crepitus are two; (1) pressure; (2) passive motion.

Pressure is usually applied transversely to one or alternately to each of the fragments with the intent of making them slip by each other. Passive motion, angular or rotary, is employed for the purpose of demonstrating that one fragment (or some bony prominence upon it) is unaffected by motion communicated to the other.

The commoner causes of error are impaction which prevents both abnormal mobility and crepitus, the interposition of soft parts which prevents crepitus or the existence of that form of fracture known as epiphyseal separation, in which crepitus is cartilaginous. Moreover, in injuries about a joint abnormal mobility may indicate either fracture or dislocation, perhaps both, and the rule that "in fracture there is mobility where before there was none, while in dislocations abnormal mobility in one direction is compensated by restricted mobility in other directions," may not be practically applicable.

X-Rays.—The report of the committee of the American Surgical Association defines very accurately the present status of the *x*-rays in the diagnosis of fractures. Among their conclusions are the following:

1. The routine employment of the *x*-ray in cases of fracture is not at present of sufficient definite advantage to justify the teaching that it should be used in every case. If the surgeon is in doubt as to his diagnosis, he should make use of this as of every other available means to add to his knowledge of the case, but even then he should not forget the grave possibilities of misinterpretation. There is evidence that in competent hands plates may be made that will fail to reveal the presence of existing fractures or will appear to show a fracture that does not exist.

2. In the regions of the base of the skull, the spine, the pelvis, and the hips, the *x*-ray results have not as yet been thoroughly satisfactory, although good skiagraphs have been made of lesions in the last three localities. On account of the rarity of such skiagraphs of these parts special caution should be observed, when they are affected, in basing upon *x*-ray testimony any important diagnosis or line of treatment.

Fig. 2206.—Malunion after Fracture of the Shaft of the Femur. Shows callus formation under periosteal bridge.

3. As to questions of deformity, skiagraphs alone, without expert surgical interpretation, are generally useless and frequently misleading. The appearance of deformity may be produced in any normal bone, and existing deformity may be grossly exaggerated.

4. It is not possible to distinguish after recent fractures between cases in which perfectly satisfactory callus has formed and cases which will go on to non-union. Neither can fibrous union be distinguished from union by callus

in which lime salts have not yet been deposited. There is abundant evidence to show that the use of the *x*-ray in these cases should be regarded as merely the adjunct to other surgical methods, and that its testimony is especially fallible.

Diagnosis.—In general the diagnosis of fracture is made by inspection and gentle palpation, aided perhaps by mensuration. Most of the commoner fractures are marked by a characteristic deformity, or by some other pathognomonic sign.

In compound fractures the diagnosis should be made with as little probing as possible. If the wound is small and clean it should be drained or sealed after it has been thoroughly irrigated, and the diagnosis made as in simple fracture. If, however, the wound is wide and befouled, the diagnosis of the exact nature of the fracture is readily determined in the course of the preliminary antiseptic toilet.

Young persons up to the age of twenty-five present two special points of diagnosis. In the first place, when they receive a fracture through the extremity of a long bone, it is very likely to follow the line of least resistance along the unossified cartilage between the diaphysis and epiphysis, thus forming an *epiphyseal separation.* The diagnosis of this condition is made on three data: first, the correspondence of the line of fracture either wholly or in greater part with the line of the epiphyseal cartilage; second, the "muffled" cartilaginous crepitus obtained when the bone ends are drawn across each other; and third, the subsequent atrophy of the torn cartilage often resulting, unless the bone has attained its full growth, in a shortened deformed limb. The most important epiphyseal separations are those of the upper extremity of the humerus and the lower extremity of the radius, since these injuries are comparatively common and these epiphyses together are responsible for two-thirds of the growth of the upper extremity. The second point of importance in the diagnosis of fracture in young persons is the frequency of incomplete fractures. The *green-stick* fracture, practically unknown in the adult, occurs with comparative frequency in the young as a result sometimes of a slight trauma. If the break is insignificant the only clinical evidence of it is an abnormal protuberance of the shaft of the bone. This may pass for a mere contusion, especially if the superficial tissues are considerably bruised. Such fractures are unimportant since they require no attention and have no more consequence than an outgrowth of callus which is absorbed in the ensuing months. More severe "green-stick" fractures produce a curving or angular deformity of the bone and a considerable protuberance of the split fragment, so that the diagnosis is not difficult.

Differential Diagnosis.—A fracture must be differentiated on the one hand from a dislocation, and on the other from a sprain or bruise. In either case the confusion is likely to arise only in the region of a joint, where, from the slight deformity, the difficulty in eliciting crepitus and abnormal mobility, and the unimportant interference with function (*e.g.*, many Colles' and some Pott's fractures), the injury may be mistaken for a sprain; or because of the great swelling of the soft parts all landmarks may be obscured. In such a contingency, if an accurate diagnosis cannot be reached by the aid of the ordinary data, an examination should be made with the patient anæsthetized, or, better still, if the apparatus is at hand, the *x*-rays may be employed.

Prognosis.—If a fracture is properly reduced and immobilized, the primary inflammatory reaction may be expected to subside in from three to ten days. During this period there is more or less discomfort; but later physiological rest and a comfortable splint may be depended upon to relieve the patient of almost all his pain. The amount of rest required depends upon the nature of the injury and the individuality of the patient. The laboring man who insists upon walking off on an ambulatory splint two days after he has received a Pott's fracture is not to be classed with the neurasthenic woman whom the same injury confines to her room until long after the bones have united. Immobilization is almost as unimportant in the treatment of Colles' fracture as it is essential in fracture of the patella.

Age affects the prognosis in that metabolism is less rapid in the aged; their bones heal more slowly and their confinement to bed may result in bed sores and permanent debility; while if they escape this, a permanent stiffening and neuralgic condition of the affected limb may result. In the young the prognosis of simple fracture is entirely good, unless there is epiphyseal separation.

Habits and *disease*, such as alcoholism, syphilis, and general debility, affect the prognosis in proportion to their severity. The shock of fracture will often bring on delirium tremens in an alcoholic subject. Such an attack may sometimes be averted by getting the patient up and about immediately, in addition to the usual therapeutic measures. Syphilis in an active stage may delay or prevent union in a broken bone, and any chronic debilitating disease may have a similar effect.

Certain qualities of the fracture itself must be considered in the prognosis. For example, the prognosis in *compound fractures* is far graver both as to life and limb than that of simple fracture. Indeed, what with the dangers of suppuration, septicæmia, delayed and malunion, it is almost impossible to give an accurate prognosis for a compound fracture until healing is well advanced. Again, *fractures of spongy bone* heal far more rapidly than fractures of the shaft. But, on the other hand, the spongy bones lie chiefly in the region of joints, and if these are invaded by the callus, or even if merely immobilized during the process of repair, the stiffness resulting from prolonged inaction may indefinitely delay complete recovery. Indeed, the union of the bone is only the skeleton of the cure as far as the patient is concerned. When the bones are sound he is "set upon his feet," but it may be weeks before he is "limbered up" enough to accomplish anything but the lightest labor. In this connection Loew's figures are instructive and represent a most successful series. Of 167 simple fractures of the leg, one was permanently disabled, and the others were able to return to work in an average of one hundred and one days (seventy per cent. of them in ninety-one days), more than twice the classical limit assigned to the healing of a fracture of the leg. In this matter of regaining function, age is of prime importance. The young and vigorous regain both strength and agility in a few weeks, while the aged and rheumatic remain stiffened and more or less completely decrepit. The joint implicated also makes a difference. The fingers and toes are especially liable to stiffening when extended. Other elements in the prognosis are afforded by the complications.

Complications.—The pain, œdema, and contusion of the soft parts during the first days, and the later stiffening of the joints, occur as complications to almost every fracture, however normal the process of repair, and they have therefore been described above. The remaining complications may be early or late, local or general.

Among the *early local complications* the most important are the laceration of the soft parts producing a compound fracture, penetration of a joint by the line of fracture, and fracture dislocation.

A *compound fracture* may be direct or indirect. Direct compound fracture occurs when the trauma causing the fracture tears open the soft parts surrounding the bone. Indirect compound fracture is caused by the protrusion through the skin of one of the fragments, perhaps at some distance from the point of injury. This may be due to displacement at the time of fracture or during the subsequent manipulation or transportation; or it may occur later by sloughing of the tissues over a sharp fragment on account of faulty splints. The distinction between direct and indirect compound fractures has an important bearing on the prognosis and treatment. In the former class the wound is often gaping, irregular, and befouled; wherefore the prognosis is bad and the primary antisepsis must be thorough. In the latter the small, clean wound may often be cleansed by superficial antisepsis, without disturbing the deeper tissues.

Fractures implicating joints, *intra-articular fractures*, imperil the integrity of the joint both by displacing the articular surfaces and by the production of callus which may invade the joint cavity and impede its motion or even unite the opposing articular surfaces by fibrous or bony union, thus altogether preventing motion.

Fracture dislocation is often a very serious condition. The various fracture dislocations will receive special mention.

Other early local complications are laceration of a nerve, gangrene from rupture, thrombosis or occlusion of vessels, profuse, even fatal hemorrhage through laceration of a large vessel, and traumatic or arterio-venous aneurism from the same cause. Gangrene and muscular contracture from improper splinting are complications of the treatment rather than of the fracture itself.

Suppuration and septicæmia, so common in direct compound fractures, are rare otherwise. *Fat embolism* is most exceptional. In the first days after fracture, fat globules may sometimes be found in the urine. Of exceptional occurrence are the cases in which within twenty-four or forty-eight hours of the injury the patient is suddenly overcome with dyspnœa and dies sometimes with symptoms of pulmonary embolism, sometimes with œdema of the lungs, sometimes with predominence of symptoms from the central nervous system, unconsciousness, paralysis, convulsions. On autopsy the pulmonary or cerebral capillaries are found occluded by minute globules of fat, derived, it is presumed, from the bone marrow. Opinions differ as to how much influence fat embolism has in the production of "delayed" shock, and irregular "delirium tremens" occurring within the first few days after fracture. *Delirium tremens* and *pneumonia* are not infrequent complications of fractures in alcoholic subjects, both on account of the shock and the confinement to bed. Either condition is a very grave one coming on during the first week and often terminating fatally.

The *late complications* of fracture are all local. Persistent pain of a rheumatic, gouty, or neuralgic character, atrophy of the muscles from disuse, arrest of development in the bone after epiphyseal injury, and stiffness of the joints from prolonged immobilization have already been alluded to. Permanent atrophy and paralysis may result from rupture of a nerve, and permanent neuralgia from the inclusion of a nerve within the callus. There is always some œdema when the limb is first allowed to hang down. This is transitory, however, unless maintained by other causes.

The callus may be painful, excessive, or weak. Pain localized in the callus is rare and suggestive of threatening suppuration, inclusion of a nerve, or hysteria. That the callus should be excessive at first is not abnormal nor is it to be expected that a small callus will suffice to weld two widely separated or widely displaced fragments. Indeed, except from an æsthetic point of view, excessive callus is not a complication unless it produces pressure on some vital structure or impedes the action of a joint or muscles. In such a case recourse must be had to the chisel, but only after several months of massage and motion have proven that resorption is not to be expected. Pathological weakness in the callus—weakness, namely, after the time necessary for consolidation has elapsed—is unusual except from considerable displacement, from compound fracture in which suppuration has occurred, or from systemic debility or disease. Primary sarcoma and secondary carcinomatous deposits have very rarely been observed after fracture. Weakness of the callus produces the condition known as delayed union.

Delayed union (failure of union, pseudoarthrosis) is that condition in which the callus uniting a fracture fails either wholly or partially to ossify, so that the fragments are connected by a mass or band of fibrous tissue, or rarely by a distinct joint.

From this definition must be excepted certain fractures, such as those of the patella, the olecranon, and other apophyses, in which bony union is unusual and unessential. A theoretical distinction may be made between delayed union, in which union is still possible, and failure of union in which it is not. But it is never certain in any given case that union is impossible unless years have passed from the time of the injury, and hence the more hopeful term is preferable.

The causes of delayed union have been briefly enumerated above. Although every form of lowered vitality has been incriminated, local conditions are to blame in the great majority of cases. Either the fracture is a "pathological" one, in which case the "pathological" factor must be removed before union can be expected, or the bone ends have not been kept in apposition, on account of faulty immobilization, the interposition of the soft tissues between the fragments, or the interposition of a considerable amount of comminuted bone detached from its periosteum. A common cause of delayed union is suppuration, notably in compound fractures. Even a slight inflammatory reaction destroys the osteogenetic power of the periosteum and leaves to the marrow the burden of ossification. Hence this process is always slow and often fails entirely. Loss of periosteum is the usual cause of delayed union after operations on bone.

Especially common is the delayed union after a comminuted or compound fracture of both bones of the leg. The fibula unites speedily, and thus holds the fragments of the tibia at such a distance from each other that the bony callus is inadequate to bridge the gap. The same thing may occur in the forearm.

Finally there are certain fractures which do not unite, although apposition, immobilization, and all the other factors are apparently perfect. Such failures are not explained.

The morbid anatomy of delayed union depends on many factors. The bones are united either by a band of fibrous tissue or by a distinct joint. In the former case there may be but little change in the shape of the fragments. Their edges may be slightly rounded off; but except for this, they remain as they were at the time of the fracture, united simply by a fibrous band in which no ossification has taken place. Or, on the other hand, there may have been some attempt at ossification, manifesting itself in exuberant callus, or in partial ossification of the fibrous band. Or, finally, there may be a progressive rarefying ostitis rendering the fragments soft and pointed and gradually absorbing them, thus constantly enlarging the gap.

Where there is a distinct joint (nearthrosis) the bone ends enlarge and become eburnated—they are said even to become covered with cartilage—and lie in a cavity containing a pseudo-synovial fluid, and surrounded by a dense fibrous capsule.

Fig. 2207.—Union of Bones of Forearm by Callus.

The prognosis depends on the amount of abnormal mobility, the time which has elapsed since the receipt of injury, the general health of the patient, and the treatment he has already undergone for the purpose of remedying the defect. In general, the prognosis should be guarded; for while union may be obtained by persistent efforts in apparently desperate cases, and after the lapse of many months, all efforts may fail even though the defect be small and the condition of the patient excellent.

Faulty union, by which term a union with deformity that might have been avoided is understood, is rather a complication of the treatment than of the fracture itself. In certain cases, on account of the nature of the fracture or the condition of the individual, any union, with however much deformity, is a proud achievement rather than a failure. Indeed, after no fracture is it possible to predict with certainty that every trace of the injury will disappear in time, while in many cases a greater or less amount of deformity will surely persist for all time. A common form of mal-union is union of the two bones of the forearm to each other (Fig. 2207), a condition which effectively limits pronation and supination.

Treatment.—The treatment of fractures in general will be considered according to the following scheme:

I. Prophylaxis.
II. Treatment of simple fractures.
  General measures.
    Reduction.
    Immobilization, temporary and permanent.
  Accessory measures.
    The management of joints.
    Massage.
    Hot air.
    Direct fixation.
III. Treatment of compound and gunshot fractures.
IV. Treatment of articular fractures.
V. Treatment of complications.
  Early—
    Gangrene.
    Nerve injury.
    Suppuration and sepsis.
  Late—
    Pain.
    Joint stiffness.
    Exuberant callus.
    Delayed union.
    Mal-union.

I. *Prophylaxis.*—The prophylaxis of fracture is more a matter of common sense than of surgery. No especial precautions need be suggested except to the surgeon. Fracture of the arm or leg of a fœtus during instrumental delivery is unfortunately not the most uncommon thing in the world, and the same may be said of fracture during operations on diseased bones. To avoid fracture in the latter class of cases it is not sufficient to leave a firm bridge of bone untouched. Besides that precaution the surgeon must be gentle in the use of heavy chisels and large forceps, lest the jar caused by the avulsion of a fragment be sufficient to split the entire shell.

II. *Treatment of Simple Fractures.—General Measures:* The first thought that arises after the diagnosis of fracture has been made concerns the *setting* of the broken bone. Yet many impediments may arise to make the setting or reduction of the fracture a matter of secondary importance. The patient's condition may be such as to demand immediate removal to home or hospital. It may be impossible to make a definite diagnosis or immediately to effect reduction on account of local swelling or spasm. In such cases transportation is the immediate question, and whether the fracture has been set or not, it is of the greatest importance that the injury already inflicted be not increased by the jolts and jars of travelling. To this end the fractured limb must either be confided to the care of an intelligent attendant who shall support it in his hands, or it must be bound firmly but not tightly to a board or a barrel stave, care being taken to immobilize the adjacent joints as well as the fragments themselves. And since the greatest danger is that the fragments may be driven through the skin and a simple fracture thus rendered compound, the dressing is to be applied with sufficient pressure near bulging fragments to secure safety in this regard. It is scarcely necessary to recommend gentleness and despatch in transportation as well as in the local manipulations.

If the patient is to remain long in bed, the quality of the bed demands consideration. If impending bed sores are foreseen, the patient will ultimately have to lie on a water bed, and he should be placed there from the beginning. If one of the long bones of the lower extremity is broken, a flat couch is necessary, such as can be produced by sliding several boards between the springs and the mattress of an ordinary bedstead. Fancy fracture beds are unessential.

The patient, once in bed with his fracture reduced and immobilized, as a rule has to pass long weeks of waiting before the member can be of use again, and it is the surgeon's part to attend during this season more to the general condition of the patient than to his fracture. The fight may be a life-and-death one, or it may be a mere question of when to get the patient about. But in any case, however insignificant, the surgeon who wishes to do full justice to his patient will not be satisfied with mere union of the broken bone, but will, by the aid of those measures grouped as "accessory," endeavor to leave his patient in the best possible condition at the time he throws off his splints and is "discharged cured."

Reduction: Many fractures cause no displacement and therefore require no reduction. Such are fractures of the ribs, pelvis, shaft of the fibula, etc. Many others are complicated by some impediment to reduction. Such an impediment may be temporary or permanent.

The local swelling caused by hemorrhage or œdema may, by obscuring the diagnosis and preventing immobilization, make it advisable to postpone reduction. Elevation of the limb and a temporary dressing applied as firmly as the patient permits will speedily reduce the swelling. Muscular spasm occasionally impedes reduction in the same way and may be overcome by similar measures or by the administration of chloroform or opium. The danger of gangrene may also discourage reduction during the first few days, although reduction often lessens this danger. In any such case reduction may usually be postponed for two or three days with perfect propriety and with no subsequent effect on union or function; but longer delay is inadvisable lest the bones acquire relations with the surrounding tissues so firm as to impede reduction.

Reduction is never literally impossible in a recent fracture, though it may well be inadvisable if the operation for the removal of the impediment to reduction involves too great a risk or puts the patient in a worse condition than before. Thus certain impacted fractures, notably fracture of the neck of the femur, are irreducible, since reduction, which could be accomplished only imperfectly and with great difficulty, would separate the ends of the bone, so that in place of a slightly deformed and shortened member a false joint would result, with considerable or complete loss of function. Another form of permanent obstruction occurs when reduction is mechanically impossible because of interposed soft parts, or fragments of bone, or interlocking of the bone ends. The associated contusion may make the diagnosis as doubtful as the treatment.

In face of such complications the surgeon may well hesitate. The choice lies between immediate operation and expectant treatment in the hope that the patient may yet have a fairly useful limb which may in any case be improved by a later operation. As a rule, immediate operation is to be preferred, and irreducible fractures involving a joint especially demand the knife, for if let alone they will almost inevitably heal with excessive callus, impaired function, and with little prospect of relief by secondary operation.

Elements which should weigh against operation are the unfamiliarity of the surgeon with such treatment, and the impossibility of obtaining asepsis. The best results will be obtained if operation is performed within twenty-four hours of the time of fracture. Later, the union is delayed by œdema and contusion. The operative method is described below.

Unless some of the above complications are present, the sooner the fracture is reduced the better. This is not only that union may progress favorably but also for the comfort of the patient; his pains are immediately lessened and the œdematous reaction is diminished.

The general principles upon which reduction is usually performed are:

1. To place the lower fragment in the same plane as the upper one, and

2. To draw it into place by relaxing the muscles as much as possible, and by traction and counter-traction.

These rules hold good because the upper fragment (the one nearest the body) is usually more or less fixed by the muscles attached to it, and the lower fragment must be

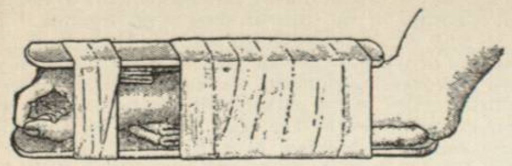

FIG. 2208.—Board Splints Applied.

manipulated with a knowledge of this position, obtained often rather from anatomy and pathology than from inspection and palpation of the broken limb.

Evidently no generalization is possible in this matter. Each fracture must be discussed individually. But few fractures are reduced directly by apposing the fragments, although local manipulations are often employed to aid traction as well as to ascertain its results.

The reduction of green-stick fractures is accomplished by forcibly bending the bone back until it is straightened. It may be necessary to break it entirely across before it will remain straight.

Small fragments, if they interfere with reduction or threaten to slough through the skin, should be removed with due antiseptic precautions.

If one of the fragments pierce a muscle, relaxation of the muscle by flexion or extension of the neighboring joints may aid materially in its extraction.

Immobilization: The apparatus employed to retain a fracture in place is called a splint. Before describing the different varieties of splints, temporary and permanent, a few rules governing their use may be laid down.

1. The splint must immobilize the broken bone. To do this it must usually immobilize the joints at each end of the bone.
2. It must not be allowed to interfere with the circulation, hence
3. Temporary splints to be used during the first few days after fracture, while the circulation of the limb is impaired, should never consist of a snug encasement.
4. Splints made of metal or board should be wide enough to prevent the circular retention dressing from encircling the limb snugly, and
5. The toes and fingers must always remain exposed as indices of the circulation in the extremity.
6. When a dressing is applied to the upper part of a limb, light compression by bandage should be carried to the toes or fingers to prevent œdema and pain.
7. Every patient wearing a splint should be inspected

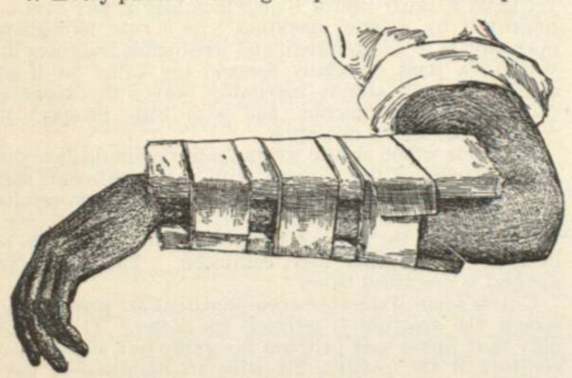

FIG. 2209.—Mode of Using Adhesive Plaster for Retaining Splints.

once a week, and the splint removed for that purpose, if necessary.

8. After the first two weeks (or even sooner) the splints should be so arranged as to allow the greatest possible freedom to adjoining joints as far as compatible with the union of the bone.

Once the fragments are in place they must be kept so. Yet in many instances during the first few days there is so much swelling about the seat of fracture that the retentive apparatus must be applied as much for pressure as for immobilization, and after the swelling has been thus reduced this primary dressing is no longer suitable. Other reasons for the use of a temporary dressing are transportation and the treatment of compound fractures. In many varieties of fracture the temporary apparatus may be entirely dispensed with, permanent dressings being applied at once.

Temporary Immobilization: The important requirements of a temporary splint are that it may be (1) everywhere obtainable, and (2) universally and readily applicable. Hence wide side splints of board, cardboard, or metal are usually employed for this purpose (Fig. 2208). Such articles are obtainable everywhere and may be bound to the limb with any cloth, though adhesive plaster makes the best binder (Fig. 2209). The board need only be wide enough to prevent the bandage from compressing

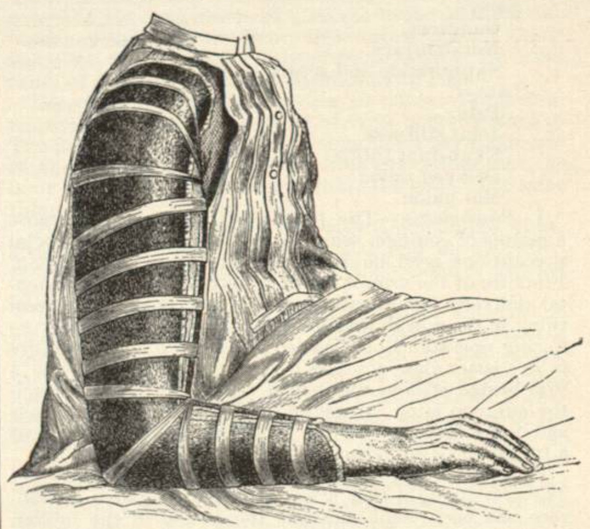

FIG. 2210.—Moulded Splint for Fracture of the Humerus.

the limb laterally and long enough to immobilize the adjacent joints. It should be roughly padded with cotton, heaped up to fill the space left by the natural depressions of the limb and thickened around the bony prominences (but not on them) so as to prevent pressure upon them.

When the material is at hand, *moulded splints* of gutta percha (Fig. 2210), leather, felt, or wire mesh make more elegant and lighter splints. But these have been discarded by most surgeons in favor of moulded splints of *plaster of Paris.* This substance is easily obtained and can readily be moulded into a splint which, for durability, stoutness, and lightness, leaves nothing to be desired. Unfortunately the plaster adheres firmly to the surgeon's hands, and although this may be prevented in some degree by anointing the hands with vaselin, and its removal assisted by glycerin and hot water, yet it is an annoyance that cannot be completely overcome.

To make a *plaster-of-Paris splint,* previously prepared bandages may be employed or the plaster may be applied to the bandage at the making of the splint. The former method is by far the simpler; but unless the bandages are hermetically sealed in tins they soon absorb enough moisture from the atmosphere to render them absolutely useless, and unfortunately their condition cannot always be determined until they are being applied.

If prepared bandages are to be used to make a moulded splint, they are immersed in hot water to which a little

salt or zinc sulphate is added. The length of splint required is measured off with a muslin bandage, which is then laid upon a towel or oilcloth. By this time the plaster bandage will be soaked through, and may be taken from the water, squeezed gently and applied back and forth until the muslin bandage (which had best be a double thickness) is covered by six or eight lengths of plaster bandage. A little of the hot water sprinkled here and there adds smoothness, and the whole is strengthened and polished with a handful of dry plaster rubbed in and moistened. This band is then applied lengthwise to the limb with the muslin bandage next to the skin. A snug roller bandage binds it in place, and the limb being laid or propped in a suitable position, there results in about six hours a light, strong splint, perfectly moulded to the limb and removable at will.

If there are no prepared bandages at hand, the plaster is poured into an agate basin, enough hot water is added to bring it to the consistence of a rather thin paste, and it is then applied to the muslin bandage between the folds of a gauze bandage, a layer of plaster being spread quite thick between every two layers of bandage. Six or eight layers of the gauze bandage are used and the dressing is finished and applied as directed above. When using the prepared bandages the tendency is not to wet them enough; when using the fresh plaster to wet it too much. Hence the latter usually sets more slowly.

Such devices as waterproofing the exterior of a splint with varnish, protecting it with rubber tissue, or strengthening it with additional plaster at its angles or with iron

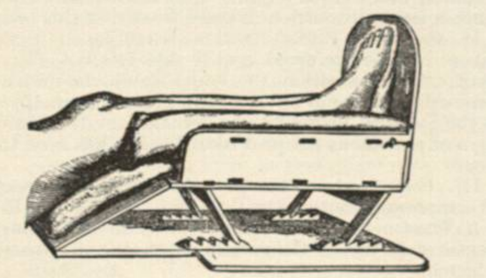

FIG. 2211.—Petit's Fracture Box.

bands or bass wood slivers, will suggest themselves to the surgeon. Such splints should last two or three weeks.

For fractures of the leg or ankle the *fracture box* (Fig. 2211), or better the *Volkmann splint* (Fig. 2212) is often applied during the first few days. Unless care is taken to prevent it, the pressure of the heel upon the splint causes excruciating pain and later ulceration. To avoid this the foot is suspended by a strip of adhesive plaster passing from the ankle under the heel and along the sole of the foot and over the top of the foot-piece to which it is attached by a reversed strip. This splint, moreover, must be well padded, especially on each side of the tendo Achillis. If pain is felt in spite of these precautions it may be relieved by pushing the cotton from under the heel up on each side of the ankle. When using these appliances a snug bandage should be previously applied to the limb in order to hasten the subsidence of swelling.

Permanent Immobilization.—The various splints described in the preceding paragraph, except the moulded splints, are too clumsy and do not produce sufficient immobilization to be useful after the first œdematous reaction has subsided. As for the moulded splints, the more one uses them the more satisfactory they seem, especially for fractures about the upper arm and leg; but when the primary reaction subsides the primary splint no longer fits and must be exchanged for a tighter one.

For strictly permanent dressings, to be changed not oftener than every week or two, a complete *encasement* of the limb in *plaster of Paris* forms a very efficient splint (Fig. 2213). The limb is first encased in a thin layer of cotton or muslin bandage (or it may be simply greased thickly with vaselin) and held in proper position while the wetted (*v. s.*) plaster bandage is applied from below upward. In applying a plaster encasement the bandage is run as for a reverse, but the "reverse" is not made, the bandage being simply turned sharply downward. Two or three thicknesses of bandage and a liberal polish of plaster are ample allowance. The toes and fingers should always be left exposed. If plaster bandages cannot be obtained the freshly prepared plaster is applied between layers of gauze bandage, in a manner similar to that described above.

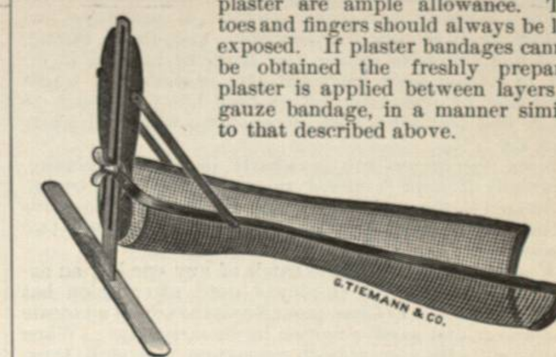

FIG. 2212.—Volkmann's T Splint.

Silicate of soda ("liquid glass") may be employed in a similar manner. This substance makes a far more elegant and somewhat lighter splint than the plaster of Paris, but it sets slowly and is neither so strong nor so enduring as the other.

Various forms of *mechanical splints* are employed in certain cases. Except where traction is necessary in order to maintain reduction, mechanical devices are rarely necessary. A past and fanciful age was rich in such appliances which were more notable for their ingenuity of construction and general clumsiness than for any aptness to their special purposes. These have been swept away by the neatness and cleanliness of modern surgery; but the ever-increasing ingenuity of the orthopedist to relieve the pain and deformity of disease promises a revival of mechanical apparatus for the treatment of fracture (for those who can afford the luxury). As yet the only notable examples of mechanical splints are employed for fractures of the thigh and spine and will be considered under those headings.

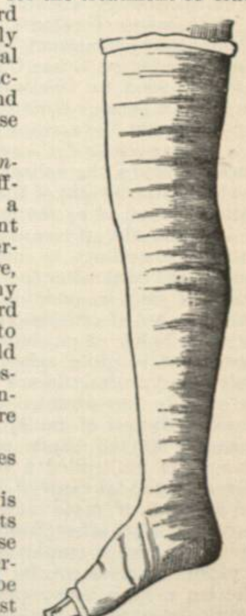

FIG. 2213.—Plaster-of-Paris Encasement for Fracture of the Leg.

Accessory Measures: The Management of Joints.—Since stiffness of the joints adjacent to a fractured bone is of such frequent occurrence as to be the universal complication of fracture, and since this more than any other thing is likely to retard convalescence, it is not far to conclude that the joints should be exercised at the earliest possible moment, and in the manner best calculated to procure satisfactory results.

Stimson lays down two rules on this point:

1. "So long as the joint is swollen and hot, so long as its use is followed by an increase of swelling and heat and by persistent pain, so long must it be kept at rest; and so long must active treatment be limited to massage or elastic compression; and, as a rule, this attitude of non-interference may be maintained until after union of the fracture has become complete. Then . . . passive motion or . . . gradually increasing use of the limb will rapidly restore the function of the joint.