attained, though much more slowly, without fasting and subnutrition, with its risk of depression and weakness, provided the patient is willing to keep permanently to the diet which has been found by careful testing to be suitable to his case.

At the present time the doctor, in order to decide as to the best treatment in severe cases, must judge of the temperament of the patient. To some it is purgatory to be continually having to think about tests and figures. These will do best with definite allowances in an otherwise rigid diet. In others the disadvantages of a half-starved condition must be balanced against the mental effect of the absence of sugar. We do not yet know whether the progress of the disease is arrested by this method in cases in which it would not be arrested by a permanent adherence to a rigid, though plentiful, diet.

For all milder cases, indeed for the majority of all cases, Dr. Allen's procedure offers great advantages. We have evidence enough that such patients, though not cured, may be freed from the signs and symptoms of their complaint. This beneficent result has been attained through the extraordinarily wide and painstaking researches of Dr. Allen on animals. None but those whose lot it has been to attempt to make researches and to describe them when made, can appreciate the perseverance and the labour which have gone to the making of Dr. Allen's book and subsequent writings. I am sure we rejoice with him that he has been the means of enabling a clear step forward to be made in the treatment of a distressing complaint.

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A SIMPLE SYSTEM OF SKELETON SPLINTING.

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CAPTAIN R.A.M.C.(S.R.).

THE value of skeleton splinting in the treatment of gunshot fractures has been generally recognized during the present war. Lieutenant-Colonel Robert Jones[1] was responsible for the introduction of this type of splint, and for the extension of its use in our army medical service. I have previously described[2] how the aluminium stapled strips contained in the field fracture box may be used to make splints of this kind. These stapled strips, however, having been designed to form imitations of the classical solid splints, do not afford an ideal method of coupling lengths for the formation of skeleton frames. The joints effected by the method are not mechanically sound, and hinge formation is not possible. I propose here to describe a system of coupling which has not these defects, and, moreover, one in which the process can be easily and rapidly carried out.

MATERIAL AVAILABLE.

Aluminium strips, $\frac{1}{2}$ in. by $\frac{3}{16}$ in., form splints which are easily malleable by hand, and are sufficiently stable for field purposes. In the case of the larger splints for the lower extremity, however, the material is not always sufficiently rigid for prolonged treatment. Further, at the present time the supply of aluminium for surgical purposes is limited.

There are similar objections to the use of copper and zinc alloys; annealed mild steel appears to be the most satisfactory material available. Annealed steel, $\frac{1}{2}$ in. by $\frac{1}{8}$ in., has much greater vertical rigidity than aluminium, and though it has more lateral spring, it is sufficiently malleable for practical use.

I will therefore describe the system of coupling in relation to the use of annealed mild steel.

Specification of Material.

The stock material consists of five-foot lengths of annealed mild steel $\frac{1}{2}$ in. by $\frac{1}{8}$ in. This material is of standard type, and is sold by any iron merchant. The strips are drilled throughout their length at 1 in. intervals with holes of $\frac{1}{8}$ in. diameter. The holes must be accurately distanced throughout the strips.

Split steel rivets $\frac{5}{8}$ in. by $\frac{1}{8}$ in. are required to couple the various lengths after they have been bent to form the splint required.

Tools Required.

A cramp of the new pattern supplied in the field fracture box; this serves to hold the strips while they are being bent in the direction of their vertical section.

A screw wrench with slots $\frac{1}{8}$ in. by $\frac{1}{8}$ in. cut in the jaws $\frac{1}{8}$ in. from the shaft (Fig. 1). This wrench holds the strips and supplies the leverage for bending them; it also serves as a hammer.

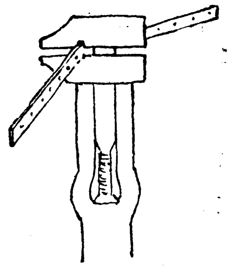


FIG. 1.—Screw wrench with $\frac{1}{8}$ in. by $\frac{1}{8}$ in. slots cut in jaws, holding a strip of splinting.

A hacksaw for cutting the material.

A triangular file for trimming the ends or for cutting the strips if the saw be not available.

A pair of "bell" pliers with a screwdriver end on one handle; the latter is used to spread the rivets, and the pliers to crush them after they are in place (Fig. 2).

Method of Cutting Strips.

To divide the mild steel strips at the required level the material is cut half through with a hacksaw, and then snapped off by hand. In using the hacksaw, the tool should only bear by its own weight lest the blade be broken.

The triangular file can be used for the same purpose, but is not as neat or quick to work with.

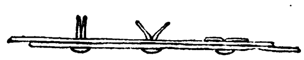
Method of Bending Strips.

The strips can be moulded on the flat by hand; if a sharp angular bend is required, the screw wrench should be used.

To bend the material on edge, the strip is fitted into the cramp, the screw wrench is fitted home on the strip close to the cramp, and then used to lever the material to the desired angle (Fig. 1). A right angle is the sharpest bend which can be effected in this way, unless the material is previously heated, and even then there is a tendency for the strip to buckle; this tendency is overcome by removing the strip from the cramp in the course of the process and beating out the angle on an anvil. If the part of the strip to be bent is first heated in the flame of a Primus stove, the procedure is much facilitated.

Method of Coupling Strips.

Strips are united in their long axis by passing split rivets through opposed holes. The rivets are then spread with the screwdriver end of the pliers and finally crushed or hammered out (Fig. 2). Three rivets give a firm longitudinal junction.



1. 2. 3.

FIG. 2.—Side view of two lengths of splinting, showing (1) rivet in place, (2) spread, (3) crushed down.

A hinge joint is formed by a single rivet.

A rigid joint at any angle is made by strutting such a hinge joint (see Fig. 3, D).

Completion of Splint for Application (Pads and Slings).

The only part of these splints which requires formal padding is the crutch in those of the modified Thomas's pattern (shown in Fig. 3 at A, in Figs. 6 and 11, and in Fig. 12 at C). This is best effected by winding tow evenly on to the part of the frame which forms the crutch; the tow is then fixed by bandaging firmly over it. For treating compound fractures in the early stage, it is desirable to cover the pad so formed with impermeable material. I have found a length of bicycle inner tube the most satisfactory; this should be rolled on to the splint in the same way as a rubber cricket bat handle is put on; it is then fixed at either extremity with a strip of adhesive plaster.

In splints for the upper extremity the crutch may often be sufficiently padded by passing a length of stout drainage tube on to that part of the frame.

In general, the splints are completed with slings. These are best made from some adaptable but inextensible material, such as old linen. In certain cases troughs of

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perforated zinc sheeting may be substituted for the fabric slings. No padding is ever needed between a linen sling and the skin.

Type Splints for the Lower Extremity.

1. *Modified Thomas's Knee Splint.*

Two full lengths (5 ft. each) of splinting and one of about 20 in. are required (Fig. 3). The crutch, A, which should

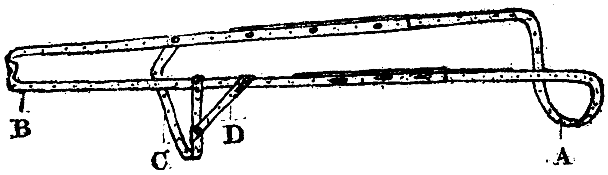

FIG. 3.—Modified Thomas's knee splint. A, Crutch; B, notch in stirrup extremity; C, prop; D, strut fixing prop.

measure about 15 in., is bent in the central part of one full-length strip. This involves two right angle bends on edge. The crutch should not form simply one section of a circle; it should be moulded as shown in Fig. 4. The stirrup extremity, B, is readily moulded by hand in the form shown in the figure from the remaining long strip. These two parts are then united by rivets to give a splint of the required length; for an average case there should be an overlap of 9 in. on the inner side and 7 in. on the outer (supposing the crutch to have been centrally placed); this gives the necessary obliquity to the crutch. Three rivets on each side give a firm junction. The prop, C, is then bent and attached to the splint by a rivet and strut, D, about 18 in. from its lower extremity; the base of the prop should measure at least 10 in. if the splint is to be used for transport.

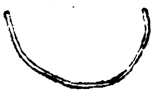

FIG. 4.—Diagram of proper shape of a thigh crutch for the right side, seen from above.

An arch may be placed between the side limbs of this splint, about the level of the knee-joint if particular rigidity is required. A footpiece, as shown in Figs. 6 and 9, may be fitted when necessary. The splint may be flexed at the knee-joint in those cases in which straight extension does not produce good alignment of the fragments of the femur; under these circumstances it will be found necessary to bend the side members of each section separately before riveting them together.

This splint, completed with linen slings, is well suited for the treatment of many cases of fractured femur as well as injuries of the knee-joint and tibia. It should be slung in the ordinary way from four points (as shown in Fig. 7), the prop only coming into action during transport.

A strap passed across the front of the thigh keeps the crutch in place during movement; another one should be passed in front of the tibia just below the knee-joint; this should only be tightened when the patient is rolled on his side; it will be found that the flat surface of the side members of the splint adapts itself closely to the surface of the thigh, thus giving excellent lateral support to the limb in the circumstances.

The fixed extension obtained by means of this splint is effected by a canvas strap passed around the notch in the stirrup of the splint and the spreader.

2. *Hodgen's Splint.*

This type (Fig. 5) is made in the same way as the previous pattern, except that an arch, C, is substituted for a

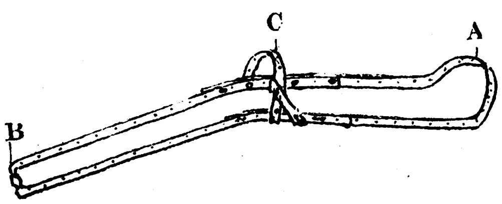

FIG. 5.—Hodgen's splint. A, Anterior thigh arch; B, stirrup notch; C, knee arch.

prop, and the side members are slightly flexed at the level of the knee-joint.

3. *Skeleton Double Incline Splint.*

This splint (Fig. 6) is made from the same elements as the modified Thomas's knee splint. The side members of

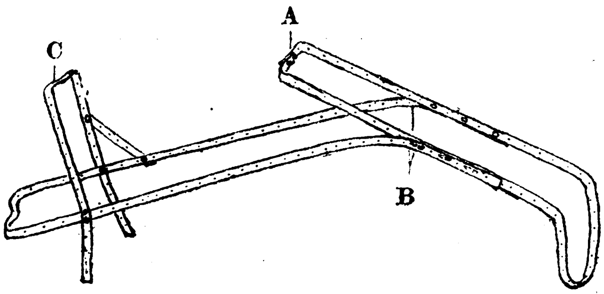

FIG. 6.—Skeleton double incline splint. A, Knee stirrup; B shows bend in lower side members of the splint; C, foot arch and props.

the crutch section are bent in and joined with two rivets to form a 4-in. stirrup, A. The side members of the stirrup section are bent to an angle of about 135 degrees at B, before being riveted to the upper part.

In the type illustrated in the figure (6) a combined foot-piece and prop C is bent from a length of about 24 in., and is riveted and strutted in the required position. If no control of the foot is required, a simple prop may be substituted.

This splint has been designed for use in cases in which both the tibia and femur are broken. It allows extension to be applied independently to each bone. The splint is shown in use in Fig. 7.

The extension appliance for the femur may be of the adhesive variety, or when insufficient whole skin is avail-

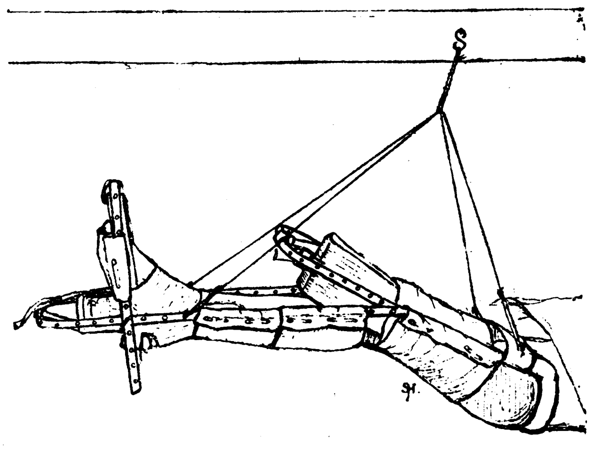

FIG. 7.—Skeleton double incline splint applied. The splint is suspended by four points from a beam. Linen slings support the limb, and fixed extension is applied separately to thigh and leg. The crutch has been padded as described in the text.

able for the purpose a collar of plaster-of-Paris may be moulded on to the condyles of the femur. A strap or elastic extension is passed from the transverse A round the spreader of the extension appliance (Fig. 7).

In general the method of application of the splint is the same as for a Thomas's knee splint; the strap in front of the thigh to keep the crutch to its work is essential. In cases where the tibia and fibula are broken the footpiece comes into use. This may be completed with fabric slings of zinc sheeting; when necessary the foot may be suspended as shown in Fig. 8.

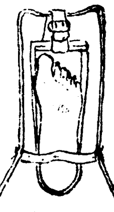

FIG. 8.—Diagram to show method of suspending the foot with an adhesive strap from the foot arch.

In some cases suspension by a single strip of fabric stuck to the sole of the foot with glue (Heusner's) may be an advantage; this is especially the case when there is paralytic foot-drop. The footpiece should then be set rather higher up on the splint than the level of the sole of the foot in order to give the necessary control of the tendency of the foot to become plantar flexed.

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4. *Knee Splint* (*Jones*).

The backbone (Fig. 10) is made from two lengths of about 42 in. riveted together at a few points and bent to shape by hand. One thickness of the splinting is not sufficiently rigid. Thigh, calf, and foot pieces of suitable dimensions made from zinc sheeting are then riveted on to the backbone. The zinc sheeting can be reinforced, if necessary, by riveting stout cardboard, linoleum, or similar material on to it. To more closely copy the original pattern of the splint, the footpiece may be made from two short lengths of the splinting.

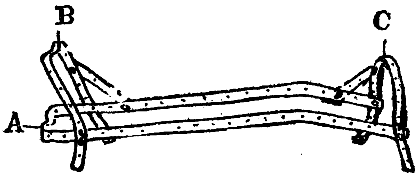

FIG. 9.—Tibia splint. A, Stirrup notch; B, foot arch hinged and strutted on to frame; C, thigh arch similarly attached.

5. *Tibia Splint.*

This (Fig. 9) is made from one full length of the splinting, and from two pieces of 24 in. and 20 in. respectively.

The main frame is bent from the full length with a notched stirrup A, and slight angles at the level of the knee-joint. The footpiece and prop B (24 in.) is made as for the double incline splint. The upper arch and props C are similarly riveted and strutted on.

The splint is best completed by fabric slings.

For any case in which the fibula is intact no extension will be required. If both bones are broken and there is any tendency to overlap, fixed extension is effected as follows: A light collar of plaster-of-Paris is moulded round the leg at the level of the tubercle of the tibia; the side members of the splint are then fixed to this collar by another encircling plaster bandage, or else two side straps may be passed up from the collar and attached to the sides of the arch C. Counter fixation having been thus secured, traction is made through a strap passed around the notch in the stirrup at A and the spreader of the extension attachment.

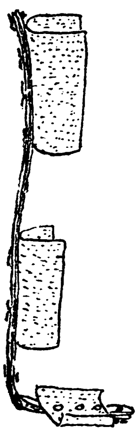

FIG. 10.—Jones's knee splint. The backbone is made from two lengths of splinting lightly riveted together; thigh, calf, and foot pieces are made from perforated zinc sheeting.

6. *A Stump Tractor* (*after Makins*).

This (Fig. 11) is made in the same way as a modified Thomas's knee splint, but it will naturally be shorter.

An apparatus for thigh stumps is made from one full length of splinting; a prop of the type shown in the figure is added, it should be of such a height that while the hip-joint is not materially flexed the lower surface of the stump is kept clear of the bed.

Extension is made from an adhesive attachment to the skin through a circular or cross-shaped spreader. The adhesive should be applied to the greatest possible surface of skin.

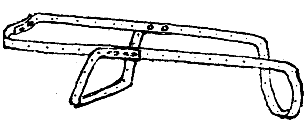

FIG. 11.—Stump tractor.

Application of Extension Apparatus.

There are certain practical considerations in relation to the general application and use of these splints which may be referred to here.

In cases of fractured femur, in the absence of wounds in the leg, a simple adhesive extension (Buck's) is the most satisfactory.

The apparatus consists of two side straps of 2-in. adhesive plaster continuous below over the spreader. The spreader should be slightly wider than the measurement between the outer surfaces of the two malleoli. The side straps are lined with lint in their lower six inches.

After shaving the limb, the side straps are applied; they should adhere to the upper two-thirds of the leg and to as much of the skin of the thigh as circumstances permit. The side straps are kept to their work by a carefully applied open wove bandage, extending from 3 in. above the level of the malleoli to the upper extremity of the plaster. Circumferential bands of adhesive plaster are never necessary, and their edges are always liable to cause pressure sores as the extension slips slightly in the course of treatment.

In the place of adhesive plaster strips of fine calico may be used, a soluble glue being employed as the adhesive medum. Heusner's glue is a satisfactory preparation of this kind, and is made of cheap ingredients; its composition is as follows:

Resin	50 grams.
Venice turpentine	5 grams.
Methylated spirits	50 c.cm.
Benzine	25 c.cm.

After the skin has been shaved the glue is painted on the required area and allowed to become "tacky"; the fabric is then pressed on to it and a bandage applied over the whole. No further application of the glue should be made. Extensions put on in this way hold very firmly for a few weeks; slight vesication sometimes occurs at the margins of the surfaces of application.

If multiple wounds prevent the use of an adhesive extension, the pull must be taken from a more limited area. In such circumstances plaster-of-Paris is the best medium. It can be applied as an anklet or knee-cap. An anklet is made by binding one or two muslin plaster bandages directly around the ankle and incorporating the tails of the extension in it. The skin is greased and if necessary shaved. The bandage should extend well down on the os calcis and forward on the instep to within an inch of the base of the toes. The anklet is moulded on to the prominent points about the ankle, and allowed to harden before any extension is applied.

The knee-cap takes its main purchase from the condyles of the femur, particularly the inner one. A plaster bandage is applied evenly to the knee-joint area, extending from one inch above the upper border of the patella to the level of the joint line. As it dries the plaster is laterally pressed and so moulded firmly on to and above the prominences of the two condyles of the femur; the grooves so formed should be held till the casing becomes firm.

These two procedures have the disadvantage that they fix the joints covered, but they allow very powerful extension to be made during the necessary period. In my experience most leather anklets if used under pressure cause sores in a few days, or even during the period of transport from clearing station to base.

Control of the Foot.

In many cases of fractured femur, when a limb has been put up on a Thomas's or similar splint, the patient is able to fully dorsiflex his foot voluntarily. If he is encouraged to do this regularly, no fixation of the foot need be practised.

In other cases, especially when there has been some injury to the external popliteal nerve, the position of foot-drop tends to become permanent. In these circumstances a foot arch should be attached to the splint as shown in Figs. 6 and 9, a bandage stretched tautly across the arch will then serve to keep the foot up. In some cases suspension from the heel with a strip of adhesive may be resorted to, as shown in Fig. 8. An alternative method is to apply a strip of fine calico to the surface of the sole of the foot with soluble glue, and to suspend from this.

Undue external rotation of the foot and leg in cases of fracture does not often occur in limbs which are put up properly extended.

The correct position of the foot is determined by comparison with the sound side, it being borne in mind that the foot rolls out naturally a little in the passive supine position.

Avoidance of Pressure Sores.

Pressure sores are, and should be, the great bugbears of the surgeon treating fractures of the lower extremity. In cases treated on splints of the above described types they may appear in the following situations:

(*a*) *Over the Area Exposed to the Pressure of the Crutch.*—Theoretically, a sore from crutch pressure should develop over the tuber ischii. Not infrequently,

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however, the skin in the genito-crural area may be eroded, and sometimes that in the ischio-sacral angle. Such sores should not appear if the patient is rolled on his side daily and the skin under and around the crutch cleaned with spirit, gently massaged, and then powdered. If wound discharges gain access to the area, even more frequent attention is necessary. It should be remembered that pressure sores are most liable to occur in the first few days after the application of a splint before the skin has adapted itself to the new situation. Great care should therefore be taken in sending patients from a clearing station to the base to minimize any necessary pressure.

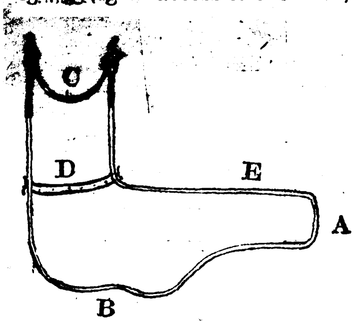

FIG. 12.—Bent arm splint. A, Hand arch which is used for a hand grip or for the attachment of an extension strap in cases of fracture of the forearm; B, notch for extension strap in cases of fractured humerus; C, axillary crutch hinged by single rivets on to main frame; D, reinforcing arch which may be omitted.

(*b*) *Over Lateral Prominences of the Limb.*—The side members of the splint may press on the limb at the knee or the ankle; such a possibility should be avoided by bending out the splint at the level implicated, and not by the insertion of a pad.

(*c*) *In Relation to Extension Attachments.*—Adhesive extensions applied as described above will not damage the skin; on the other hand, transverse bands of adhesive strapping at the level of the tubercle of the tibia and about the ankle are prolific sources of sores.

Plaster-of-Paris appliances gain a very positive hold of the limb, and if a very powerful extension is applied sores may result, but they are not frequent if the plaster casing is carefully moulded to the limb and allowed to harden properly before any pull is applied. Such extensions should be changed if the limb shrinks much in size from the subsidence of swelling or from muscle wasting.

TYPE SPLINTS FOR UPPER EXTREMITY.

Modified Straight Thomas's Arm Splint.

This splint is a small replica of the lower extremity type (Fig. 3). It can be made from one full length of splinting and a piece of about 16 in. A small prop should be placed at about the elbow level.

FIG. 13.—Bent arm splint diagrammatically applied for a case of fractured humerus. The axillary crutch is padded by a length of drainage tubing. F, Extension strap for a case of fractured humerus.

The Bent Arm Splint.

This (Fig. 12) is made from one full length of splinting bent on the flat to the form shown in the figure, and from a 12 in. length. The 12 in. strip is bent in a half circle to form an axillary crutch, C; this is pivoted on to the two free extremities of the main frame. A 9 in. arch, D, may be placed at a convenient level in the elbow region in order to reinforce the splint as a whole. The crutch is padded with rubber tubing and internal slings applied to the frame to complete the splint for use.

For cases of fracture of the humerus when light extension may be required, the hand is fixed to a pad on the frame either at A or E. Extension is then made by a strap or a few turns of rubber bandage passing over the front of the forearm and around notch B. The splint is shown diagrammatically applied in Fig. 13. When the splint is used for fractures of the forearm, extension is obtained by fixing the upper arm to the posterior part of the frame and extending from A through an adhesive attachment to the wrist and hand. The pivoting of the crutch (C) allows of easy temporary or permanent abduction of the arm.

Hinged Elbow Splint.

The frame is made (Fig. 14) from two upper side pieces of about 7 in. length; the forearm and hand arch require a length of about 40 in. The single rivet hinge joint at the elbow is fixed at the required angle by one or two struts. The splint is completed with zinc troughs, as shown in figure.

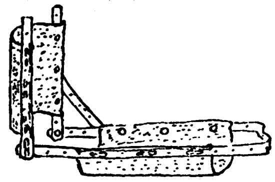

FIG. 14.—Hinged elbow splint strutted at a right angle.

Jones's Elbow Splint.

The backbone of this splint is made (Fig. 15) of two lengths of about 26 in., riveted together at a few points. Two troughs are added, as shown in the figure. This splint can be bent so as to be used as an anterior splint if necessary.

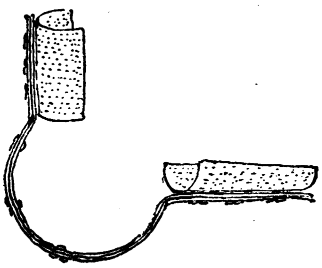

FIG. 15.—Jones's elbow splint.

Wrist Splint.

The forearm and hand frame (Fig. 16) is made for average cases from a length of 36 in. The upper arm arch and side pieces are bent from a length of about 12 in. The latter is hinged and strutted on to the main frame. If it is desired to put the hand up in extension the frame is bent at B, as shown.

Slings are arranged to hold the upper arm and forearm. The wrist can be held extended by a single narrow band across the palm, if it is desired to leave the fingers free.

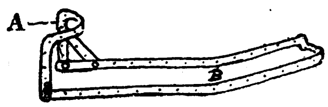

FIG. 16.—Skeleton of forearm and wrist splint.

CONCLUDING NOTES.

It should be understood that the measurements and details given for all the above described splints are for average cases. Modifications in size and design will often be necessary, and are readily carried out.

If aluminium strips be used on the same system the ease with which angular bends can be carried out on edge with this material will make many of the above described single rivet and strut joints unnecessary.

The splints can always be reinforced, if exceptional rigidity is required, by the addition of arches or by riveting extra lengths on to the main frame.

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[1] Robert Jones: The Mechanical Treatment of Gunshot Fractures, BRITISH MEDICAL JOURNAL, 1915, i, 101. [2] Max Page: Aluminium Skeleton Splints, BRITISH MEDICAL JOURNAL, 1915, i, 839; and Notes on the Transport of Cases of Fractured Thigh, BRITISH MEDICAL JOURNAL, 1915, ii, 173.

MEDICAL inspection in Boston under the supervision of the School Board came into force on November 22nd, 1915. A report by Dr. W. H. Devine, Director of Medical Inspection, on the physical examination of children in the public schools from December 1st, 1915, to April 1st, 1916, states that 49,777 pupils were examined; of these, 34,792 were found to present defects. The conditions classed as "defects" included defective nasal breathing, hypertrophied tonsils, bad teeth, defective palate, cervical glands, pulmonary disease (24 tuberculous, 456 non-tuberculous), heart disease (organic 725, functional 888), nervous disease, chorea, joint and bone disease (tuberculous 49, non-tuberculous 877), skin disease, rickets, malnutrition, and mental deficiency (243). The number of cardiac cases, according to Dr. Devine, suggests that the prevention of heart disease offers a great field for research in prophylactic medicine.

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