This invention relates to orthopedic correcting appliances, more particularly for the relief and treatment of flat-feet, sunk insteps, and like afflictions of the foot.

5 The human foot constitutes a non-rigid arch construction built up of relatively displaceable parts of fixed shape (the bones) which are held together by ligaments and controlled as to position and movement by muscles. If the muscular system be strained beyond the limits of its endurance, the arch construction gives way, with the result that the bones assume abnormal positions and the influence of the weight of the body. The transitional and final stages of such deformation, which may even go to the point of complete destruction of the normal construction of the foot, are to be found in the various known forms of instep subsequence, sunk instep, flat-foot, spread foot, and their consequences (crooked toes, and the like).

In order to counteract or to correct abnormal displacement of the bones of the foot recurve has hitherto usually been had to the use of rigid supports placed beneath the instep or of circumferential strapping or bandaging of the front part of the foot, which however implies loss of freedom of movement within the foot structure. With a view to relieving the strain on the arch of the foot it has also been proposed to place a strap or band around the front part of the foot, and then either to attach two tensioning straps to this encircling element which are crossed over beneath the sole and made fast to the ankle or to the heel, or to attach a pulling strap on the under side which is likewise made fast to the heel.

Appliances of this nature are not satisfactory, since the tension of the longitudinal straps, in view of its direction, tends to pull the encircling gaiter member back towards the heel, with the result that this member ceases to be capable of gripping the pier common to both the transverse arch and the longitudinal arch of the foot, namely the first of the metatarsal bones to which the big toe is articulated, at the point best suited for a fast hold thereof, that is to say adjacent its forward end; moreover, the transverse binding action of the gaiter is then no longer in the direction of the transverse arch but obliquely thereto, which is likewise unsatisfactory.

In the appliance according to the present invention the point of application of the longitudinal tension strap to the gaiter member encircling the forepart of the foot is fixed by being anchored, preferably to the big toe, the result being thereby achieved that the encircling transverse binder is kept in the right position for sustaining the transverse arch and at the same time grips the anterior pier of the arch as nearly as possible at its forward end, so that both the transverse arch and the longitudinal arch are tied across and sustained in a favorable manner, with the avoidance of the drawback peculiar to known appliances of this nature which merely serve to sustain the longitudinal arch and consist for this purpose of a tension member looped around the phalangial portion of the big toe at the forward end and made fast to the heel at the rear end. This drawback consists in the fact that in the application of the straining force to the phalangial portion of the big toe the phalanx of this toe is pressed towards the “ball” of the toe in a manner counter to all natural stresses, while at the same time the nose portion of the appliance passing between the big toe and the adjacent toe exercises an undesirable spreading action upon the metatarsal bones to which these toes are articulated. This unnatural pressure and spreading action become so insufferable to the user as to render the necessary prolonged wearing of the appliance impossible.

The most important types of foot deformation due to ligamental and muscular insufficiency are shown diagrammatically in the accompanying drawings, in which:

Fig. 1 shows in skeleton form the longitudinal arch of the foot, and, in dotted lines, the manner in which this arch can give way and subside.

Fig. 2 is a plan view of the transverse arch of the foot, while Figs. 3 and 4 are cross-sections showing the same flattened, and in the normal condition, respectively.

Fig. 5 shows the normal position, and, in dotted lines, two abnormal positions of the big toe relatively to the metatarsal bones.

Fig. 6 shows the skeleton of the foot from below, with the correcting appliance according to the present invention, to illustrate the torsional action exerted upon the heel, the latter being represented by the os calcis.

Fig. 7 shows, in full lines, the normal position, and, in broken lines, the abnormally tilted position of the os calcis.

Figs. 8 and 9 show the correcting appliance according to the invention in the operative position on a foot, as seen from the dorsal side and from the sole, respectively.

Fig. 10 shows the appliance alone, in perspective view.

It is the purpose of the appliance according to
the invention to tie the longitudinal arch shown in Fig. 1, and also the transverse arch shown in Figs. 2 and 4, by straining force applied at the piers of these arches, and thus to relieve the tension on the arches which strive to counteract the natural deformation of the arches normally brought about in walking or other movement involving strain thereon, and to effect or facilitate the restoring of these muscles into their initial position. For this purpose, as shown in Figs. 8, 9, and 10 and indicated in the remaining figures of the drawings, the appliance according to the invention consists of a transverse binder \( a \) encircling the foot at the forward end of the metatarsal bones, the portion \( a \) in contact with the dorsal portion of the foot being made of non-elastic material such as leather, fabric, or the like, while the portion \( a \) in contact with the sole and attached to the above-mentioned portion at both sides for instance by adhesion or stitching consists of two parts made of elastic material such as rubber and adapted to be tightened up by any suitable means. According to the adjustment of the tensioning of these parts, the binder \( a \) will tend with more or less force to restore the transverse arch of the foot to its normal condition after each subsidence due to overload, and to assist or restore into the normal position the inner muscles which normally fulfill this function as soon as the load is taken off the foot. After passing through slots \( b \) in a flat plate \( c \), which can be attached to a thin or even soft pressure-distributing backing \( d \), the parts \( a \) of the binder are preferably united to a tension strap \( e \) which is attached, say by means of a buckle \( g \) or the like, with adjustable tension, to a ring \( f \), for instance of leather, which is adapted to grasp the heel, and which is slightly obliquely set. As can be seen from Fig. 10, the relatively broad tension strap \( e \) of rubber is divided at one end by a longitudinal slot into two narrower straps which constitute the parts \( a \) of the binder \( a \). The adjustment of the tension of these parts \( a \) and of the tension strap is effected by drawing the latter to a greater or less extent through the clamping buckle \( g \) in the direction of the horizontal component of the spreading of the foot in walking, the tension strap is elastically deformed and then restores the arch of the foot and the muscles and ligaments pertaining thereto into the initial or resting position, or initiates and facilitates this restoring, as soon as the load is taken off. The position of the point of application of the tensile force exerted by the strap is fixed by the means now to be described, which means also serve to correct the position of the toe.

Whereas given normal foot development, the phalanx of the big toe is in alignment with the adjoining metatarsal bone, permanent deformation through collapse generally involves upward inclination, and sometimes downward inclination of the phalanges relatively to the metatarsals, according to whether, in consequence of relaxing or straining of the flexing or stretching muscles of the big toe, the one or the other of these sets of muscles becomes predominant. Whereas the latter condition, the permanently downwardly bent toe, is corrected in a manner dependent on the subject matter of the present invention, the first mentioned abnormality (turned up toe) is corrected in accordance with the invention by the application to the toe at a point in front of the ball joint, of a torsional force directed essentially downwards and towards the inner edge of the foot, with the avoidance as far as possible of any thrust on the joint at the root of the big toe. This torsional force is brought to bear by the tension of a non-elastic nose \( h \) which is passed through the base of the joint of the big toe, and attached, with adjustable tension, by means of elastic straps \( h \) and \( k \), to the above-mentioned plate \( c \). The strap \( h \) may for example be fixedly attached to the plate \( c \), while the strap \( k \) is passed through a slot in this plate and held fast therein by clamping fixation. The adjustment of the tension is effected in a manner similar to that adopted in connection with the tension strap \( e \), namely by pulling the free end of the strap \( k \) to a greater or less extent through the slot provided for it in the plate \( c \). In order to fix the nose \( h \) in position and to prevent the same from cutting into the fork between the toes, there is resiliently attached to the dorsal portion \( a \) of the binder \( d \) a rigid outrigger \( i \) which passes between the big toe and the adjacent toe, keeping at a certain distance from the base of the gap therebetween to a point on the front portion of the sole between these two toes where it holds the nose \( h \) in a fixed position, for instance by means of a small swivel member \( j \), so that this nose \( h \), when drawn downwards and towards the inner edge of the foot, can not cut into the fork between the toes. This arrangement also ensures the maintenance of the proper direction of the force exerted by the nose \( h \) upon the big toe. By means of its straps \( h \) and \( k \), this nose also holds the plate \( c \) in its required position adjacent the forward end of the pier of the arch, and tends to turn the toe back into its normal position without pressing it to any appreciable extent against the metatarsal to which it is articulated. The effective force thus exerted is taken up by the outrigger \( i \). It is desirable to provide an articulating or moving joint between the latter and the binder \( d \), so that it may be capable of adapting itself to the gait of the wearer, and not set up any additional drag or strain giving rise to discomfort. In the form of construction shown, this articulation connection is obtained by providing the outrigger \( i \) with an eyelet \( j \), by which it can travel along a steel wire \( c \) secured by its ends to the binder \( d \). This form of the articulated joint is shown in Fig. 10.

The bad posture of the foot engendered by the development of flat-foot results in the tilting of the os calcis inwards, which is tantamount to rotation of this bone towards the outside. Whereas given sufficiently strong muscles the os calcis bears with a portion of its under surface which is in alignment with or slightly outside the load axis, this bone becomes turned and displaced outwards, under the influence of the load, when the muscles give way. The result is the inward tilting of the foot. This deformation is initiated and only rendered possible by the giving way of the highly important big toe flexor muscle \( k \) (Fig. 5) which runs from the under side of the big toe to the calve of the leg, and which has a tendon which passes beneath the prominence \( l \) on the os calcis \( m \). On contraction, this muscle draws the prominence \( l \) on the os calcis upwards and inwards, so that the whole of this bone is turned inwards from the action of the load, and held in this position.

In order to prevent this displacement of the os calcis outwards it is necessary as far as possible to provide a force component which counteracts this rotation. This result is achieved in accordance
with the invention by two features, namely:

1. By the feature that the point of application of the force exerted by the tension strap e, and with it the direction of this force, is so adjusted that a horizontal component of force is directed towards the centre line of the body as is set up, as shown diagrammatically in Figs. 6 and 7. The tension strap e is not disposed in the longitudinal axis of the foot but at an angle thereto, with the result that an inwardly directed component of force is set up. In order to give the heel ring a better hold, and to prevent displacement of the tension strap e into alignment with the axis of the foot, the heel ring is preferably provided with grooving f, or other roughening elements which press into the skin and ensure a firm hold without infecting any injury. It will be clear without further explanation that the pull of the strap e effects, through the intermediary of the ring f, a rotation of the os calsis in a direction counter to that in which it tends to become rocked in consequence of muscular deficiency.

2. By the feature that the action of the elastic pull exerted upon the big toe in a downward direction so assists and strengthens the long flexor muscle that it is restored to its full efficiency and thus enabled to exert its above-mentioned torsional and pronating action upon the os calsis by co-action with the prominence i (the sustentaculum talus) on this bone.

I claim:

1. An orthopedic appliance for correcting deformations of the foot, comprising in combination an adjustable tensional binder strap adapted to encircle the foot in the region of the metatarsal bones and to cross-tie the transverse arch of the foot, a longitudinal tension strap adapted to lie against the sole of the foot and attached at one end thereof to the said binder strap and adapted to be fastened at its other end to the heel of the foot for the purpose of cross-tying the longitudinal arch of the foot, an adjustable noose adapted to be looped around the big toe of the said foot and fastened near both its ends to the said binder strap next the point of attachment of the longitudinal tension strap to the binder strap, means for determining the position of another point of the said noose relatively to the binder strap, so as to be held remote from this strap and for causing a tension created in the noose to exert a downwardly directed torsional pull upon the said toe.

2. An appliance as claimed in claim 1, in which said means consist of a distancing outrigger articulately attached by one end to the portion of the said binder strap intended to contact with the dorsum of the foot and secured by the other end to the said noose.

3. An appliance as claimed in claim 1 in which the said means consist of a distancing outrigger articulately attached by one end to the portion of the said binder strap intended to contact with the dorsum of the foot and secured by the other end to the said noose at a point which, when the appliance is in use, is adapted to be near the base of the sole of the foot substantially between the bases of the big toe and of the second toe adjacent the said big toe.

4. An appliance as claimed in claim 1 in which the said tension strap is longitudinally slit over part of its length, the branches of the strap produced thereby forming portions of the said binder strap.

5. An appliance as claimed in claim 1 in which the portion of the said binder strap which is intended to contact with the dorsum of the foot is made of non-elastic material while the portion thereof intended to contact with the sole of the foot as also the said longitudinal tension strap are made of elastic material.

MARTIN JUNGMANN.