This invention relates to ladders and a method of manufacturing the same. More particularly, it concerns an improved ladder construction incorporating a novel rung and a unique method for forming the rungs thereof and connecting them to the ladder siderails.

Because of the functions served by ladders, it is essential that they possess two basic features, i.e., that they are sufficiently strong to carry the weight of a person or persons using them, and secondly that they be light in weight to facilitate movement from place to place as required without the use of special handling equipment. These requirements have led to the extended use by ladder designers and manufacturers of light metals such as aluminum, magnesium or alloys including one or both of these metals, with the result that extremely light and strong ladders are presently available solely due to the inherent characteristics of these metals. Yet, there remains room for improvement, particularly in the assembly of the rungs between the siderails and at spaced intervals along the length thereof. In ladders of this type heretofore available, perhaps the most common technique employed in connecting the ladder rungs to the siderail thereof has been to extend a tubular rung through a siderail aperture having a diameter substantially the same as or slightly larger than the rung diameter and upsetting the end of the rung outwardly to secure the connection. Examples of such constructions may be found in U.S. Patents No. 1,912,331 or No. 2,760,706. In other instances, the rungs are secured in place by welding or brazing. Although such connections of the rungs to the siderails are satisfactory to prevent direct separation of these components, there results a considerable weakening of the siderail due to the considerably large hole which must be formed necessarily in the siderails or, if welding or brazing is used, due to the heat stresses imposed on the metal from which the siderails are formed. Also, particularly where swaging or upsetting techniques are employed, the strength of the connection relies largely on the resistance of the upset portion of the rung to deformation by bending. When such a ladder is subjected to rough handling, therefore, the severe bending stresses which occur between the rung and siderail result in a loosening of the joint and thus, a defective ladder.

To circumvent this problem, further proposals have been advanced (see, for example, U.S. Patents No. 2,618,487 and No. 2,552,630), but have resulted in a comparatively complex assembly of either giving rise to increased cost of manufacture or adds considerably to the overall weight of the ladder or both.

Also, it has been proposed, particularly where wooden siderails are used with metallic rungs, to form the rungs having a dovetail projection on the shed which are passed through the siderails and bent over at their ends to effect the attachment of the rung to the siderail (see, for example, U.S. Patents Nos. 1,445,573 and 1,503,880). Such construction affords a minimum of interference with siderail strength, but on the other hand, the only resistance offered to separation of the rung from the siderail resides in the bent over portion of the shed metal and any friction which may exist between the prongs and the siderails in which they are imbedded. As a result, when subjected to rough use, the extreme pull out forces due to bending moments incurred at the connection of the rungs to the siderails are likely to cause separation of the rung from the siderail producing a loose joint, and accordingly an unsafe ladder.

Another problem experienced in the use of rungs or steps for ladders formed from light metals is the difficulty in achieving a suitably light rung section. In rung constructions heretofore available, the direct bending moments imposed thereon in use have required suitably heavy rung cross-sections. To some extent, this problem has been mitigated by the use of tubular rungs but here, the requirement for a sufficient amount of material to effect the joint between the rung and the siderail has restricted the lightness of rung cross-section employed. Although obviously, the rung could be built up at its end portions for this purpose, such would add materially to the cost of manufacture as compared with a rung having a continuous cross-section throughout its length.

Accordingly, a principal object of this invention is to provide a new and improved ladder incorporating a novel rung structure and method for its formation as well as a unique method of connecting the rung to the ladder siderails by which the aforementioned problems are substantially and effectively overcome. Another object of this invention is the provision of a new and improved ladder construction by which the connection of the rungs to the siderails may be effected in an extremely economical manner, which connection is exceptionally strong and yet in no way detracts from the siderail strength characteristics or overall ladder weight.

A further object of this invention is that of providing a new and improved light metal ladder rung or step which is extremely resistant to bending loads imposed thereon while at the same time being facilitating an extremely strong and effective connection of the rung to the ladder siderail in an economical manner without in any way sacrificing overall lightness in weight.

A further object of this invention is the provision of a ladder of the type referred to in which the rungs are connected to the siderails in a manner such that maximum resistance to angular deformation or bending at the connection is afforded without removal of any substantial portion of the ladder siderail and resulting weakening thereof.

Another object of this invention is that of providing a ladder rung structure of the type referred to and method for its manufacture which is adaptable to all forms of ladder rungs whether they be tubular, channel shaped, round, square or wide tread.

A still further object of this invention is the provision of a new and improved method for the manufacture of light metal ladders which is extremely economical in practice and which results in a ladder having superior strength characteristics and yet which is extremely light in weight.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description, while indicating preferred embodiments of the invention is given by way of illustration only, since it will become apparent to those skilled in the art from this description that various changes and modifications can be made without departing from the true spirit and scope of this invention.

In general, the aforementioned objects are accomplished by extruding a light metal rung having a cross-section defining a plurality of rod-like rib portions interconnected by relatively thin integral wall portions and then cutting back the wall portions at the ends of the rung to leave the rib portions extending as studs. These studs are then passed through corresponding apertures formed in the siderails and riveted or otherwise expanded to secure the rung-siderail connection. Preferably, the rung rib portions are arranged to be positioned at the top and
bottom of the rungs when the ladder is in use to reinforce the rung against the compressive and tensile stresses which exist at these points respectively. In one form of the invention, the rung cross-section may be generally circular and include at least two reinforcing rib portions integrally formed with a pair of arcuate wall portions, the wall portions being cut back at the ends to permit the rib portions to extend as studs for riveting to the ladder side-rails. Alternatively, the rung cross section may be four sided so as to achieve a flat tread rung and three or four rib portions may be formed therein and extended as the rivet studs. Or, if a wide tread rung of the type used extensively in stepladders is to be desired, the rib portions may be formed at the corners of the step cross section interconnected by at least three integral wall portions, which are cut back at their ends to leave extending the rib portions in the form of rivet studs.

A more complete understanding of the invention and its various forms may be had by reference to the accompanying drawings in which:

FIG. 1 is a fragmentary side elevation in partial cross-section of the ladder of this invention;

FIG. 2 is a cross section taken along line 2—2 of FIG. 1;

FIG. 3 is a perspective view of an extended blank from which the ladder rung of this invention is formed;

FIG. 4 is a perspective view of the completed rung of this invention prior to its assembly with the ladder side-rails;

FIG. 5 is an enlarged fragmentary elevation in partial section illustrating the connection of the rung to the ladder side-rails;

FIG. 6 is a partial perspective view illustrating a modified form of the ladder rung of this invention; and

FIG. 7 is a cross-sectional view illustrating still another modified form of the invention.

Referring now to the drawings and particularly to FIGS. 1 and 2 thereof, a section of a ladder formed in accordance with the present invention is shown having a pair of side rails generally designated by the numeral 10, and in the form illustrated are of I-shaped cross-section having a central web portion 12 between a pair of flanges 14. While a light metal siderrail of this configuration is suitable for use with this invention, it is contemplated that other shapes may be used, such as for example, the siderrails may be of C-shaped cross-section or in some instances if desired, may be of wood, in which case they would be of a rectangular cross-section. At intervals along the siderrails corresponding to spacing between rungs, are provided sets of at least two holes 16 and 17 suitably shaped for attachment of rungs to the web 12 in a manner which will be more fully described herinafter.

A plurality of rungs 18 are spaced at intervals between the siderrails, the cross section of each rung defining a plurality of relatively heavy rod-like reinforcing rib portions, there being two such ribs 20 and 21 in the embodiment of FIGS. 1 and 2 diametrically opposed and interconnected by relatively light semicircular wall portions 22 formed integrally therewith to form a rung of circular external cross-section. Desirably, the external surfaces of the rungs are fluted or serrated to provide a traction surface on the exterior of the rung.

The walls 22 on each end of the rungs are cut back to leave a portion of the ribs extending as rivet studs 24 and 25 respectively. The studs extend through the apertures 16 and 17 and are expanded over the web 12 adjacent the apertures by riveting to form heads 26 and 27.

As shown in FIG. 1, the angular profile of the rungs with respect to the longitudinal center-line 28 of the siderrails is such that a line 30 passing through the center of the heads 26 and 27 and correspondingly the axes of ribs 20 and 21 makes with the line 28 an angle α. The angle α preferably approximates 15°, so that when the ladder is placed against a building or other support in use, the line 30 assumes an approximately vertical position. Accord-ingly, the rib portions 20 and 21 are positioned, in use, at the extreme lower and upper portions of the rung, the positions of maximum loading in tension and compression respectively imposed by external loading of the rung from above. Thus, it will be seen that in the new and improved ladder rung of this invention, there exists a concentration or relatively heavy cross-section of material at the points of maximum stress, permitting an extremely thin wall portion interconnecting these rib portions and a corresponding reduction in weight as compared to a uniform or conventional cross-section. Further, the extension of the rib portions as studs extending through the apertures 16 and 17, and the expansion or riveting of the end thereof to form the rivet heads 26 and 27 results in a pressure between the heads and their adjacent holding surfaces in the siderrail web to add substantial strength to the joint to resist forces in shear, tension, torsion, or bending. Yet, because of the relatively small apertures required in the siderrail web 12, the siderrail is weakened an insubstantial amount as compared with prior art teachings.

The unique method for forming the ladder of the present invention may be understood by reference to FIGS. 3, 4 and 5 of the drawings. As shown in FIGURE 4, a rung is formed by extruding a cross-section defining the ribs 20 and 21 and integral wall portions 22 and severing the extrusion into lengths to form blanks 32. A portion of the walls 22 near each end of the blank 32 are cut back such as by machining, abrading or other well known techniques to leave end portions of the blanks 32 extending as studs 24 and 25 respectively. After the rungs 18 are thus formed, they are aligned with the apertures 16 and 17 in the siderrail web 12, inserted therethrough and the outer ends thereof expanded or riveted to form the heads 26 and 27. In this manner, the highly desirable ladder structure is formed and assembled in an extremely simple and economical manner.

In the embodiment of FIG. 6, the rung takes the form of a channel-shaped wide tread step 34, the cross-section of which is defined by a plurality of longitudinally extending rib portions 36, formed integrally with connecting side wall portions 38 and a top wall or tread portion 40 having upwardly facing treads 42. As in the first mentioned embodiment, the walls 38 and 40 are cut back at the end of the rung to leave extensions of the ribs 36 in the form of studs 44 to be inserted in corresponding spaced apertures in the ladder siderrail and riveted thereto.

A still further preferred modified embodiment of the ladder rung of this invention is illustrated in FIG. 7 of the drawings. As shown in this figure, a rung incorporating the present invention may be formed having a quadrilateral or trapezoidal cross-section with upper wall or tread 46 under which a rib portion 48 is integrally formed, side walls 50 and a bottom wall 52. A pair of rib portions 54 are provided at the corners of the walls 50 and 52 to resist the tensile stress imposed on the lower portion of the rungs when loaded. Again, as in the preceding embodiments, the walls 46, 50 and 52 in use will be cut back to leave extending the ribs 48 and 54 as rivet studs for connection of the rung to the ladder siderrails.

Thus, it is well to appreciate one skilled in the art that the foregoing objectives are completely and adequately fulfilled by the present invention. Because of the unique cross-sectional configuration of the rungs, an extremely strong and light rung section is afforded, while at the same time providing a highly desirable means for attachment of the rung to the ladder siderrails. The ability to attach portions of the rung to the siderrails substantially enhances the strength of the connection because of the inherent qualities which derive from a rivet-type connection. In other words, after the studs 24 and 25 are inserted through the apertures 16 and 17 and the ends thereof riveted, not only is the rung held against removal from the siderrails by the rivet heads 26 and 27, but also that portion of the stud which remains in the aperture is expanded so
as to develop extreme pressure against the sides of the holes and thus firmly anchor the rung in place. Accordingly, the resulting ladder is light in weight, exceptionally strong to withstand the loads imposed thereon, and further is resistant to the damaging effect of forces resolved into the rung-side rail joints by rough handling.

Since the present invention may take many diverse forms, it is to be distinctly understood that the foregoing description is illustrative only and not limiting, the true spirit and scope of the invention being defined by the appended claims:

I claim:

1. A ladder comprising in combination:
   a pair of side rails having sets of holes formed therein at longitudinally spaced intervals, each of said sets having at least two holes;
   and a plurality of rungs extending between said side rails, said rungs each including an extruded length of light metal of a generally circular cross section defining two rod-like rib portions, said rib portions being diametrically opposed and interconnected by semicircular wall portions, the wall portions at each end of said length being cut back to leave said rib portions extending as studs;
   said studs being received in said holes and expanded to connect said rungs to said side rails, said rib portions and said studs in each of said rungs being spaced along the length of said side rails to provide resistance to bending of said rungs together with resistance to bending between said rungs and side rails in a direction of length of said side rails.

2. A ladder comprising in combination:
   a pair of side rails having sets of holes formed therein at longitudinally spaced intervals, each of said sets having at least two holes;
   and a plurality of rungs extending between said side rails, said rungs each including an extruded length of light metal of a channel-shaped cross section defining a wide tread step including four rib portions connected by a pair of integral side wall portions and a top wall portion, the wall portions at each end of said length being cut back to leave said rib portions extending as studs;
   said studs being received in said holes and expanded to connect said rungs to said side rails, said rib portions and said studs in each of said rungs being spaced along the length of said side rails to provide resistance to bending of said rungs together with resistance to bending between said rungs and side rails in a direction of length of said side rails.

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