

Feb. 2, 1937.

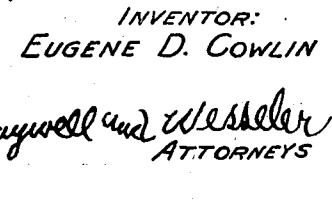
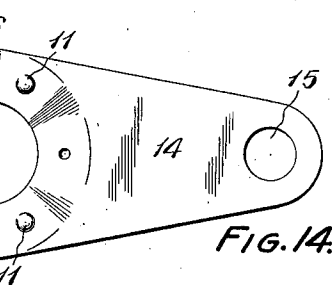
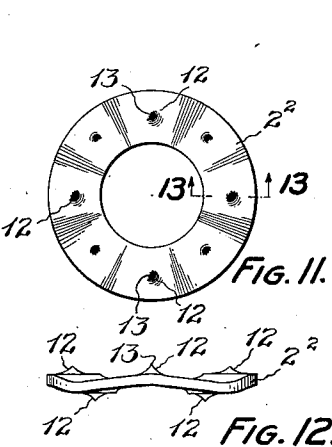
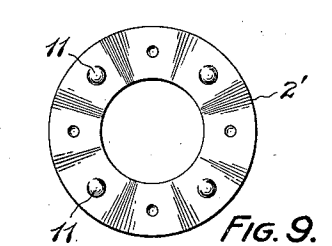
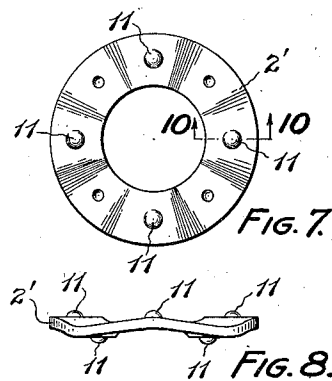
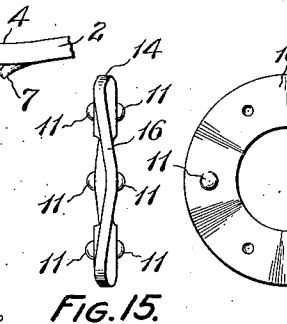
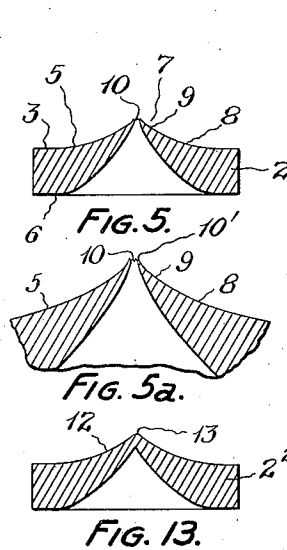
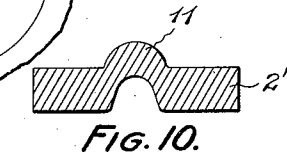
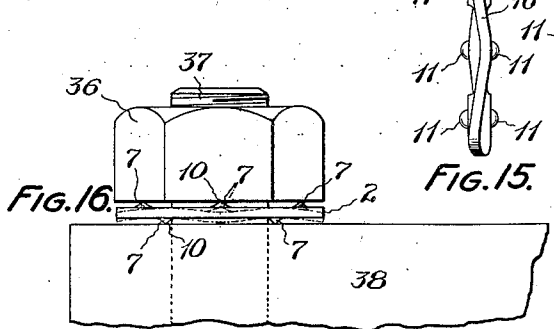
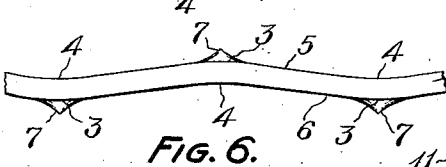
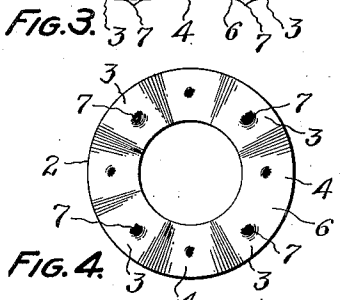
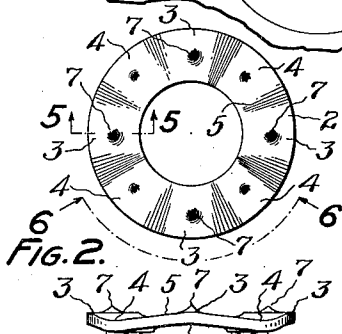
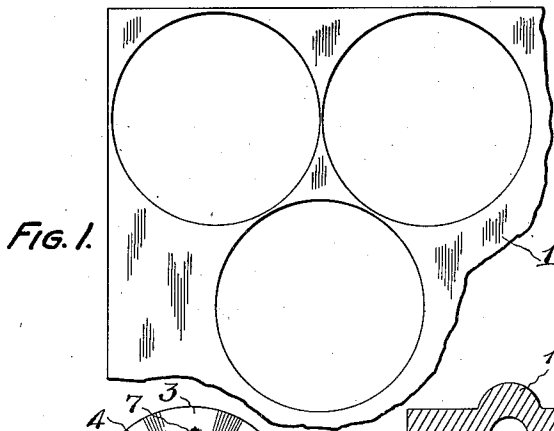
E. D. COWLIN

2,069,402

LOCK WASHER

Filed June 29, 1935

3 Sheets-Sheet 1



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Feb. 2, 1937.

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2,069,402

LOCK WASHER

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3 Sheets-Sheet 2

Fig. 17.

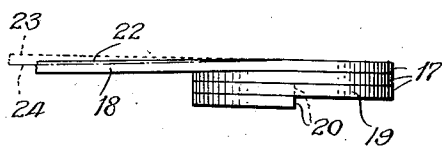


Fig. 18.

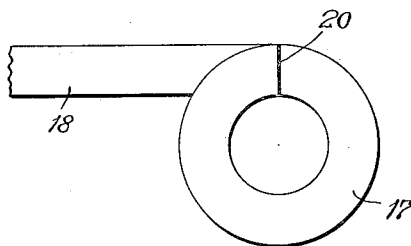


Fig. 19.

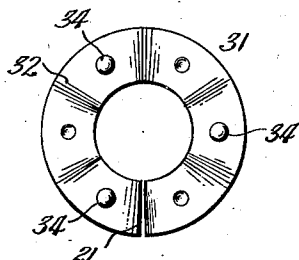


Fig. 20.

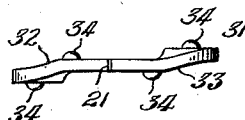


Fig. 21.

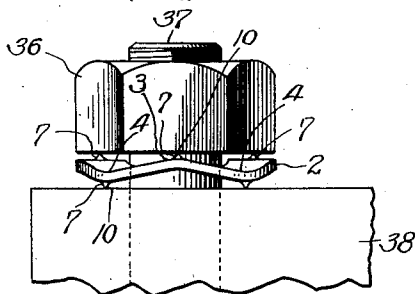


Fig. 22.

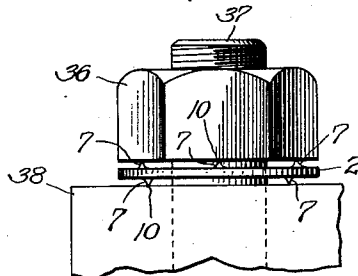
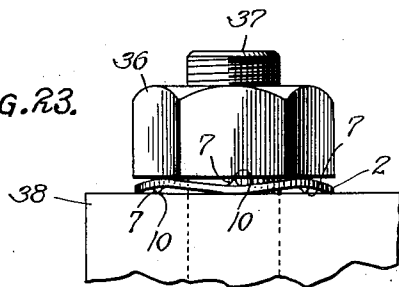


Fig. 23.



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LOCK WASHER

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3 Sheets-Sheet 3

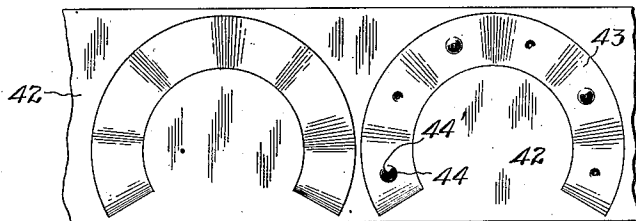


FIG. 24.

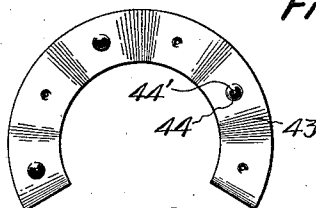


FIG. 25.

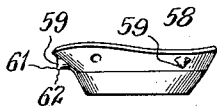


FIG. 36.

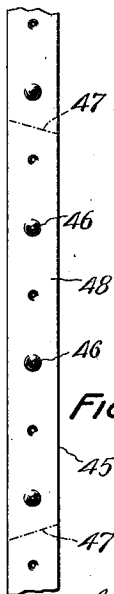


FIG. 26

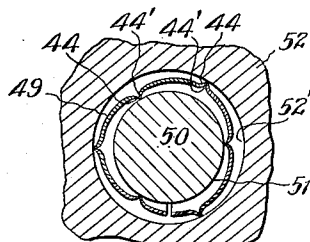


FIG. 37.

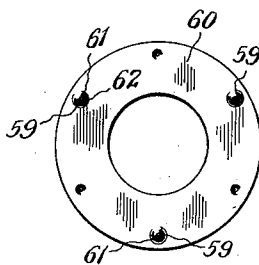


FIG. 37

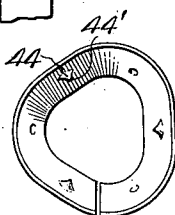


FIG. 27.

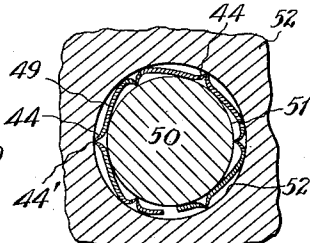


FIG. 30.

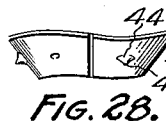


FIG. 28.

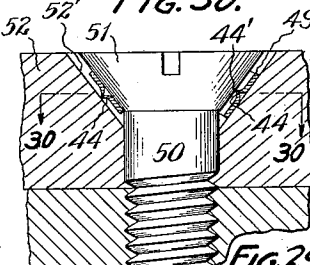


FIG. 29.

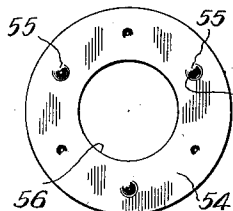


FIG. 35.

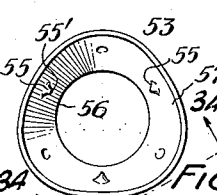


FIG. 32.

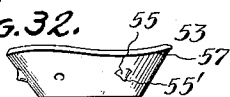


FIG. 34.

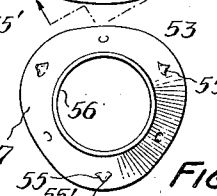


FIG. 33.

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UNITED STATES PATENT OFFICE

2,069,402

LOCK WASHER

Eugene D. Cowlin, Massillon, Ohio, assignor to
Eaton Manufacturing Company, a corporation
of Ohio

Application June 29, 1935, Serial No. 29,125

14 Claims. (Cl. 151—35)

My invention particularly relates to lock washers for use where tight connections are necessarily maintained, for instance, maintaining electrical conductivity in radio and other electrical apparatus. The invention also lends itself for use in many other fields where a more positively locking washer is required than any concerning which I am informed.

It is an object of the invention to provide an efficient, long-life washer of the aforementioned type which will be simple in construction, economical to manufacture, non-entangling with other like washers, and which will lend itself to automatic assembling. The principle of the invention may be applied to washers of all sizes and gauges and intended for either light or heavy duty.

My improved washer is essentially a ring plate or a conical open-ended shell, either closed or split, which, in unstressed condition, has non-plane or rolling faces, the washer being provided with outwardly-tapered locking projections or ribs upon either or both faces. Against these locking projections either the nut or the bolted seat, or both, abut and press when the washer stock is compressed by the tightening of the nut. Conical or approximately conical locking projections are preferred as being the strongest form of projection for resisting distortion in operation and for transmitting stresses uniformly to the main body of the washer. Preferably, these locking projections have exterior gripping edges formed by piercing entirely through the washer stock when forming the projections.

Washers having a wavy contour in unstressed condition are a very desirable type and are described and shown in the instant application.

Preferably, the aforesaid locking ribs are located on the crests of the respective waves of the washer faces and preferably centrally of the inner and outer peripheries of the ring plate of which the washer is made. Preferably, also, the locking projections are equally spaced one from the other, i. e., the contour of the washer faces is of uniform wavy appearance. Locking projections may be applied, with certain advantages, adjacent the inner or the outer periphery of the washer, thus forming a series of half-conical locking projections along either or both peripheries.

The washers may be made by stamping the blanks from flat sheets or strips or, in the case of split ring washers, by coiling strip material and forming and cutting the blanks one at a time from the coil. The locking projections may be of

various types and shapes, and may have open-ended or closed outermost tip terminal portions, i. e., the punches with which the projections are formed in the die may entirely pierce the blank or simply distort the same sufficiently to form the projection out of the blank material without breaking through the latter. The preferred form of washer, however, is obtained by entirely piercing the blank when forming the locking projections, thus creating exterior gripping edges around the openings thus formed in the projections. Some of the suitable forms of projections are: conical, tapered projections with rounded terminals, and projections having rather flat main body members with sharply deflected central terminal portions.

The annexed drawings and the following description set forth in detail certain means illustrating my invention, such means constituting, however, only a few of many forms in which the principle of the invention may be embodied.

In said annexed drawings:

Figure 1 is a plan view of a fragment of sheet material from which three blanks for one form of my improved washer have been stamped;

Figure 2 is a top plan of one form of my improved wavy-type washer;

Figure 3 is an edge view of the washer shown in Figure 2;

Figure 4 is a bottom plan of the washer shown in Figure 2;

Figure 5 is a vertical section, upon an enlarged scale, taken in the plane indicated by the line 5—5, Figure 2;

Figure 5^a, is a fragmentary view, similar to Figure 5 but on a greatly enlarged scale;

Figure 6 is an enlarged developed edge view, taken from the plane indicated by the line 6—6, Figure 2;

Figure 7 is a top plan of a wavy-type washer having a modified form of locking projection;

Figure 8 is an edge view of the washer shown in Figure 7;

Figure 9 is a bottom plan of the washer shown in Figure 7;

Figure 10 is an enlarged section, taken in the plane indicated by the line 10—10, Figure 7;

Figure 11 is a top plan of a wavy-type washer having locking projections of the general type shown in Figures 2, 3, and 4, except that in the latter figures, a washer is shown in which the punch with which the projections were made pierced through the blank material; whereas, in Figure 11 is shown a washer in which the punch

did not pierce through the blank material when the projections were made;

Figure 12 is an edge view of the washer shown in Figure 11;

5 Figure 13 is an enlarged section, taken in the plane indicated by the line 13—13, Figure 11;

Figure 14 is a plan of a terminal plate suitable for use in radio and analogous apparatus, which terminal plate is integrally formed with
10 one type of my improved wavy-type lock washer;

Figure 15 is an end view of the terminal plate shown in Figure 14;

Figure 16 is a view illustrating the use of one of the closed-ring wavy-type lock washers in a nut and bolt assembly, the full-line showing of the washer therein being a partly compressed condition of the washer, for instance, when the washer has been compressed into a substantially flat condition; the broken line showing of the
20 washer in said figure being that of a still further compression which deflects those sections of the washer which were originally convex upwardly into a form convex downwardly, and vice versa;

Figure 17 is a plan view of washer stock wound
25 into a helix, having material for three split-ring washer blanks, there being indicated in dotted line the plane of a proposed cut by which one blank will be removed from the assembly, there also being indicated by dot-and-dash line a plane
30 which is perpendicular to the axis of the helix, and by a broken line the extension of the upper normal helical surface or plane of the coiled assembly, it being noted that the stock is wound at an angle to the perpendicular plane less than
35 the angle made therewith by the normal helix so that the stock is wound under an initial tension;

Figure 18 is a side view of the assembly shown in Figure 17;

40 Figure 19 is a plan view of a washer of the split-ring type whose body member is a wavy contour in unstressed condition, this washer being provided with one form of my improved locking projections, the washer ends being so related
45 as to provide for non-entanglement of the washers when shipped or stored in bulk, even if the washers have no positive non-entangling outwardly-projected end portions;

Figure 20 is an edge view of the washer shown
50 in Figure 19;

Figures 21, 22, and 23 are views illustrating, somewhat more in detail than is shown in Figure 16, the effect upon one of the closed-ring wavy-type lock washers in a nut and bolt assembly, as
55 the nut is tightened upon the bolt from its initial engaging position with the washer to its fully tightened position; Figure 21 showing the conditions when the nut exerts no pressure, Figure 22 showing the conditions when the washer is
60 semi-compressed, the washer being under partial tension, and Figure 23 showing the conditions when the washer is fully compressed, the waves of the washer having become reversed in positions under the conditions shown in Figure 23;

65 Figure 24 is a plan view of a fragment of a steel strip and shows the progressive formation therein of a plurality of washer blanks of a split-ring shell type, which are pressed out of the steel strip into wavy formation with locking
70 projections before they are severed from the strip in split individual washer blanks;

Figure 25 is a plan of one of the completely pressed washer blanks made from the strip shown in Figure 24;

75 Figure 26 is a fragmentary plan of a metal

ribbon pressed so as, when cut into separate lengths, to form a wavy washer blank of the split-ring shell type of each of the severed strip portions;

Figure 27 is a plan of the completed split-ring
5 wavy shell type of washer made from one of the steel strip pressed portions of Figures 24 and 26, after the blank has been rolled into conical shape;

Figure 28 is a side view of the washer shown
10 in Figure 27;

Figure 29 is a vertical section through a washer of the type shown in Figure 28 in position upon a suitable cap or machine screw which is held
15 by the washer against turning or loosening in a suitable seat with which the screw engages, the view showing the fully tightened position of the screw and the compressed condition of the washer;

Figure 30 is a plan section, taken in the plane
20 indicated by the line 30—30, Figure 29;

Figure 31 is a plan section, similar to Figure 30, but showing the condition of the washer before the screw has been tightened;

Figure 32 is a top plan view of another form
25 of shell-like washer which has been blanked out from sheet metal and formed into the completed washer, it being of the closed shell type and having an irregular or wavy top portion and a
30 round-regular bottom hole that will not interfere with the threads of the screw or bolt;

Figure 33 is a bottom plan of the washer shown in Figure 32;

Figure 34 is a side view of the washer shown
35 in Figure 32, the view being taken from the planes indicated by the line 34—34, Figure 32;

Figure 35 is a plan view of a flat blank which may be used for forming the closed-shell type of washer shown in Figures 32, 33, and 34;

Figure 36 is a side view of a washer of the
40 character shown in Figures 32, 33, and 34, in which substantially the upper half is of wavy contour, and is provided with the locking projections, and substantially the lower half is of circular cross-section for smooth engagement
45 with the outer surface of the screw or bolt; and

Figure 37 is a plan view of a flat blank which may be used for forming the type of washer shown in Figure 36.

Referring to the annexed drawings in which
50 the same parts are indicated by the same several numbers in the different views, steel sheet material 1 is shown in Figure 1, from which, by one method of making my improved washer, three washer blanks have been stamped which
55 by suitable operations are formed into complete washers, such as the washer 2, Figure 2, which is one form of the washers embodying my improvements. This washer 2 is of wavy contour, clearly seen in Figure 3, having crests
60 3 and intermediate troughs 4, four such crest portions being shown, for purposes of illustration, and an equal number of alternate trough portions, these crests and troughs being preferably of uniform dimensions, as shown in Figure
65 3, but not necessarily so. The number of crests and troughs may also vary within desirable and suitable limits. The top and bottom faces, 5 and 6, respectively, of the washers 2, are provided with extending nibs 7, the same forming
70 locking projections, in the stressed condition of the washer, as hereinafter fully explained; these nibs 7 being located, preferably, at the outermost points of the crests 3 and comprising, in 75

the form of washer shown in Figures 5 and 5^a, rather flat main portions 8 and sharply outwardly-deflected terminals 9 having apertures 10 therethrough. Figure 5^a is an exaggerated showing of the portions 8 and 9 and aperture 10 of the locking projections 7 which serves to illustrate the roughened and pointed edges 10' formed by the entire piercing of the blank with the punch when making the projections 7.

10 In Figures 7, 8, 9, and 10, is shown a washer 2', of essentially similar body structure to that of the washer shown in Figure 3, but in which the locking projections 11 are of substantially semi-spherical contour and not formed with terminal
15 apertures, such as illustrated by the apertures 10 in Figures 5 and 5^a.

The washer 2², shown in Figures 11, 12, and 13, is similar to the washer shown in Figure 3, except that the locking projections 12 are not
20 provided with the apertures 10 and the terminal portions 13 of the projections 12 are of substantially conical construction.

In Figures 14 and 15, I show the application of one form of my improved washer to a resilient terminal plate 14, suitable for use in electrical and radio apparatus, which plate 14 is provided with a hole 15 adapting the plate 14 for attachment to an electrical conductor, the
25 plate 14 also being formed integrally with an enlarged washer portion 16 having locking projections 11 of substantially the same construction as those in Figure 8.

In Figure 16 I show the application of a washer 2 or 2² intermediate the base of a nut 36 engaging a bolt 37, and any suitable supporting seat 38, the washer 2 being intended to serve securely to lock the nut 36 and thus prevent the latter from backing off the bolt 37 after the nut has been tightened as desired. In the
30 full line showing of the washer in Figure 16, the nut 36 has been partly tightened resulting in a compression of the washer, by reason of the engagement of the nut 36 with the upper locking projections 7, to a substantially flat position of the washer body. In other words, the upwardly convex portions of the washer body have been deflected downwardly and the upwardly concave portions straightened, so as to compress the washer into a substantially plane structure. Thereafter, a further tightening of the nut 36 results in further deflecting the aforementioned upwardly convex portions of the washer below the normal central horizontal plane of the washer body, and in deforming the
35 aforementioned upwardly concave portions into upwardly convex portions, as indicated by the broken line showing in Figure 16. A full tightening of the nut 36 would result in forcing the respective washer portions opposed to the projections 7 against the working faces of the nut 36 and the seat 38, respectively, thus preventing further rotation of the nut. As the nut 36 is tightened, the upper locking projections 7 or 12, whose terminal portions 10 or 13 may, if desired, be of a hardened structure, dig into the opposed face of the nut 36, preventing the backward rotation of the latter during use, and also the lower locking projections 7 dig into the material of the supporting seat 38, particularly if the seat 38 is of comparatively soft material such as wood. The seat 38 may, of course, be of any suitable material that is desired for the particular duty involved. Certain methods of producing the locking projections 7, such as forming the same cut in the plane 20 is made so as to form the

from the material of the washer blank, will result in themselves in hardening the terminal portions 9 and 13 without any special hardening operation.

Figures 21, 22, and 23 further illustrate the conditions shown in Figure 16, which have just been described. In Figure 21, the washer 2 is in unstressed condition, and in Figure 23, the washer 2 is shown in fully stressed condition. It will be noted that the crests 3 and troughs 4 are respectively reversed in positions in Figure 23 from the positions shown in Figure 21. Figure 22 shows a semi-compressed condition of the washer wherein the wavy contour thereof has been changed to a substantially flat shape. The effect of reversing the curves by compression of the washer into the condition shown in Figure 23 is to provide a constant tension over a wide reactive range, thus fully protecting the assembly against looseness, the reversibility of the curves under pressure effecting the maintenance of a constant non-fatiguing tension under the screw, bolt, or nut, and the locking projections resisting any tendency of the screw, bolt, or nut to back off.

The washers shown in Figures 19 and 20 are of the split-ring type. One suitable method of making such washers comprises coiling washer stock into a helix and cutting the individual washers one at a time from the coiled assembly, as illustrated in Figures 17 and 18. These latter figures also illustrate one method of so forming split-ring washers as to render them non-entangling in storage or shipping, and to that end, washer stock 18, preferably of keystone cross-section, is coiled upon a mandrel by suitable tools into a helix, the coiling being as close as possible and under an initial tension which may be produced as illustrated by the plane lines in Figure 17. The plane 22 designates the actual winding plane. 23 designates the plane of the upper normal helical surface in which the stock 18 would lie just previously to being wound, if no axial tension therein were induced. The plane 24 designates that plane which is perpendicular to the axis of the helix and which passes through the place in the upper or outermost surface of the stock where it is bent or flexed out of the normal helical formation. Since the stock 18 as a whole is bent or flexed at the place of bending, the lower surface of the stock as viewed in Figure 17, or that surface of the stock which adjoins the last-formed convolution of the coiled stock, bears a relation to the normal helical formation similar to that of the upper surface of the stock. Therefore the angle at which the stock 18 is wound is less than that of the normal helical formation but not substantially less than that of the respective planes perpendicular to the axis of the helix and passing through the place of bending in the upper and lower surfaces of the stock and hence the stock is wound under initial tension. In this winding or coiling, and as is well-known to those skilled in the art, the keystone cross-section is altered and a rectangular cross-section of the material of the coils of the helix is obtained. The coils 17 are cut from the helix one at a time to form the separate washers 19. As illustrated in Figures 17 and 18, the third washer from the incoming stock 18 is removed after each successive coil 17 is formed. I illustrate three coils 17 in Figure 17, of which the lowermost coil will be removed by cutting in the plane 20 to form the blank of an individual washer 19. This

washer blank with as narrow a gap 21 between the adjacent washer ends as is practicably possible, particularly when the ends of the completed washer are not provided with positive outwardly-directed non-entangling projections.

When the washer blank is cut from the coiled helix along the plane 20, the axial tension is relieved and the adjacent ends of the blank snap slightly inwardly relative to each other so as to overlap slightly in the plane 20, if the coiling has been perfectly close. In other words, the prolongation of the bottom helical surface of the upper washer end across the gap 21 would substantially enter or lie slightly below the upper helical surface at the lower end of the washer. This construction provides a non-entangling washer in a plane pattern or, in other words, with ends of uniform cross-section. Within the limits specified, viz., from the normal helical plane 23 to the plane 24 which is perpendicular to the axis of the helix, the washer stock 18 may be placed under tension when coiled so as to provide, after the individual washers are severed, varying amounts of overlap of the adjacent washer ends or a registry of the washer ends. Also, the size of the gap 21 and the precise closeness of coiling govern the nature of the desirable relation of the washer ends to each other to prevent entangling. Preferably, the various factors which result in the final relationship of the washer ends are coordinated so as to provide a condition at the washer ends in which the extension of the lower substantially helical surface at the upper end of the washer would contact with the upper substantially helical surface at the lower end of the washer, and the improved split-ring washer herein shown, viz., the washer of Figures 19 and 20, is so portrayed.

After the washer blanks have been cut from the helix shown in Figure 17, they are subjected to suitable operations to form the improved form of washer shown in Figures 19 and 20.

In Figures 19 and 20, I illustrate a split-ring washer 31 of the wavy type, in unstressed condition, which is provided upon its upper and lower faces 32 and 33, respectively, with a plurality, three as shown, of semi-spherical locking projections 34. The washer 31 is provided with a gap 21 between the washer ends which is relatively small, the forming of the washer by the coiling and cutting process shown in Figures 17 and 18 having been under such suitable tension as to cause the helical surfaces of the adjacent ends substantially to register, resulting in a non-entangling type of washer by reason of the smallness of the gap 21 and the nature of the relation of the adjacent washer ends to each other.

It is the form and relationship of the washer ends which results in the non-entangling feature thereof, so that portions of the washer blank remote from the ends may be distorted, when producing the form of washer shown in Figure 20, without destroying the non-entangling feature of the ends which has been produced by the making of the washer blanks in the manner illustrated in Figures 17 and 18.

The action of the washer of closed-ring type in practice is as follows: When the nut is screwed down upon the washer interposed between the nut and the supporting seat, the lower face of the nut engages the uppermost tips of the upper locking projections and, upon a further tightening of the nut, moves these projections downwardly, causing the adjacent portions of the washer body to deflect downwardly. This re-

sults in a resilient but positive pressure of the upper projections against the lower face of the nut and an equally resilient pressure of the lower projections against the face of the seat toward which the nut is being screwed. A continued tightening of the nut will deflect the several portions of the washer body which are opposed to the several projections against the faces of the nut and seat and thus prevent further rotation or tightening of the nut.

The form of washer which has locking projections with apertures, such as the aperture 10 in terminal 9, Figures 5 and 5a, possesses very desirable holding properties in that the piercing of the metal to form the aperture 10 provides roughened edges 10' which exercise a biting action upon the nut and seat.

The resilient pressure of the locking projections against the faces of the nut and seat is not destroyed by extreme tightening of the nut. This is a particularly important improvement in washers of this class. This resilient pressure is maintained in the extreme tightened position of the nut and no permanent distortion of the washer takes place as a result of the extreme tightening of the nut due to the fact that the washer material is not stressed beyond its elastic limit by the utmost permissible deflection thereof.

The outermost tip or terminal of the locking projection, which withstands the severest strain, is entirely surrounded by metal on all sides which supports and strengthens it and reinforces its locking action.

As hereinbefore mentioned, the tips of the locking projections which require the greatest wear-resisting properties can be hardened, or may be hardened even in fabricating, since the punch and die compact and toughen the metal. However, any excessive hardness or brittleness at the terminal tips will not result in their breakdown inasmuch as the surrounding metal provides a uniformly distributed support for these tips.

My improved washer has no parts thereof which are likely to break off and become enmeshed in the machinery or other apparatus in which it is used. The improved stamped washer has a smooth inner and outer periphery which will not injure the hands of the mechanic in assembly. Also, the stamped washer utilizes all the metal between the bolt hole and the outer circumference of the washer, no portion of the washer being cut away, so that a very substantial construction is provided which also provides a uniform bearing surface for the nut. Furthermore, my improved washer has no inwardly-projecting tongues or other parts to become entangled in the threads of the bolt with which the nut engages.

In my improved washer, thinner metal can be used than has been used for washers of equivalent duty inasmuch as the load is applied centrally of the washer and uniformly around the periphery of the washer. Furthermore, the individual deflecting portions of my improved washer by reason of the complete support provided therefor are, in fact, beams which are supported at each end, rather than mere cantilevers anchored to the body of the washer, as is true when such complete support is not provided.

This improved washer assures a definite pressure of the locking projections on the opposed faces of the nut and seat for a wide range of relative positions of the nut and seat, and also

possesses a follow-up or a continuing tensioning action, thus maintaining contact of the locking projections with the base of the nut in the event of an accidental partial rotation of the nut.

By reason of the provision of three or more locking projections extending equal distances from each face of my improved washer, the latter will lie flat on whichever side it is laid, thus making it adaptable for automatic assembly.

In the use of my improved washer as a part of a terminal clip or equivalent device in electrical and radio and other similar apparatus, efficient and continuous electrical contact is assured by reason of the follow-up tension of the washer.

I direct particular attention to the fact that when spring tension is exerted upon the nut by the deflection of a portion of the washer body, the said washer body is supported on two spaced points and the tension being exerted on the nut is at a point intermediate the spaced supporting points.

Referring particularly to Figures 24-31, inclusive, I therein illustrate a form of split-ring wavy type of washer which is a conical shell, and is intended for use between the flat head of a countersunk cap or machine screw and the wall of the conical hole in the seat which the screw engages. Of the many methods of forming such conical shell type split washers, I illustrate two, one in Figure 24, and the other in Figure 26. In forming these washers I first press out of metal strips the washer formation with suitable locking projections, and then sever the individual portions into washer blanks which are subsequently rolled into conical shape.

In Figure 24, I show a metal strip 42 of substantially the width of the diameter of one of the desired blanks, and this strip 42 is pressed so as to form laterally-extending locking projections 44 with the terminal apertures 44' and to form the desired wavy contour of the completed washer, after which the individual blank portions are cut from the strip 42 to form separate washer blanks 43, such as illustrated in Figure 25. These blanks can be rolled into completed conical washers, such as washer 49, Figures 27 and 28.

In Figure 26, I illustrate the use of a metal strip 45 of ribbon formation, and of a width equal to the vertical height of the desired conical shell-type washer. This ribbon strip 45 is also first pressed so as to form the desired wavy contour and the locking projections 46, after which ribbon lengths suitable for the desired size of washer are cut from the ribbon strip 45 along the lines 47, so as to provide a blank 48 having one edge longer than the opposite edge, whereby the blank 48 can be rolled into a conical split shell which shall serve as the completed washer 49, Figures 27 and 28. One preferred arrangement of locking projections 44 consists of a single series positioned in a plane perpendicular to the plane containing the axis of the washer, the projections laterally extending from the washer body and extending inwardly and outwardly alternately.

In Figures 29, 30, and 31, I illustrate the use of one of my improved split-shell type of washers with a screw 50 having a flat conical head 51, the screw 50 engaging a suitable seat 52 having a conical recess 52' within which the conical head 51 may be countersunk. Figure 31 illustrates the condition of the washer 49 before the screw 50 has been tightened, and Figures 29 and 30 illustrate the condition of the washer 49 after the

screw 50 has been tightened. It will be noted from an inspection of Figures 29 and 31, in connection with Figure 30 which is a plan section through Figure 29, that the wavy contour of the washer 49 has been reduced in depth of crests and troughs in tightening the screw 50 and that the terminals of the locking projections 44 alternately tightly engage the wall of the seat recess 52' and the outer surface of the screw head 51 to prevent the backing off or loosening of the screw 50.

Referring particularly to Figures 32, 33, 34, and 35, I therein disclose a closed-shell type of washer 53 formed from sheet metal material. One method of making this closed-shell washer 53 is to stamp out flat blanks 54, Figure 35, from sheet steel, and then press or otherwise suitably form the blank 54 into the completed washer 53. Preferably, the laterally-extending locking projections 55 with the apertured terminals 55' are formed when the blank 54 is stamped out. When the blank 54 is pressed into suitable shape for the desired form of completed washer 53, the wavy or desired irregular outline is formed in the shell body, the latter being made of conical formation and, preferably, the wavy or irregular outline is limited to a top portion 57 of the shell and the lower portion or, at least the extreme lower portion, is formed of regular circular cross-section, so that the smaller lower end hole 56 of the shell is round and does not interfere with the threads of the screw or bolt 50. Thus the top of the washer is irregular to set up a tension over the head 51 of the screw or bolt 50, and the locking projections 55 and the roughened edges of the apertured terminals 55' engage the countersunk surface of the seat 52 and the undersurface of the head 51 of the screw or bolt 50.

Referring particularly to Figures 36 and 37, I therein disclose a closed-shell type of washer 58 formed from sheet metal material, and of a character similar to the washer shown in Figures 32, 33, and 34, except that the washer 58 is of the desired wavy irregular outline for substantially its upper half, and is of regular circular cross-section, for substantially its lower half, locking projections 59 being formed in the wavy upper half of the shell body. One method of making the type of washer 58 is to stamp out flat blanks 60, Figure 37, from sheet steel, and then press or otherwise suitably form the blank 60 into the completed washer 58. The lower half of the washer 58 of regular circular cross-section provides means for smoothly and effectively engaging the outer surface of the screw or bolt and permits the convenient turning of the latter, when tightening, without blocking or damaging engagement of the washer therewith by reason of wavy or irregular lower portions of the washer intersecting the path of movement of the screw or bolt as it is being turned. Preferably, the locking projections 59 have apertured terminals 61 formed with roughened or biting edges 62.

What I claim is:

1. A lock washer comprising a split ring plate of wavy contour in the unstressed condition of the plate, said plate having end portions brought into juxtaposition to prevent washer entanglement in shipping or handling, at least one of the faces of the plate being provided with a plurality of spaced outwardly-extended locking projections whose bases are entirely surrounded by the body of the plate.

2. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having an outwardly-extended locking portion on the convex side of each of a plurality of the plate waves upon both washer faces, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

3. A lock washer of annular wavy formation including a plurality of spring sections having substantially rigid outwardly-extended locking portions on the convex sides of the washer waves, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

4. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having outwardly-extended locking portions disposed on the crests of the plate waves, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

5. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having outwardly-extended locking projections with rounded terminal portions and disposed upon the convex sides of the plate waves, said waves, under compressive force applied to the locking projections, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

6. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having conical locking portions outwardly-extended in planes perpendicular to planes intersecting the washer axis at right angles, said locking portions being disposed on the convex sides of the plate waves, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

7. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having outwardly-extended locking portions on the convex sides of the plate waves whose bases are entirely surrounded by the body of the plate, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

8. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and hav-

ing outwardly-extended locking portions on the convex sides of the plate waves, said locking portions having apertured terminals, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

9. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having outwardly-extended locking portions on the convex sides of the plate waves, said locking portions having rough apertured terminals, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

10. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour and having outwardly-extended locking projections on the convex sides of the plate waves, said locking projections being chambered and having annular terminal portions, said waves, under compressive force applied to the locking projections, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

11. A lock washer comprising a split ring plate having non-entangling end portions, the plate being of wavy contour and having outwardly-extended locking portions disposed upon the crests of a plurality of the plate waves upon both faces of the washer, said waves, under compressive force applied to the locking portions, being changeable in position over a range of positions from upper convex formation to upper concave formation and vice versa.

12. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt and having at least one of its faces of wavy contour in the unstressed condition of the plate, the wavy plate portion having a plurality of outwardly-extended locking projections disposed on the crests of the face waves and whose bases have circular perimeters and are entirely surrounded by the body of the plate.

13. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate faces being of wavy contour in the unstressed condition of the plate, said plate faces each having an outwardly-extended conical locking nib on the convex side of each of a plurality of the face waves whose base is entirely and symmetrically surrounded by the body of the plate.

14. A lock washer comprising a spring plate having an aperture for accommodating a screw or bolt, the plate being of wavy contour in its unstressed condition, at least one of the plate faces having a plurality of outwardly-extended locking projections disposed on the crests of the waves, the bases of said locking projections being entirely surrounded by the body of the plate.

EUGENE D. COWLIN.