April 25, 1933. O. F. EWERT 1,905,277

METHOD OF MAKING SPLINE COUPLINGS

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Fig. 1.

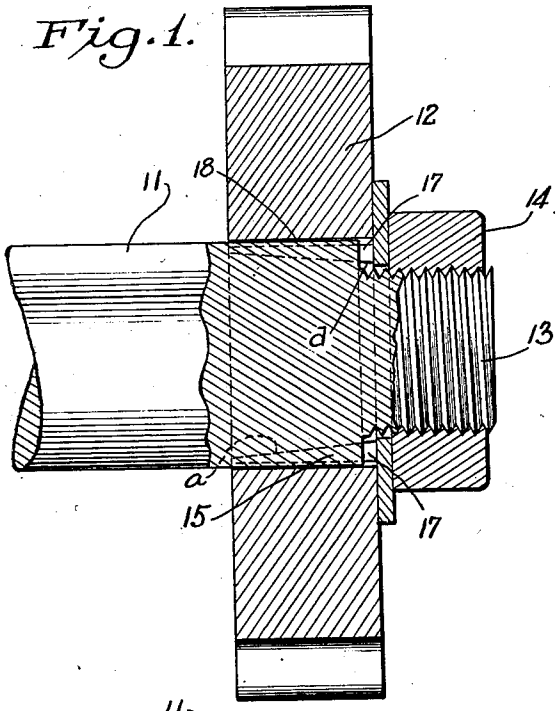


Fig. 2.

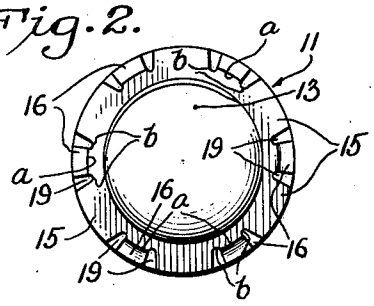


Fig. 4.

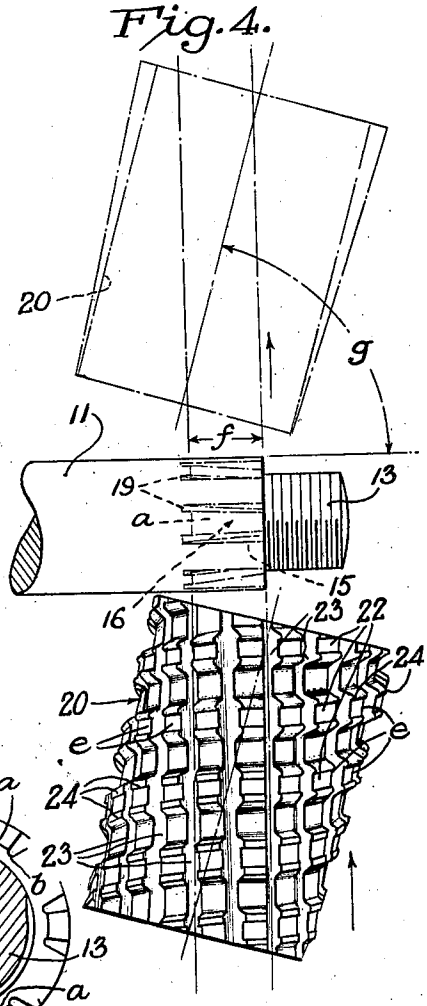


Fig. 3.

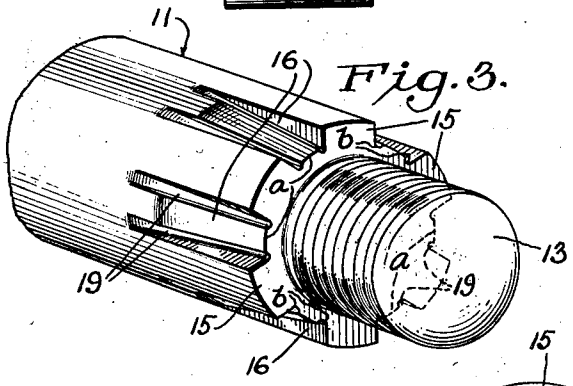
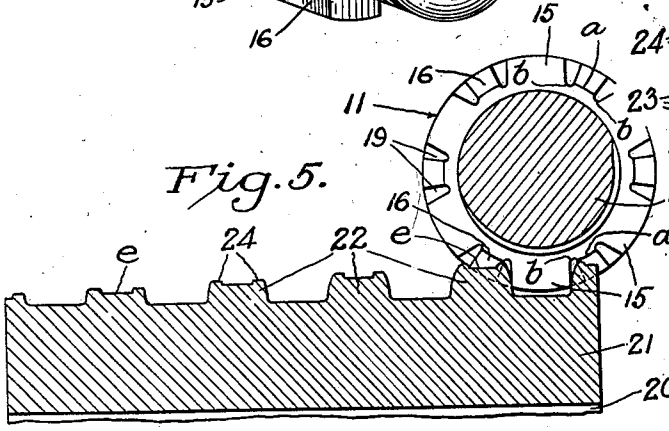


Fig. 5.



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Fig.6.

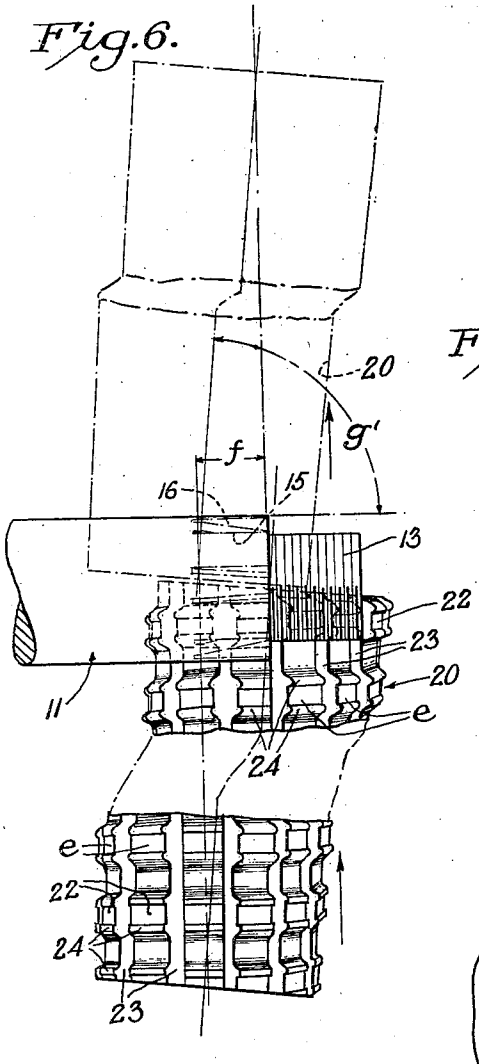


Fig.7.

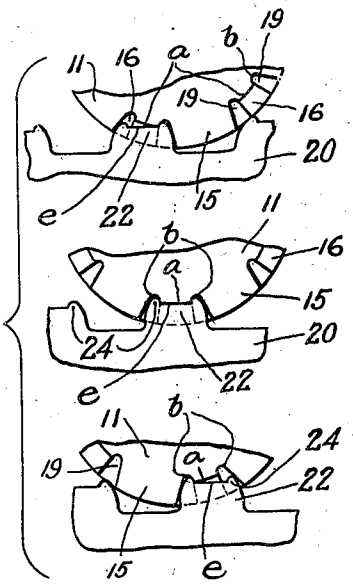
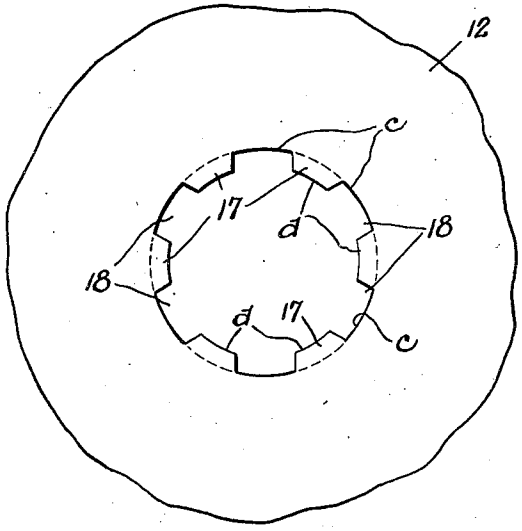


Fig.8.



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METHOD OF MAKING SPLINE COUPLINGS

Application filed August 3, 1931. Serial No. 554,625.

The present invention relates to a new method of making spline couplings adapted for example to secure an outside member, such as the hub of a gear, to an inside member, such as a shaft, and has particular reference to the forming of a spline shaft having parallel integral keys with tapered bases.

The primary object of the present invention resides in the provision of a novel method of generating keys of the foregoing character on the inside member or spline shaft of a spline coupling.

Other objects reside in the provision of a novel method of hobbing the inside member of a spline coupling with parallel integral keys having tapered bases which results in accurate forming and spacing of the keys, which makes possible forming of the tapered bases without interference regardless of the varying radius along the taper, which produces bases or roots for the keys that are concentric in cross-section to the axis, and which permits of a high rate of production.

A further object resides in the provision of a novel method of hobbing rotary members with peripheral projections or keys uniformly spaced about the axis of rotation and extending generally longitudinally of the axis, which method comprises feeding the member and a suitable hob relatively to each other through cutting engagement along a path inclined to the hob axis so as to project the general longitudinal form of the hob along said path to provide a foreshortened form on the keys and the intervening spaces, generally along said axis of rotation.

The invention is illustrated in connection with the accompanying drawings, in which:

Figure 1 is a fragmentary axial sectional view of a coupling assembly made by a method embodying the features of my invention.

Fig. 2 is an end elevational view of the inside member.

Fig. 3 is a fragmentary perspective view of one end of the inside member.

Fig. 4 is a diagrammatic view illustrating the preferred form of hobbing method employed in splining the inside member.

Fig. 5 is a fragmentary sectional view showing the hob in engagement with the spline shaft.

Fig. 6 is a view similar to Fig. 4 but illustrating the use of a single thread hob.

Fig. 7 is a diagrammatic representation in three fragmentary views of successive stages in the generating action.

Fig. 8 is a fragmentary end view of the outside end member.

While the invention in its broad aspects is not limited to the specific details of any particular spline coupling, it is herein described in connection with a coupling comprising an inside member in the form of a shaft 11 and an outside member in the form of a gear 12 adapted to be rigidly secured thereon. The end of the shaft 11 is formed with a reduced threaded extension or stud 13 adapted to receive a suitable nut 14.

Formed integrally with the end of the shaft 11 are a plurality of generally longitudinal generated spline keys 15 separated by interdental spaces 16. The keys 15 are parallel, that is to say, the outer longitudinal edges are parallel. The sides of each key 15 are parallel, and hence the sides of each space 16 converge inwardly. Preferably, the keys 15 are formed in uniformly spaced relation about the shaft 11.

The roots *a* of the spaces 16 are tapered longitudinally to form a tapered or conical base for the keys 15. Obviously, due to the taper, the side edges *b* of the root of each space 16 converge. The roots *a* in cross-section are arcuate, and concentric to the axis of the shaft 11.

The hub 12 of the gear is formed with a plurality of generally longitudinal projections 17 separated by interdental keyways 18. The projections 17 conform in number, spacing and shape to the spaces 16, and the keyways 18 conform similarly to the keys 15. Thus, the keyways 18 are parallel and have parallel sides and inner arcuate roots *c*. These roots define a cylindrical base for the keys 15 adapted to receive the shaft 11. Also, the projections 17 are tapered longi-

tudinally, and have converging sides and inner arcuate faces *d* concentric to the axis of the shaft 11. These faces define a conical bore adapted to seat snugly on the conical base of the shaft 11. Preferably, clearance grooves 19 are formed in the keyways 16 at the longitudinal margins of the roots *a*.

In use, the gear hub 12 is fitted onto the splined end of the shaft 11 with the keys 15 and projections 17 in interfitting relation. The hub 12 is tightly secured against the tapered base of the keys 15 by means of the nut 14. It will be evident that looseness between the shaft 11 and the gear 12 can be fully taken up, and that a tight connection, held definitely against relative rotation by the keys 15 and 17, is obtained. Thus, the gear hub 12 can not become loose.

The keys 15 are produced by a generating or hobbing method which makes possible the formation of the keys 15 integral with the shaft 11 without encountering interference even though the roots of the spaces 16 converge in width along the taper, and obviously makes possible a high rate of production. Generated keys are correctly formed and accurately spaced even though the radius of the roots of the keyways changes along the taper.

In carrying out the method, a special hob 20 is used. The hob 20 has a cylindrical body 21, and may have any suitable number of threads. Preferably, the hob 20 is of the multiple-thread type, and in Figs. 4 and 5 is shown as having three threads 22 intersected by inclined generally longitudinal flutes or gashes 23. A single-thread hob 20 with one thread 22 intersected by gashes 23 can also be used in the method, and is shown in Fig. 6. In each form of hob, the threads 22 are tapered from one end to the other of the body 21. It will be noted that the taper progresses both along the threads and longitudinally of the hob in an axial plane, and that the outer faces *e* of the hob teeth are therefore laterally inclined in accordance with the axial taper.

Ribs or lugs 24 are formed on the hob teeth to cut the clearance grooves 19. For cutting a spline shaft without the clearance grooves 19, a hob similar to the hob 20 but with the clearance lugs 24 removed would be used.

It will be understood that the hob thread or threads 22 may have any desired contour depending on the form to be generated on the keys 15, and that in the present instance, the thread contour is such that straight parallel sides will be formed on each key, and the roots of the spaces 16 will be concentric to the axis of the shaft 11.

The method of operation is illustrated in Figs. 4 to 7. Referring first to Fig. 4, the the multiple-thread hob 20 is inclined to the shaft 11 to bring the threads 22 at the cutting side of the hob into parallel relation to the keys 15 to be cut. The effective length and taper of the hob 20 are definitely related to the length of the shaft section to be splined. Assuming *f* as representing the length of the shaft section, a hob 20 is provided having a length such that when it occupies the proper angular position the projection of its effective length in an axial plane of the shaft 11 perpendicular to an axial plane of the hob will coincide with the length *f*, and having a degree of taper that will produce the desired degree of taper on the shaft. The angular position of the hob 20, as well as the length and degree of taper of the hob obviously depend on the number of the hob threads 22. For a triple-thread hob 20, the angle *g* subtended with the shaft 11 is relatively small, and the hob is relatively short.

When using a single-thread hob 20, as shown in Fig. 6, the hob also is inclined to locate its thread 22 parallel to the keys 15 to be cut, and its effective length and taper are determined by the length of the shaft section *f* to be splined. In this instance, however, the angle *g'* subtended with the shaft 11 is relatively large, and hence the hob is relatively long. It will therefore be evident that a single-thread hob is suited best for the generation of relatively short keys 15, and that where keys of substantial length are to be formed, a multiple-thread hob is most advantageous.

In operation, with a hob 20, either single- or multiple-thread, having the foregoing specifications and the correct angular position, and positioned also to take the desired depth of cut, the hob 20 and the shaft 11 are rotated in timed relation, and the hob is gradually fed relatively across the shaft in a direction at an angle to the hob axis, for example in the direction of the arrow, into the position indicated in dotted outline. In crossing the shaft 11, the hob 20 generates the keys 15 with the desired form.

The feed effects a rolling or generating action by reason of which the keys and the roots of the spaces 16 are correctly and accurately formed, and which avoids interference even though the roots of the spaces are tapered and hence variable in width and radius along the taper. The generating action is illustrated in Fig. 7. It will be evident that as the feed proceeds and the hob axis gradually crosses the axis of the shaft, the spaces 16 are cut to full depth progressively from the outer end to the inner end of the shaft section *f*. By reason of the taper of the hob threads, the roots of the spaces are tapered.

It will be evident that by reason of the inclination of the hob axis to the path of feeding movement, the longitudinal form of the hob thread will be projected along the

path of movement so as to cut progressively a foreshortened form on the keys 15 and the spaces 16 along the axis of rotation of the inside member 11. Since, for the preferred form of coupling, the hob thread 22 is tapered in height and uniform in width at the pitch line along its length, the keys 15 are uniform in width, and the roots *a* of the spaces 16 are tapered as described. The invention in its broad aspects is not limited to the specific form of the hob thread since various forms may be used so as to produce different kinds of keys 15 and spaces 16.

The lugs 24 on the hob cut the grooves 19. The edges *b* are not generated with sharp corners, but by reason of the grooves 19, the outer edges of the projections 17 can be sharp. If the grooves 19 were not provided, the longitudinal edges of the projections 17 would be made slightly rounded or chamfered.

The hub 12 of the gear may be splined in any suitable manner. Preferably, a taper bore coincident with the inner faces *d* of the projections 17 is formed, and then a suitable broach is pulled axially through the taper bore to form the keyways 18 defining the projections 17.

I claim as my invention:—

1. The method of hobbing an inside member of a spline coupling which comprises positioning the member and the hob in operative relation with the hob axially inclined to the perpendicular to the member, rotating the member and the hob in timed relation, and feeding the hob relatively across the axis of said member in a path at an angle to the hob axis during said rotation through cutting engagement.

2. The method of hobbing the inside member of a spline coupling which comprises positioning the member and the hob in operative relation to generate keys on the member upon relative movement therebetween transversely of the member, the hob being inclined longitudinally to the member and being of a length such that the projection foreshortened of its effective length along the path of movement on the member is coincident with the length of that portion of the member to be hobbed, rotating the member and the hob in timed relation, and feeding the hob relatively across the member during said rotation through cutting engagement.

3. The method of hobbing the inside member of a spline coupling which comprises positioning the member and a longitudinally tapered hob in operative relation to generate uniformly spaced, integral keys with tapered bases on the member upon relative movement therebetween transversely of the member, the hob being inclined longitudinally to the member, rotating the member and the hob in timed relation, and feeding the hob relatively across the member in a path other than an extension of the hob axis during said rotation through cutting engagement.

4. The method of hobbing a spline shaft section with longitudinal keys having tapered bases which comprises positioning the section and a longitudinally tapered hob in operative relation to generate the keys upon relative movement therebetween transversely of the section, with the hob inclined longitudinally to the normal of the section at an angle corresponding to the angle of the hob thread, rotating the shaft section and the hob in timed relation, and feeding the hob relatively across the section during said rotation through cutting engagement.

5. The method of hobbing a spline shaft section with longitudinal uniformly spaced, integral keys having tapered concentric bases which comprises positioning the section and a hob in operative relation to generate the keys upon relative movement therebetween transversely of the section, with the hob inclined longitudinally to the normal to the section at an angle corresponding to the angle of the hob thread, and with the hob thread tapered in height from one end to the other and the backs of the hob teeth inclined laterally, rotating the shaft section and the hob in timed relation, and feeding the hob relatively across the section during said rotation through cutting engagement.

6. The method of hobbing a spline shaft section with parallel keys having tapered bases which comprises positioning a hob having a cylindrical body and a tapered thread at an angle to the normal of said section corresponding to the angle of the thread and in a position longitudinally of the section such that the projection of the effective length of the hob on the section is coincident with the length of the section to be hobbed and the projection of the thread taper on said section is coincident with a taper of the bases of the keys, rotating the shaft section and the hob in timed relation, and feeding the hob relatively across the section during said rotation through cutting engagement.

7. The method of hobbing a spline shaft section comprising rotating the section and a hob having a longitudinally tapered thread in timed relation, with the hob axially inclined longitudinally to the section, and moving the hob relatively across the axis of the section in a path at an angle to the hob axis during said rotation through cutting engagement.

8. The method of forming a spline coupling comprising hobbing the inside member to form thereon parallel integral keys with tapered bases, forming a tapered bore

in the outside member, and broaching the bore of the outside member to form therein longitudinal projections with parallel cylindrical bases and adapted to interfit with the keys on the inside member.

9. The method of hobbing a spline shaft section comprising rotating the section and a multiple-thread hob having longitudinally tapered threads in timed relation, with the hob inclined longitudinally to the section, and moving the hob relatively across the section in a direction at an angle to the hob axis during said rotation through cutting engagement.

10. The method of hobbing a spline shaft section with longitudinal keys having tapered bases which comprises positioning the section and a longitudinally tapered multiple-thread hob in operative relation to generate the keys upon relative movement therebetween transversely of the section, with the hob inclined longitudinally to the normal to the section at an angle corresponding to the angle of the hob threads, rotating the shaft section and the hob in timed relation, and feeding the hob relatively across the section during said rotation through cutting engagement.

11. The method of hobbing a cylindrical shaft section to form parallel longitudinal keys with tapered bases which comprises providing a hob having a thread tapering in depth from end to end and of a length such that when inclined at the thread helix to the section the projection of the effective hob axis in an axial plane of the section perpendicular to an axial plane of the hob coincides in length with the portion of the section to be hobbed, positioning the hob, rotating the section and the hob in timed relation, and simultaneously feeding the hob relatively in a straight path perpendicularly across the axis of the section through cutting engagement therewith.

12. The method of hobbing a cylindrical shaft section to form parallel longitudinal keys with tapered bases and with clearance grooves along the longitudinal margins of the bases which comprises providing a hob having a thread tapered in depth from one end to the other and having clearance lugs along the sides on the tops of the teeth, positioning the hob relative to the section at an angle to the normal to the section corresponding to the thread helix, rotating the section and the hob in timed relation, and simultaneously feeding the hob relatively across the section in a direction at an angle to the axis of the hob through cutting engagement with the section.

13. The method of hobbing a spline shaft section which comprises providing a longitudinally tapered hob having teeth with clearance lugs on their tops along the side margins, positioning the hob at an angle to and at one side of the section, rotating the section and the hob in timed relation, and moving the hob relatively across the section at an angle to the hob axis during such rotation through cutting engagement to form generally longitudinal keys on the section and to impart a longitudinal taper to the bases of the keys corresponding to the projected taper of the hob.

14. The method of hobbing the inside member of a spline coupling with elongated generally longitudinal laterally alined peripheral keys of predetermined length, the keys being separated by longitudinal spaces having root surfaces concentric in form about the axis of rotation, said method comprising providing a hob having a predetermined longitudinal contour, rotating the hob, relatively feeding the hob in a rectilinear path extending across said axis at an angle to the hob axis through cutting engagement with the member, the hob being axially inclined from a perpendicular to said first axis at an angle corresponding to its lead angle, the hob section having an effective length such that the projection of its form along said path in an axial plane of the member is coextensive in length with the keys to be cut, and during said engagement rotating the member in timed relation to the rotation of the hob and the feeding movement relative thereto.

15. The method of forming a spline coupling comprising hobbing the inside member to form thereon parallel integral keys with tapered bases and clearance grooves along the longitudinal margins of the bases, forming a tapered bore in the outside member, and broaching the bore of the outside member to form therein longitudinal projections with parallel cylindrical bases and sharp longitudinal corner edges, the projections being adapted to interfit with the keys on the inside member.

In testimony whereof, I have hereunto affixed my signature.

OTTO F. EWERT.