No. 746,061. PATENTED DEC. 8, 1903.

H. F. FULLAGAR.

FLUID PRESSURE TURBINE.

APPLICATION FILED SEPT. 16, 1901.

NO MODEL.

Fig. A.

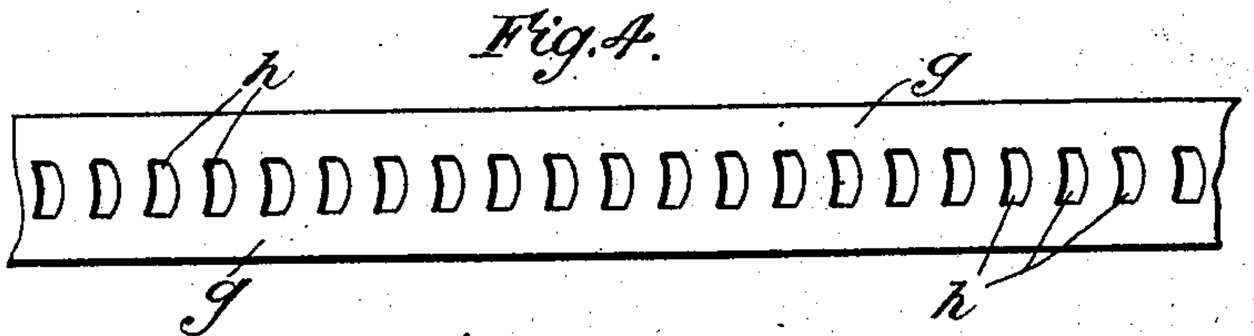


Fig. 1.

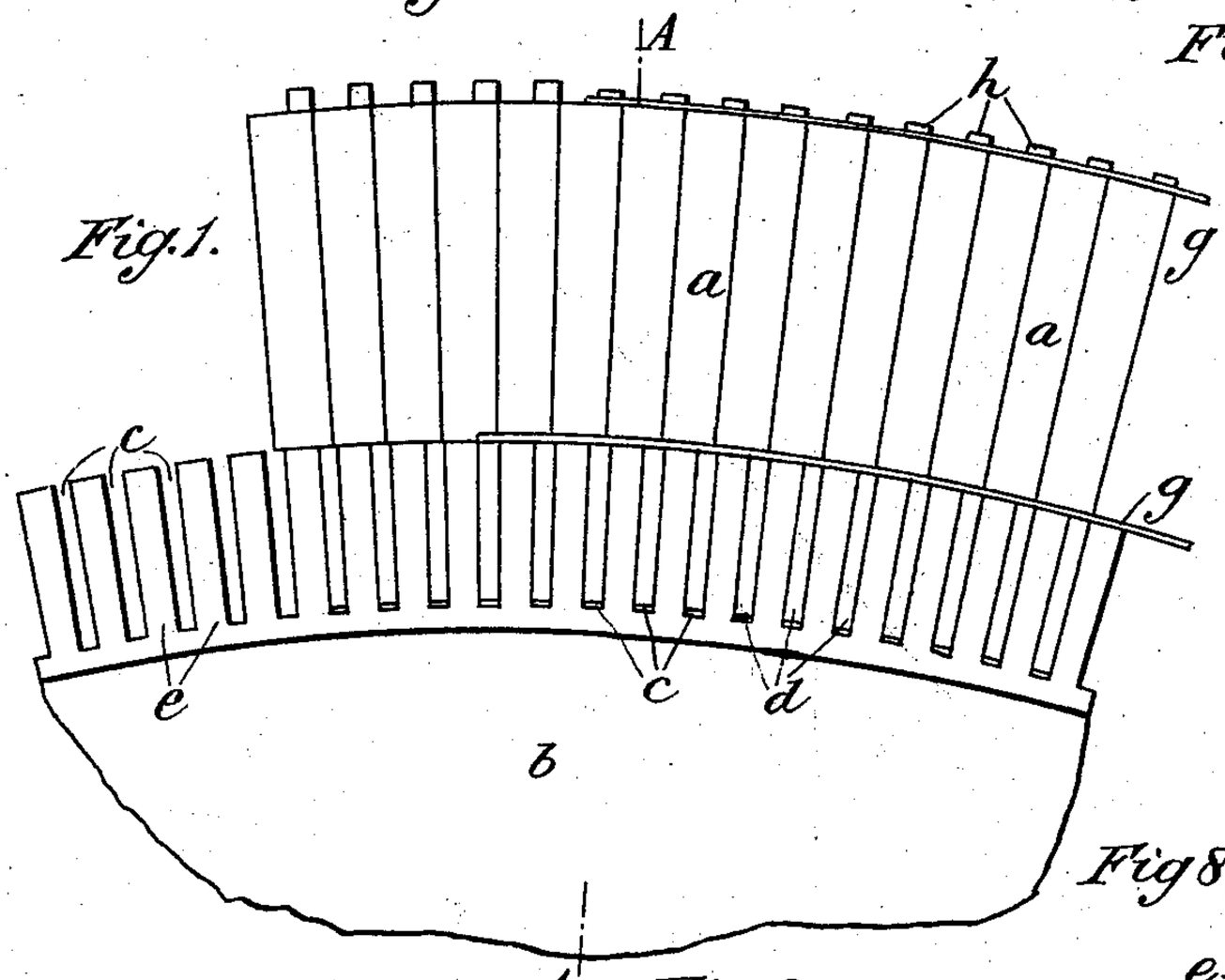


Fig. 2.

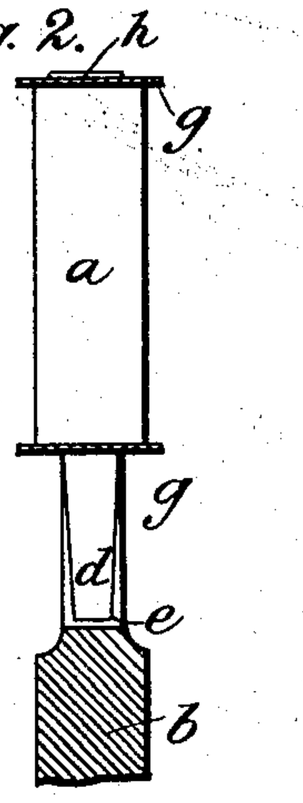


Fig. 3.

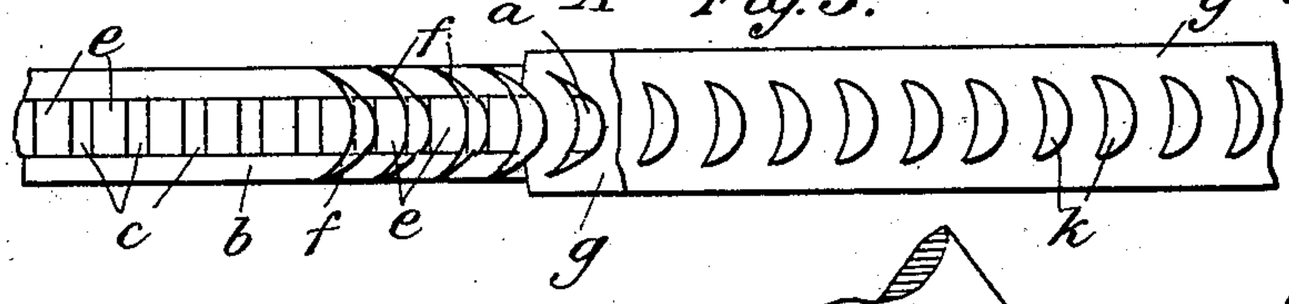


Fig. 8

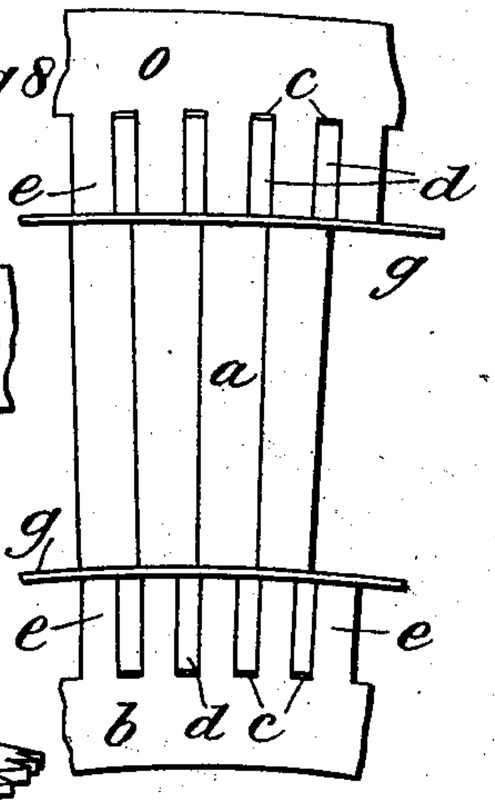


Fig. 5.

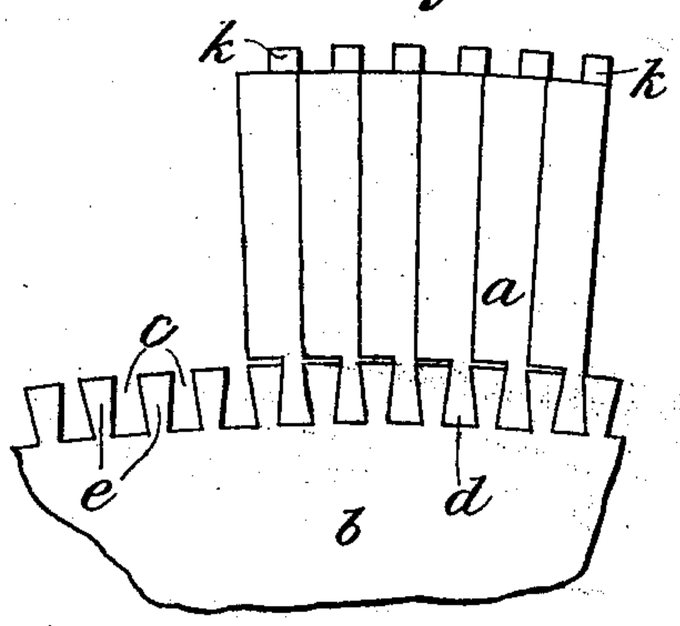


Fig. 6.

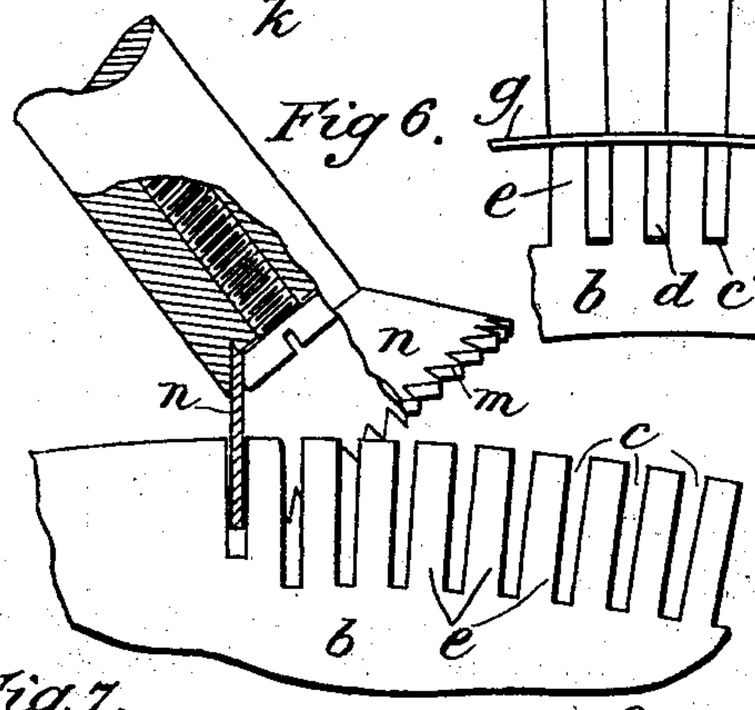
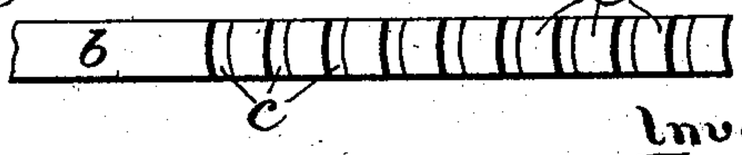


Fig. 7.



Witnesses

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No. 746,061. Patented December 8, 1903.

UNITED STATES PATENT OFFICE.

HUGH FRANCIS FULLAGAR, OF NEWCASTLE-UPON-TYNE, ENGLAND.

FLUID-PRESSURE TURBINE.

SPECIFICATION forming part of Letters Patent No. 746,061, dated December 8, 1903.

Application filed September 16, 1901. Serial No. 75,651. (No model.)

To all whom it may concern:

Be it known that I, HUGH FRANCIS FULLAGAR, a subject of the King of Great Britain and Ireland, residing at Newcastle-upon-Tyne, county of Northumberland, England, have invented Improvements in Fluid-Pressure Turbines and Turbine-Pumps, of which the following is a specification.

In steam and like turbines, especially those of the compound type, in which several successive rings of blades are employed, the total number of fixed and rotary blades used is very large, often five thousand or more. Consequently it is of importance that the method of attaching such blades to the parts by which they are to be carried should not only be inexpensive, but also of such a simple nature that it can be rapidly effected.

Now this invention has for its object to enable a large number of blades of simple form to be attached in a cheap, simple, and ready manner to the circumference of a ring or disk of steel or other metal, which may, if desired, be narrower in width than the blades projecting radially from it, so that the whole shall form a strong ring of blades suitable for use in the construction of a fluid-pressure turbine whether of the simple or compound type and which in the case of a rotary ring of blades shall be capable of withstanding the centrifugal force to which such blades are subjected when in use. For this purpose according to this invention the blades are attached radially to the outer or inner circumference of a ring or disk by inserting the inner or outer ends of the blades, as the case may be, in notches in the said ring or disk and subjecting the teeth between the notches or the ends of the blades therein, or both the teeth and the blade ends, to lateral pressure, so as to upset or expand the metal of the one or the other, or both, in a circumferential direction, so that the blades will be held in place by circumferential pressure set up directly between the adjacent surfaces of the blade ends and teeth without the use of intervening distance blocks or pieces. By this construction the blades will be securely locked to the ring or disk, and the teeth and blades will support each other in a very effective manner in a circumferential direction, so that there will be no liability of the teeth moving apart and releasing the blades. Furthermore, by the construction described the necessity for accurate fitting of the parts, heretofore usual, is avoided.

In the accompanying illustrative drawings, Figure 1 is a side view, Fig. 2 a cross-section on the line A A of Fig. 1, and Fig. 3 a plan, showing part of a rotary ring or disk with blades secured thereto according to this invention. Fig. 4 is a plan of a baffler. Fig. 5 is a similar view to Fig. 1, showing a modification. Fig. 6 shows in side elevation, and Fig. 7 in plan, part of a modified form of notched disk, Fig. 6 also showing a milling-cutter for forming curved notches in the said disk. Fig. 8 is a side view showing another modification.

For the construction in the manner described of a rotary ring of blades the blades *a* are, as shown in Figs. 1, 2, and 3, attached radially to the outer circumference of a flat ring or narrow disk *b*, (hereinafter called a "disk,") preferably of mild steel, in the circumference of which are cut a number of transverse radial notches *c*, that may be either parallel with the axis of the disk, as shown, or inclined to such axis. The blades *a* may conveniently be formed by cutting suitable lengths from a strip of material—such as brass, delta metal, or steel—which has been drawn, rolled, milled, or otherwise formed to the required section and has its two edges parallel to one another. The ends *d* of the blades *a* thus formed are inserted in the notches *c* and secured in place by lateral pressure produced by calking, hammering, or compressing the opposite sides of the blade ends *d* or the opposite sides of the intervening teeth *e* on the disk *b* or the opposite sides of both the blade ends *d* and the teeth *e*, thereby causing either the blade ends or the teeth, or both, to expand in a circumferential direction and cause the blade ends and teeth to firmly grip each other. To give greater security, the notches *c* in the disk *b* or the ends *d* of the blades *a* or both the notches and blade end may be made of slightly dovetail or equivalent shape, as shown in Fig. 5. When the blades *a* are made of ductile metal, a dovetail-shaped head can be readily formed on the ends thereof to be

secured to the disk *b* by holding each blade in a suitable die made in parts and provided with a countersink or recess into which the end of the blade can be hammered, upset, or riveted. Usually, however, it will be more convenient to use parallel notches and blade ends, as in Figs. 1, 2, and 3, and by means of one or more pairs of punches suitably arranged at opposite sides of the disk to compress sidewise first the ends of the teeth *e* of the disk *b* and then the ends *d* of the blades *a* between them, by which means both of the parts mentioned will be caused to assume a slightly dovetailed shape and give sufficient security. To facilitate this method of attachment, the thin edges *f* of each blade *a*, which contribute little to the tensile strength of the blade, may be removed from both sides of that end portion *d* of the blade which enters a notch *c*, so as to present square or flat sides or edges upon which the punches can act. Also the ends *d* of the blades *a* may before being inserted in the notches be pressed between dies to better adapt their cross-section to the shape of the notches *c* in which they are to be fixed.

In order to save weight and to reduce fluid friction, the blades *a* may be made considerably wider than the portion of the disk *b* to which they are to be fixed (see Fig. 2) and be surrounded both at their outer ends and at their inner ends near the outer circumference of the disk with a thin annular baffler *g*, consisting of one or more thicknesses of metal ribbon, the edges of which may be arranged to revolve in any desired proximity to adjacent stationary surfaces in the turbine, so as to thereby prevent the streams of the working fluid while passing through the turbine from spreading radially. In the example each baffler *g* consists of a single thickness of metal. Each baffler is formed with holes *h*, Fig. 4, corresponding to the positions of the blades *a*, and each blade has a tenon formed on each end thereof by cutting away a portion of the thin edge *f* on each side. Each of the holes *h* is preferably formed with parallel sides and curved ends to conform to the shape of the tenon portion of the blade extending therethrough. The tenons *d* on the inner ends of the blades are passed through the holes *h* in the inner baffler *g*, Fig. 4, placed around the circumference of the disk *b* and into the notches *c* of the said disk, where they are secured, as hereinbefore described. The outer baffler *g* is placed over the outer tenons *k* and secured thereto by riveting over the outer ends of the tenons.

As shown in Fig. 3, the baffler *g* at its ends is in contact with a blade *a* and is formed with a notch, by means of which it partially encircles the blade.

By placing a number of disks *b* of the same diameter upon a mandrel the notches *c* in all of them can be sawed or cut simultaneously, thus effecting a great saving of time, the notches thus formed being straight. If desired, however, the disks *b* can be formed with curved notches, (see Figs. 6 and 7,) approximating in shape to the section of the ends *d* of the blades *a* to be secured therein; but in this case the disks will need to be cut separately by a cylindrical or conical cutter, made, for example, by forming teeth *m* on the edge of a steel tube or cone *n*.

The stationary or guide blades of a fluid-pressure turbine can in a similar manner to that hereinbefore described for a set of rotary blades be attached radially to the notched inner circumference of one or more fixed rings. Such stationary blades can also be provided with annular bafflers like *g*, if desired.

The blades *a*, constituting a rotary or stationary ring of blades, may, if desired, and as shown in Fig. 8, be secured in the manner hereinbefore described at both their inner and outer ends to inner and outer disks or rings *b* and *o*, so as to form a ring of blades, the inner and outer ends of which are firmly supported by continuous metal rings.

The invention may advantageously be used in the construction of turbines designed for use as pumps, as well as in those designed to be used as motors.

What I claim is—

1. A turbine-wheel comprising a blade-carrier formed around its periphery with a series of alternately-arranged notches and teeth each extending from one side of said carrier to the other, the notches each having substantially parallel sides from its outer to its inner end and the teeth being integral with said carrier, and a series of blades having solid ends fitting said notches from end to end and held therein by friction between them and the walls of said notches.

2. A turbine-wheel comprising a blade-carrier formed around its periphery with a series of alternately-arranged notches and teeth each extending from one side of said carrier to the other and a series of blades having solid ends with substantially parallel sides from their inner to their outer ends and fitting said notches from end to end and gripped and held directly and solely by and between said teeth.

3. A turbine-wheel comprising a blade-carrier formed around its periphery with a series of alternately-arranged notches and teeth each extending from one side of said carrier to the other, and an annular row of blades having tenon-like ends with substantially parallel sides from their inner to their outer ends and fitting said notches from end to end and held solely by and between said teeth.

4. A turbine-wheel comprising a blade-carrier formed around its periphery with a series of alternately-arranged notches and teeth each extending from one side of said carrier to the other, and a series of blades made of crescent-section and with tenon-like ends with substantially parallel sides from their in-

ner to their outer ends and fitting said notches and held solely by and between said teeth.

5. A turbine-wheel comprising a blade-carrier formed around its periphery with a series of alternately-arranged notches and teeth each extending from one side of said carrier to the other and a series of blades having their outer portions of greater width than the outer periphery of said carrier and solid end portions of less widths fitting said notches and held firmly therein by and between said teeth.

6. A turbine-wheel comprising a blade-carrier formed around its periphery with a series of alternately-arranged notches and teeth each extending from one side of said carrier to the other and a series of blades made of crescent-section and having their outer portions of greater width than the outer periphery of said carrier and with tenon-like ends of less widths fitting said notches from end to end and gripped and held directly and solely by and between said teeth.

7. In a fluid-pressure turbine or turbine-pump, an annular carrier, blades fixed to and made of greater width than the periphery of said carrier so as to overlap each side of said periphery, and an annular baffler fixed to one end of said blades, and of greater width than said blades.

8. In a fluid-pressure turbine or turbine-pump, an annular carrier formed at its periphery with alternately-arranged notches and teeth, a ring of blades made of greater width than the notched periphery of said carrier and having centrally-arranged tenon-like ends held in said notches by and between said teeth, and annular bafflers fixed to the ends of said blades and of greater width than said blades, substantially as described for the purpose specified.

9. In a fluid-pressure turbine or turbine-pump, the combination of an annular blade-carrier the outer periphery of which is formed with alternately-arranged notches and teeth, a ring of radially-arranged blades having tenon-like inner ends held in said notches by and between said teeth, and also tenon-like outer ends, and annular bafflers secured to the inner and outer ends of said blades and made of greater width than said blades, substantially as described.

10. In a fluid-pressure turbine or turbine-pump, the combination of concentric inner and outer rings having notched outer and inner peripheries respectively, an annular group of blades having tenon-like ends secured in the notches in said inner and outer rings, and annular bafflers fixed to the ends of said blades and adjacent to the notched peripheries of said rings, and of greater axial width than said blades and the periphery of each ring, substantially as described.

11. A turbine-wheel comprising a central carrier, a group of blades fixed to and around the periphery of said carrier, and an annular baffler fixed to and around said group of blades adjacent to said carrier and of greater width in an axial direction than said blades and the periphery of said carrier.

12. A turbine-wheel comprising a central carrier, a group of blades fixed to and around the periphery of said carrier, and annular bafflers fixed to and around the inner end portions of said blades, said bafflers being each of greater width, in an axial direction, than said blades.

13. A turbine-wheel comprising a central body having its outer peripheral portion reduced in width, an annular group of blades fixed to the peripheral portion of said body and of greater width than the peripheral portion of said carrier, and annular bafflers fixed to the end portions of said blades.

14. A turbine-wheel comprising a central body having its outer periphery formed with a series of alternately-arranged notches and teeth, an annular group of blades having their inner ends reduced in width so as to form centrally-arranged tenons that are located in said notches and are gripped sidewise by and between said teeth, and an annular baffler fixed to the inner ends of said blades adjacent to said carrier and of greater axial width than said blades and the periphery of said carrier.

15. A turbine-wheel comprising a central body having its outer periphery formed with a series of alternately-arranged notches and teeth, an annular group of blades having their inner ends reduced in width so as to form centrally-arranged tenons that are located in said notches and are gripped sidewise by and between said teeth, and annular bafflers fixed to the inner and outer ends of said blades and of greater axial width than said blades and the periphery of said carrier.

16. As an article of manufacture, a baffler for the ends of turbine blades or buckets, comprising a sheet or strip of metal having notches or slots at the ends and two or more openings between the ends, the said openings having parallel sides and curved ends.

Signed at Newcastle-Upon-Tyne, in the county of Northumberland, England, this 27th day of August, 1901.

HUGH FRANCIS FULLAGAR.

Witnesses:
W. SPELMAN BURTON,
PERCY CORDER.