Feb. 28, 1939. E. SCHMIDTMANN 2,149,232

TUNNEL CONSTRUCTION

Filed Aug. 24, 1936 3 Sheets-Sheet 1

Fig. 1.

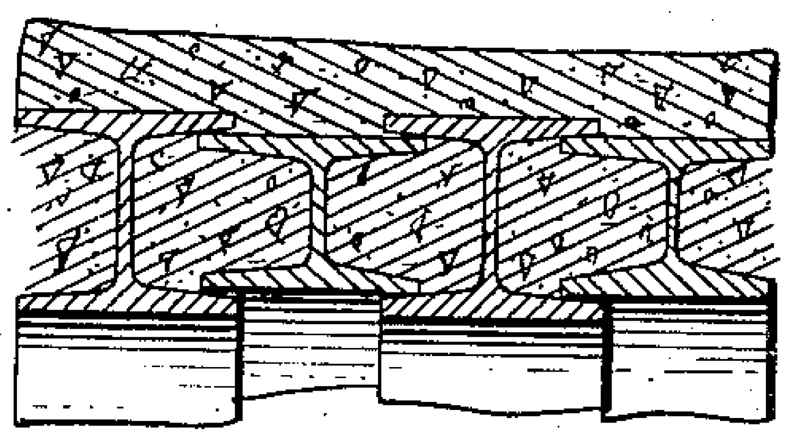


Fig. 2.

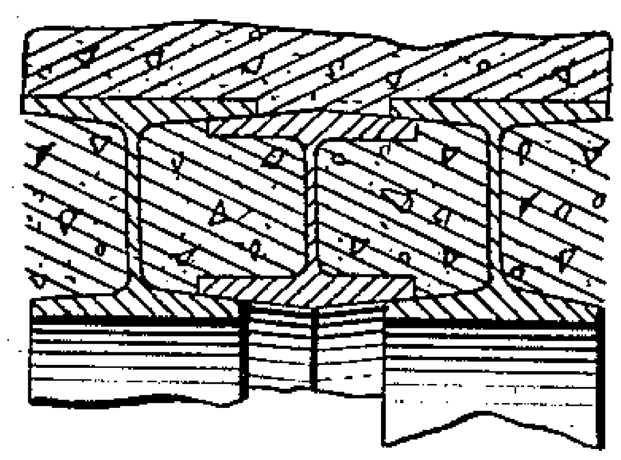


Fig. 3.

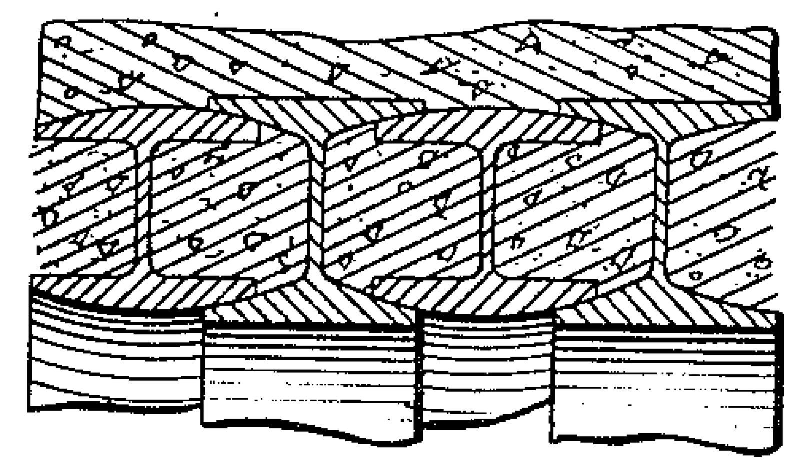


Fig. 4.

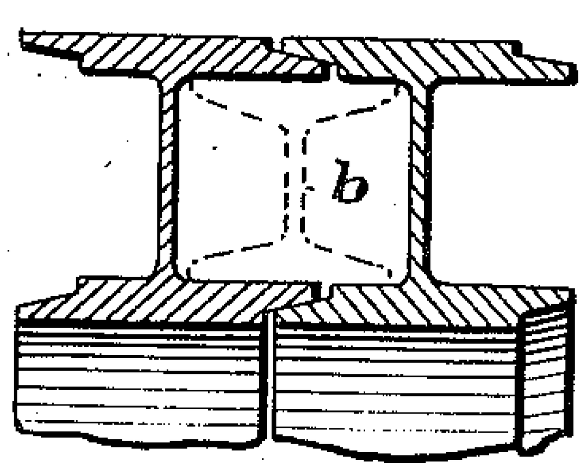


Fig. 5.

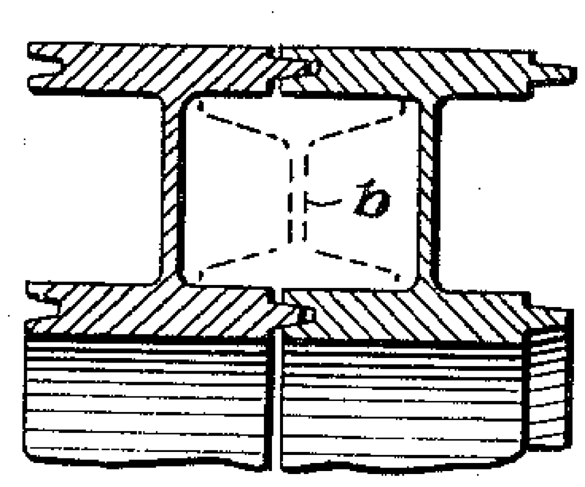


Fig. 6.

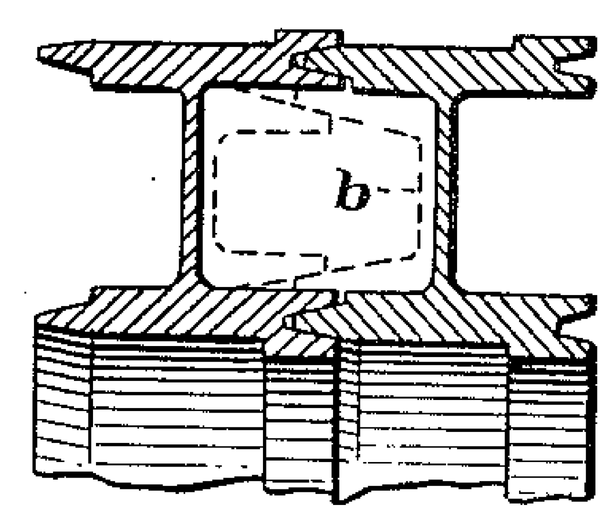


Fig. 7.

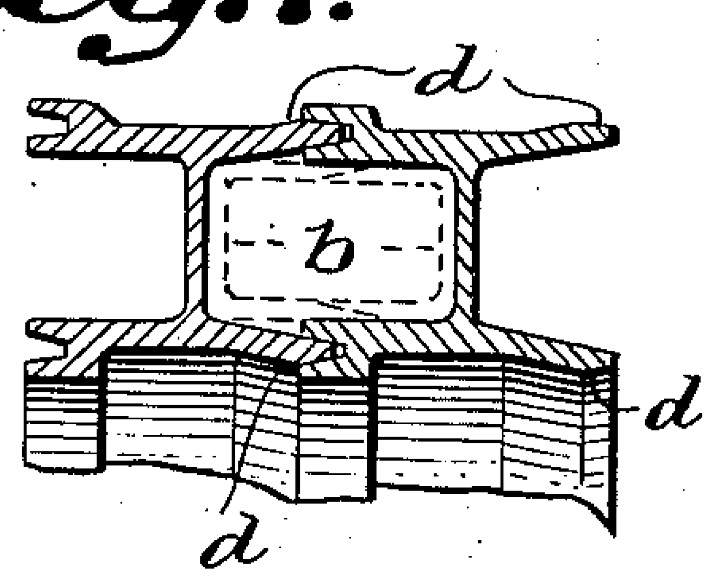


Fig. 8.

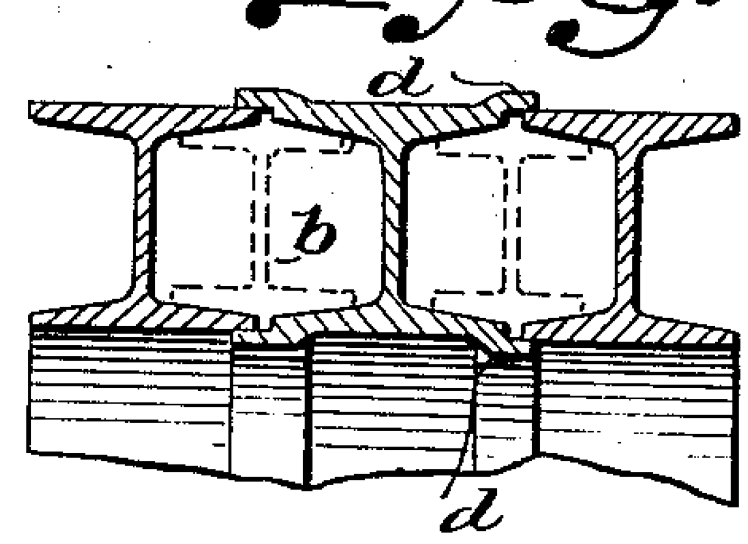
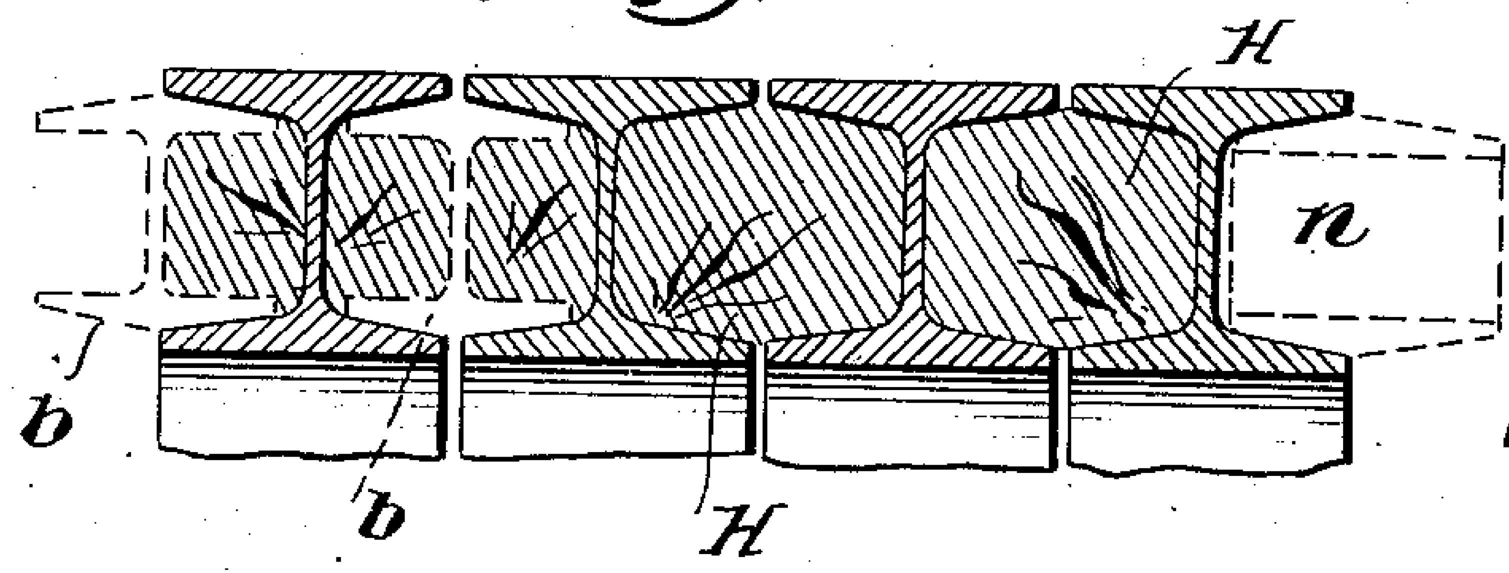


Fig. 9.



Inventor

Emil Schmidtmann

by Alfred Müller

Atty

Feb. 28, 1939.

E. SCHMIDTMANN

2,149,232

TUNNEL CONSTRUCTION

Filed Aug. 24, 1936

3 Sheets-Sheet 2

Fig. 11

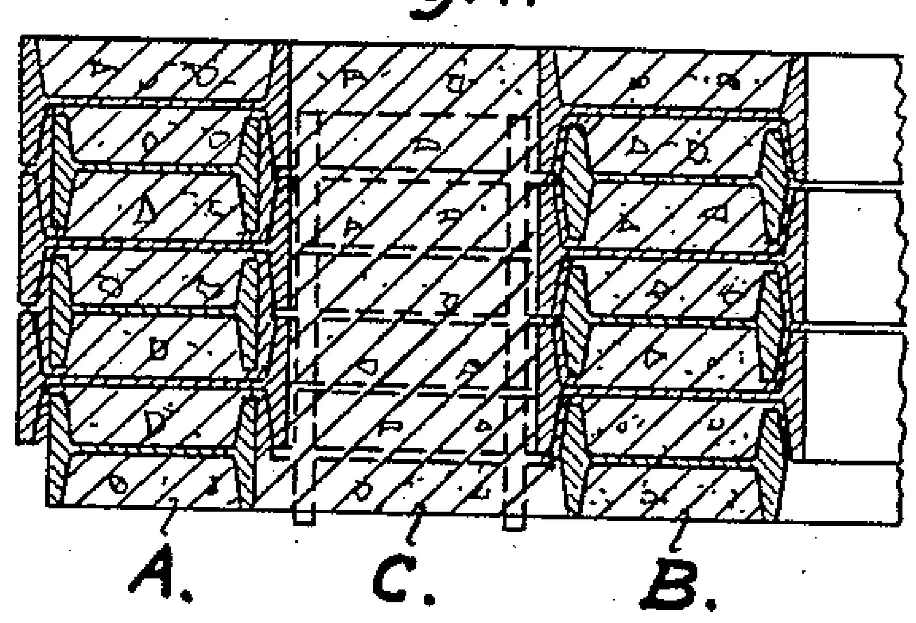


Fig. 12

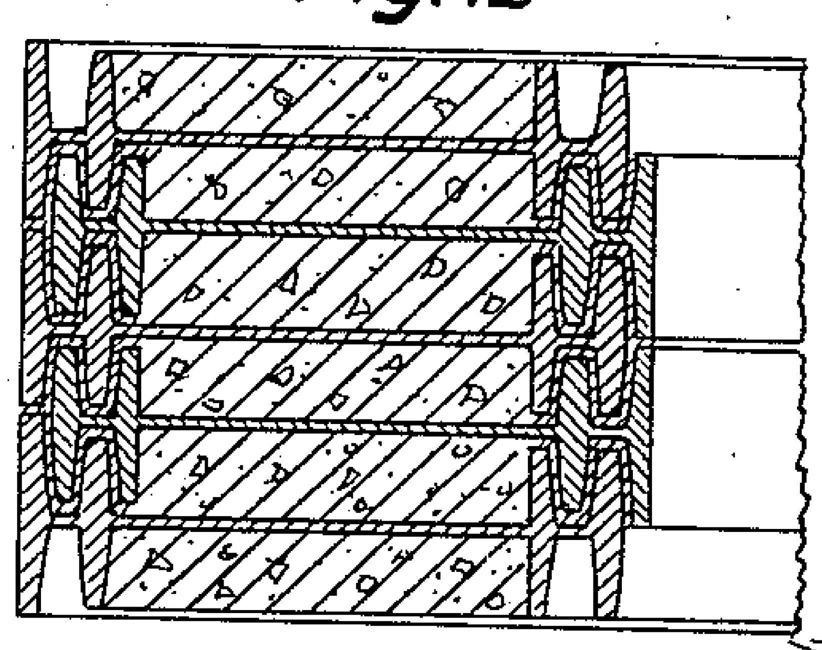


Fig. 13

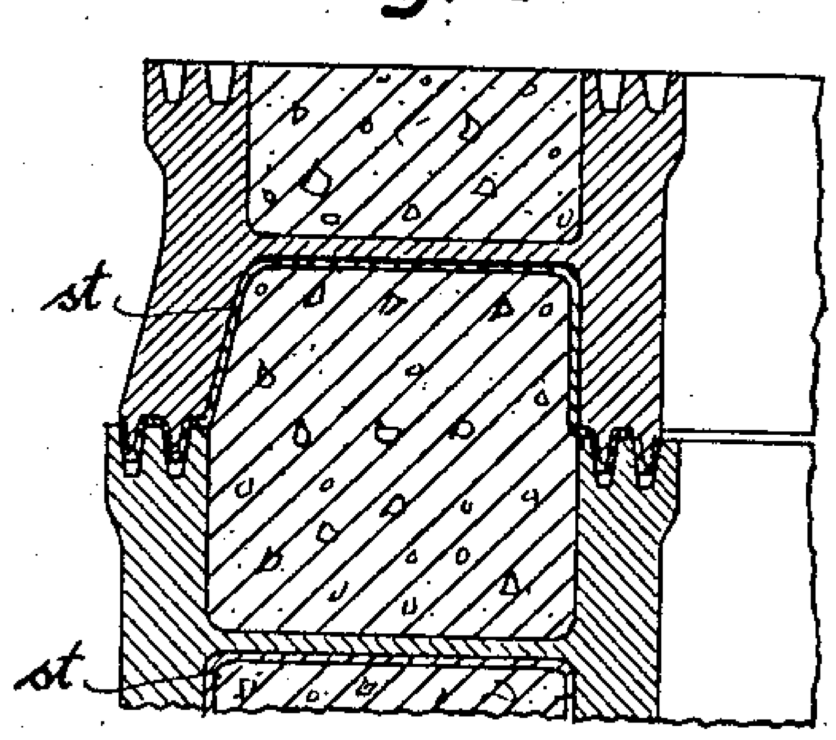
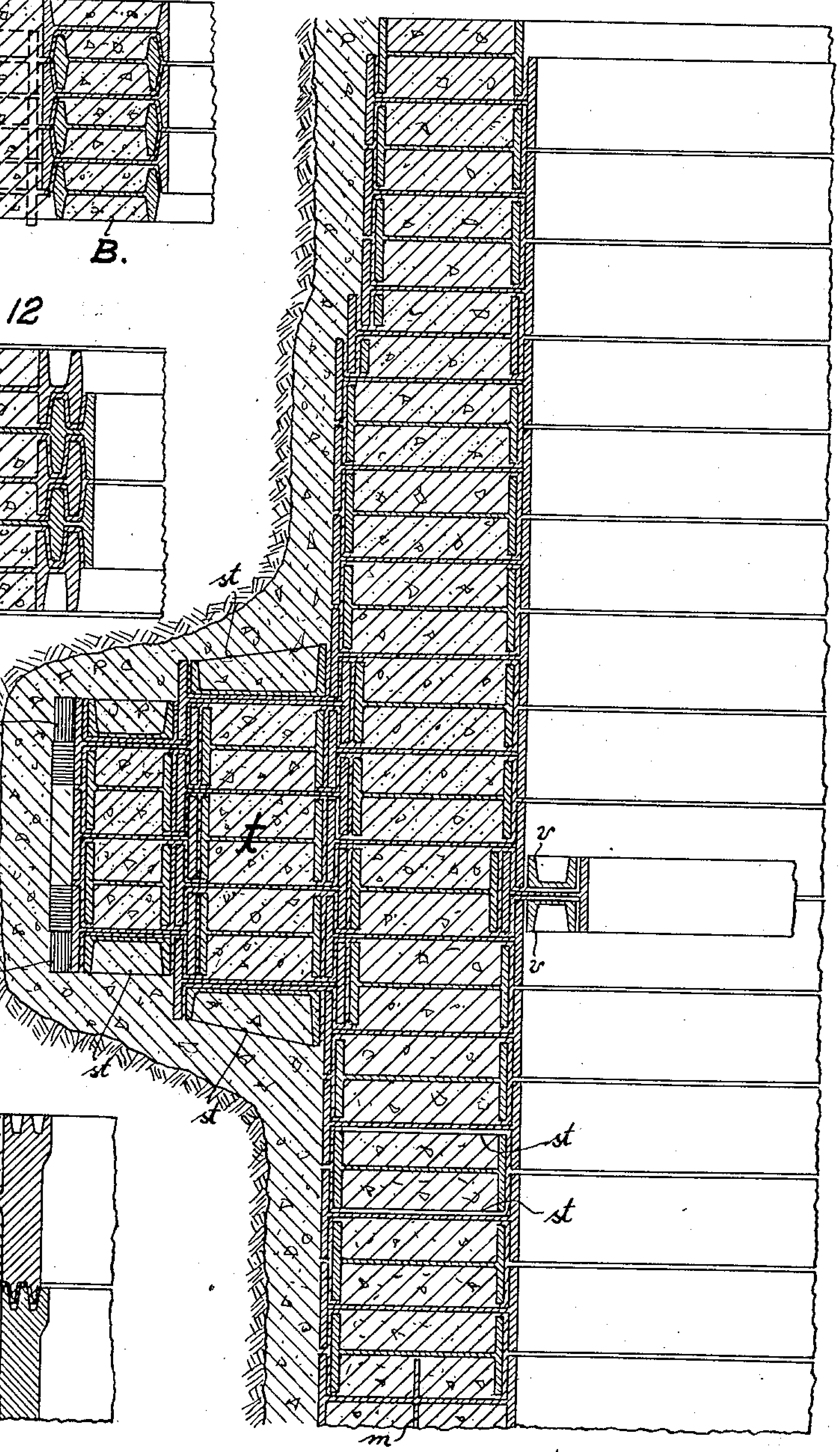


Fig. 10



Inventor:
Emil Schmidtmann,
By Alfred ... Atty.

TUNNEL CONSTRUCTION

Filed Aug. 24, 1936 3 Sheets-Sheet 3

Fig. 14

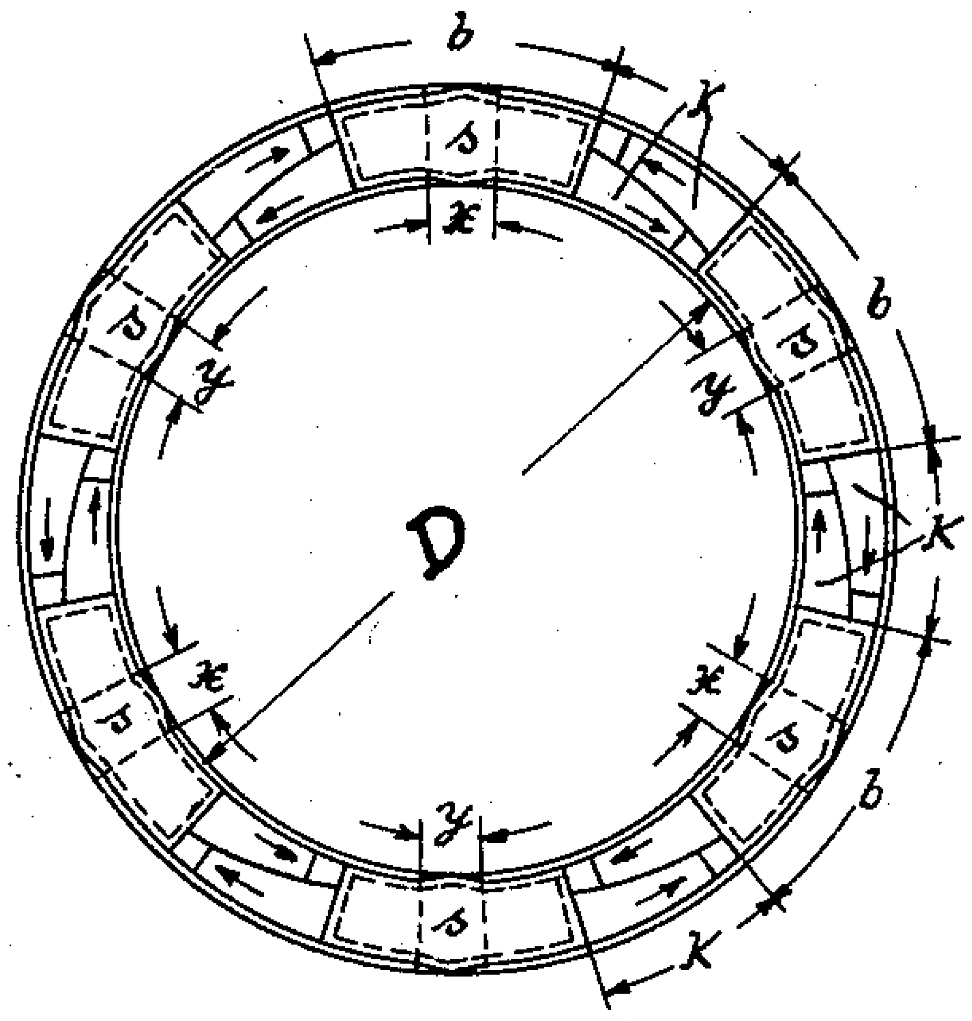


Fig. 15

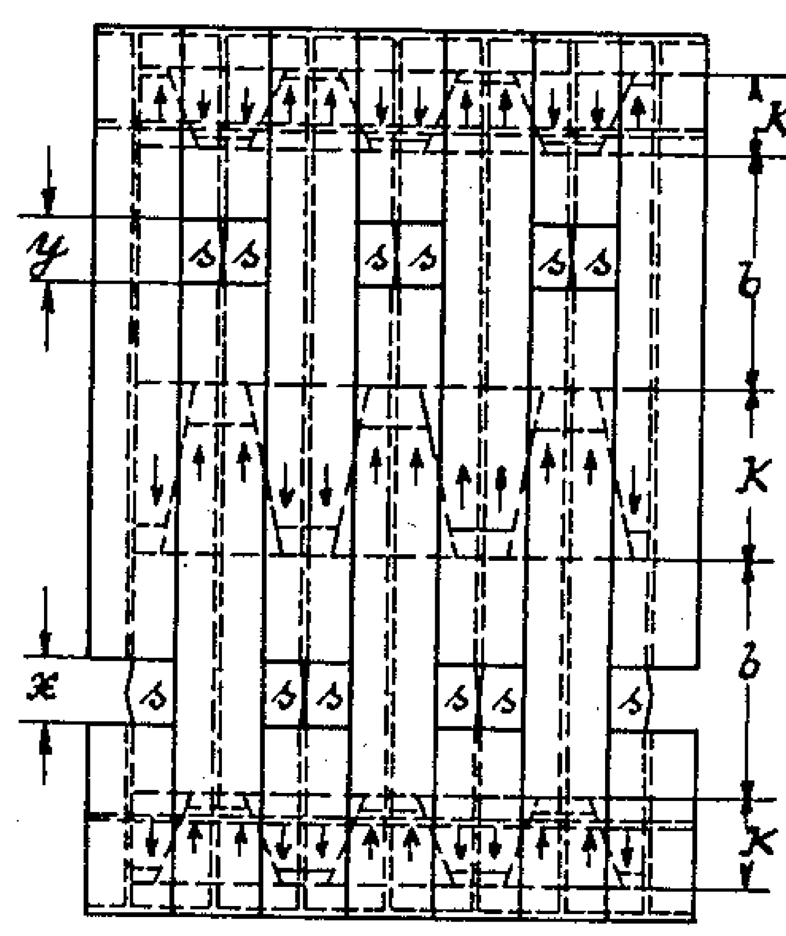


Fig. 16

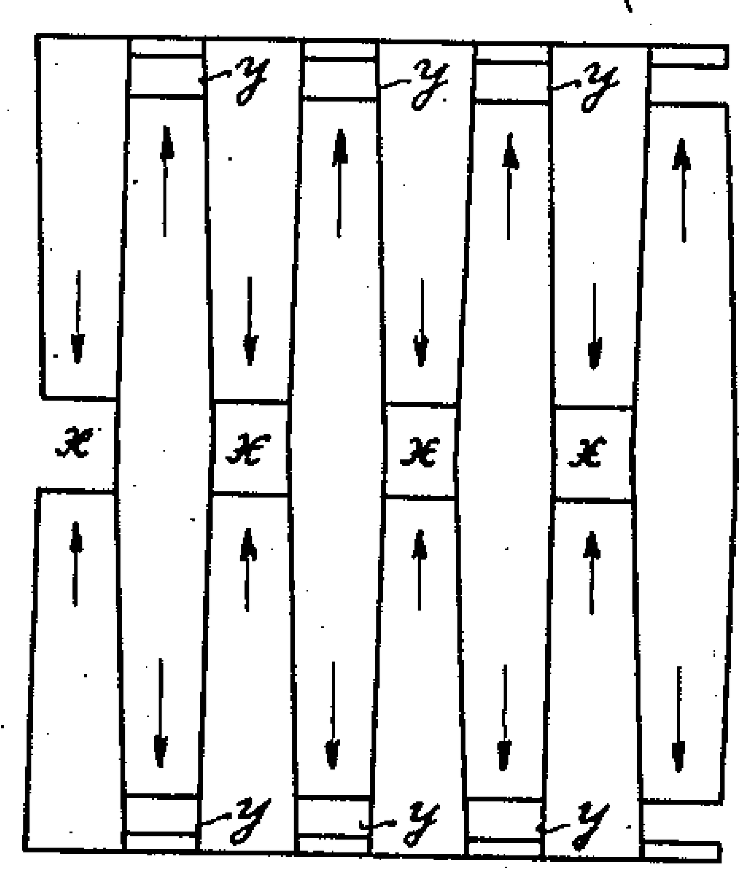


Fig. 17

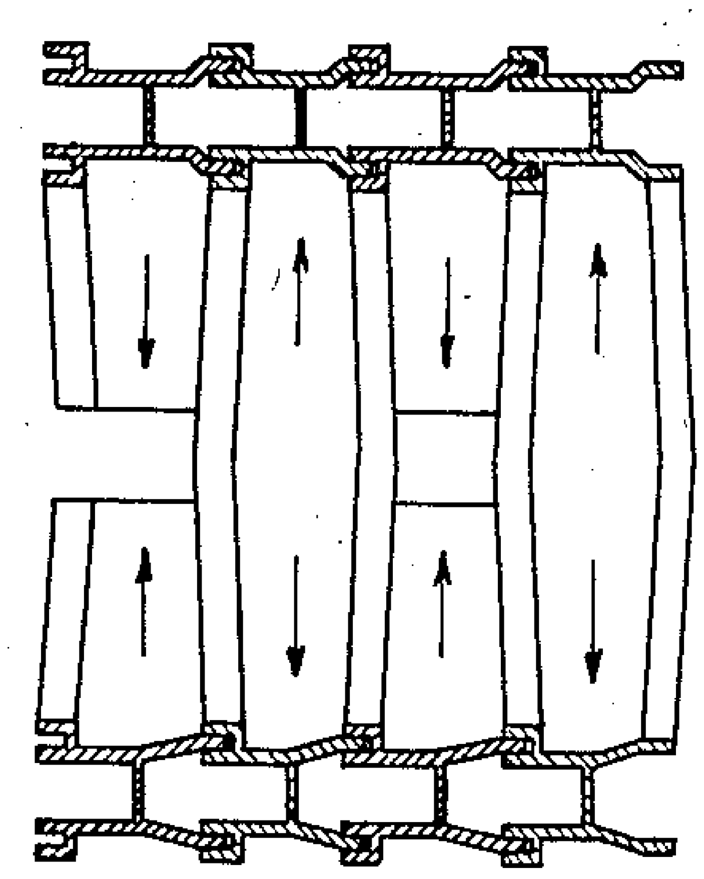


Fig. 18

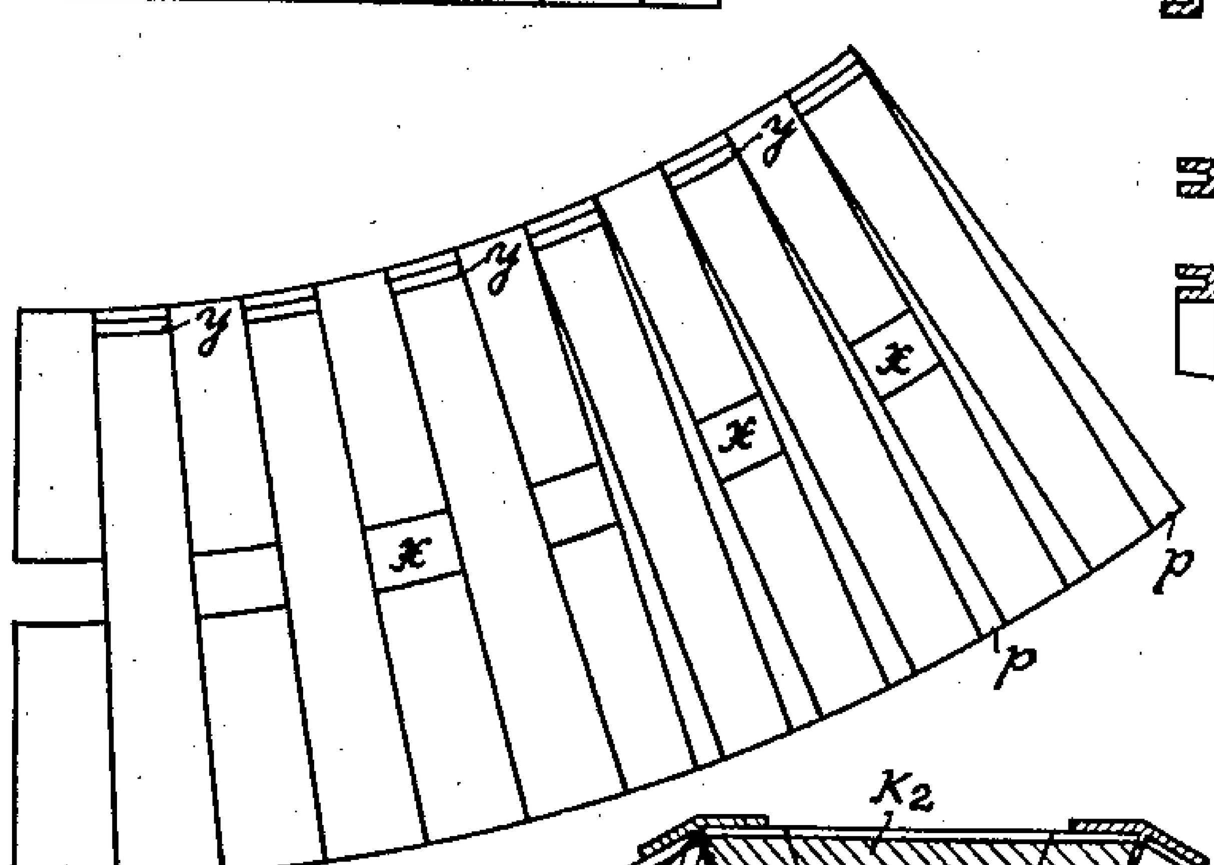


Fig. 19

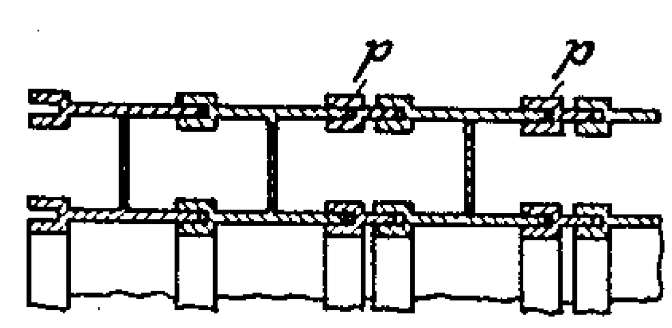


Fig. 19a

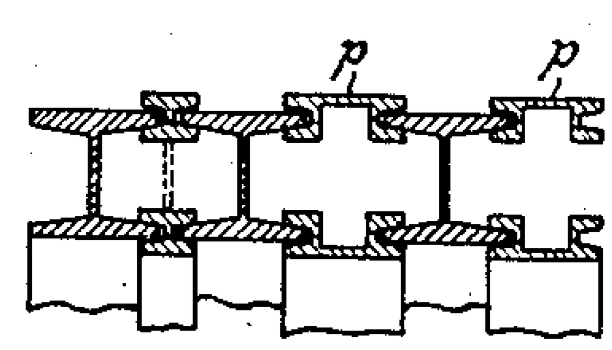


Fig. 21

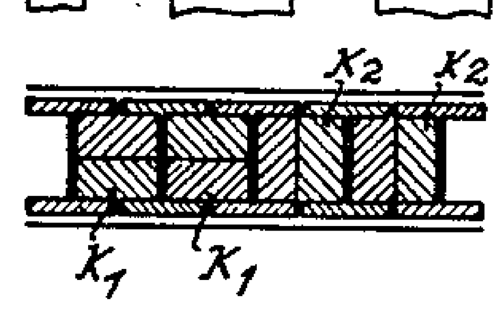


Fig. 20

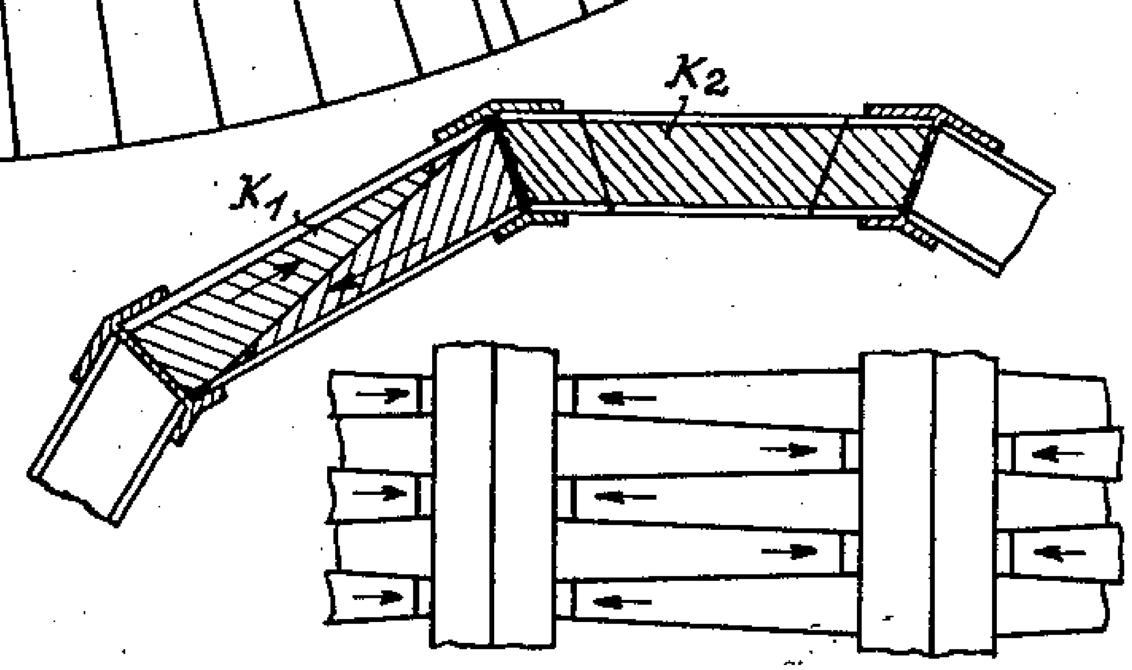


Fig. 22.

Inventor:
Emil Schmidtmann,
By [illegible],
Atty.

Patented Feb. 28, 1939 2,149,232

UNITED STATES PATENT OFFICE

2,149,232

TUNNEL CONSTRUCTION

Emil Schmidtmann, Gelsenkirchen, Germany

Application August 24, 1936, Serial No. 97,583
In Germany February 14, 1934

4 Claims. (Cl. 61—45)

My invention relates to the construction of mine galleries, mine shafts, tunnels, and the like. The object of the present invention is to simplify such constructions, while at the same time giving them considerable strength and great flexibility. To this end, I use separate sections made of steel, preferably in the shape of rings, which I then connect with each other by frictional interengagement. In accordance with my invention, the adjoining annular steel sections of the desired profile cross-section and of suitable dimensions are hydraulically or by mechanical forces pressed so strongly against and partially into each other in axial direction as to form a strong friction joint, which not only is capable of withstanding great bending and shearing stresses, but is also flexible because of the complete absence of any screws, bolts or the like usually employed in such structures.

Typical longitudinal sections through the upper walls of mine galleries and tunnels constructed in accordance with this invention are shown on Sheet I of the drawings (Figs. 1–9) while the same typical vertical sections through perpendicular mine and winding shafts are shown on Sheet II of the drawings (Figs. 10–13), whereas on Sheet III of the drawings there is shown in Fig. 14 the flexible character of a circular mine gallery, and in Fig. 15 a side-view thereof.

Figs. 16 and 17 show in side view and longitudinal section respectively a mine gallery illustrating the flexible character of a mine gallery the sections of which are connected by a friction joint, while Fig. 18 is a diagrammatic top plan view of a curved flexible mine gallery, the upper longitudinal sections of which are shown by Figs. 19 and 19*a*. Finally, Figs. 20—22 show a polygonal mine gallery illustrating the friction joint, Fig. 20 representing the upper cross-section, Fig. 21 the upper longitudinal section and Fig. 22 a top plan view of such a polygonal mine gallery.

The cross section of a mine gallery or tunnel may be a circle, a polygon, ellipsis, a parabola or the shape of a horse-shoe, while for the vertical shafts only a circular cross-section is used.

In Fig. 1 is shown a short piece of the upper longitudinal section of a mine gallery or tunnel made up of annular sections of I-shaped cross-section, which hydraulically or by mechanical means are pressed or forced laterally, that is, in the axial direction, against and into each other, so that the outer peripheries of the flanges of the annular sections of smaller profile will abut and both frictionally and resiliently press against the inner peripheries of the flanges of the annular sections having the larger profile. In this way, the annular sections are frictionally firmly joined as shown by the sectional view of Fig. 1.

Where, as shown in the sectional view of Fig. 2, the outer peripheries of the flanges of the smaller annular sections are conically rolled to correspond to the taper of the inner peripheral surfaces of the larger annular sections, the finished structure, after the annular sections of successively smaller and larger size have been forced together and into each other, will be as shown in Fig. 2 of the drawings.

In the embodiment shown in Fig. 3 the flanges are spherically shaped, permitting the frictional engagement, similarly as in Fig. 2, to be effected over a wider surface.

If perfectly smooth outer and inner walls are desired I-profiles such as shown in Figs. 4 and 5 are used which are all of the same height and which have the same moments of inertia and resistance. In the embodiment shown in Fig. 5 slightly conical projections and corresponding recesses, i. e. keys and grooves, are provided in the edges of the flanges, whereby the interengaging friction surfaces for the production of the friction joint are doubled as compared with the embodiment shown in Fig. 4.

The same is the case of the embodiment shown in Fig. 6, except that here the cross-section of one of the edges of the flanges is made greater, making the flanges stronger and more resistant. Moreover, the advantage is obtained that this particular shape of the flanges furnishes an abutment for the engagement of the tool used in pressing the ring-sections together.

The I-profiles shown in Fig. 7 are provided with projecting edges *d* which may either be formed during the rolling operation, or are subsequently produced as the annular sections are rounded.

According to Fig. 8, the structure is produced by a combination of normal I-profiles such as shown in Fig. 1 and especially wide-flanged profiles, the flanged edges *d* of which are produced during the rolling operation or are subsequently shaped during the rounding of the annular sections.

The embodiment of Fig. 9 shows normal I-profiles the flanges of which abut with their edges against each other. In this case, intermediate ring-shaped solid members H of hard wood are used which completely fill the hollow spaces between the adjoining I-profiles.

The friction coefficient between the metal and the wood is considerably greater than that between metal and metal, and the shearing strength of the hard wood is considerable and almost as resistant as that of the steel section.

Instead of the inclined inner faces of the flanges of the I-profiles as shown in Fig. 9, there may also be provided parallel faces, which, as a matter of fact, may be the case in all the embodiments shown in Figs. 1–9, without the character and effect of the friction joint being affected thereby. Everyone skilled in the art is aware of the fact that not only conical hubs can be pressed on conical journals, but that also cylindrically bored hubs can be hydraulically pressed onto cylindrical axles.

Instead of intermediate rings H of hard wood, there may also be pressed into the hollow spaces between the I-profiles hollow, angular or otherwise shaped bodies *n*. Said bodies then produce a friction-joint which may be modified as desired.

The I- or U-profiles shown in broken lines at *b* in Figs. 4 to 9 represent reinforcement elements which, as the adjoining annular sections are pressed together, are likewise forced into sharp and well-fitted contact with each other so as to fully restore the homogeneity which is interrupted at the joints.

Said reinforcement elements also can consist of hollow profiles which are open at their ends, but which may also be closed as, for instance, by the reinforcing elements *b* in Figs. 14 and 15.

No such elements are shown in Figs. 1 to 3, in which by the hatching is indicated that the hollow spaces between the I-profiles can be filled with concrete, which is especially done when a rigid mine or tunnel structure is designed.

The intermediate space between the periphery of the structure and the surrounding ground can also be filled in with concrete, as is indicated in Figs. 1 to 3.

Figs. 10 to 13 show vertical sectional views through winding shaft walls which in most cases are made water-tight and which consist of either circular or elliptical ring-sections of I-profiles which are axially firmly forced and pressed into each other, horizontal and vertical packings being interposed. Each shaft is provided with supporting structures shown at *t* in Fig. 10 and consisting of two or more concentric rings surrounding the shaft structure. The inner supporting ring or section *v* (Fig. 10) serves the purpose of securing the shaft timbering and the battens.

In a double shaft structure (Fig. 11) A is the outer structure column, B the inner structure column, while C indicates a possible third intermediate column, which may either be a separate column by itself or may also be connected with the other two columns.

The flanges of the I-profiles in Figs. 10 to 13 can have parallel, tapering or spherical faces and single-grooved edges, as shown in Fig. 12 or several grooves, as shown in Fig. 13.

Figs. 12 and 13 and the intermediate flanges *m* in Fig. 10 as well as the electrically welded cross bars *st* in Figs. 10 and 13 constitute further embodiments and modifications of the I-profiles, the number of which can be increased as desired, and which are all, according to the same principle, subjected to the elastic and yielding frictional interengagement or pressing together with or without the interposition of packing material. The packing material is placed between the flanged peripheral faces and upon the flanged end faces as the ring sections are assembled.

All the structural columns and the intermediate spaces as well as the spaces around the columns are filled with concrete.

The rings of the shaft structure each consist of one piece of I-shaped rolled iron, electrically welded at the abutting ends in case a mine explosion need not be feared, or each of two or more circular sections which at the vertical abutting joints can also be electrically welded, or which in well-known manner are peripherally, but not axially connected by screws, ties or shrink collars so as not to prevent expansions or upsettings.

The axial joint is produced by the sections being pressed into each other. Therefore, the shrink bands Z or clamps (not shown) only contribute to the increase in the vertical stiffening of the outer sections of the supporting rings *t*, for the latter are not only provided as supports, but also act to increase the resistance of the shaft structure against buckling.

The iron U-shaped rings or sections *u* used for the supporting rings *t* and the U-shaped fastening rings *v* can also be replaced by I-profiles or otherwise shaped rings, while, vice versa, the I-rings can be replaced by U-shaped rings, or the like, in any desired arrangement or combination.

The interposed and compressed relatively thick packings of smooth labyrinth-like ribbed material permit pulling and upsetting of such a shaft structure to the largest extent, because in the axial direction anchoring by screws, or the like is not required.

Also in this shaft-, gallery- or tunnel structure according to Figs. 10 to 13, reinforcing and homogenizing elements *b* as used in the embodiments shown in Figs. 4 to 9 can be pressed in together with the sections thereby producing also at the joints a complete homogeneity.

Figs. 14 to 22 show more particularly resilient circular or otherwise shaped ring sections for mine galleries, tunnels, etc. by the formation of increased spaces at the joints *x* and *y* between the ends of the sections. With increasing pressure of the surrounding ground and the resulting decrease of the spaces *x* and *y*, the sections have a mutually relative movement. The initial friction produced upon the sections being axially pressed together, produces in the peripheries of the ring sections a gliding friction which increases in accordance with the principle of rope friction. Upon reduction of the diameter D the flange peripheries are pressed into still more intimate contact so that not only the frictional energy, but also the deforming energy must increase, whether the cross-section of the structure is a circle, an ellipsis, or the like.

Figs. 14 and 15 show a more especially resilient mine-gallery or tunnel structure embodying my invention, the two figures being respectively a cross-section and a longitudinal section. At *x* and *y* are indicated the gaps at the joints as well as the reinforcing and homogenising bridges *b* shown also in Figs. 4–9. In the present embodiment they are in the shape of pressed-in hollow bodies provided with closed welded ends, though this is not absolutely essential. The hollow bodies, moreover, may be provided with conical faces *s* which have a wedge-like action to increase the friction and deformation work, if the diameter D of the structure and the gaps *x* and *y* at the joints, on an increase of the dynamic pressure of the ground become smaller.

Also the pressed-in pairs of wedges *k* enclosed by the profiles in Figs. 14 and 15 act in the same way toward an increase of the friction and deformation work. A wedge-shaped construction of the peripheral end faces of the ring sections in Figs. 16 and 17 produces the same effect.

These beforementioned three expedients may be used singly or combined in order to produce an increase of the friction and deformation work.

On curved stretches as shown in Fig. 18, the gaps *x* and *y* are preferably increased only toward the interior. In the case of parallel boundaries of the peripheral front edges of a section, there may also be inserted on curved stretches conical fittings *p*, as indicated on the right in Figs. 18, 19 and 19*a*.

Figs. 20 and 21 show a polygonal structure embodying my invention. This structure is made resilient by the use of solid (or hollow) wedges k_1 or k_2. The former act radially, while the latter act axially toward an increase of the friction and deformation work. Moreover, the straight or curved structural parts of this polygonal structure may be given conical boundaries for the purpose of increasing the friction and deformation work on the diameter of the polygonal structure being reduced.

If one assumes that the wedge-shaped faces in Figs. 16 and 17 and in Fig. 22 are turned through an angle of 90° so that the wedge action is not axial but radial as in the case of the wedges *k* in Fig. 14, there results the same characteristic feature of the additional increasing friction and deformation work when the cross-section of the structure is reduced.

Also, in the case of curves, the rolled profiles of Figs. 1 to 8 can be pushed or pressed more or less deeply into each other, to a greater extent toward the interior and to a smaller extent toward the exterior.

The axially pressed-in members of cross-grained hard wood or the hollow steel nipples shown at *n* in Fig. 9 can be made conical or wedge-shaped on curves in a resilient structure.

If the reinforcing bridges *b* and the pairs of wedges *k* in the case of an especially resilient structure according to Figs. 14 and 15 fill out the entire periphery and space between the profiles, this friction of the axially pressed-in pairs of wedges and bridges usually completely suffices, and the profiles or sections need not be especially pushed or pressed into each other, but only need be joined or pressed together laterally, as indicated in Figs. 14, 15, 16, 18, 20, 21 and 22 and also in Fig. 9.

In all the above described structures, several layers of rolled ring sections can be used concentrically one around the other, or equidistantly spaced apart from each other. Also, the ring sections may be used in the shape of continuous spirals; in the case of multiple walls, like or different directions of turns and different pitches of the screw threads may be used.

While I have hereindescribed and in the drawing shown only I-shaped cross-sectional iron sections, it is, of course, fully understood that my invention is not limited thereto and that in my mine-, shaft- or tunnel constructions also iron-sections of U-shaped cross-section can be used.

What I claim is:

1. A mine-, shaft- or tunnel-construction, comprising sections of rolled profile irons of I-shaped cross-section joined together with their flanged surfaces in the axial direction of the structure, reinforcing members of steel inserted between said sections in frictional contact therewith also in the axial direction of the structure bridging the joints between said sections, and welded transverse connecting elements extending in the axial direction of the structure in frictional engagement.

2. A mine-, shaft- or tunnel-construction as specified in claim 1, including nipples of steel and hard wood intermediate said sections in frictional engagement therewith, packing material between the joints, and filling and packing material inside and outside said sections.

3. A mine-, shaft- or tunnel construction as specified in claim 1, in which the joints of said sections are peripherally increased and in which the conically enlarged reinforcing members are movably disposed in said peripherally increased gaps, including pairs of wedges inserted intermediate said conically enlarged reinforcing members for increasing the friction and deformation of said sections.

4. In a mine-, shaft- or tunnel-construction, separate sections of rolled profile irons of I-shaped cross section joined together with their flanges in frictional engagement in the axial direction of the structure.

EMIL SCHMIDTMANN.