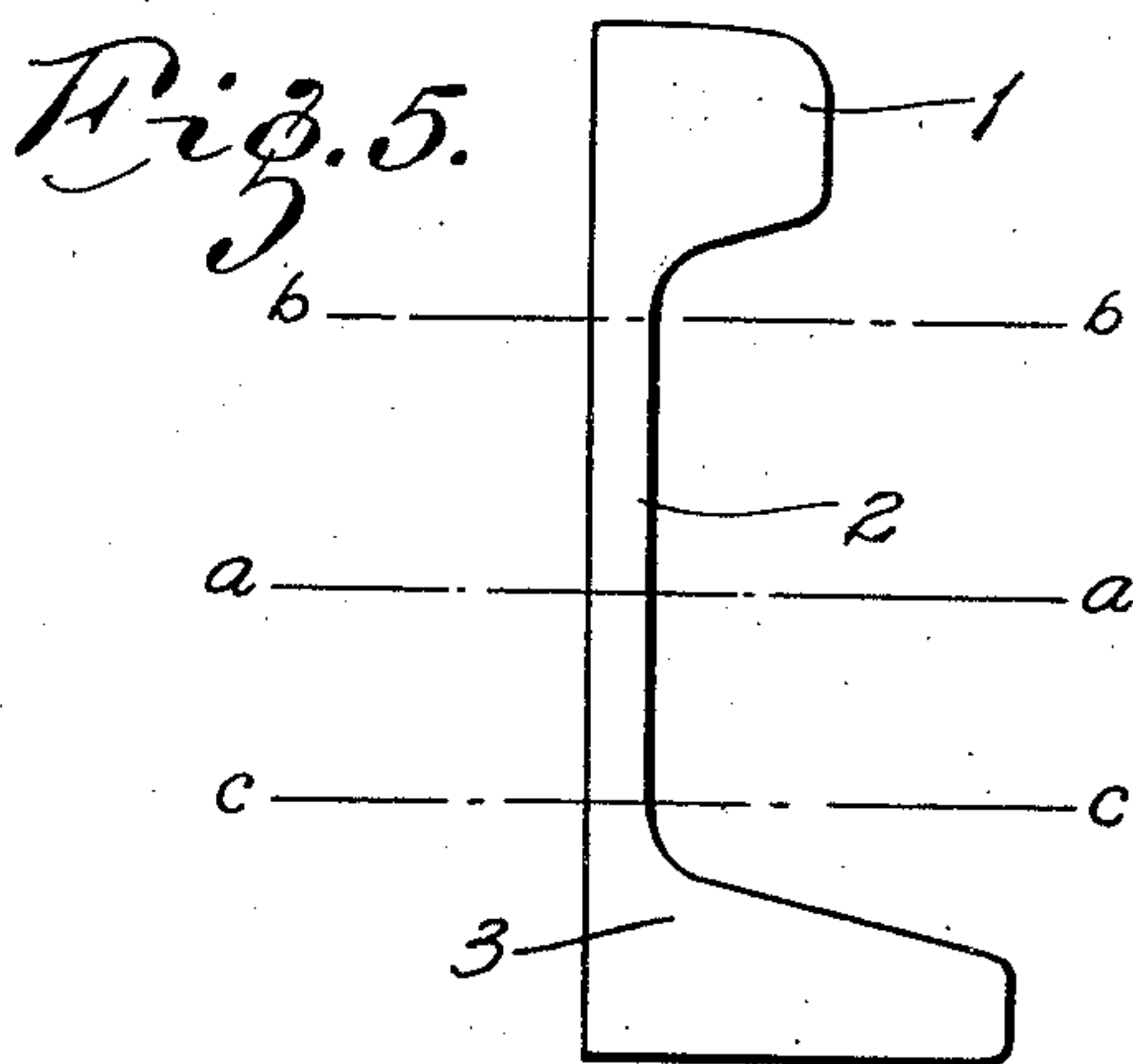
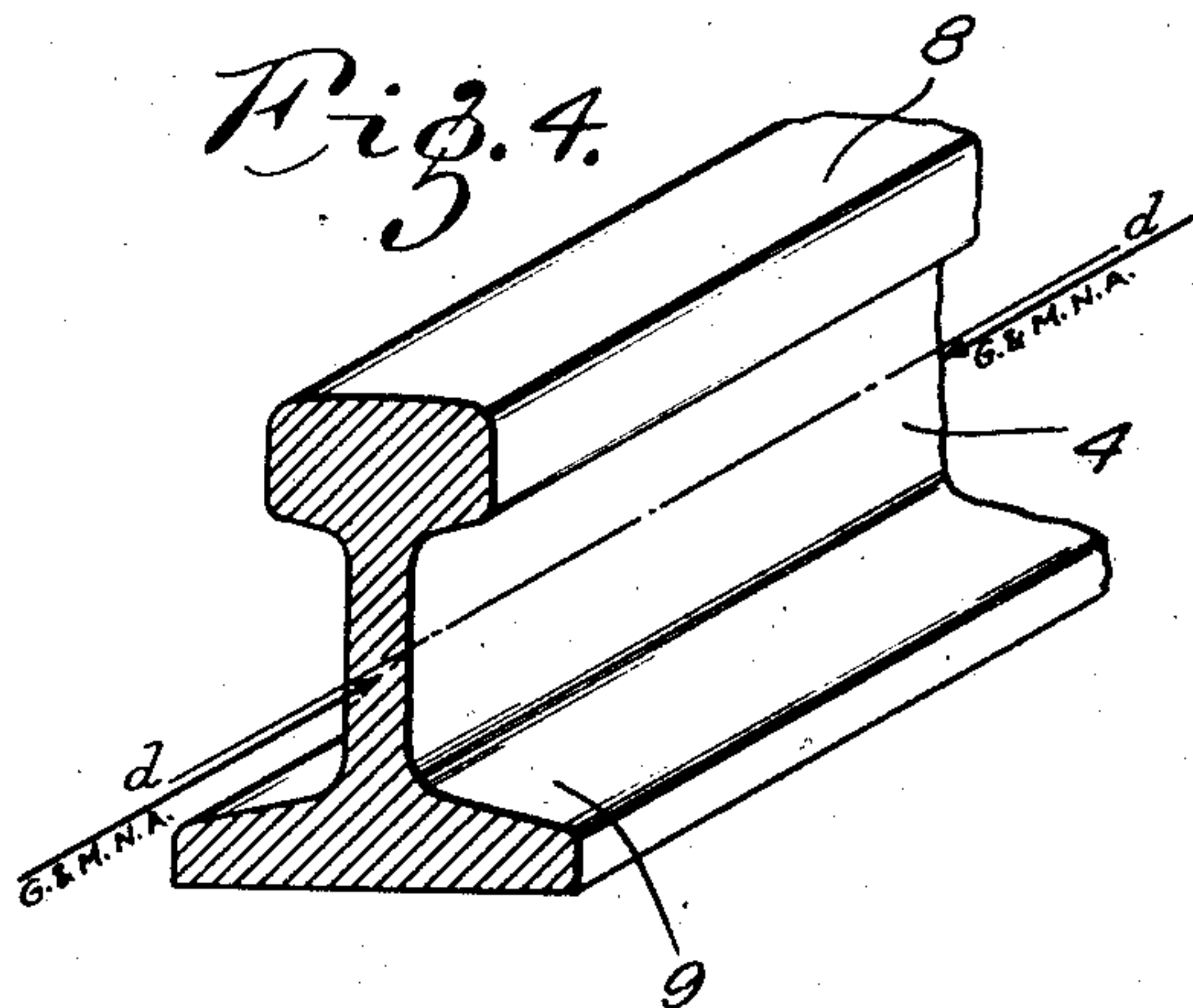
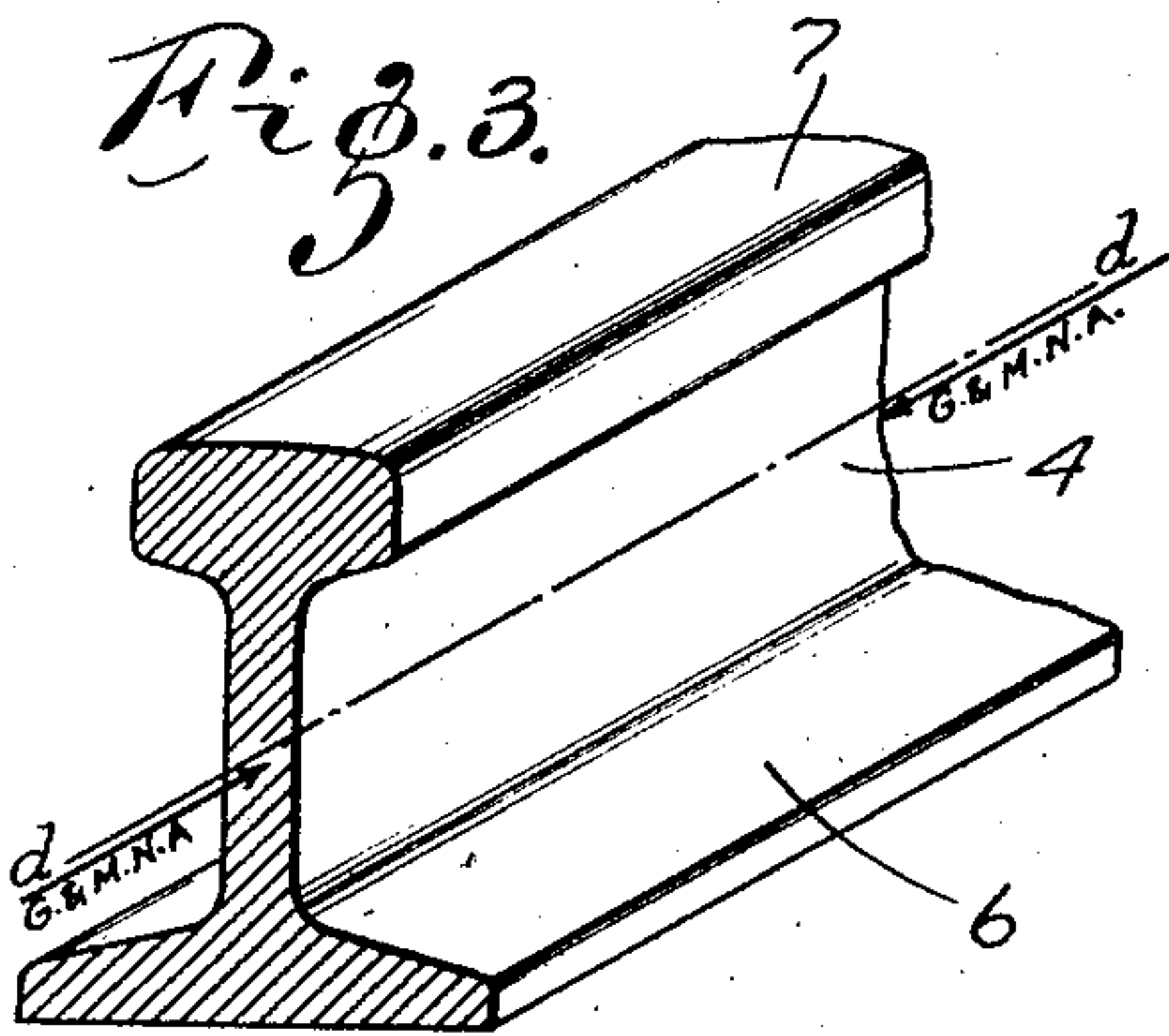
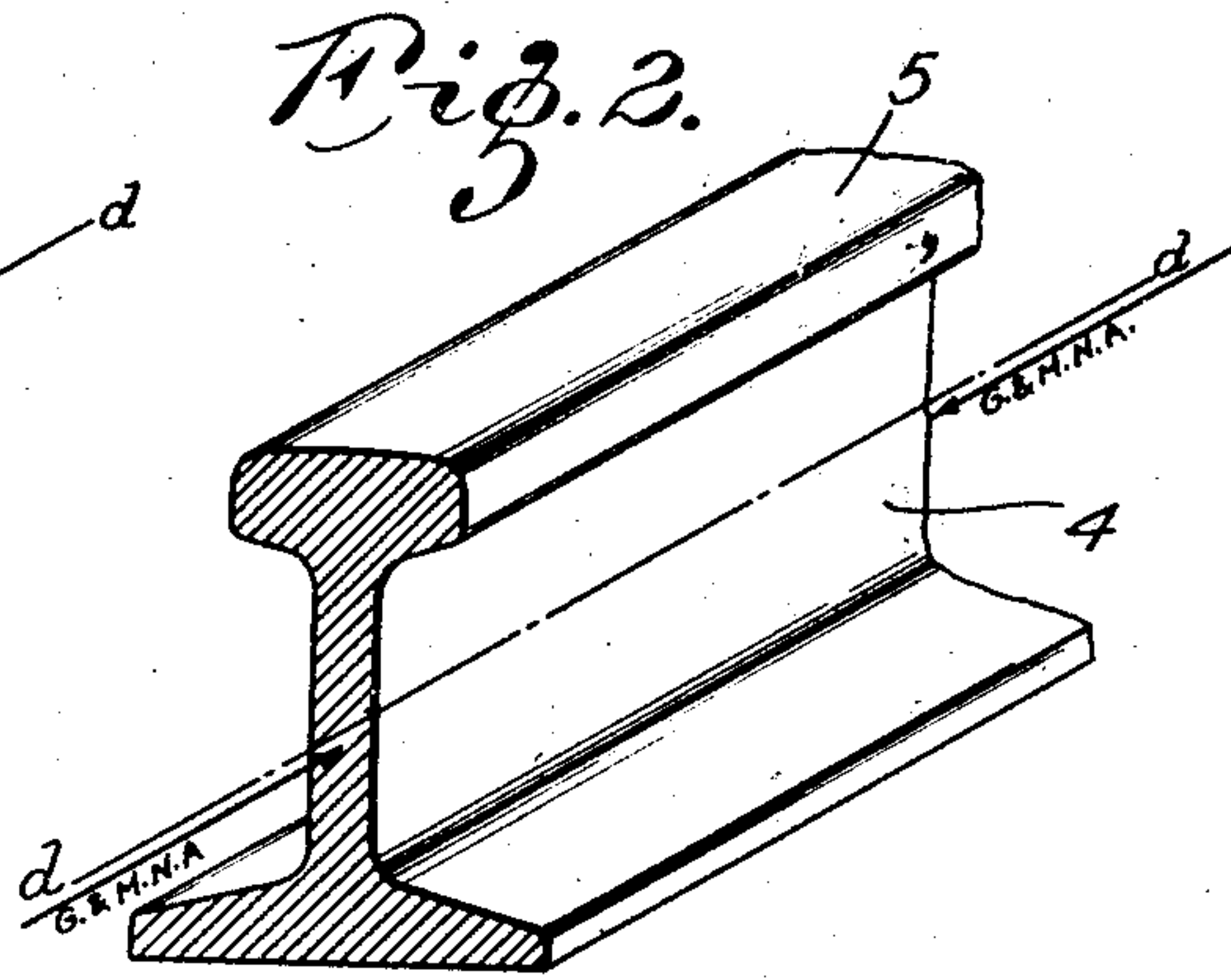
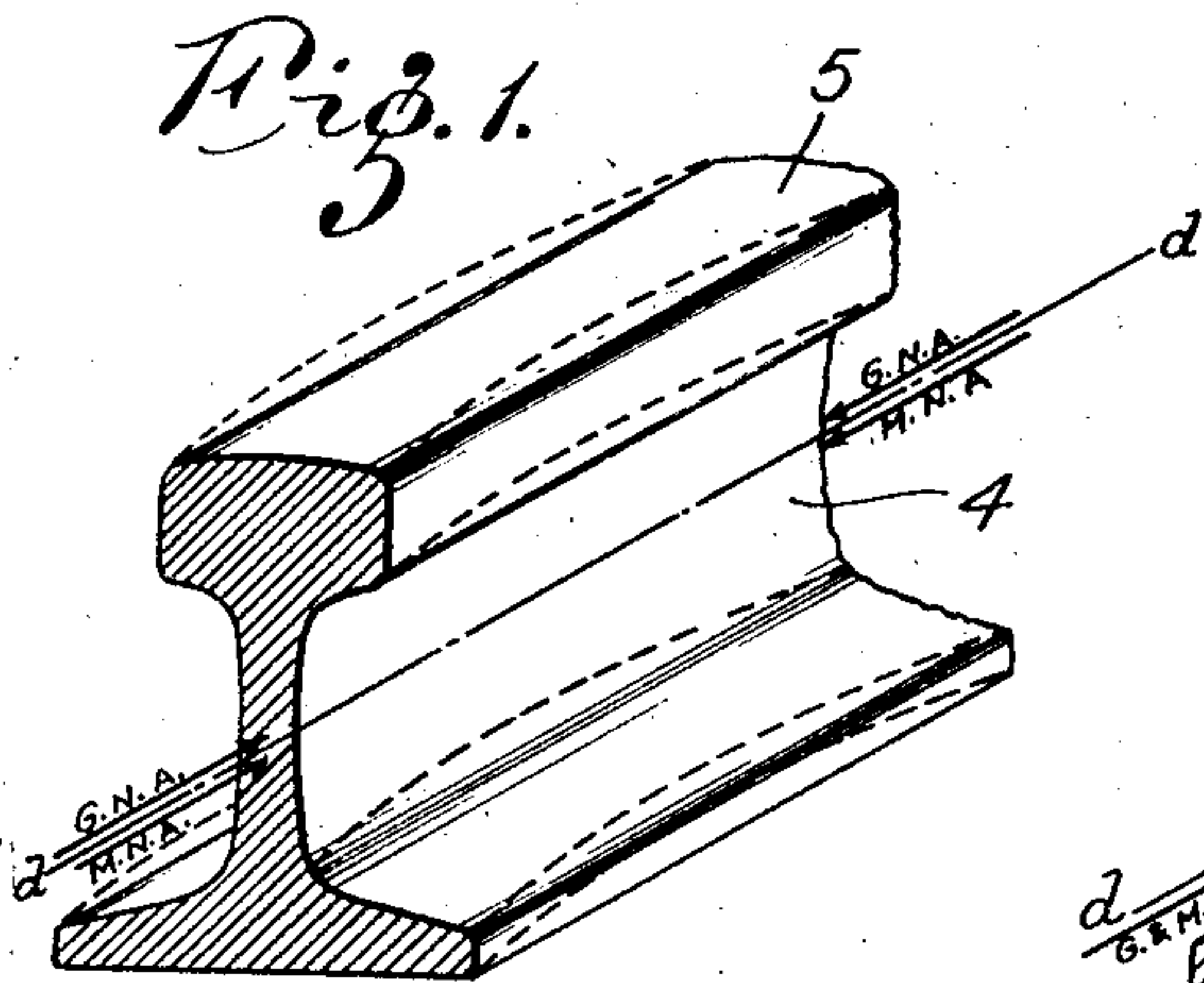


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STRUCTURE HAVING COINCIDENCE OF NORMALLY ECCENTRIC
AXES OF FORCE AND MASS
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STRUCTURE HAVING COINCIDENCE OF NORMALLY ECCENTRIC AXES OF FORCE AND MASS.

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This invention relates to the production of integral structures having an unsymmetrical section on an axis and which, due to the action of internal forces, are subject to distortion in the course of production.

The phenomenon of force, as that term is here employed, is to be understood as a single force with its equal opposing force, or any number of forces whose resultant is a single force. Such force may be any phenomenon, as heat, water, electricity, light, etc., to which the structure is capable of responding. The structure may be any mass which, as an element, is of unsymmetrical section on at least one co-ordinate.

A balanced internal force, the energy of which is exerted in the same co-ordinate planes as an external force, will have the same effect on the structure if the signs of the resultant forces are as those of the external forces and will bear the same relation to the center of gravity of the structure. If the signs of the resultant forces are opposite to those of the external force, then the effect on the structure is that of tension rather than compression, but the work done is the same.

The present invention is concerned with the effect of internal force exerted within a structure, and has for its general object the production of structures unsymmetrical on at least one co-ordinate, in which the position of the effective resultant of internal forces shall coincide with the center of gravity or geometrical neutral axis of the structure. This position of the effective resultant force in a structure, I have designated the "metallurgical neutral axis," and it is a further object of the invention to provide a novel method of determining the position of this metallurgical neutral axis in a given structure, and by re-designing, or re-distributing the mass of, the structure, to secure coincidence of the metallurgical neutral axis with the geometrical neutral axis of the structure.

While not, in any sense, limited thereto, my invention will probably find its widest application in the manufacture of steel rails, and the accompanying sheet of drawing illustrates my invention as embodied in a rail structure.

In said drawing—

Figure 1 is a true section of a rail pro-

jected in perspective, the rail being one of a standard construction;

Figure 2 is a similar view showing a rail of this standard in which the area of the base section is the same as that of Fig. 1, but having a less amount of metal in the head in order to cause the metallurgical neutral axis to coincide with the geometrical neutral axis;

Figure 3 is a similar view of a rail of the same standard showing the amount of metal in the base increased relative to that in the head, for the same purpose;

Figure 4 is a similar view of a rail of the same standard showing a re-distribution of the metal in both the head and base of the rail to bring about the coincidence of the metallurgical neutral axis with the geometrical neutral axis, as in Figs. 2 and 3, but in which the area of the head of the rail shown in Fig. 1 is preserved; and

Figure 5 is a diagrammatic view in end elevation of one-half of a rail with indications thereon showing the manner of dividing a rail into sections for the purpose of determining the metallurgical axis of the rail.

In Fig. 1, I have shown two lines with arrowheads at either end of the rail pointing in opposite directions, and which are designated, respectively, by the letters G. N. A., representing the geometrical neutral axis, and the letters M. N. A., representing the metallurgical neutral axis. The position of the latter is conditioned by internal forces, but for the purpose of illustration, they may be considered as external forces operating at opposite ends of the rail. These lines, or axes, are shown to be out of coincidence. If, now, an external force be applied normal to the section at the center of gravity of the section, represented by the line G. N. A. at the left and is opposed by an equal force at the opposite face and lying in the same co-ordinate planes, represented by the line G. N. A. at the right of Fig. 1, then compression exists and no general distortion of the rail will result other than direct compression diminution in dimension.

If the same force conditions are applied but located below one co-ordinate plane and in the other co-ordinate plane, as illustrated by the line G. N. A. at the left of Fig. 1

and the line M. N. A. at the right of Fig. 1, the rail will assume a distorted condition, as illustrated by the dotted lines in such figure. This arched condition of the rail is normal in the present processes of manufacturing rails, and after leaving the cooling beds, the rails have to be bent cold to straighten them. This is done by a process known as "gagging", and in this straightening process, bending force is applied to the rail at various points along its length in a direction at right angles to its longitudinal axis, and, as is well known, this gagging of the rail requires that the rail be bent beyond its elastic limit in order to give a permanent set. Such bending of the rail beyond its elastic limit uses up approximately forty per cent or more of the strength of the rail before it is put in the track. Furthermore, at the points of gagging, small nuclei are found, and it is my opinion that under rolling load and weaving of the rail, these are developed into transverse fissures, causing the rail to break. These transverse fissures are very deceptive and unsafe and have been the subject of investigation and research by skilled engineers for many years without any scientific cause for their presence being discovered and without any means being devised for preventing their occurrence. While my opinion is as above, I am not in a position to affirm unqualifiedly that transverse fissures in rails are caused as a result of gagging the rails. However, the weakening of the rail resulting from bending it beyond its elastic limit, at present a necessary evil existing in the manufacture of rails, is obviously something which should be avoided if possible, and this, it is the main object of my invention to accomplish.

In the manufacture of steel rails, heat is necessarily involved. The heat expands the metal and the removing of heat contracts the metal. The force involved is the same in both cases, although the sign is different. The position of the effective resultant of this cooling force varies with the design of section of the structure; it may be a point, a line, or a plane.

From what has been stated above, it will be clear that if the center of gravity or geometrical neutral axis of the rail section of Fig. 1 is made to coincide with what I have termed, and designated in said figure, the metallurgical neutral axis, then a force applied to the section at the line G. N. A., or its center of gravity, and opposed by an equal force at the opposite face of the rail applied at the line of its metallurgical neutral axis will produce no distortion of the rail, but only compression. To bring about this coincidence of the metallurgical with the geometrical neutral axes of the rail, I proceed in the following manner:

In the case of a rail, I would first ascertain

the position of the geometrical neutral axis of the rail, which is done according to a well-known method, and said axis may be indicated by the line $a-a$ in Fig. 5. I next divide the rail into three sections, as indicated by the lines $b-b$ and $c-c$, the three sections being indicated, respectively, by the numerals 1, 2 and 3. It will be understood, of course, that for this purpose, the rail can be divided into any number of sections. I next ascertain the center of gravity of the respective sections, divide the perimeter of each section by the area thereof to obtain the cooling power of each section, then multiply each of the respective cooling powers by the distance of the center of gravity of each area from a plane of selection and divide the sum of these products by the sum of the respective cooling powers. This will give the position of the resultant force of the three cooling powers from the plane of selection. In other words, it will denote the distance of the metallurgical neutral axes from the plane of selection. I next compare the position of this metallurgical neutral axis with that of the geometrical neutral axis, indicated by the line $a-a$ in Fig. 5. If, as illustrated by Fig. 1, it is found that eccentricity exists, i. e., that the two axes are out of coincidence, I alter the section and re-compute. By making two or more alterations and computations, a sequence is established that permits exact determination of the point, line, or plane of coincidence of the geometrical neutral axis and the metallurgical neutral axis.

In Fig. 1, I have indicated, for the purpose of comparison, the center of the web 4 of the rail by a line $d-d$, and it will be seen that the line of the geometrical neutral axis is located above the line $d-d$, while the line of metallurgical neutral axis is located below it. By observing Fig. 2 in which, according to the method above outlined, the head 5 of the rail has been redesigned to bring about coincidence of the geometrical and metallurgical neutral axes, it will be seen that this common axis is located below the line $d-d$. Thus, it will be observed that alteration of the section of Fig. 1 that caused the movement of the geometrical neutral axes in one direction causes the movement of the metallurgical neutral axis in the reverse direction, so that no matter what the character of the structure involved, a point, plane, or line exists, and only one, where the resultant of the cooling forces and the center of gravity of the section coincide.

In both Figs. 3 and 4, the geometrical and metallurgical neutral axes of the respective rails coincide, as in Fig. 2, the only difference being that in Fig. 3, the area of the base 6 has been increased relative to that of the head 7 to bring about the coincidence of

the two axes, while in Fig. 4, the area of the head 8 is the same as that of the head of the rail illustrated in Fig. 1 and the area of the base of the rail 9 has been correspondingly enlarged to bring about coincidence of the two axes. In the three structures of Figs. 2, 3 and 4, the thickness of the web of the rail is maintained substantially constant to minimize internal strains.

From all of the above, it will be apparent to those skilled in the art that by designing the rail section in the manner described to bring about a coincidence of the metallurgical neutral axis with the geometrical neutral axis or center of gravity of the rail, opportunity is offered for the rail to cool straight and thereby retain the full measure of its designed strength, and by avoiding the necessity of bending the rail straight after it is cooled, to prevent the cause of uncertain and unsafe zones in the rail incident to gagging.

While, for convenience, I have referred to changing the areas of the head and base of the rail, respectively, it will be understood that such alterations as to the head would correspond to altering section 1 of Fig. 5, and such alterations as to the base of the rail, to altering section 3 of Fig. 5.

I claim:

1. A structure having at least one unsymmetrical section and subject to the effect of forces tending to distort it, in which the geometrical neutral axis of the structure and the metallurgical neutral axis are caused to coincide.

2. A structure having at least one unsymmetrical section and subject to the effect of forces tending to distort it in the process of manufacture, in which the geometrical neutral axis of the structure and the metallurgical neutral axis are caused to coincide.

3. The herein described method, which consists in determining the geometrical neutral axis of a structure having an unsymmetrical section on one co-ordinate, ascertaining the position of the metallurgical neutral axis of said section relative to its geometrical neutral axis, and changing the mass of one element of said section to bring about coincidence between the metallurgical and geometrical neutral axes of the section.

4. The herein described method, which consists in determining the geometrical neutral axis of a structure having an unsymmetrical section on one co-ordinate, ascertaining the position of the metallurgical neutral axis of said section relative to its geometrical neutral axis, and re-distributing the mass of said structure to bring about coincidence between

the metallurgical and geometrical neutral axes of the section.

5. The herein described method, which consists in determining the geometrical neutral axis of a structure having an unsymmetrical section on one co-ordinate, ascertaining the position of the metallurgical neutral axis of said section relative to said geometrical neutral axis, and if eccentricity exists, altering the section and re-computing, and repeating this process until a sequence is established that permits exact determination of the point, plane or line of coincidence of the geometrical neutral axis and the metallurgical neutral axis.

6. A structure, the section of which is unsymmetrical on an axis and in the manufacture of which an internal force is involved, the resultant axis of the force and the geometrical neutral axis of the mass being substantially coincident.

7. A structure of unsymmetrical mass on an axis and in which an internal force is involved, the resultant point of the force being substantially coincident with the center of gravity of the mass.

8. A structure having a section of unsymmetrical distribution of metal on an axis and which is heated and subsequently permitted to cool in the process of manufacture, in which the metallurgical neutral axis and the geometrical neutral axis substantially coincide.

9. A rail having a section of unsymmetrical distribution of metal on an axis and which is heated and permitted to cool in the process of manufacture, in which the metallurgical neutral axis and the geometrical neutral axis substantially coincide, the web of said rail section being of substantially constant thickness to minimize internal strains.

10. A structure having a section unsymmetrical on an axis, the center of summation of the mass about a point being substantially the same as the resultant of internal forces in said structure present during the process of manufacture thereof.

11. The herein described method which consists in determining the position of a resultant internal force due to its presence and subsequent elimination or diminution during the process of manufacture of a structure, and determining the relation of the position of the resultant internal force to the center of gravity of the structure.

In testimony whereof, I have hereunto set my hand.

HARRY F. ROACH.