

[54] ELECTROMAGNETIC RAIL BRAKE

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252/62.51, 62.55; 335/296

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[57] ABSTRACT

An electromagnetic rail brake for railroad vehicles has a plurality of yoke shaped brake shoe elements positioned successively in the direction of travel of the vehicle with the central portions of the elements extending through an excitation coil which has its axis transverse to the direction of travel. Each brake shoe element comprises two halves which are bolted together and pole pieces are attached to the lower ends of each of the arms of the brake shoe elements so that a surface of the pole piece is engageable with the rail surface. The brake shoe elements are made of soft steel having high magnetic permeability and low magnetic coercive force and the pole pieces are of ferritic cast iron with globular graphite. The pole pieces may be either triangular or quadrangular in shape when viewed vertically.

8 Claims, 9 Drawing Figures

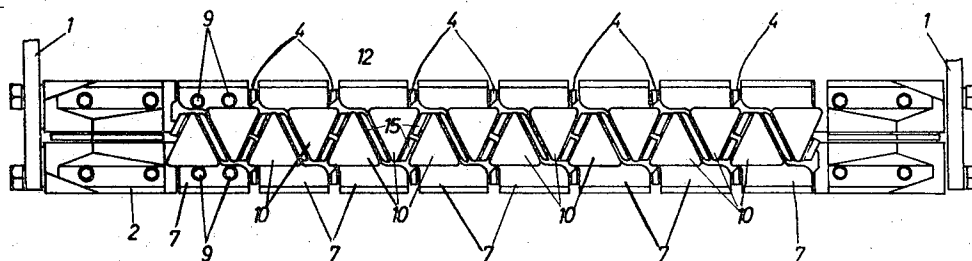


FIG. 1

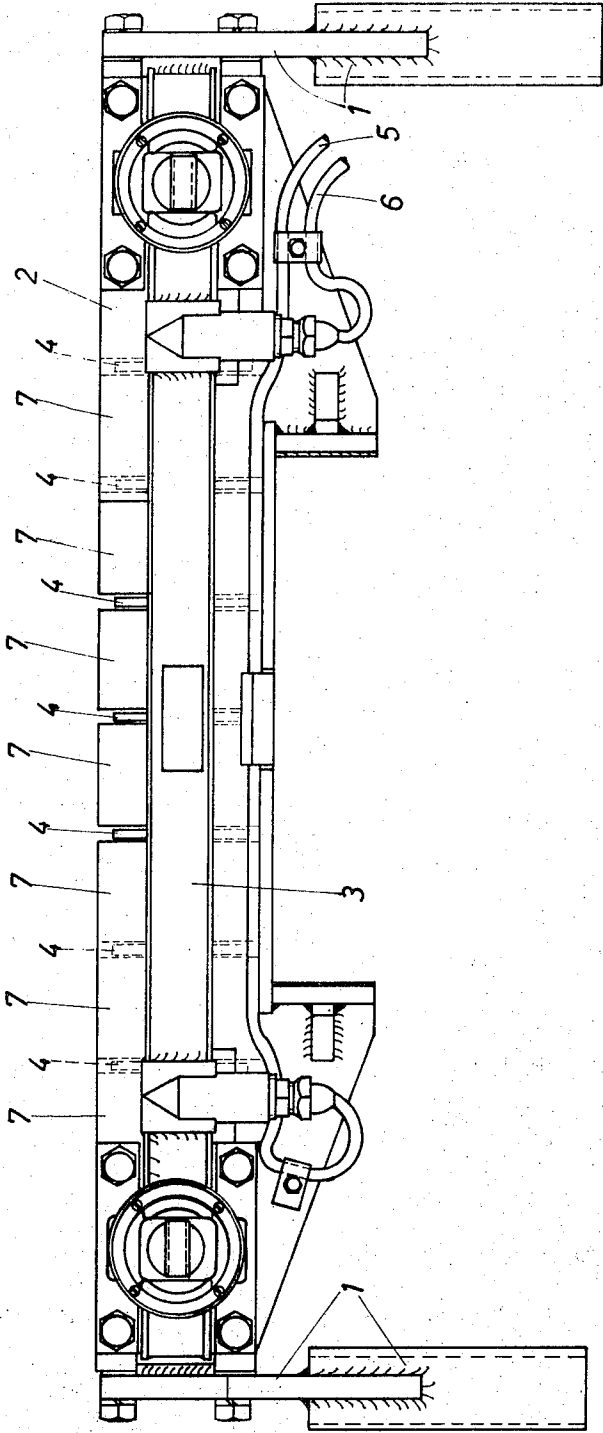


FIG. 2

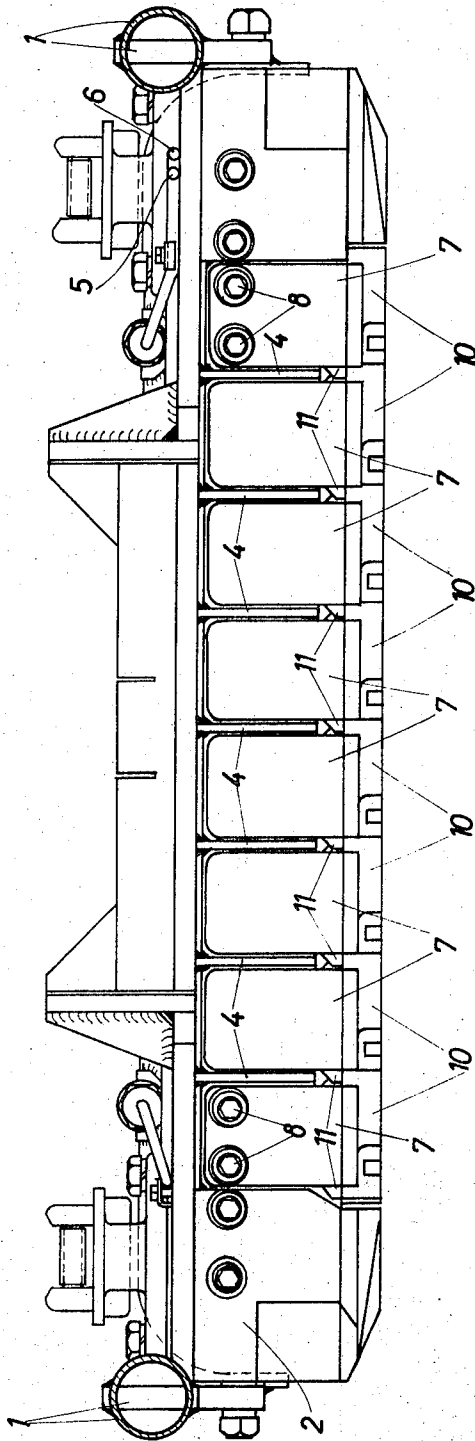
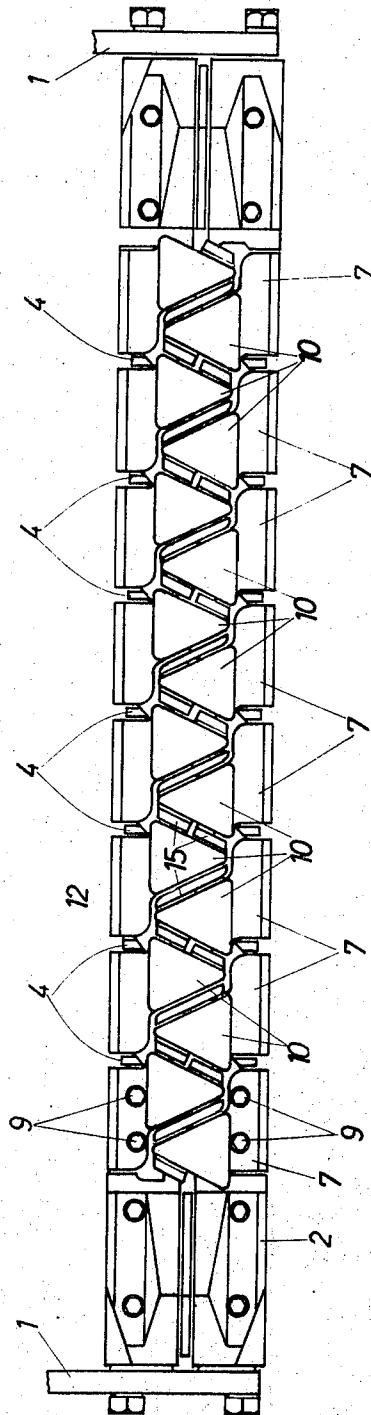


FIG. 3



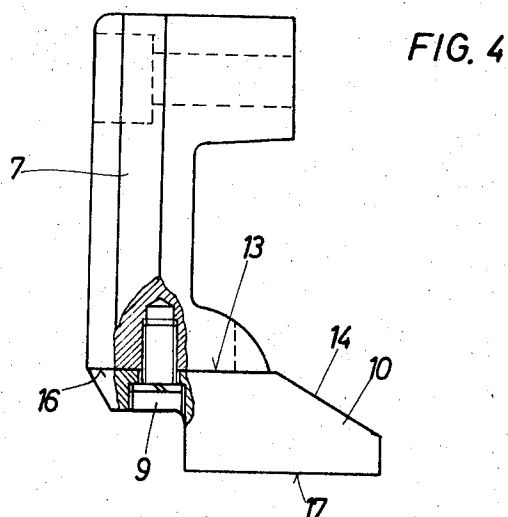


FIG. 5

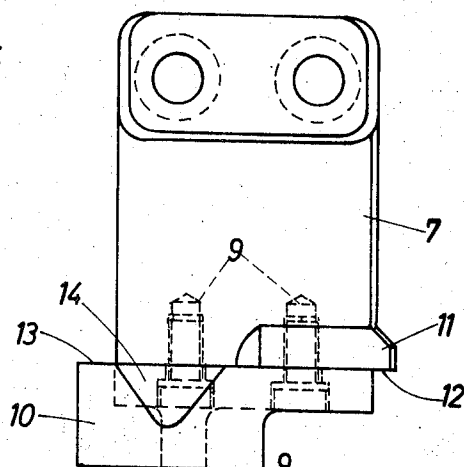
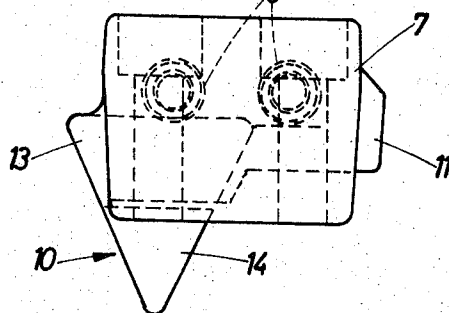


FIG. 6



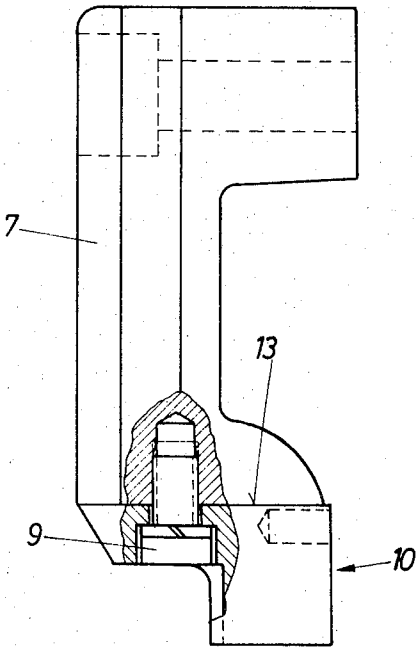


FIG. 7

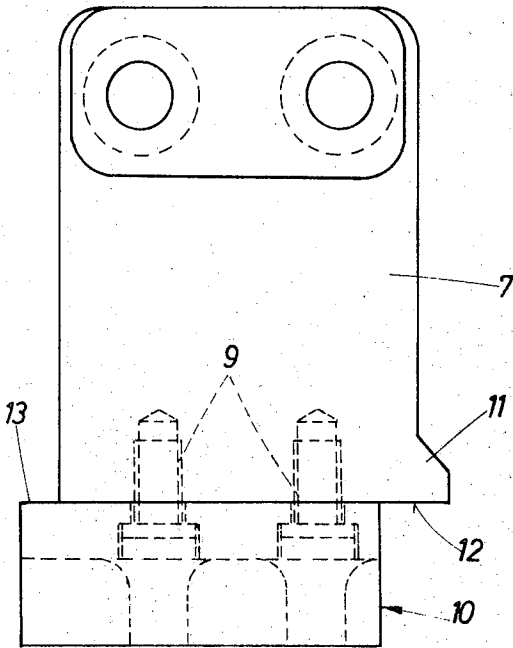
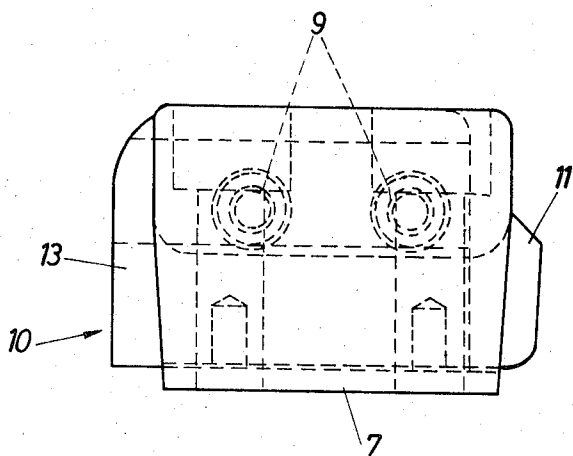


FIG. 8

FIG. 9



ELECTROMAGNETIC RAIL BRAKE

The present invention relates to an electromagnetic rail brake for railroad vehicles of the type comprising an excitation coil and a plurality of brake shoes positioned successively in the direction of travel and having pole pieces on the portions of the brake shoe elements facing the rail such that the pole pieces engage the rail during braking, more particularly, to the structure of the brake shoe element and pole piece and the materials from which they are made.

In the electromagnetic rail brake to which the present invention relates, the brake shoe elements are generally yoke shaped so as to have a central portion extending through the excitation coil which is positioned with its axis transverse with respect to the direction of travel of the vehicle. Each brake shoe element has a pair of vertical arms depending from its central portion with pole pieces attached to the lower ends of these arms. During the braking operation, the electromagnetic rail brake is lowered in the direction of the adjacent rail of the pair of rails over which the railroad vehicle is traveling and upon excitation of the coil, the brake shoes are urged firmly against the head of the rail by means of the electromagnetic force which is generated.

The brake shoe should be constructed of a material which has maximum wear resistance in that it must be capable of resisting the wear produced by frequent sliding contact along a rail during braking. On the other hand, the brake shoe must have maximum magnetic permeability in order to produce a maximum level of induction in the brake shoe and a resulting maximum force of attraction between the brake shoe and the rail in response to a given voltage which is passed through the excitation coil. In addition, the brake shoe material must be characterized by a hysteresis loop that exhibits a low magnetic coercive force in order to obtain low hysteresis losses when the excitation coil is subjected to alternating current.

Electromagnetic rail brakes have been constructed wherein the brake shoes are subdivided into a plurality of movable segments in order to facilitate adaption of the brake shoe to the cross sectional shape of the head of the rail. Brake shoes have also been mounted so as to be freely movable with respect to the arms of the electromagnet which arms are also movable with respect to the core of the coil of the electromagnet in order to obtain optimum contact between the brake shoe and the head of the rail. The subdividing of the brake shoes into segments has the disadvantage that the segments may become welded together because of the friction heat generated during braking. Constructing the brake shoes so as to be freely movable has the disadvantage that considerable air gaps are formed and their high magnetic resistance makes it impossible to achieve the advantage of improved contact between the brake shoe and the rail.

It has also been proposed to construct an electromagnetic rail brake wherein the excitation coil is mounted within an elongated elliptical housing positioned parallel to the rail and carrying a brake shoe on its lower portion with the brake shoe comprising a plurality of yoke shaped members arranged side by side and capable of limited free movement in all directions. However, it has been found that such a rail brake has a disadvantageous leakage of magnetic flux during braking

which leads to a reduction in the force of attraction between the brake shoe and the rail. This in turn reduces the efficiency of the electromagnetic rail brake.

An electromagnetic rail brake has also been constructed so as to comprise an excitation coil having its axis positioned transverse of the direction of travel of the vehicle and a plurality of yoke shaped brake shoe elements extending through the coil and positioned side by side in the direction of travel and movable reciprocally between separation plates. Such a construction has been found to be disadvantageous since during braking the brake shoe elements tilt slightly in the direction of travel of the vehicle so that the brake shoes do not contact uniformly the rail with the entire contact surface which is adjacent to the rail head. This has the effect of significantly lowering the efficiency of the brake. Also, the tilted pole pieces are worn so as to be rounded which shortens considerably the useful operating life of the brake shoe elements. These difficulties occur particularly in electromagnetic rail brakes operating by the eddy current effect.

In an attempt to eliminate the disadvantage of the rounded wear of the pole pieces as described above, it has been proposed to construct adjacent elements of a multi-element brake shoe so as to partially overlap each other in the direction of travel of the vehicle. This is intended to prevent the tilting of the elements in the direction of travel during braking without impeding in any way the movement of the elements with respect to each other during braking when in contact with the rail. To achieve this result, the ends of the arms of each brake shoe element were provided with projections extending in the direction of travel on one side and a corresponding recess on the other side so that the projections of all of the elements extended into the recess on the arm of the next successive element having the same polarity. A pole piece can then be attached to each surface of the brake shoe element arm which is facing toward the rail and it has even been proposed to construct the pole pieces so as to form the above mentioned projection on the one hand and to define the above mentioned recess on the other hand. The pole pieces may be triangular or quadrangular in shape and a flat element of non-magnetic material can be positioned between adjacent pole pieces of different polarity with the flat non-magnetic element being attached on one of two adjacent pole pieces and in order to support such a pole piece extending the non-magnetic element beyond the end of the arm facing the pole piece of the actual brake shoe element. The non-magnetic elements each have a surface which is flush with the surface of the pole piece contacting the rail but the non-magnetic member is made of a material which is softer and less wear resistant than the pole pieces. It is preferable to weld the pole pieces onto their corresponding brake shoe element arms and, similarly, the flat elements can be welded onto the corresponding pole pieces. Particularly in an electromagnetic rail brake constructed in this manner and utilizing the eddy-current effect, the brake shoe elements can comprise two halves bolted to each other.

In electromagnetic rail brakes for railroad vehicles, every brake shoe must comply with a number of conditions and particularly the requirements relating to the characteristics of the material. The material requirements are in mutual contradiction so that up to the present time, these requirements have not been met in

present known rail brakes. In order to obtain a maximum efficiency the components of the rail brake which conduct the magnetic flux during braking were made of a material having a good magnetic conductivity, such as soft steel. However, when such magnetic rail brakes are employed in vehicles traveling at speeds greater than 60 miles per hour, the rate of wear greatly increases and this results in a rapid significant decrease in braking efficiency. In an attempt to overcome these difficulties in electromagnetic rail brakes having a plurality of yoke shaped brake shoes of magnetic material that are positioned side by side and freely movable within certain limits on the lower portion of the coil former, it has been proposed to make the brake shoe elements of ferritic cast iron containing globules of graphite therein. The cast iron has a ferritic structure wherein carbon is precipitated therein in the form of small graphite spheres or globules and thus possesses a relatively favorable magnetic permeability and coercive force and also a favorable tensile strength, Brinell hardness and abrasive resistance. However, in comparison to soft steel such as St 37, the magnetic conductivity of the cast iron is about 30 percent less and thus the braking efficiency of an electromagnetic rail brake equipped with such brake shoes is significantly reduced.

It is therefore the principal object of the present invention to provide a novel and improved electromagnetic rail brake for rail vehicles.

It is another object of the present invention to provide an electromagnetic rail brake of the type described herein which combines optimum braking efficiency with optimum wearing characteristics of the brake shoes.

It is a further object of the present invention to provide an electromagnetic rail brake of the type described herein having a novel and improved relationship between the structural features and material characteristics of the brake shoe elements and the pole pieces.

According to one aspect of the present invention, an electromagnetic rail brake for railroad vehicles may comprise an excitation coil having its axis transverse to the direction of travel of the vehicle and a plurality of brake shoe elements positioned side by side in the direction of travel. The brake shoe elements are yoke shaped and each has a central portion extending through the coil. A plurality of pole pieces are mounted on the surfaces of the arms of said brake shoe elements facing toward the rail surface. The brake shoe elements are made of a soft steel having high magnetic permeability and low magnetic coercive force and the pole pieces are made of ferritic cast iron with globular graphite therein. Each brake shoe element may consist of two halves that are bolted together and each brake shoe element has two pole pieces which are bolted to the ends of the element arms facing toward the rail. The brake shoe elements are movably mounted between separation plates and two adjacent brake shoe elements partially overlap each other to prevent tilting in the direction of travel. The pole pieces may be either triangular or quadrangular in shape. A magnetic insulation element is preferably provided between adjacent pole pieces.

Other objects and advantages of the present invention will be apparent upon reference to the accompanying description when taken in conjunction with the fol-

lowing drawings, which are merely exemplary, wherein;

FIG. 1 is a top plan view of an electromagnetic rail brake incorporating the present invention;

FIG. 2 is a side elevational view of the rail brake of FIG. 1;

FIG. 3 is a bottom plan view of the rail brake of FIG. 1;

FIG. 4 is a front elevational view of a half of a brake shoe element incorporated in the rail brake of FIGS. 1-3;

FIG. 5 is a side elevational view as viewed from the right in FIG. 4;

FIG. 6 is a top plan view of the brake shoe element half of FIG. 4; and

FIGS. 7-9 are views corresponding to those of FIGS. 4-6 of a modification of a brake shoe element half.

Proceeding next to the drawings wherein like reference symbols indicate the same parts throughout the various views a specific embodiment and modifications of the present invention will be described in detail.

As may be seen in FIGS. 1-3, the electromagnetic rail brake comprises a frame 1 to which is attached a coil former 2 having mounted thereon an excitation coil 3 and separator plates 4. As can be best seen in FIG. 2, the plates 4 are vertical and extend perpendicularly of the coil former 2 and are spaced in the direction of the longitudinal axis of the coil former. The axis of excitation coil 3 extends perpendicularly to the longitudinal axis of the coil former 2. The coil 3 is connected to a source of alternating voltage by means of cables 5 and 6.

The frame 1 is mounted on a railroad vehicle so as to be capable of being raised and lowered and is so positioned that the coil former 2 is in parallel with one of the two rails on which the railroad vehicle is traveling. Thus, as seen in FIG. 2, the rail is in parallel with the longitudinal axis of the coil former 2 and is positioned just below this coil former.

Mounted on the coil former are eight yoke shaped brake shoe elements that are positioned successively or in side by side relationship along the direction of the longitudinal axis of the coil former. Each brake shoe element 7 is positioned between two separator plates 4 and its central cross piece that connects its two downwardly depending arms passes through the central opening of the coil 3. The brake shoe elements 7 taken as a whole form a brake shoe.

Each brake shoe element 7 consists of two identical halves, such as may be seen in FIGS. 4-6, with the halves being joined together by bolts 8. Each half has a triangular pole piece 10 mounted thereto by means of two bolts 9.

As viewed in the direction of travel of the vehicle as seen in FIG. 4, the pole piece 10 is substantially L-shaped and comprises a first horizontal arm which is attached by vertically positioned bolts 9 onto the lower surface 16 of brake shoe element 7. The lower surface 16 is on the end of the lateral arm of the yoke shaped brake shoe element and this surface is facing toward the rail. The other arm of pole piece 10 is connected or integral with the first arm on the end thereof which faces toward the vertical central longitudinal plane of the brake shoe element 9. This second arm extends vertically downwardly and has a surface 17 which is engageable with the rail surface. As a result of this arrangement, the bolt connection between the brake

shoe element 7 and the pole piece 10 is not subjected to the effects of wear of the pole piece 10 during the operation of the rail brake. As a result, the pole piece 10 can be easily disassembled even after long periods of operation of the magnetic rail brake and this facilitates a simple replacement of a worn pole piece.

Each pole piece 10 consists of ferritic cast iron comprising spheroidal or nodular graphite therein according to German Industrial Standards (DIN 1693). Each brake shoe element 7 or the halves of each element consists of a soft unalloyed steel of small carbon content having high magnetic permeability and low magnetic coercive force. Such a steel has a maximum carbon content of 0.25 percent and may be according to German Industrial Standards (DIN 17 100).

The brake shoe elements 7 are movably mounted between the separator plates 4. In order to prevent tilting in the direction of travel during braking, i.e., when the triangular base surfaces of the pole pieces 10 are in contact with the rail surface, two adjacent brake shoe elements 7 overlap each other. For this purpose, each half of each brake shoe element 7 is provided with a projection 11 extending in the direction of travel and each pole piece 10 of a half is mounted so as to leave free a lower surface 12 on the projection 11 and to project on the opposite end of the half so as to define an upper surface 13 in the direction of travel. As can be best seen in FIGS. 2 and 3, each pole piece surface 13 engages surface 12 of projection 11 of the adjacent half of the next successive brake shoe element 7 upon which is mounted a pole piece 10 of like polarity.

In every brake shoe element 7, each triangular pole piece 10 is positioned with its tip directed away from its bolts 9 and below the surface 12 of the opposite half of brake shoe element 7. However, there is a considerable gap between the tip of the pole piece and the surface 12 since the pole piece is provided with a sloping surface 14 at its side which is adjacent to the surface 12 as can be seen in FIGS. 4-6.

Magnetically insulating flat elements 15 are positioned between adjacent pole pieces 10 of different polarity in order to avoid magnetic short circuits. These flat elements are attached to a pole piece 10 in each case and thus can be readily replaced together with the pole piece. The insulation elements 15 are so mounted that their lower surfaces are in the same plane together with the triangular lower surfaces of all of the pole pieces 10 so that the insulating elements and pole pieces are in simultaneous contact with the rail surface during the braking operation. This structure provides for insulating magnetically the pole pieces from each other.

In the modification of FIGS. 7-9, the pole pieces 10 consist of angular elements as can be clearly seen in FIG. 7. The angular pole pieces 10 are provided with a substantially quadrangular surface which is in contact with the rail surface. Similarly as described above, each quadrangular pole piece is attached to a brake shoe element half as also shown in FIGS. 7-9. These pole pieces similarly are formed of ferritic cast iron having globular graphite therein and the brake shoe element 7 also consists of soft steel having a high magnetic permeability and a low magnetic coercive force.

The brake shoe element 7 in FIGS. 7-9 are also provided with projections 11 each having a lower surface 12 as well as an upper surface 13 on pole piece 10 so that the elements can be arranged side by side partially

overlapping each other in the same manner as described above.

It is therefore apparent that the present invention is a highly effective yet simple embodiment of the concept that in order to obtain a high efficiency in an electromagnetic rail brake for railroad vehicles, the parts conducting the magnetic flux during braking should consist of a material having good magnetic conductivity and sections of these parts which increase as much as possible the resistance should be present in the magnetic circuit in order to obtain good braking efficiency over long periods of operation even in railroad vehicles that are operated at speeds exceeding 60 miles per hour. According to the present invention, the pole pieces which are of lesser magnetic conductivity constitute only a small portion of the magnetic circuit and this portion is practically limited to the wearing surface with which the brake shoe contacts the rail surface. The present invention can be incorporated in electromagnetic rail brakes utilizing lateral poles and also in connection with electromagnetic brakes comprising eddy-current poles.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions, and accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. An electromagnetic rail brake for railway vehicles comprising an excitation coil having its axis transverse to the direction of travel of the vehicle and parallel to the rail surface, a plurality of brake shoe elements of soft steel having high magnetic permeability and low magnetic coercive force positioned successively in the direction of travel, said brake shoe elements each being yoke shaped and each having a central portion and two vertical arms depending from the ends of said central portion, each brake shoe element having its central portion extending through said coil, the end surfaces of the arms of each of said brake shoe elements facing toward the rail surface, a pole piece on each of said arm end surfaces wherein each brake shoe element has two pole pieces bolted thereto, said pole pieces being of ferritic cast iron with nodule graphite.

2. An electromagnetic rail brake as claimed in claim 1 wherein said central portion is divided such that each brake shoe element comprises two halves which are bolted together through the divided central portions.

3. An electromagnetic rail brake as claimed in claim 1 and comprising a coil former extending in the direction of travel of the vehicle, a plurality of separator plates spaced along said coil former, said brake shoe elements being moveably mounted between said separator plates, adjacent brake shoe elements partially overlapping each other to prevent tilting of the elements in the direction of travel of the vehicle.

4. An electromagnetic rail brake as claimed in claim 1 wherein said pole pieces each have a triangular surface directed toward the rail surface.

5. An electromagnetic rail brake as claimed in claim 1 wherein each pole piece has an L-shape when viewed in the direction of travel and comprising a first arm fastened to the end surface of an arm on said brake shoe element and a second arm having a lower surface which is engageable with the surface of the rail.

7.

6. An electromagnetic rail brake as claimed in claim 1 wherein said pole pieces each have a quadrangular surface directed toward the rail surface.

7. An electromagnetic rail brake as claimed in claim 5 wherein the first arm of each pole piece has an upwardly directed horizontal surface extending longitudinally from one end of a brake shoe element, the other end of each brake shoe element having a downwardly directed horizontal surface extending longitudinally outwardly therefrom, said horizontal surfaces of successive brake shoe elements contacting each other in

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overlapping relationship to prevent tilting of the brake shoe elements in the direction of travel of the vehicle.

8. An electromagnetic rail brake as claimed in claim 5 wherein each pole piece has a tip extending away from the arm end surface to which it is attached, the upper surface of said tip is sloping and extends below the downwardly directed horizontal surface of the other half of the brake shoe element.

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