Nov. 7, 1933. T. G. LE CLAIR 1,934,434

BUS CONSTRUCTION

Original Filed March 26, 1927 2 Sheets-Sheet 1

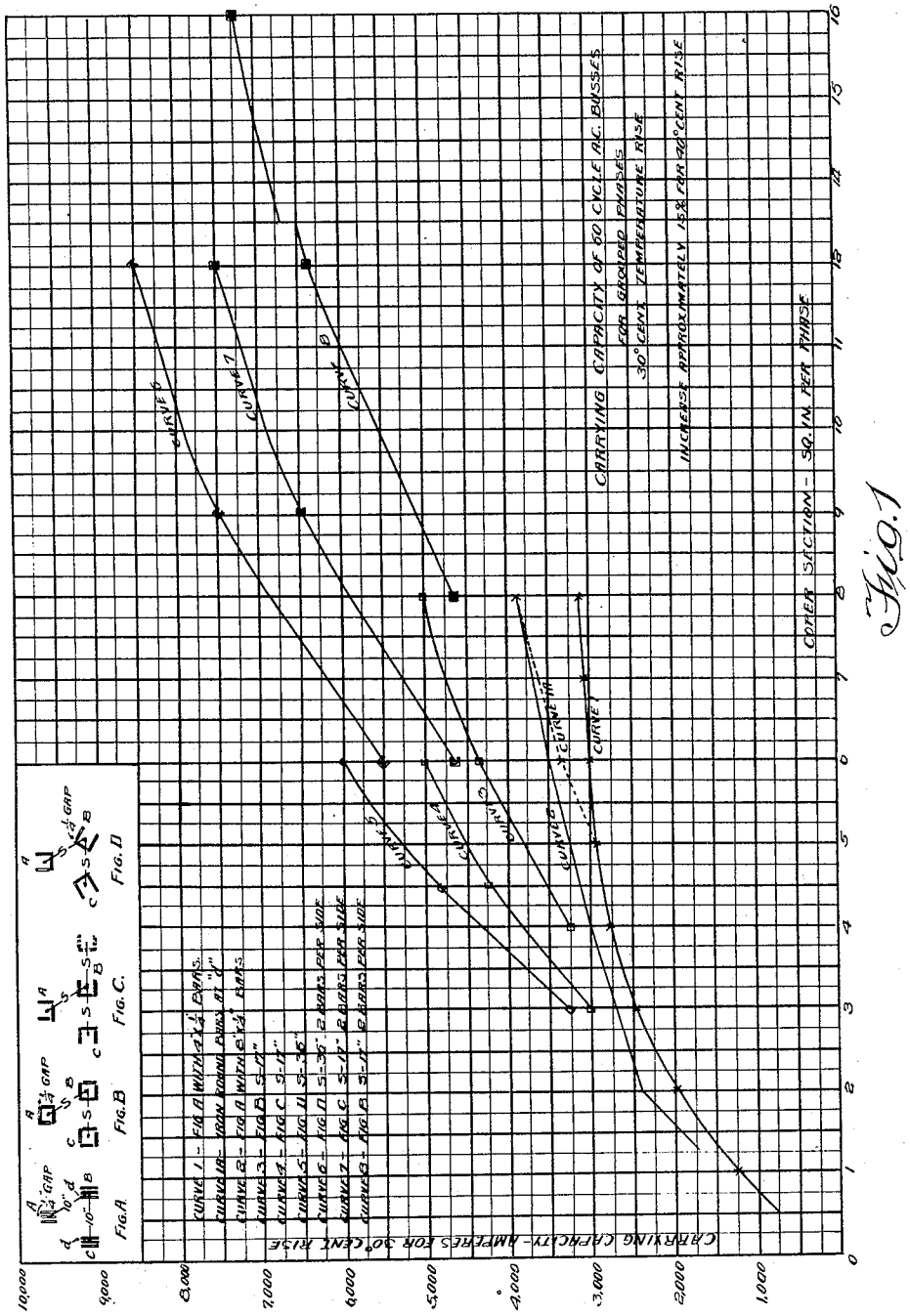


Fig. 1

Inventor:
Titus G. LeClair
By Brown Boettcher Dennis
Attys

Nov. 7, 1933. T. G. LE CLAIR 1,934,434

BUS CONSTRUCTION

Original Filed March 26, 1927 2 Sheets-Sheet 2

Fig. 2.

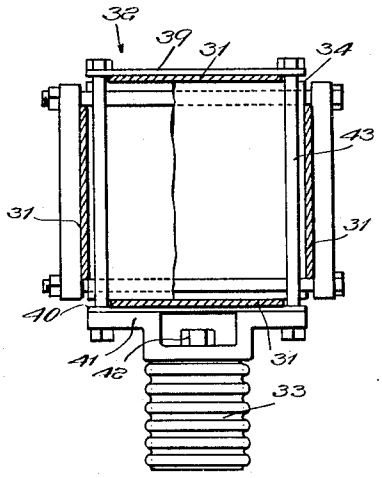


Fig. 3.

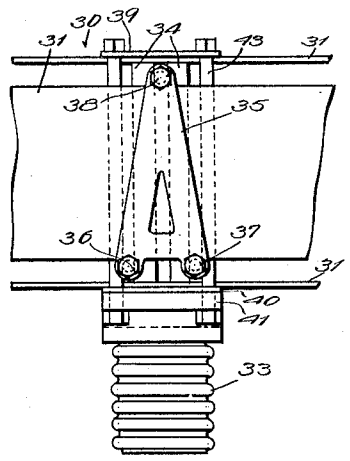


Fig. 4.

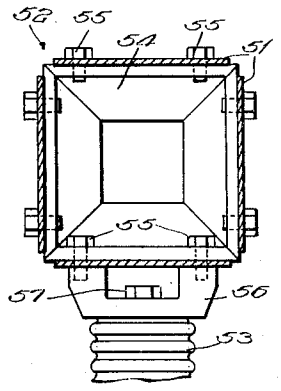
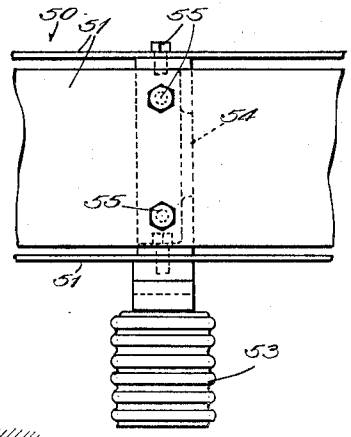


Fig. 5.



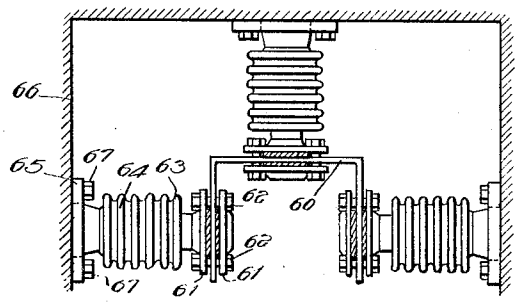


Fig. 6.

Inventor:
Titus G. Le Clair
By Brown Boticker & Dienner
Attys

Patented Nov. 7, 1933 1,934,434

UNITED STATES PATENT OFFICE

1,934,434

BUS CONSTRUCTION

Titus G. Le Clair, Chicago, Ill.

Application March 26, 1927, Serial No. 178,561
Renewed June 5, 1931

24 Claims. (Cl. 173—13)

My invention relates to busses, and more particularly to electrical busses especially adapted for carrying heavy currents.

The increased demands for electrical power have made it necessary to supply large blocks of power at low voltage. Obviously, high voltage conductors are not always desirable for the reason that the cost of the protective apparatus necessitated thereby is prohibitive. I propose to provide a novel bus construction, particularly designed for carrying heavy current having a capacity in excess of 3,000 amperes.

It is well known that the alternating flux of an alternating current causes a higher impedance in the center of an electrical conductor or bus than in the outer portions thereof. This results in the current being forced to the outer surface of the bus, producing the so called skin effect. By skin effect I mean any uneven distribution of the current in a bus or conductor due to the flux inherent in the current. This effect is undesirable for the reason that it results in heat losses. Since the skin effect becomes more pronounced as the current is increased, it becomes essential that a bus be designed wherein the skin effect can be substantially obviated, or at least minimized, to such an extent as to make practical the transmission of heavy currents.

Now in a multiphase transmission system, if the phases are placed in proximity voltages are induced in each of the opposite phases, which are not uniform over the entire cross section of each of the busses and result in the current being forced to the inner or near side thereof. This action is frequently referred to as the proximity effect. The result of this effect is to augment the heat losses, due to the previously discussed skin effect. Therefore, the bus to be designed must take into consideration both of these deleterious effects.

It has been found from experimentation that a tubular or cylindrical conductor will transmit heavy currents with relatively small losses, as far as the skin or proximity effects are concerned. However, this type of conductor is not satisfactory for large bus work due to the difficulty of mounting it, as well as due to the impracticability of making connections thereto.

The object of my invention is to provide an improved bus construction having the desirable features of a tubular conductor, in addition to being easy to handle and mount and having a low reactance.

In accordance with the general features of my invention, I provide a tubular bus having a polygonal cross-section and preferably composed of a plurality of parallel bars arranged with their adjacent edges spaced from each other. This spacing permits the air to circulate freely in the bus construction, thus augmenting the cooling of the bus bars.

Other objects and advantages of my invention will more fully appear from the following detailed description taken in connection with the accompanying drawings, which illustrate several embodiments thereof and, in which:—

Figure 1 is a graphical illustration of the ratings of busses of grouped phases above 3,000 amperes at 60 cycles;

Fig. 2 is an elevation partly in section of a bus embodying the features of the present invention and showing a mounting therefor;

Fig. 3 is a side view of the bus and mounting shown in Fig. 2;

Fig. 4 is a view of a modified type of bus and mounting;

Fig. 5 is a side elevation of the modification shown in Fig. 4; and

Fig. 6 is a view of a modified form of bus especially adapted for isolated phase work.

Referring now to the drawings in detail, in which like reference numerals designate similar parts throughout the several views, and more particularly to Figure 1, I have illustrated graphically the ratings of busses on grouped phases above 3,000 amperes at 60 cycles. The horizontal spaces of this graph denote the copper section of the busses in terms of square inches per phase. The vertical spaces of this graph represent the carrying capacity of the busses in terms of ampere under standard conditions. This standard condition is shown as being a 30° C. rise over the temperature of the ambient.

In the left hand upper corner of the graph I have illustrated more or less diagrammatically four types of bus construction. Below these illustrations I have listed the necessary data for correlating the curves shown on the graph with the four illustrations of the bus construction. All bars are ¼th inch thick by 4 inches, 6 inches, or 8 inches wide. For instance, the center point on curve 6 represents six bars of 6 inches by ¼th inch copper and the upper point on the same curve means six bars of 8 inches by ¼th inch copper. Furthermore, as noted on the chart, should the standard temperature at which a bus is operated be a 40° C. rise above the ambient, then the values denoted by the curves would be increased by approximately 15%.

In each of the four illustrations or figures A, B,

C, and D shown on the upper left hand corner of the graph, I have illustrated three phases A, B and C. Figure A shows the usual way of arranging the bus bars. Figures B, C and D illustrate busses provided with the features of my present invention.

In figure A is shown a three phase bus, each phase consisting of three bars, the phases being set in an equi-lateral triangle on 10 inch centers. This is the usual way of disposing the bus bars. It will be noted that the current in the A phase bus is practically all in the very bottom edge of the bars, and the usefulness of the upper half of the bars is more in the nature of a radiator than a conductor. In the lower phase bars B and C the current is disposed for the main part in the top edge of the bars, or the edges of the bars facing each other. This means that the outer bars of the phases B and C do not convey very much current. The foregoing conditions are due, primarily, to the skin effect and to the so called proximity effect. These effects are deleterious for the reason that they result in relatively high heat losses.

Curve 1 of the graph represents the carrying capacity of a bus construction such as that shown in fig. A wherein each of the bars is 4 inches by ¼th inch. It will be observed from this curve that this type of conductor is not an efficient conductor for current exceeding 3,000 amperes. Once the 3,000 mark is reached the carrying capacity of this type of bus cannot be very materially increased by increasing the copper section thereof. Thus, it will be evident that this type of bus is entirely unsatisfactory for carrying current in excess of 3,000 amperes.

Curve 1A represents the carrying capacity of a bus similar to that represented by curve 1 with the exception that each phase of the bus construction is provided with iron around the bars at *"d"* (see fig. A). Even though the addition of magnetic steel or iron does tend to increase the carrying capacity of the bus, still the increase is not so great as to render the type of bus shown in fig. A practical as a conductor for high capacity current.

Curve 2 represents the carrying capacity of a bus like that shown in fig. A, wherein each of the bars is 8 inches by ¼th inch. The curve is believed to be self explanatory.

In each of the bus constructions shown in figs. B, C and D of the graph, it will be observed that the bars of each phase are arranged in a polygonal shape. This arrangement enables the phases to be positioned relatively close together without incurring any bad effects due to the so-called proximity effect. This construction also greatly reduces the deleterious skin effect. Obviously, by reducing both the skin effect and the proximity effect the heat losses of each phase will be substantially decreased so as to render practical the carrying of current in excess of 4,000 amperes.

In each of the constructions shown at B, C and D in the graph of Fig. 1, the bus phases are arranged so as to be on the corners of an equilateral triangle. When the space limitations or the allowable reactive drop does not demand that phases be on the corners of an equi-lateral triangle, the dotted arrangement shown in C may be employed. It will be found that this arrangement has a carrying capacity practically equivalent to that of the bus construction shown at D.

Curves 3 to 8, inclusive, are believed to be self explanatory from the data given in Fig. 1. These curves illustrate the carrying capacities of various forms of the three types of bus constructions B, C and D. Of course, it is to be understood that the carrying capacity of each of these bus constructions may be materially increased by separating the phases further apart, or by increasing the number of bars in each phase.

Curve 7 gives the rating of C on 17 inch centers. If the phases are separated further the ratings of these busses will be raised somewhat, but not so high as curve 6. Curve 6 gives the rating of D on 36 inch centers, and the rating of this bus would be lower on the closer centers, but not so low as curve 7. In curve 8 the rating may be very materially increased by one or both of two methods, either by a wider opening of the corners of the rectangle or by further separating the phases. If both these things are done we may obtain a bus perhaps higher in capacity than that given in curve 6.

In Figs. 2 and 3 I have illustrated one form of a mounting for a bus embodying the features of my present invention. This type of mounting is especially adapted for use in connection with a single phase bus line. In this construction the bus 30 comprises four sides, each of which includes a single copper bar 31. These bars are arranged in a polygonal or rectangular shape and are properly spaced and supported by the clamping device, designated generally by the reference character 32. This device 32 is in turn mounted upon a supporting insulator 33.

Positioned between the bars 31 are a pair of spacing members 34—34, which may be made of iron. These members are each rectangular in shape and they serve to properly space the bars 31. The bars 31 abut the sides of the spacers 34—34. The side bars 31—31 of the bus 30 are held in contact with the spacers 34—34 by means of a pair of diametrically opposed clamping plates 35—35. Each of these plates 35 is triangular in shape, and is connected to the opposite plate by means of three bolts 36, 37 and 38. The upper bolt 38 extends between the spacers 34, whereas both of the bolts 36 and 37 are positioned on the outer sides of the spacers.

Positioned on top of the top bus bar 31 is a clamping plate 39, and positioned on the bottom of the bottom bus bar 31 is a similar plate 40. These plates are made of steel having as low magnetic properties as it is possible to get. The plate 40 is disposed on top of a mounting member 41, which is secured to the top of the insulator 33 by means of the bolt 42. The top plate 39 is connected to the bottom plate 40, as well as to the member 41, by means of four vertical bolts 43. These bolts are disposed at right angles to the bolts associated with the plates 35—35.

The clamp construction shown in Figs. 2 and 3 is such that the bus bars are held accurately in position and yet they are permitted to slip longitudinally, if necessary, under expansion. This movement of the bars is permissible for the reason that the bars are not pierced by the bolts of the clamping device 32.

In Figs. 4 and 5 I have illustrated another form of bus construction wherein the bus is designated generally by the reference character 50. The bus comprises essentially a plurality of copper bars 51, preferably four in number, arranged in a rectangular shape. The bars are held in this shape by means of a clamping device, designated generally by the reference char-

acter 52, which is suitably carried by an insulator 53.

The clamping device 52 includes a spacer 54 made of magnetic steel angle iron. The parts composing the spacer 54 are arranged in a rectangular shape and are welded together at the corners. Each of the bars 51 is secured to a side of the spacer 54 by means of bolts 55 which pierce the bar. It will be observed that the lower pair of bolts 55 are used to secure the bus to a member 56 comprising a non-magnetic steel casting. This casting is in turn secured to the insulator 53 by means of a bolt 57.

In general, the form shown in Figs. 4 and 5 is not as desirable as the modification shown in Figs. 2 and 3, for the reason that the bolts pierce the copper bus bars.

Both forms of the clamp construction shown and described may be used to support three sided busses instead of rectangular busses. This may be accomplished by simply omitting one of the sides of the busses from the construction. It will be evident that even though one of the sides is omitted, the construction of the clamp need not be altered or changed for supporting the other three sides of the bus.

This same general type of supporting clamp may be used for supporting a hexagonally shaped bus by simply making the inner casting or spacer six sided instead of four sided. Furthermore, each side of the busses may comprise as many bars as desired.

In Fig. 6 I have shown a three sided or channel shaped bus 60. Each side of this bus is embraced by a pair of clamping plates 61 which are connected by bolts 62. One of the clamping plates 61 is connected to a casting 63 formed integral with an insulator 64. The other end of the insulator 64 is provided with a mounting plate 65 which is secured to the wall 66 by bolts 67. The three insulators 64 cooperate with the wall 66 to properly support the channel bus 60.

It will be observed that in the first two forms of my bus, illustrated in Figs. 2 and 3 and Figs. 4 and 5, the edges of the bus bars are spaced from each other, thus permitting the air to circulate freely between the bars. This natural ventilation augments the cooling of the bus.

I claim:—

1. An electrical bus construction comprising a plurality of bars arranged so as to have a rectangular cross section, and spacing means disposed between the bars, said bars having their adjacent edges spaced from each other to allow the air to circulate freely therebetween.

2. An electrical bus construction comprising a plurality of flat bars disposed about a common centre in the form of a polygon, spacing members between the bars and holding them spaced apart, and means forcing the bars against the spacing members, said means holding the adjacent edges of the bars spaced apart.

3. An electrical bus construction comprising a plurality of flat bars disposed about a common centre in the form of a polygon, spacing members between the bars, clamping means including members bearing against the outer faces of certain of the bars, a support, and clamping means securing the bus construction to the support and bearing against the outer faces of the other bars.

4. A bus supporting construction comprising a plurality of clamping plates arranged in a polygonal shape about the periphery of the bus, a spacing member disposed within the dimensions of the bus and adapted to be engaged by the sides of the bus, and a plurality of bolts connecting the opposite clamping plates for causing said plates to tightly clamp the sides of the bus to the spacing member, said bolts including both vertical bolts and horizontal bolts, all of which bolts extend along the free sides of the spacing means.

5. In combination, a plurality of bus bars disposed substantially at right angles to each other and defining a rectangle, rectangular spacing members disposed between the bars and in contact therewith, and means cooperating with said spacing members for holding the bars against the sides of the spacing members.

6. In combination, a rectangular spacing member, bus bars disposed about the spacing member in contact with each of the sides thereof, and means holding the bars against the respective sides of the spacing member.

7. In combination, a rectangular spacing member, bus bars disposed about different sides of the spacing member and in contact with the sides thereof, clamping members at the outer faces of the bars, and securing bolts disposed at right angles to the clamping members and holding them against the outer faces of the bus bars, said clamping members holding the bars against movement away from the spacing member.

8. In combination, a rectangular spacing member, bus bars disposed about the spacing member and in contact with the sides thereof, clamping members at the outer faces of the bars, and horizontal and vertical bolts connecting the clamping members and holding them against the bars, said clamping members holding the bars against movement away from the spacing member, the bolts being disposed inside of the bars.

9. In combination, a rectangular spacing member of open construction, bus bars disposed about at least three of the sides of said member in contact with the sides thereof, and means holding the bars against the sides of the spacing member.

10. An electrical bus conductor construction comprising a plurality of electrically parallel connected flat bars of great width relative to their thickness disposed in angular relation about a common center and constituting the current carrying portion of the bus, said bars including spaced side portions defining the sides of a polygon.

11. An electrical bus conductor construction comprising a plurality of bars electrically connected in parallel and disposed about a common center in the form of a polygon, the bars being each flat on at least one side and arranged so that flat sides of the respective bars constitute the sides of the polygon, spacing members between the bars and holding them spaced apart to form narrow, longitudinally extending ventilating slots in the polygon, and means for forcing the bars against the spacing members.

12. An electrical bus conductor construction comprising a plurality of bars electrically connected in parallel and disposed about a common center to form the sides of a polygon, the bars being each flat on at least one side and arranged so that flat sides of the respective bars constitute the sides of the polygon, spacing members between the bars and holding them spaced apart to form narrow, longitudinally extending ventilating slots in the polygon, and means coacting with the spacing members for securing the bars against appreciable relative movement toward

and away from each other while permitting longitudinal expansion and contraction of the bars independently of each other and of the securing means.

13. A single phase multiple bar bus supporting construction comprising a plurality of pairs of clamp members electrically connected together by the bus and disposed about the bus, the pairs of clamp members being angularly disposed to one another, spacing means disposed within the bus for separating the bars, and means for forcing said clamp members toward the spacing means to tightly clamp the bars of the bus thereto, one of said clamp members being formed for attachment to a supporting insulator.

14. In a bus, a horizontally disposed tubular conductor having narrow longitudinal slots at the top and bottom, the tubular conductor being polygonal in cross section, with at least some outer sides flat and of a width approximating the full width of the polygon.

15. In a bus, a horizontally disposed tubular conductor having narrow longitudinal slots at the top and bottom and extending to the inside of the tube, the tubular conductor being rectangular in cross section, and the combined width of all the slots being less than the combined width of the conducting portions of the outer sides of the rectangle.

16. In a bus, a horizontally disposed tubular conductor having narrow longitudinal slots at the top and bottom, the tubular conductor being a flat sided polygon in cross section and made up of bars clamped on their outer sides.

17. A bus bar conductor for carrying large currents comprising a plurality of horizontally extending parallel connected bar conductors arranged to define a hollow polygon having horizontal and vertical conducting sides and having openings at the top and bottom for effecting a natural circulation of air therethrough.

18. A bus conductor comprising a plurality of flat sided members of conducting material, of relatively great width in proportion to their thickness and of relatively great length in proportion to their width, arranged to form the sides of a polygon, said members being spaced at adjacent edges to provide ventilating slots therebetween, said members being electrically connected in parallel.

19. A bus of a rectangular cross section including a plurality of metal members, each having at least one flat outer side, secured in spaced relation, said members including spaced parallel extending current carrying portions defining two sides of the rectangle and, at right angles thereto, spaced current carrying portions defining the other two sides of the rectangle, all electrically connected together in parallel relation to constitute a single bus conductor, certain adjacent current carrying portions being spaced to provide ventilating slots.

20. A bus comprising a horizontally disposed tubular conductor having narrow longitudinally extending slots at the top and bottom open to the atmosphere to permit the natural circulation of air therethrough, and having at least one flat outer longitudinally extending side to facilitate clamping of flat members thereto.

21. A composite bus conductor comprising a plurality of conducting members of the same material arranged to form the sides and the web of a longitudinally extending channel and spaced apart to define longitudinally extending slots between the web and the flanges, said members being electrically connected in parallel.

22. A composite bus conductor comprising four metal members secured together to define a rectangle, certain adjacent members being spaced apart to form longitudinally extending openings to the interior of the rectangle, the outer surfaces of the members being flat, whereby the bus conductor has parallel planar surfaces on opposite outer sides thereof.

23. A bus conductor comprising a plurality of members arranged to define an inclosure polygonal in cross section and having certain opposite outer flat surfaces lying in spaced parallel planes, certain of said members being spaced apart to form longitudinally extending open ventilating slots from the inside to the outside of the polygon, the members being electrically connected together to form a single conductor.

24. A bus comprising a plurality of parallel connected conducting members arranged to form a flat sided tube with certain opposite outer surfaces lying in spaced parallel planes to facilitate the clamping of connections thereto.

TITUS G. LE CLAIR.

CERTIFICATE OF CORRECTION.

Patent No. 1,934,434. **November 7, 1933.**

TITUS G. Le CLAIR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, lines 96-97, claim 21, for "material" read materials; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 23rd day of January, A. D. 1934.

F. M. Hopkins

(Seal) **Acting Commissioner of Patents.**