June 28, 1938. E. L. BARRETT 2,121,851

METHOD OF MAKING AND ASSEMBLING LAMINATED STRUCTURES AND APPARATUS THEREFOR

Filed July 6, 1936 3 Sheets-Sheet 1

Fig. 1.

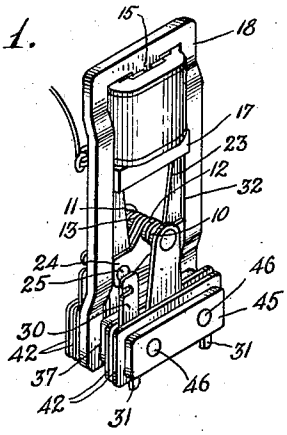


Fig. 2.

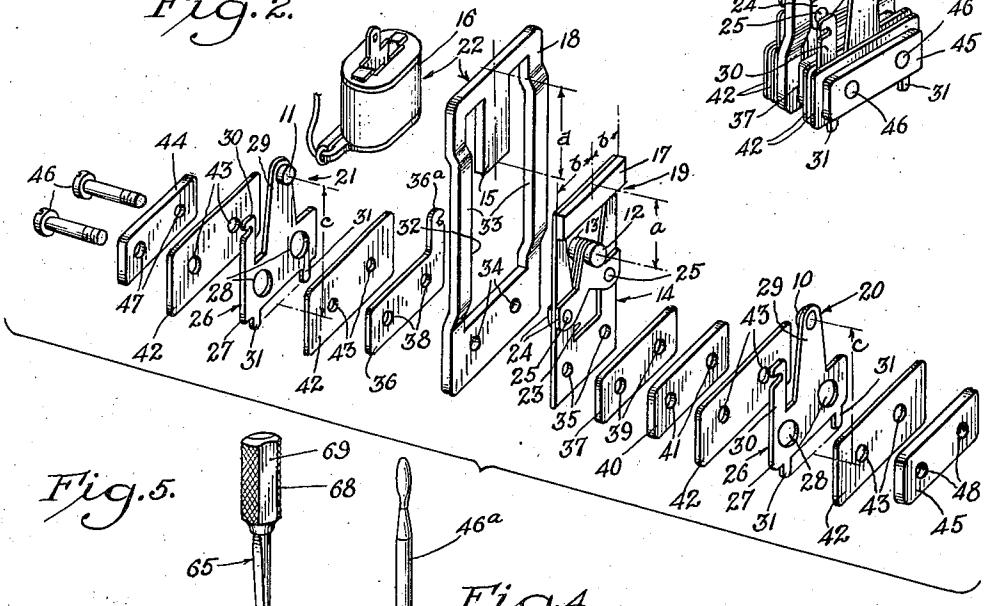


Fig. 5.

Fig. 4.

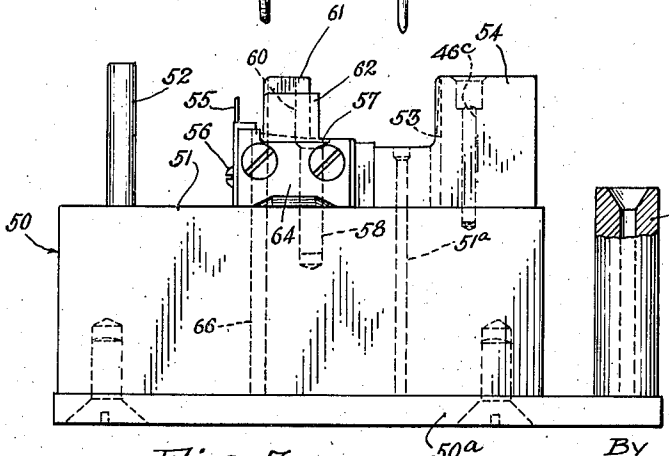


Fig. 3.

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Fig. 6.

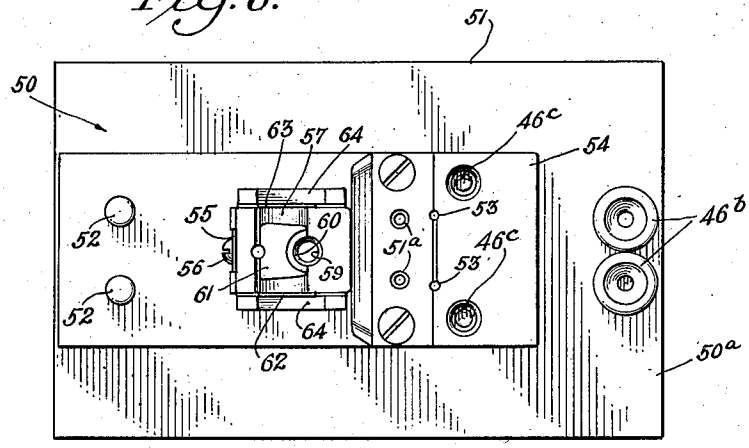


Fig. 7.

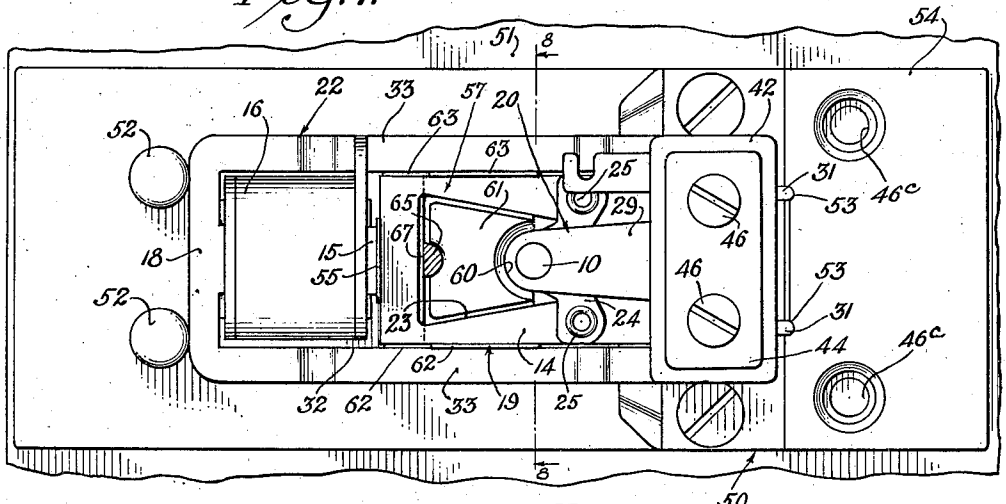


Fig. 8.

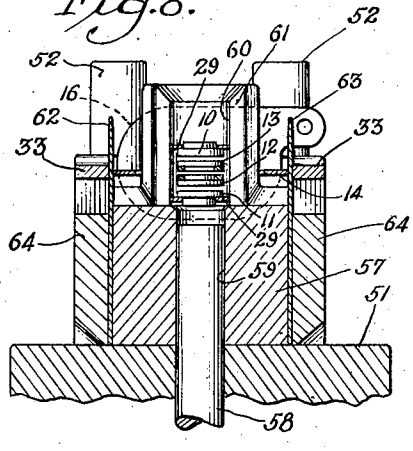
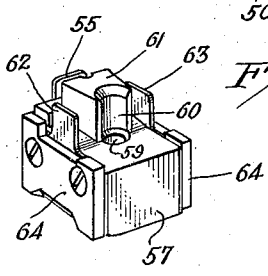


Fig. 9.



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Fig. 10.

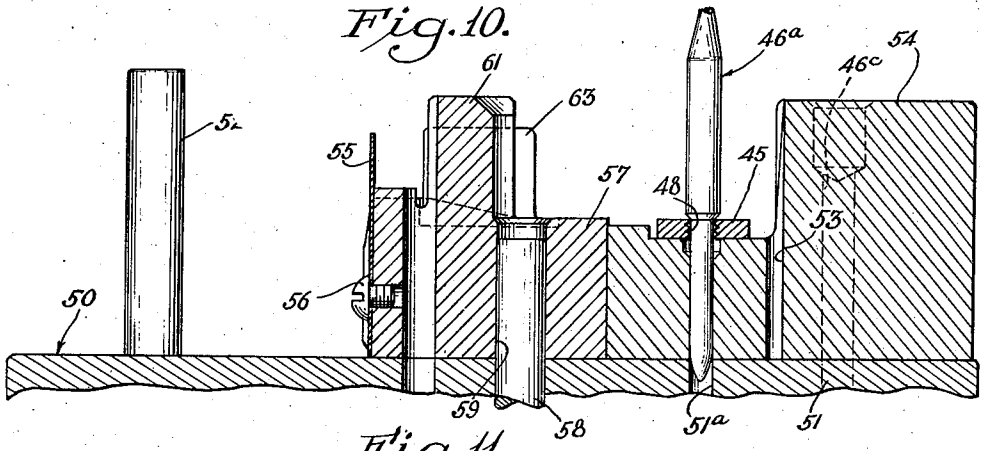


Fig. 11.

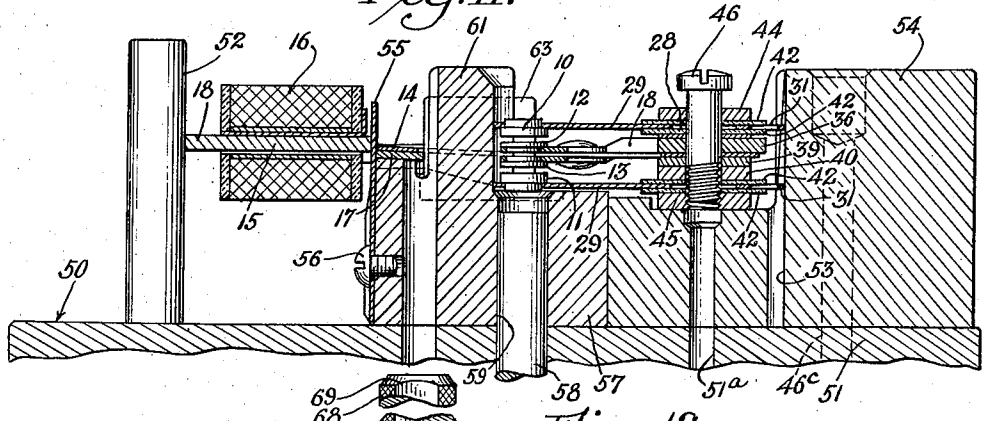
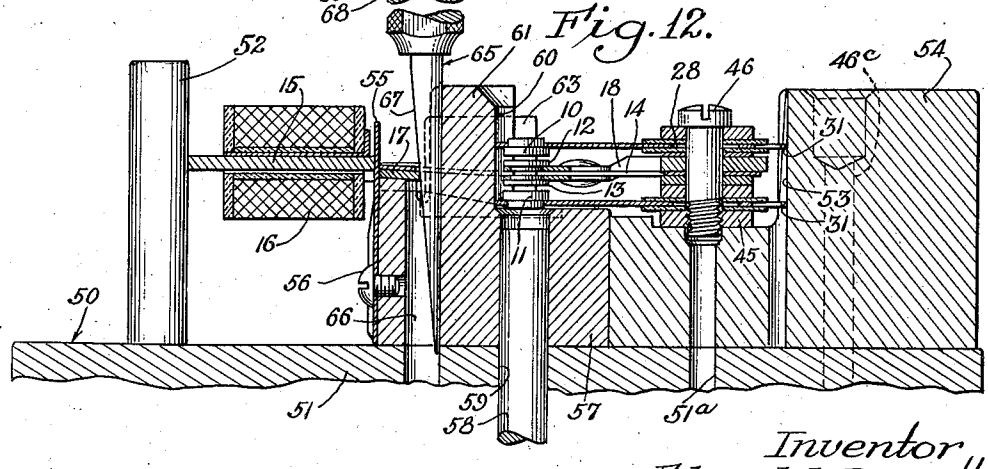


Fig. 12.



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UNITED STATES PATENT OFFICE

2,121,851

METHOD OF MAKING AND ASSEMBLING LAMINATED STRUCTURES AND APPARATUS THEREFOR

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Application July 6, 1936, Serial No. 89,051

19 Claims. (Cl. 29—155.5)

The invention relates to a method of making and assembling laminated structures such as vibratory motors, as well as to a novel apparatus particularly adapted for use in carrying out such method.

It is frequently necessary to assemble structures composed of dissimilar laminations with the individual laminations arranged in precisely determined relative positions. Vibratory motors are an example of structures of this type and the present invention is especially adapted for use in their assembly.

Vibratory motors of the type herein contemplated are frequently used as an element of devices commonly known as "B battery eliminators" for automobile radio receiving sets. The function of the vibratory motor or vibrator in such case is to interrupt periodically the flow of an electric current. The current interruption in the vibrator is performed by two or more cooperating make and break contacts. One of these contacts is relatively fixed and the other is carried by a resilient reed which is ordinarily vibrated at a frequency of approximately 120 cycles per second by a suitable electromagnetic driving means. The contacts are preferably spaced only a few thousandths of an inch when in their idle position and in addition, they must be accurately alined if they are to meet squarely and operate effectively without undue wear or arcing. Also, it is common practice to include in the electromagnetic driving means, an armature carried by the reed which swings past the face of an energizable pole piece at an extremely small distance therefrom. The clearance between the pole piece and armature is preferably made of the order of three thousandths of an inch to minimize the reluctance of the magnetic path therebetween and thus increase the efficiency and effectiveness of operation. If the spacing is increased, the magnetic force applied to the armature is decreased so that it may fail to start while the device will be broken or rendered inoperative if the armature strikes the pole piece during its swinging movement. As a consequence this clearance must be adjusted with great nicety and precision. It will be seen that the difficulties of effecting these adjustments of the various parts of a vibratory motor are rather great when it is borne in mind that these motors are ordinarily made on a large scale production basis.

The primary object of the invention is to provide an improved method of assembling laminated structures of such character that the several laminations may be arranged in certain predetermined relative positions and secured together in their assembled relation all with a minimum expenditure of time and by an unskilled operator.

A more specific object of the present invention is to provide an improved and simplified method of assembling the parts of vibratory motors in such manner that a relatively unskilled workman is able to assemble with great rapidity the parts required to form a completed vibratory motor in which the moving parts such as the contacts, armature and its cooperating pole piece, are all accurately positioned with respect to each other with great nicety and precision, the improved method being thus particularly adapted for use in large scale production.

Another object of the invention is to provide an improved method of assembling vibratory motors by fashioning a series of sub-assemblies each having a minimum number of dimensions, which must be accurately determined, and then forming the completed device by assembling the individual sub-assemblies on a jig or fixture including a plurality of fixed dimension reference points formed by suitable abutments and gauges that cooperate with the accurately dimensioned parts of the sub-assemblies to position the moving parts of the completed vibratory motor in the precise relation required.

A further object of the invention is to provide a fixture adapted for use in assembling laminated structures such as vibratory motors having a plurality of moving parts that must be related with great precision, the fixture including a major number of fixed dimensioned reference parts as compared to the number of accurately dimensioned component parts of the vibratory motor, thus simplifying the manufacture of the parts of the motor without sacrificing the quality of the finished device.

Further objects and advantages of the invention will become apparent as the following descriptions proceed and the features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which

Figure 1 is a perspective view of a vibratory motor made in accordance with the present invention.

Fig. 2 is an exploded perspective view of the component parts of the vibratory motor shown in Fig. 1 illustrating particularly the various sub-assemblies used in forming the same.

Fig. 3 is a side elevation of a novel fixture preferably utilized in assembling the vibratory motor shown in Fig. 1.

Fig. 4 is a detail view of one of the removable pins used with the fixture shown in Fig. 3.

Fig. 5 is a detail perspective view of a wedging device used with the fixture shown in Fig. 3.

Fig. 6 is a plan view of the fixture shown in Fig. 3.

Fig. 7 is an enlarged plan view of the fixture shown in Fig. 3 with a completed vibratory motor in position thereon.

Fig. 8 is a transverse sectional view along the line 8—8 in Fig. 7 of the fixture and vibratory motor shown therein illustrating particularly the means for alining the contacts and reed of the motor.

Fig. 9 is a detail perspective view of a removable portion of the fixture shown in Fig. 3.

Fig. 10 is a longitudinal section of the fixture illustrating the first step in the method of assembling the vibratory motor on the fixture.

Fig. 11 is an enlarged longitudinal section of the fixture similar to Fig. 10 and illustrating a subsequent step in the assembling of the vibratory motor.

Fig. 12 is also an enlarged longitudinal section of the fixture illustrating the final steps in the assembly of the vibratory motor thereon.

For purposes of illustration, the novel method of assembly and apparatus for use therein contemplated by the present invention have been described herein as applied to the assembly of a laminated vibratory motor of the type described and claimed in the copending application Serial No. 52,987, filed December 5, 1935, by Edward L. Barrett and Max J. Manahan, and issued as Patent No. 2,072,578. It will be understood, however, that the present invention is applicable to a large number of other types of vibratory motors and similar laminated structures.

The vibratory motor shown in Fig. 1 is of a generally laminated construction and includes a plurality of make and break contacts illustrated in the form of a pair of relatively fixed contacts 10 and 11, which cooperate with movable contacts 12 and 13, carried by a vibratory reed 14. These make and break contacts serve to periodically interrupt electrical circuits such as the input circuits of the primary winding of a step-up transformer (not shown) in a B-battery eliminator. The reed 14 is vibrated at a relatively high frequency of the order of 120 cycles per second by a suitable electromagnetic driving arrangement which in the present instance, includes a pole piece 15 energized by an electromagnet winding 16 and a cooperating armature 17 carried by the reed. The entire structure is mounted as a unit on a rigid supporting member such as the rectangular flat frame 18 illustrated.

From the foregoing, it will be apparent that the vibratory motor illustrated embodies two principal sets or groups of relatively moving parts; first the armature 17 and its cooperating pole piece 15; and second, the two sets of cooperating make and break contacts. The clearances between these parts and alinement thereof must be set with great precision and accuracy if the completed device is to operate satisfactorily. This will be even more apparent when the order of magnitude of the dimensions involved is considered. Thus, the clearance between the adjacent portions of the armature 17 and the pole piece 15 is approximately only about 0.003 inch. Moreover, the cooperating contacts must be accurately alined both transversely and longitudinally so that they will meet squarely upon contact thereof if undue wear and arcing is to be avoided in the completed device. The clearance between the pole piece 15 and armature 17 is very critical since if it is too large, the reluctance of the magnetic path therebetween will be greatly increased so that the device may fail to start when a predetermined minimum voltage is applied to the energizing winding 16. Thus, when such a vibratory motor is used in an automobile radio receiving set, for example, the battery voltage may fall to a value of say 4 volts even though the rated voltage output of the battery is 6 volts so that the motor must be designed to start even when only a comparatively weak voltage is available. On the other hand, if the armature 17 is positioned too close to the face of the pole piece 15, it will strike the same thus causing the reed to stick and fail to operate at all or else to operate very erratically and unsatisfactorily. If only a very small number of such vibratory motors were to be manufactured, the parts could be fabricated by skilled machinists with extreme accuracy so that the proper clearances could be had. In ordinary commercial practice, however, when thousands of these motors are being produced in a single factory, such a procedure is impractical. In such commercial practice it is desirable to form most of the parts of the device by punch press operations and in addition the assembly operations are usually performed by relatively unskilled workmen.

The present invention contemplates the utilization of a novel method of assembly by means of which the desired accuracy in clearances and alinement for the completed device is had with the use of a minimum number of precise or accurate dimensions in the component parts, and in which a minimum amount of reliance is placed upon the skill of the operator. In constructing such a vibratory motor, a plurality of sub-assemblies are preferably fabricated individually and then assembled to form the complete unit. In the device illustrated, three principal types of sub-assemblies are preformed prior to the final assembly operation. These sub-assemblies are, first, a reed assembly designated generally by the numeral 19; second, two similar contact supporting assemblies designated by the numerals 20 and 21, respectively; and third, a frame assembly designated by the numeral 22. It will be noted that these sub-assemblies are all arranged in the form of superposed laminations.

The reed assembly 19 includes a reed 14 of generally rectangular shape made of a high grade of spring steel, for example. An elongated aperture 23 having outwardly flaring sides in the upper portion thereof is formed in the reed to provide certain desired resilient characteristics therein. The armature 17 is made of steel or other magnetizable material having a high magnetic permeability and is substantially rectangular in shape. The armature is spot welded or otherwise rigidly secured to the upper edge of the reed 14. The outer face of the armature is slightly curved or slanted so that it will not contact the adjacent face of the pole piece despite its arcuate path of movement. The contacts 12 and 13 are supported on the reed 14 by a pair of contact supporting members 24 to which they are preferably welded in order to reduce as much as possible the weight on the reed. The members 24 span the aperture 23 and are rigidly secured at their opposite ends to the reed 14 by brass rivets 25. The reed assembly 19 thus constituted is formed in such manner that the parts thereof will be arranged in a predetermined accurately dimensioned relation. Preferably the reed 14 itself is cut from suitable stock by a compound die so that the marginal edges and apertures therein are all formed simultaneously by the same die. The armature 17 is secured to the reed and the contacts 12 and 13 are secured to the mem-

bers 24, all before the latter are secured to the reed 14. Then the reed 14 and members 24 are positioned in a suitable jig or work fixture and held therein in predetermined relation while the rivets 25 are secured in place. The centers of the contacts 12 and 13 are thus positioned at an accurately determined longitudinal distance "a" (Fig. 2) from the forward face of the armature 17 and at an accurately determined lateral distance "b" from the parallel side edges of the reed.

The contact supporting sub-assembly 20 includes an elongated contact supporting member 26 made of electrical conducting material such as spring copper or the like. This contact supporting member 26 includes a rectangular base portion 27 having large apertures 28 therein and an upwardly extending portion 29 to which the contact 10 is rigidly secured, preferably by spinning over a shank portion thereof which extends through an aperture in the portion 29. An extension 30 is also formed on the member 26 to which an electrical conductor may be conveniently secured. A pair of laterally displaced ears 31 are formed on the lower edge of the contact supporting member 26 and serve to aid in positioning the sub-assembly 20 during the assembly operation, as hereinafter described. The permissible size of the holes 28 is somewhat limited by the necessity for minimizing the size of the base portions of the members 26 as well as to avoid reducing the cross-sectional area of any part thereof beyond a safe amount. On the other hand the edges of holes 28 must be out of electrical contact with the screws positioned therein and even spaced a sufficient distance therefrom so that any metal shavings or the like which get in the same during manufacture will not cause a short circuit in the completed device. Consequently the holes 28 must be located in an accurately determined position with respect to the ears 31, which determine the position of the members 26 during the final assembly operation. Also the contacts 10 and 11 should be located at a fairly accurate distance "c" from the outer ends of the ears 31 so as to bring them into longitudinal alinement with the contacts 12 and 13 as will hereinafter appear. A compound die is preferably used to form the supporting members 26 so that the apertures therein as well as the edge configuration are all formed simultaneously and in a predetermined relative position without possibility of error by a single stamping operation.

The other contact supporting sub-assembly 21 is in general identical with the sub-assembly 20 described above except that the contact 11 included therein faces in the opposite direction with respect to the contact 10. The same numerals have been used to identify identical parts and it will thus be seen that the sub-assembly 21 includes a contact supporting member 26 having a rectangular base portion 27 provided with enlarged holes 28 therein. Positioning ears 31 are also provided on the lower edge of the supporting member 26.

The frame assembly 22 is shown in Fig. 2 with the energizing winding 16 removed in order to better illustrate the construction thereof. It will be understood that the winding 16 is secured in place on the pole piece 15 in the course of the fabrication of the sub-assembly 22. The frame 18 is generally rectangular in shape being stamped or otherwise formed from a sheet of iron or other material having a relatively high magnetic permeability. The pole piece 15 is integral with the upper end of the frame 18 and extends into a centrally located rectangular opening 32 defined thereby. It will be noted that the side members 33 of the frame 18 are offset from the plane of the frame so that the spacing between the contacts may be readily inspected and adjusted after the vibratory motor is completely assembled. A pair of holes 34 are formed in the base portion of the frame 18. These holes are adapted to register with holes 35 formed in the base portion of the reed 14 as well as with the holes 28 in the contact supporting members 26. The frame assembly 22 need have at most only one accurately determined longitudinal dimension when the vibrator is assembled in accordance with the present invention. This dimension is the distance "d" between the upper edge of the frame 18 and the active face of the pole piece 15. In addition the inner edges of the side members 33 are parallel and spaced apart an accurately determined distance. The entire frame and pole piece are formed by a single punch press operation to effect this dimensioning. That is the outer edge of the frame and end of the pole piece are preferably formed by a single shearing operation.

A pair of rectangular metal spacers 36 and 37 are positioned on opposite sides of the base of the frame 18 and reed 14, respectively, these spacers having registering holes 38 and 39 formed therein. It will be noted that the spacer 36 is provided with an upstanding terminal portion 36a adapted for connection to an electrical conductor. An electrical circuit is completed from the terminal 36a to the contacts 12 and 13 through the metal spacer 36, frame 18, reed 14 and contact supports 24. A second metal spacer 40 having registering holes 41 formed therein is positioned on the spacer 37 so as to compensate for the thickness of the frame 18 in spacing the contacts 10 and 11 equidistant from the contacts 12 and 13, respectively.

Rectangular insulating members 42 are positioned on opposite sides of the contact supporting members 26 so as to insulate them from the remaining portion of the vibratory motor. These insulating members 42 are also provided with registering holes 43. Rectangular end members 44 and 45 are placed on the opposite faces of the stack formed by the parts described above. A pair of screws 46 pass through registering holes 47 formed in the end member 44 as well as through the registering holes in the other members of the stack described above and are threaded in tapped holes 48 formed in the end member 45.

After the laminations or elements of the structure such as the sub-assemblies, spacers and insulators have been formed as described above they are assembled to form a complete vibratory motor. In general this assembly operation comprises arranging the laminations in superposed relation in predetermined order, bringing the laminations approximately into predetermined relative positions by arranging the corresponding holes therein in concentric relation, moving the opposed portions of such laminations as the reed and frame into abutment with the opposite sides of a gauge to space the same accurately, and securing the laminations fixedly together. The holes in the laminations are preferably brought into alinement by stringing them on a positioning pin or the like and one or more fixed abutments may be used to guide the lami-

nations into position as they are strung on the pin.

The final assembly of the laminations or elements is preferably performed on an improved jig or work fixture exemplified by the fixture 50 in Fig. 3. A base 51 supports three principal members of the fixture 50, which define reference points cooperating with the accurately dimensioned portions of the sub-assemblies described above to position the parts of the vibratory motor in accurate longitudinal alinement and adjustment. In the construction illustrated, these principal members for effecting longitudinal positioning are a pair of opposed abutments spaced apart a predetermined distance and a flexible flat sheet metal gauge of carefully determined thickness. One of the abutments is formed by a pair of vertical pins 52 rigidly secured to the base 51 in spaced relation and adapted to bear against the end face of the frame 18 (Fig. 7). The second abutment is formed by the inner faces of vertical grooves 53 formed in a block 54, which is also rigidly secured to the base 51, by pins 46c the inner faces of the grooves being located at a predetermined distance from the opposed faces of the pins 52. The third member, or gauge, is illustrated in the form of a thin substantially rectangular flexible sheet of metal 55, which is secured in a vertical position by a screw 56 to a face of a supporting block 57. The block 57 is preferably detachably secured to the fixture base 51 by a vertically extending pin 58, which is rigidly secured to the base 51 and adapted to be slidably positioned in a hole 59 formed in the bottom of the block 57. The purpose of the detachable connection between the block 57 and base 51 is described more in detail below.

The cooperating make and break contacts are brought into lateral alinement also during the assembly operation by a suitable abutment and spacing gauge arrangement on the fixture 50. The lateral positioning of the contacts 10 and 11 secured to the contact supports 26 is fixed by the ears 31 which are disposed in the abutment grooves 53. In addition the extended portions 29 of the supports 26 are disposed within a complementary arcuate recess 60 formed in an upstanding projection 61 formed on the removable block 57 (Fig. 9). This recess also aids in alining the cooperating contacts. As was pointed out above the contacts 12 and 13 are located at an accurately dimensioned lateral distance from the edges of the reed 14. A pair of thin sheet metal vertically disposed gauges 62 and 63 secured to the opposite sides of the block 57 by plates 64 serve to position the reed laterally so as to bring the contacts 12 and 13 into lateral alinement with the contacts 10 as shown in Fig. 8. A more important function of the gauges 62 and 63 is to determine accurately the spacing between the adjacent portions of the reed 14 and side members 33 of the frame 18.

In assembling the vibrator described above on the fixture 50, the end member 45 of the stack of laminations of the vibratory motor is first positioned on the fixture 50 by a pair of removable pins 46a. The reduced lower end portions of the pins 46a are inserted through the holes 48 in the end member 45 and in a pair of holes 51a formed in the base 51 of the fixture. When the pins 46a are not in use, they may be placed in readily accessible receptacles 46b mounted on the end of base plate 50a of the fixture 50. The position of the assembly pins 46a during the assembling operation is shown in Fig. 10. The remaining parts of the vibratory motor are then strung on the pins 46a in proper sequence. The pins 46a thus pass through the registering holes formed in the base portions thereof so as to position them approximately in their proper alinement. The positioning pins 46a are then lifted out of the holes in the parts of the motor and placed in the receptacles 46b. Then the screws 46 are inserted into the alined holes in the laminations and are screwed part way into the tapped holes formed in the end member 45 so that the reed 14 is held in position on the frame 18, as shown in Fig. 11, in such manner that a limited amount of relative longitudinal movement is permitted.

After the laminations of the vibratory motor have thus been assembled on the fixture 50 as shown in Fig. 11 and approximately in their proper positions, they are then moved into accurately determined relative positions. The armature 17 is preferably first positioned in the precise relation desired with respect to the end of the pole piece 15 since this is the most critical dimension in the completed unit. In the arrangement illustrated, the armature 17 is moved wedgingly into engagement with the adjacent surface of the gauge 55 by a wedge pin 65. The requisite slight longitudinal motion of the reed 14 is permitted by the small clearance between the holes 35 and the screws 46. Thus, the pin 65 is inserted into a complementary recess or hole 66 formed in the fixture 50 and a flat angularly disposed front surface 67 thereof bears against the rear edge of the armature 17. A knurled head 68 is formed on the pin 65 in order that it may be readily gripped by the operator and this head is also preferably provided with a flat surface 69 thereon which is located at 90 degrees about the axis of the pin with respect to the wedging surface 67. Thus, if the operator places the thumb of his right hand against the flat surface 69 and inserts the pin 65, the wedging surface 67 will always be brought into contact with the rear edge of the armature 17. As the pin 65 is pushed downwardly into the hole 66, the armature 17 is moved to the left as viewed in Fig. 12 so that it presses against the sheet metal gauge 55. Since the gauge 55 is resilient, it is consequently moved over slightly into firm contact with the end surface of the pole piece 15. As a result of this relative movement of the pole piece 15 and armature 17 into tight contact with the opposite faces of the gauge 55 the adjacent portions thereof are accurately spaced a predetermined distance. As was pointed out above, this clearance or distance is ordinarily of the order of about 0.003 inch so that very little tolerance or variation is permissible.

While the pin 65 is still in the position described above, thus holding the armature 17 and pole piece 15 in proper position, the ears 31 on the contact supporting members 26 are firmly seated against the bottoms of the grooves 53. By thus moving these projections or ears 31 against such a fixed abutment, the contacts 10 and 11 are spaced a predetermined longitudinal distance "c" from this fixed abutment on the fixture. At the same time, the contacts 12 and 13 carried by the reed 14 are also spaced a predetermined longitudinal distance from the fixed abutment 52 on the fixture 50 since, as was noted above, the length "d" of the pole piece 15 from the outer end of the frame, the thickness of the gauge 55, and the distance "a" from the outer face of the armature 17 to the contacts 12 and 13 are all accurately determined. It will thus be seen that the longitudinal alinement of the cooperating make and

break contacts is precisely fixed and at the same time, the spacing of the edges of the holes **28** in the contact supports **26** about the screws **46** is also fixed. This latter relation is accurately determined since the lower ends of the screws **46** are positioned in the enlarged upper ends of holes **51a** in the fixture **50** while the holes **28** in the contact supports **26** are located at a predetermined distance from the ends of the projections or ears **31**, which are in turn pressed tightly against another portion of the fixture **50**, namely the bottoms of the grooves **53**. As has been previously noted, the gauges **62** and **63** are positioned between the lateral edges of the reed **14** and the adjacent portions of the frame side arms **33**, thus spacing the same equidistantly therefrom. Also, these gauges serve to center the reed **14** and the contacts **12** and **13** carried thereby transversely with respect to the center line of the fixture **50**. The projections **31** on the contact supports **26** cooperate with the abutment grooves **53** to position the contact supports accurately in a transverse direction with respect to the center line of the fixture **50** so that the cooperating make and break contacts **10** to **13**, inclusive, are brought into transverse alinement. After the parts have been thus alined on the fixture in the manner described, the screws **46** are then screwed tightly into the tapped holes **48** in the end members **45** so that the parts of the vibratory motor are held fixedly in their assembled positions.

After the vibratory motor has been assembled as described above, the wedging pin **65** is removed and the completed vibrator is lifted off of the fixture **50**. In case the gauge **55** or the gauges **62** and **63** bind on the associated parts of the vibratory motor due to their frictional contact therewith, the block **57** may be lifted off of the fixture base at the same time the vibratory motor is removed therefrom. The gauges may then be readily disengaged from the cooperating parts of the vibratory motor without danger of distorting the reed or other parts of the device.

From the foregoing, it will be apparent that a simple and economical method of assembling laminated structures such as vibratory motors has been provided. In applying this improved method to the particular vibratory motor illustrated, the critical dimensional relations of the various parts are all determined with great nicety and precision even though the assembly operation be carried out by a relatively unskilled operator. These critical dimensional relations for the particular device illustrated are as follows in the order of their importance: first, the clearance between the armature **17** and pole piece **15**; second, the clearance between screws **46** and the edges of the holes **28** in the contact supports **26**; third, the clearance between the transverse edges of the reed **14** and the adjacent side arms **33** of the frame **18**; and fourth, the alinement of the cooperating make and break contacts.

Although a particular embodiment and application of the present invention has been described and illustrated in detail as an exemplification thereof, it should be understood that no intention may properly be inferred from this action to limit the invention to the particular embodiment and application described, but on the other hand, it is intended to cover in the appended claims all modifications within the spirit and scope of the invention.

I claim as my invention:

1. The method of assembling a laminated structure such as a vibratory motor, including laminations having apertures in corresponding portions thereof, which comprises, stringing the laminations in superposed relation and predetermined order on an assembly pin or the like inserted through the apertures therein, guiding the superposed laminations approximately into their proper relative positions in the assembly, moving the opposed portions of a plurality of the laminations lying in a generally common plane into abutment with the opposite sides of a gauge to space the same accurately, and securing the laminations fixedly together.

2. The method of assembling a laminated structure such as a vibratory motor, including laminations having apertures therein, which comprises, assembling the laminations in superposed relation in a predetermined order, bringing the laminations approximately into their predetermined relative positions by arranging the holes therein substantially in alinement, moving the opposed portions of a plurality of the laminations lying in a generally common plane into abutment with the opposite sides of a gauge to space the same accurately, and securing the laminations fixedly together.

3. The method of assembling a vibratory motor provided with an open rectangular flat sheet metal frame having an integral pole piece extending into the opening defined by the frame and an armature carried on the free end of a flat sheet metal reed adapted to swing past the pole pieces in close proximity thereto in the operation of the device, the reed and frame having holes in the portions thereof opposite the ends on which the pole piece and armature are carried, which comprises, positioning the reed and frame in face-to-face contact with a portion of the reed overlying the opening defined by the frame, bringing the armature and pole piece approximately into their proper relative positions by stringing the same on a positioning pin or the like and thus bringing the holes into registration, securing the reed loosely on the frame in such position so as to maintain the parts approximately in such position while permitting a limited amount of endwise movement therebetween, spacing the adjacent portions of the pole piece and armature a precise distance apart, and fixedly securing the reed to the frame while maintaining such spacing.

4. The method of assembling a vibratory motor including a frame having an energizable pole piece rigid therewith and an armature carried by the free end of an apertured resilient reed and adapted to swing past the pole piece in close proximity thereto in the operation of the device, which comprises, positioning the frame against a fixed abutment, placing the reed on the frame with the armature disposed approximately in position adjacent the end of the pole piece, securing the reed loosely in such position, inserting a thin metal gauge between the adjacent portions of the armature and pole piece, exerting a wedging pressure on a wall of the aperture in the reed against the resistance of the fixed abutment and thereby moving the armature into engagement with one face of the gauge while moving the other face of the gauge into contact with the end of the pole piece thus accurately determining the clearance between the armature and the pole piece, and rigidly securing the reed to the frame while maintaining the armature and pole piece in contact with the gauge.

5. The method of assembling a vibratory motor provided with a frame having an energizable pole

piece rigid therewith and an armature carried by the free end of a resilient reed and adapted to swing past the pole piece in close proximity thereto in the operation of the device, which comprises, positioning the reed on the frame with the armature disposed approximately in position adjacent the end of the pole piece, securing the reed loosely in such position, inserting a thin sheet metal gauge between the adjacent portions of the armature and pole piece, wedging the armature into contact with one face of the gauge and moving the other face into contact with the pole piece thereby accurately determining the clearance between the armature and the pole piece, and rigidly securing the reed on the frame while maintaining the armature and pole piece in contact with the gauge.

6. The method of assembling a vibratory motor having a frame provided with spaced elongated side arms and a flat vibratory reed adapted to swing in a plane transverse to the common plane of said side arms, the reed and frame having holes in corresponding portions thereof, which comprises, stringing the reed and frame in superposed relation on a positioning pin or the like, guiding the reed and frame approximately into position, inserting thin sheet metal gauges between the lateral edges of the reed and the adjacent portions of the frame side arms to space the lateral edges of the reed equidistantly from the side arms of the frame, and securing the reed fixedly to the frame in such position.

7. The method of assembling a vibratory motor provided with a frame having spaced side arms connected by an end member having a pole piece thereon with the end of the pole piece located a predetermined distance from the end of the frame and a pair of cooperating make and break contacts carried by respective sheet metal supporting members, one of said contacts being located a predetermined distance from an end of its supporting member and the other of said contacts being located a predetermined distance from the opposite end of its supporting member, which comprises, positioning said supporting members on the frame with portions thereof overlying the aperture therein and with the contacts approximately in alinement, positioning the end of the frame against a fixed abutment and positioning the end of one of the contact supporting members a predetermined distance from such end of the frame to bring the contact carried thereby a predetermined distance from the fixed abutment, and positioning the end of the other contact carrying member against a second fixed abutment located a predetermined distance from the first fixed abutment to bring the contacts accurately into alinement, and securing the supporting members fixedly to the frame while in such positions.

8. The method of assembling a vibratory motor having a frame provided with spaced elongated side arms and a flat vibratory reed adapted to swing in a plane transverse to the common plane of the side arms, the reed having an armature on the free end thereof adapted to swing past the pole piece in close proximity thereto in the operation of the device, which comprises, positioning the reed on the frame between the side arms thereof and with the armature disposed approximately in position adjacent the end of the pole piece, securing the reed loosely in such position, moving the reed and pole piece longitudinally relatively with respect to each other until the adjacent portions thereof are spaced an accurately determined distance, securing the reed and pole piece against relative longitudinal movement when in such accurately determined position, moving the reed and frame laterally relatively with respect to each other until the lateral edges of the reed are spaced equidistantly from the side arms of the frame, and securing the reed fixedly to the frame in such position.

9. The method of assembling a vibratory motor provided with a flat sheet metal frame having a rectangular aperture therein with an integral pole piece extending into said aperture and an armature carried on the free end of a flat sheet metal reed adapted to swing past the pole piece in close proximity thereto in the operation of the device, the reed and frame having holes in the portions thereof opposite the ends on which the pole piece and armature are carried, which comprises, positioning the reed and frame in face-to-face contact with a portion of the reed overlying the aperture in the frame, moving the pole piece and armature approximately into their proper relation by stringing the same on a positioning pin or the like and thus bringing the holes into registration, securing the reed loosely on the frame in such position so as to maintain the parts approximately in such position while permitting a limited amount of relative movement therebetween, spacing the adjacent portions of the pole piece and armature a precise longitudinal distance apart, moving the reed and frame laterally with respect to each other until the lateral edges of the reed are spaced equidistantly from the adjacent side edges of the aperture in the frame, and securing the reed fixedly to the frame in such position.

10. The method of assembling a vibratory motor provided with a flat sheet metal frame having a rectangular aperture therein with an integral pole piece extending into said aperture, an armature carried on the free end of a flat sheet metal reed adapted to swing past the pole piece in close proximity thereto in the operation of the device, and cooperating contacts carried by the reed and a sheet metal contact support, the motor parts having holes in corresponding portions thereof, the hole fashioned in said contact support being larger than the other holes; which comprises, arranging the frame, reed and contact support in superposed relation in the order named with an apertured insulating strip between the portions of the reed and contact support having said holes therein, positioning the reed and frame in face-to-face contact with a portion of the reed overlying the aperture in the frame, moving the pole piece and armature approximately into their proper relation by bringing the holes therein into registration, positioning the holes in each of the motor parts in concentric relation by stringing the same on a positioning pin or the like, securing the reed loosely on the frame in such position so as to maintain the parts approximately in such position while permitting a limited amount of relative movement therebetween, spacing the adjacent portions of the pole piece and armature a precise longitudinal distance apart, moving the reed and frame laterally with respect to each other until the lateral edges of the reed are spaced equidistantly from the adjacent side edges of the aperture in the frame, and inserting a securing member into the alined holes to hold the parts fixedly in position with the edges of the larger hole in spaced relation to the securing member.

11. The method of making a vibratory motor which comprises fashioning the following sub-

assemblies (*a*) a frame having an energizable pole piece thereon provided with an active face located at an accurately dimensioned distance from an oppositely facing bearing surface on the frame, (*b*) a flat sheet metal resilient reed having an armature secured to the outer end thereof and an electrical contact secured to the intermediate portion thereof at an accurately dimensioned distance from the outer face of said armature, (*c*) a sheet metal contact support with an electrical contact secured thereto adjacent its outer end at an accurately dimensioned distance from a bearing surface thereon; and assembling said sub-assemblies by positioning the bearing surface on the frame against a fixed abutment, securing the reed loosely to the frame with the armature disposed approximately in position adjacent the active face of the pole piece, inserting a gauge between the adjacent portions of the pole piece and armature, moving the armature toward the pole piece thus bringing the armature and pole piece into contact with the opposite faces of the gauge to space the same accurately, positioning the bearing surface on the contact support against a second fixed abutment located at a predetermined distance from the first-named abutment and in opposed relation thereto thereby bringing the contact on the contact support into alinement with the contact on the reed, and securing portions of the reed and the contact support rigidly to the frame in such positions.

12. A fixture for use in assembling a laminated structure such as a vibratory motor comprising, in combination, a base, means on said base for maintaining the superposed laminations of the structure approximately in their proper relative positions, a thin flexible gauge insertable between opposed edge portions of a plurality of the laminations in abutting relation thereto, and means for detachably securing said gauge to said base whereby the gauge may be removed from the base with the assembled laminated structure and subsequently disengaged therefrom without danger of distorting the abutting laminations.

13. A fixture for use in assembling a laminated structure such as a vibratory motor comprising, in combination, a base, a positioning pin carried by said base and adapted to have apertured laminations strung thereon in superposed relation, means for guiding the laminations strung on said pin into predetermined relative positions, a gauge carried by said base and insertable between opposed portions of a plurality of said laminations, and means for moving the opposed portions of such laminations into contact with the opposite sides of the gauge to accurately space the same.

14. A fixture for use in assembling a laminated structure such as a vibratory motor comprising, in combination, a base, a positioning pin carried by said base and adapted to have apertured laminations strung thereon in superposed relation, means including a plurality of fixed abutments on said base for guiding all of the laminations into their approximate final positions and for guiding a portion of said laminations into their exact final positions, and means including a gauge carried by said base and insertable between opposed edges of a second portion of the laminations for accurately positioning the same in their final positions.

15. A fixture adapted for use in assembling a vibratory motor including a frame having an energizable pole piece rigid therewith and an armature carried by the free end of an apertured resilient reed and adapted to swing past the pole piece in close proximity thereto in the operation of the device; comprising in combination, a base, means including a longitudinally movable pin extending outwardly from said base and adapted to be inserted into registering holes in the motor parts for positioning them in superposed relation with the armature disposed approximately in position adjacent the end of the pole piece, a thin metal gauge mounted on said base and disposed between the adjacent portions of the armature and pole piece, means for exerting a wedging pressure on a wall of the aperture in the reed to move the armature into contact with said gauge, and means including a fixed abutment on said base for resisting endwise movement of the frame when said gauge is pressed between the adjacent faces of the pole piece and armature.

16. The method of making a frame sub-assembly for a vibratory motor, which comprises, punching from a sheet of metal a substantially flat rectangular portion of sheet metal having a central opening therein with an integral pole piece extending into the opening, said punching operation including a simultaneous shearing of the end of the pole piece and the adjacent outer edge of the frame in order to space such edge and such end a predetermined fixed distance.

17. The method of assembling a laminated structure such as a vibratory motor, including laminations having apertures in corresponding portions thereof, which comprises, stringing the laminations in superposed relation and predetermined order on an assembly pin inserted through the apertures therein, positioning a gauging member in frictional engagement with opposed portions of a plurality of the laminations which are spaced apart in the general plane thereof not only to position the laminations accurately with respect to each other but also to hold the same frictionally in such position, then removing the assembly pin and inserting a securing member in the apertures previously occupied by the pin.

18. The method of assembling a laminated structure such as a vibratory motor, including a plurality of laminations, which comprises, arranging the laminations in superposed relation and predetermined order in approximately the desired relative positions thereof, moving the opposed portions of a plurality of the laminations spaced apart in the general plane thereof into abutment and frictional engagement with the opposite sides of a thin metal gauge inserted therebetween, and securing the laminations fixedly together while disposed in frictional engagement with the gauge.

19. A fixture for use in assembling a laminated structure such as a vibratory motor comprising, in combination, a base, means on said base for maintaining the superposed laminations of the structure approximately in their proper relative positions, and a gauge insertable between opposed edge portions of a plurality of the laminations in abutting relation thereto and loosely disposed on said base whereby the gauge may be lifted from the base with the assembled laminated structure and subsequently disengaged therefrom without danger of distorting the abutting laminations.

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