United States Patent

[11] 3,579,771

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[45] Patented **May 25, 1971**
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[54] **MACHINE FOR AUTOMATICALLY ASSEMBLING ARMATURE CORES AND COMMUTATORS THEREFOR**
13 Claims, 32 Drawing Figs.

[52] **U.S. Cl.** **29/33,**
29/205, 29/597
[51] **Int. Cl.** **H02k 15/02**
[50] **Field of Search** ..... 29/205, 205 (CC), 33.9, 33.91, 597, 33

[56] **References Cited**
UNITED STATES PATENTS

2,270,472	/1942	Poole et al.	29/205X

Primary Examiner—Andrew R. Juhasz
Assistant Examiner—James F. Coan
Attorney—Ira Milton Jones

ABSTRACT: Feeding mechanism successively brings armature cores and commutators therefor to an assembly station where they are held in coaxial endwise spaced relationship and where rotation imparting mechanism brings each armature core and commutator pair into correct angular relationship. A ram then pushes the commutator axially towards the armature core with the terminal tangs on the commutator facing the core, and presses it onto the shaft thereof, moving the commutator through a die which straightens tangs that may be askew. The tank straightening die has a round hole that slideably accepts the commutator, and longitudinally extending circumferentially spaced parallel grooves that slideably accommodate the tangs. When the commutator reaches proper position on the armature shaft, and while still in the die, a tang-shaping member having circumferentially spaced parallel fingers, one for each tang, telescopes over the commutator, each finger moving along one of the grooves to engage under the tang therein and lift it into contact with the bottom of the groove.

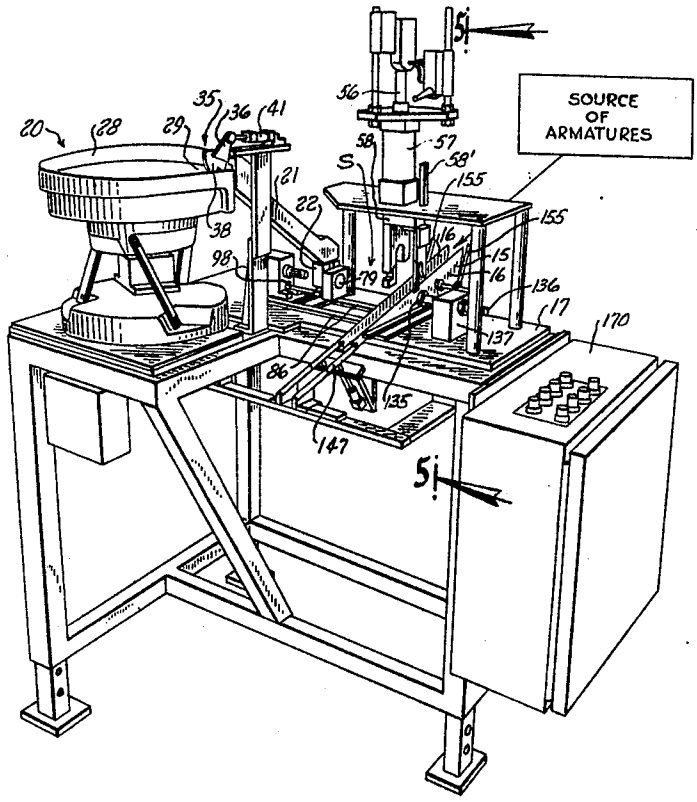


Fig. 1.

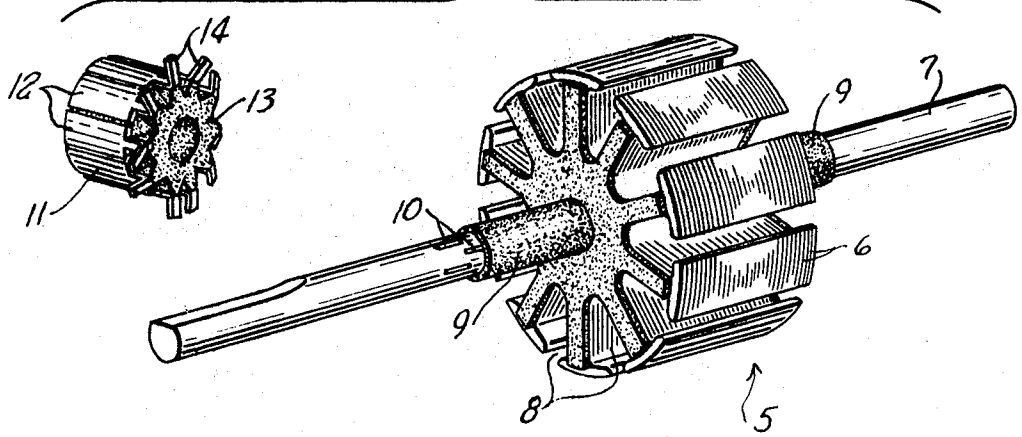
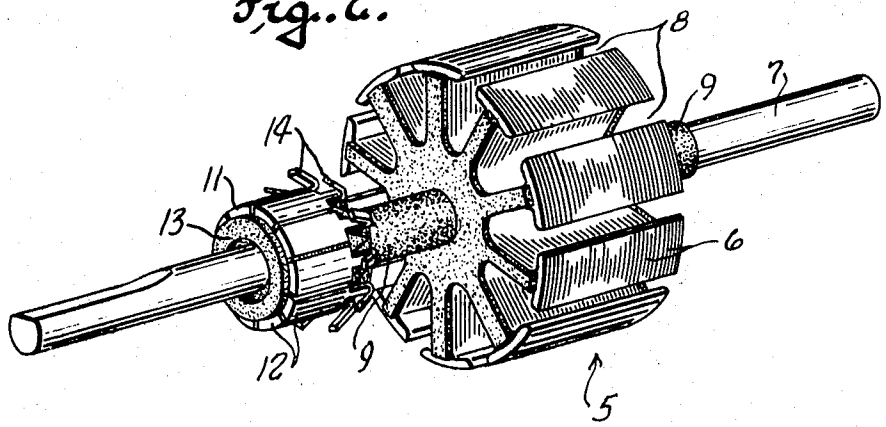
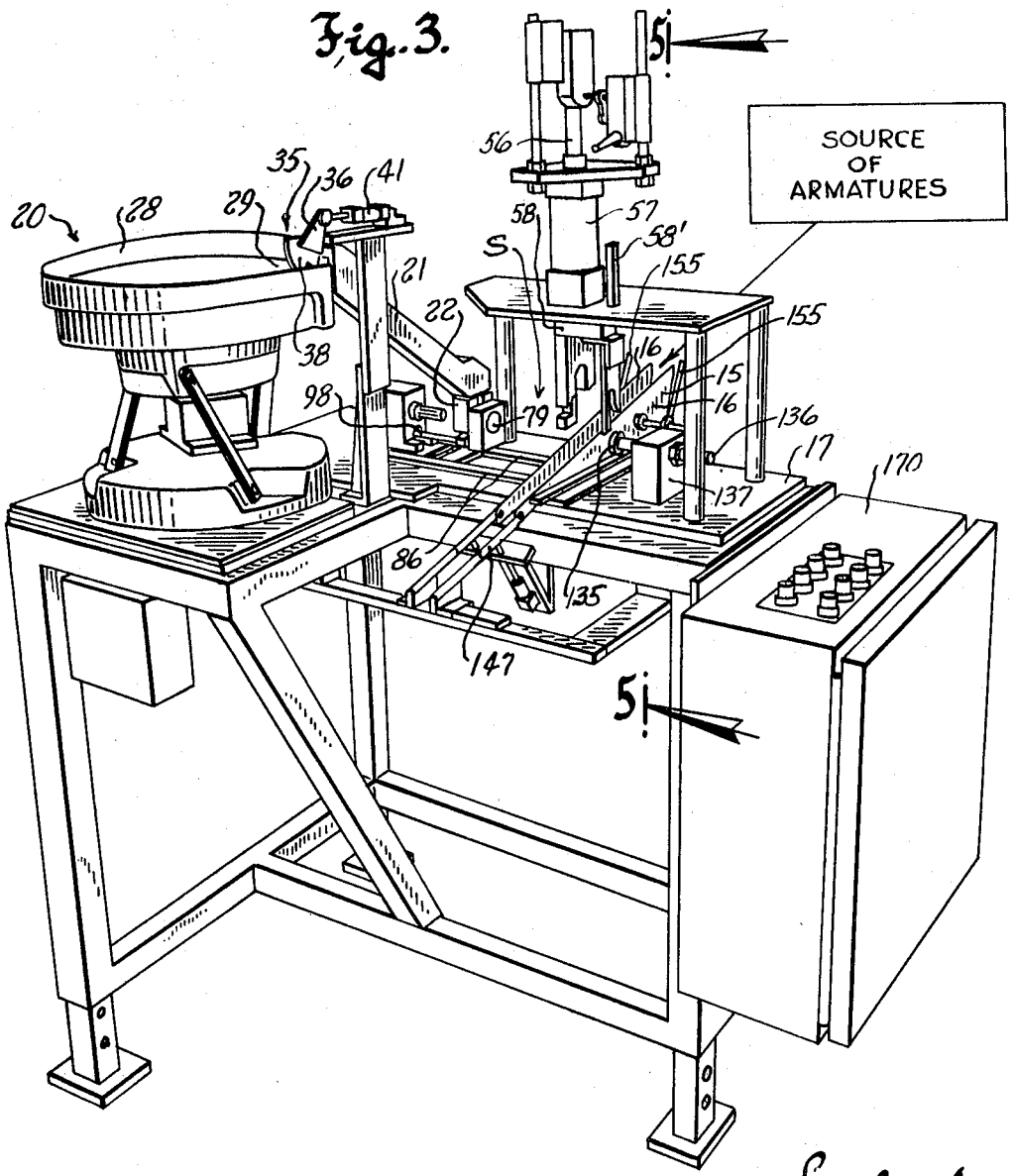


Fig. 2.



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Fig. 3.



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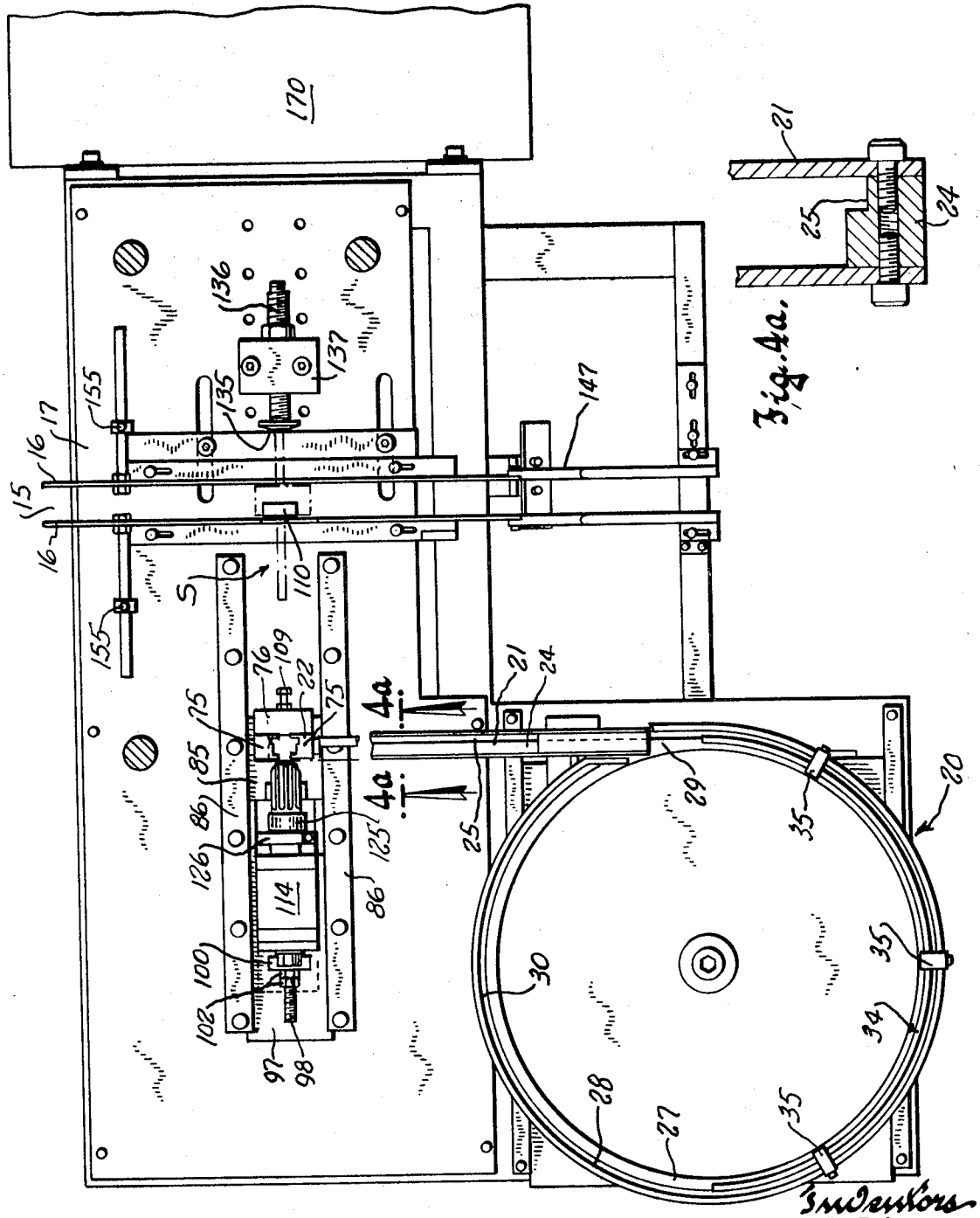


Fig. 4.

Fig. 4a.

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Fig. 5.

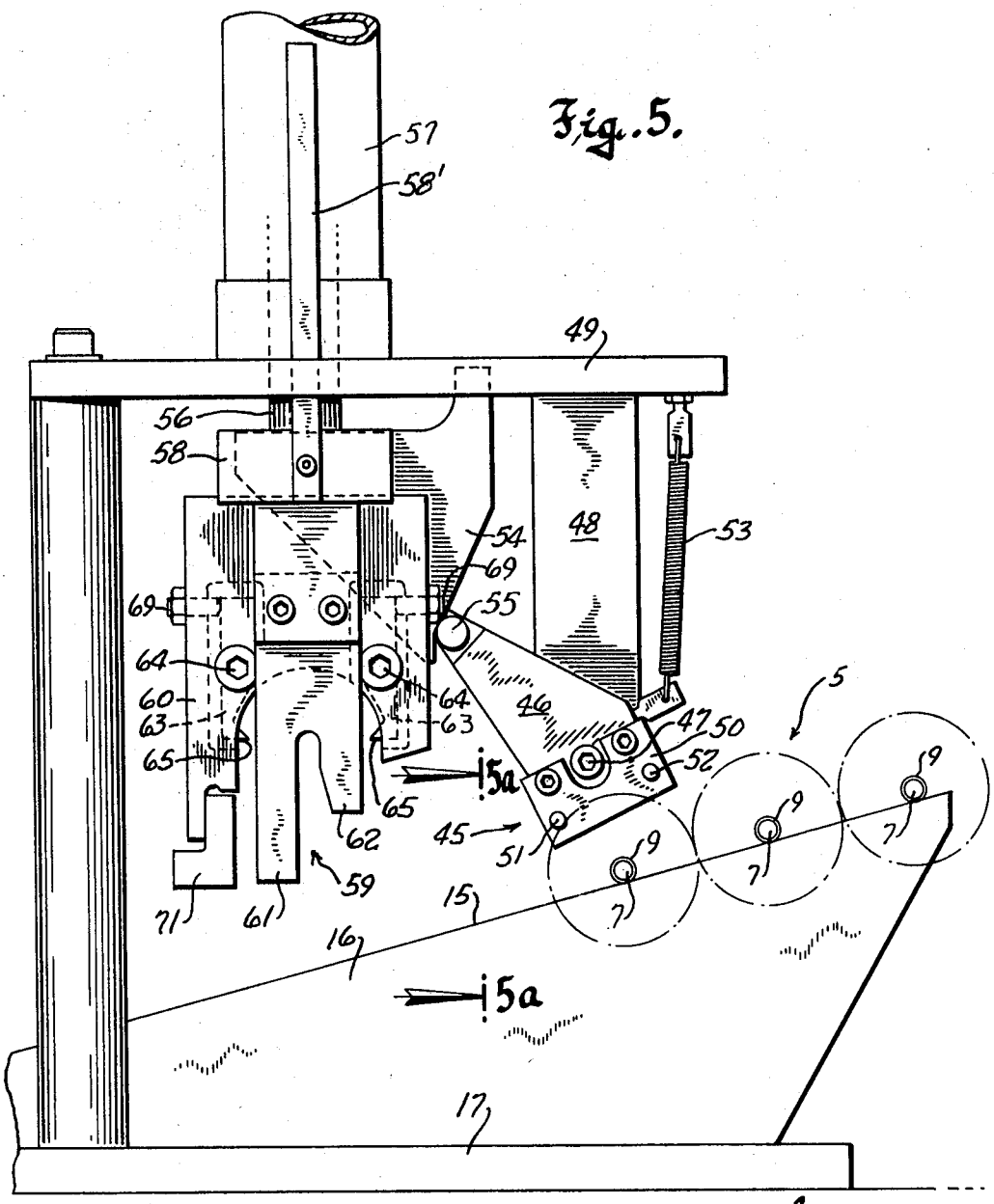
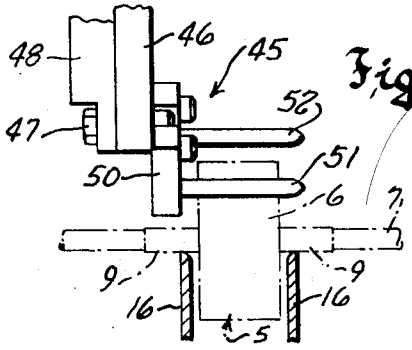
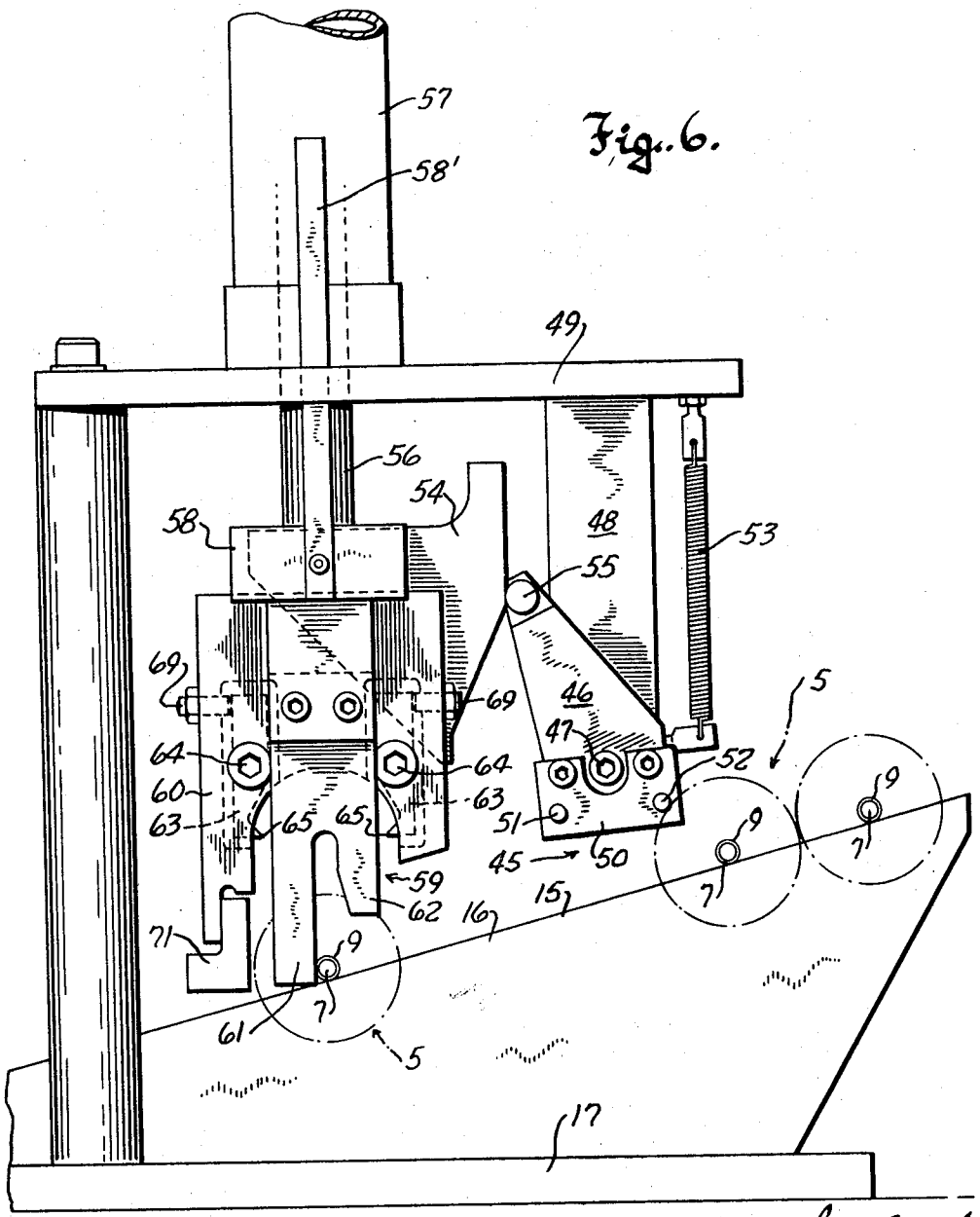


Fig. 5a.



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Fig. 6.



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Fig. 7.

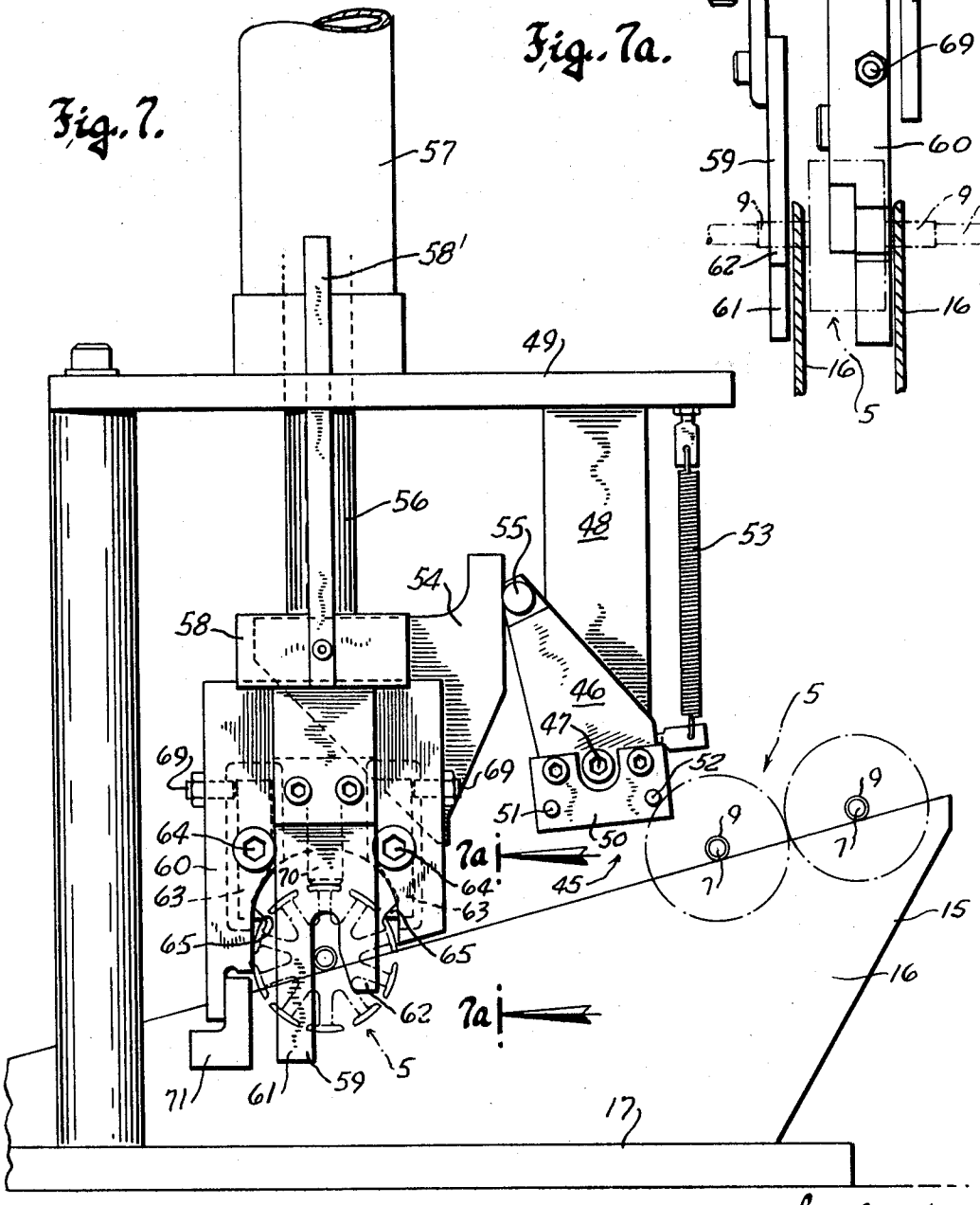


Fig. 7a.

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Fig. 8.

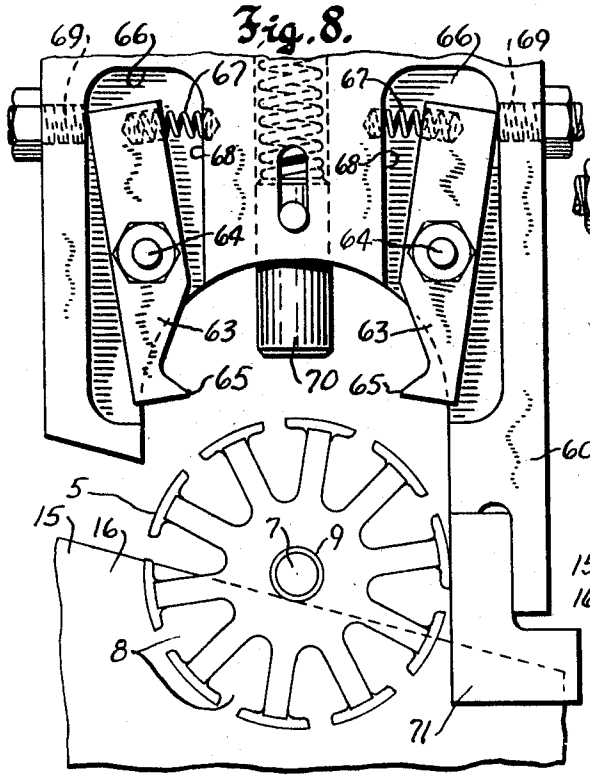


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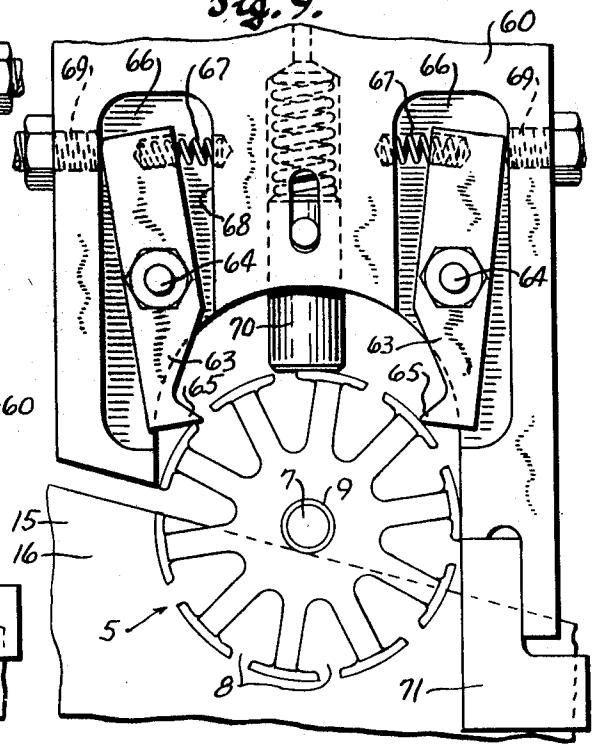
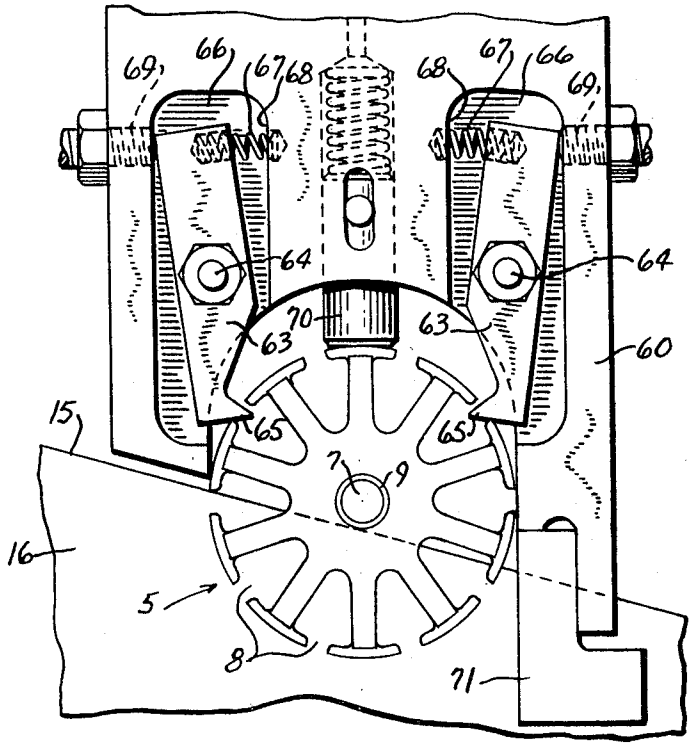


Fig. 10.



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Fig. 11.

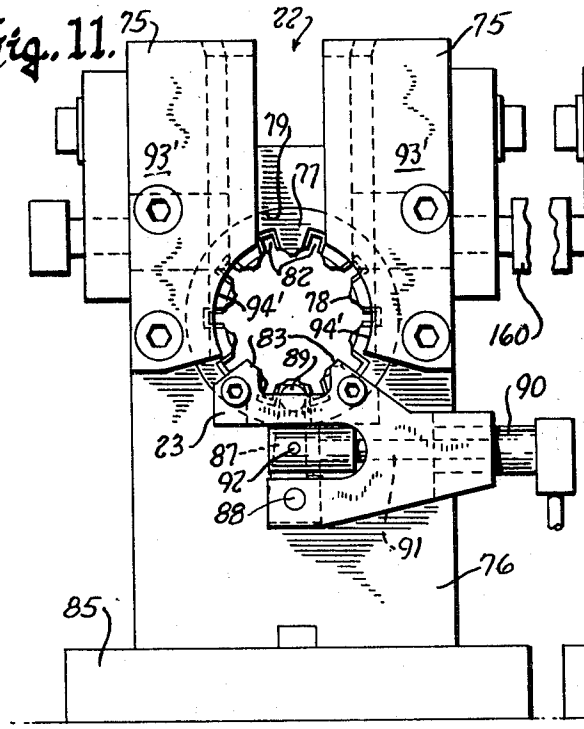


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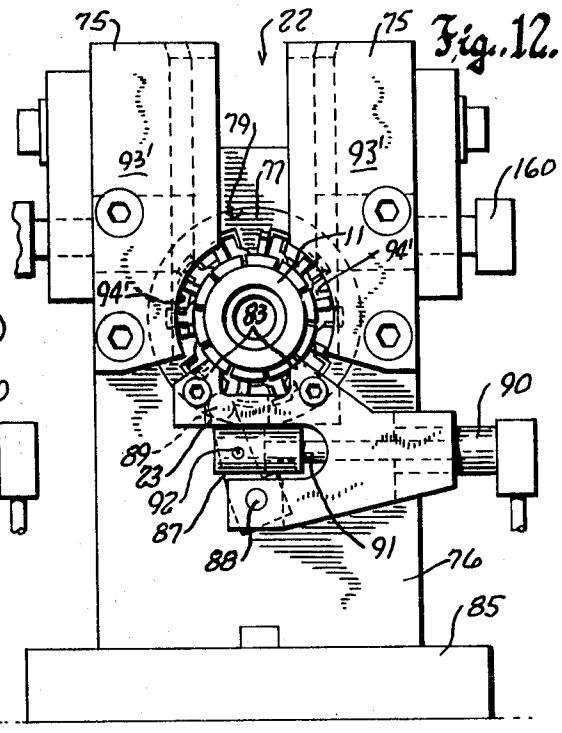
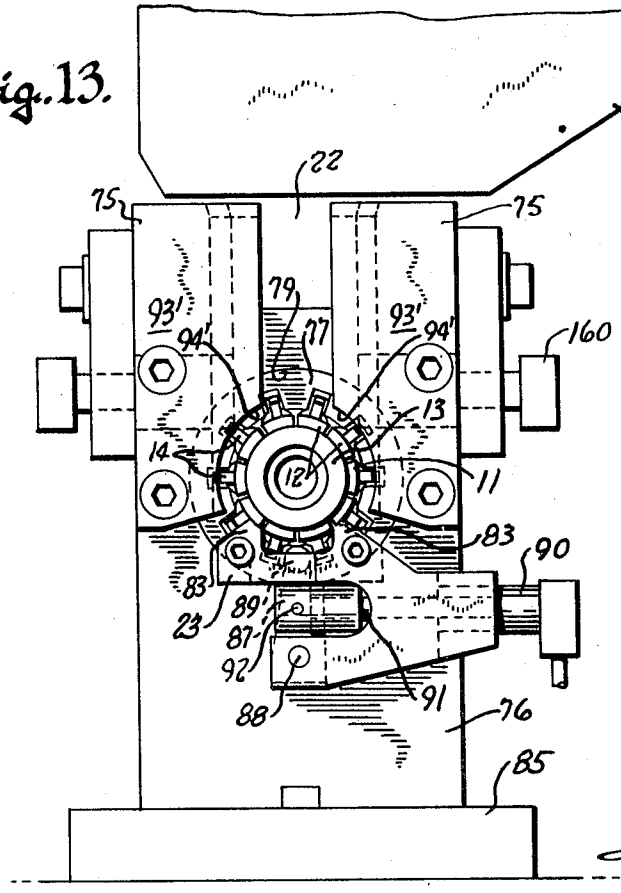
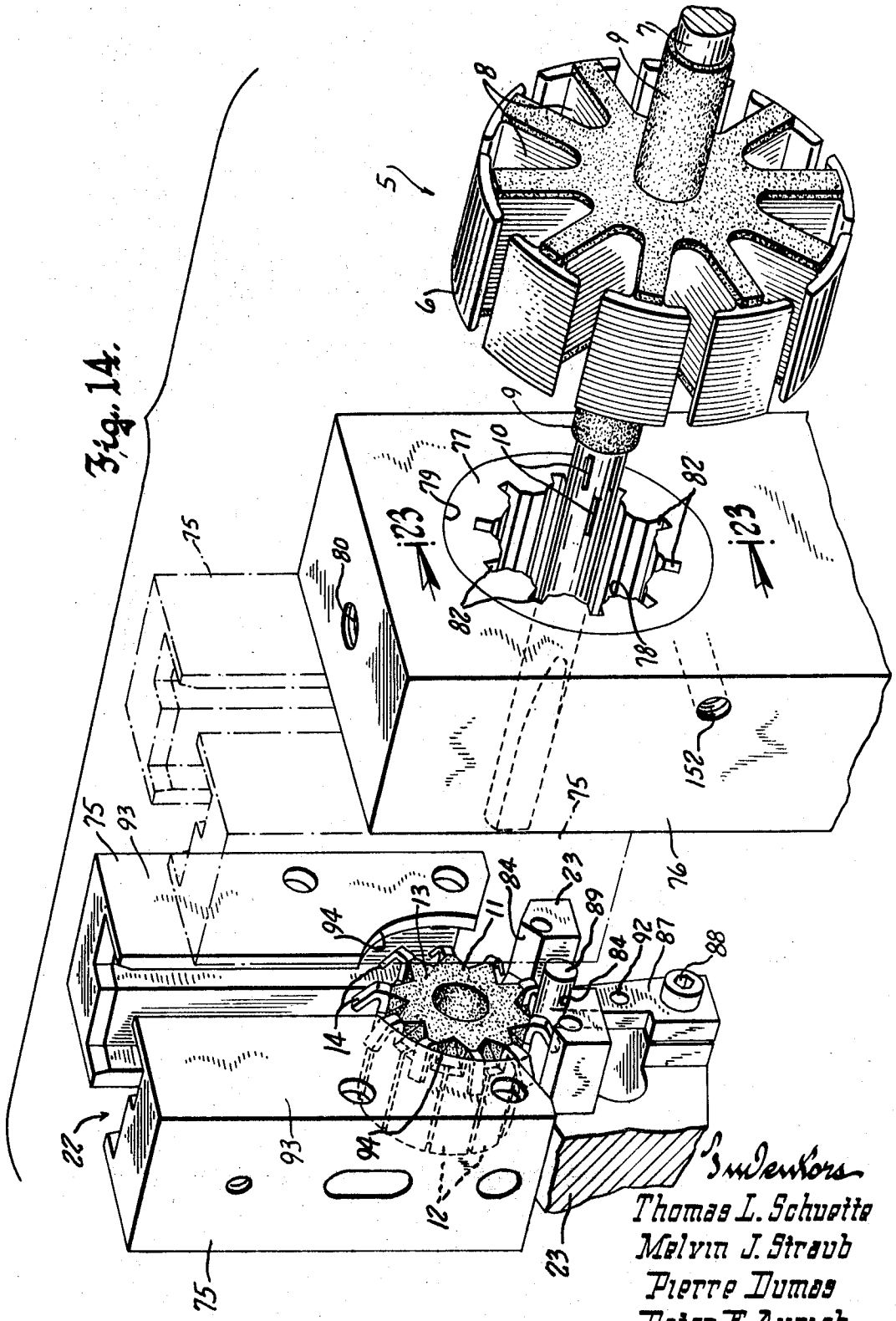


Fig. 13.



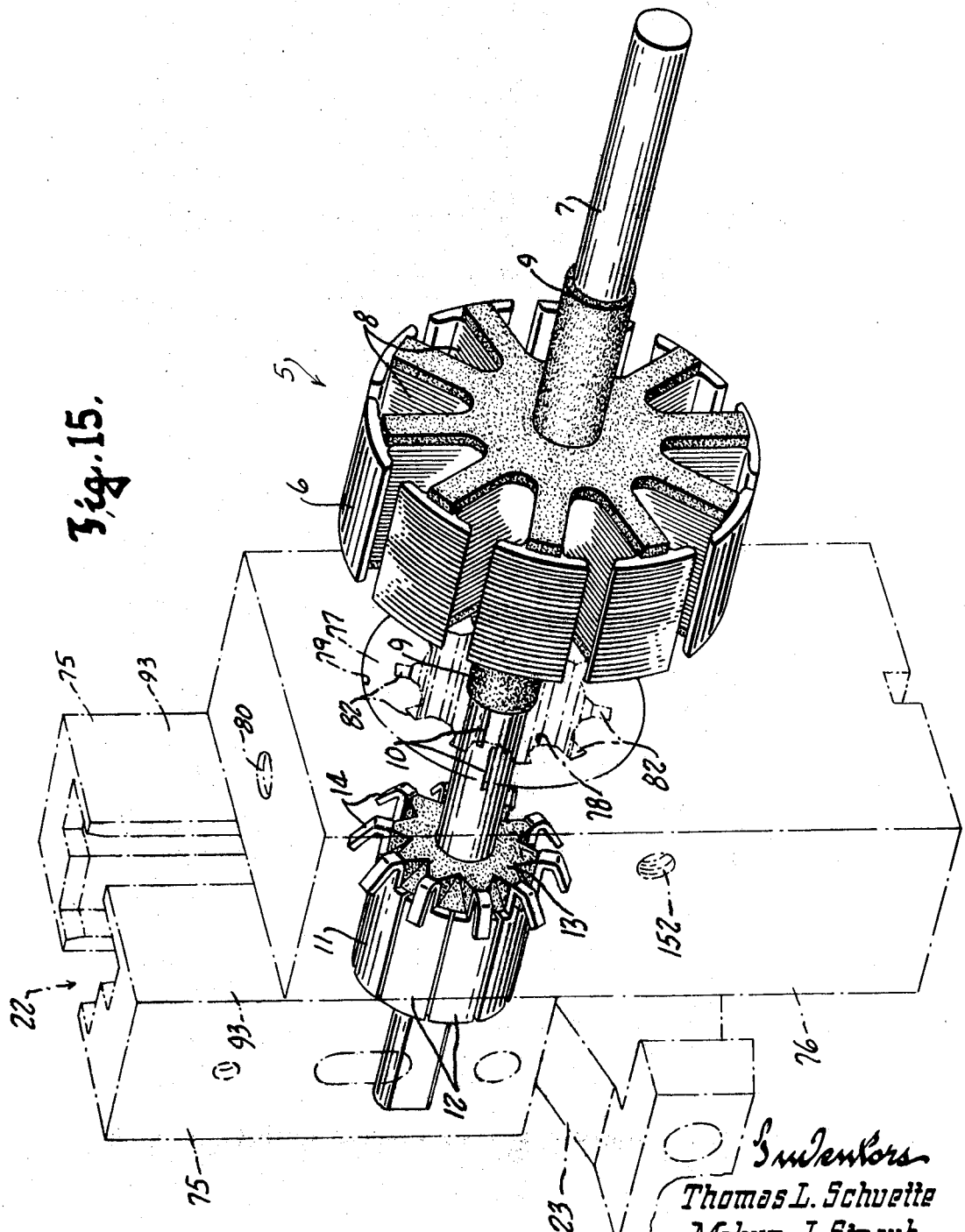
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Fig. 14.



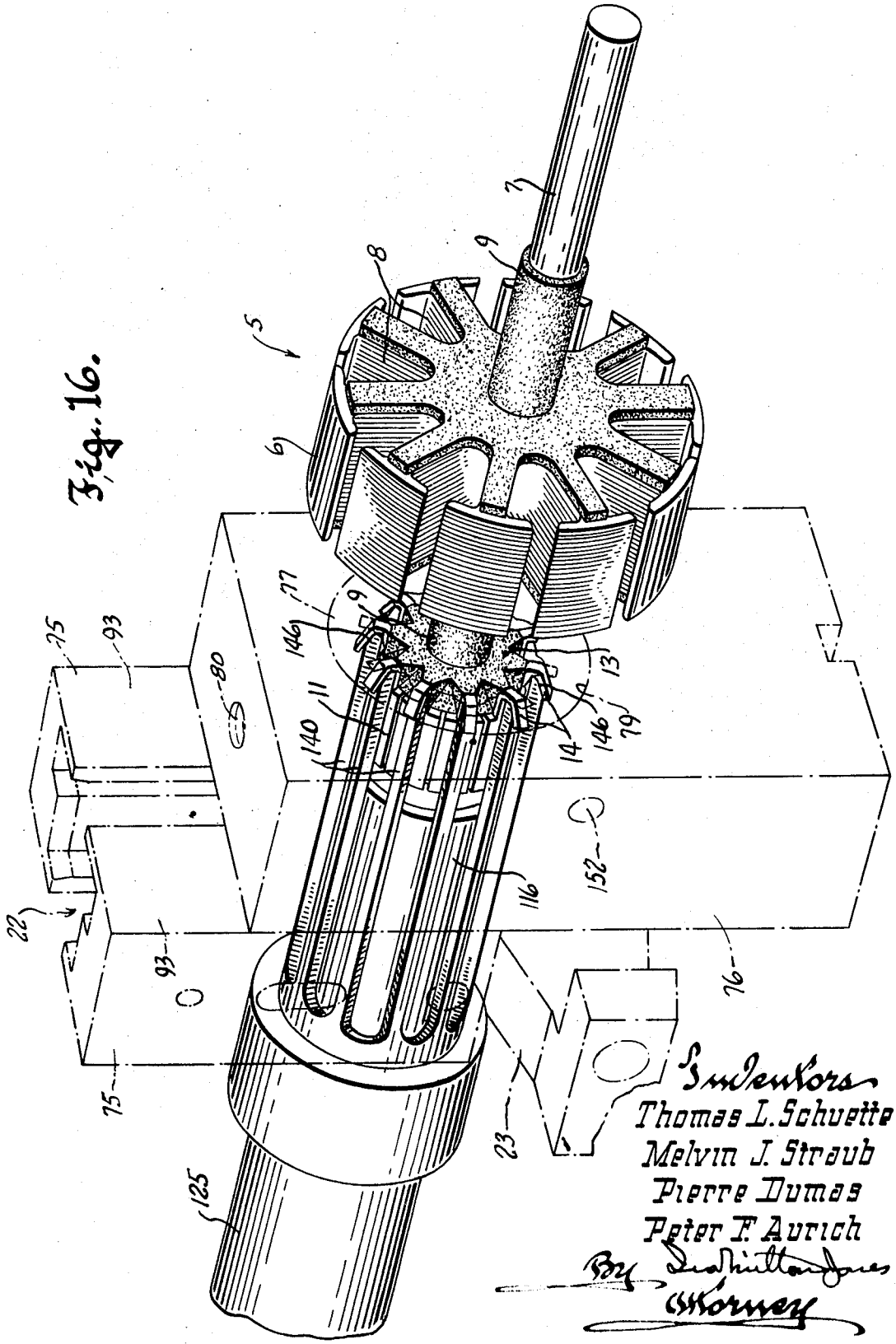
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Fig. 15.



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Fig. 16.



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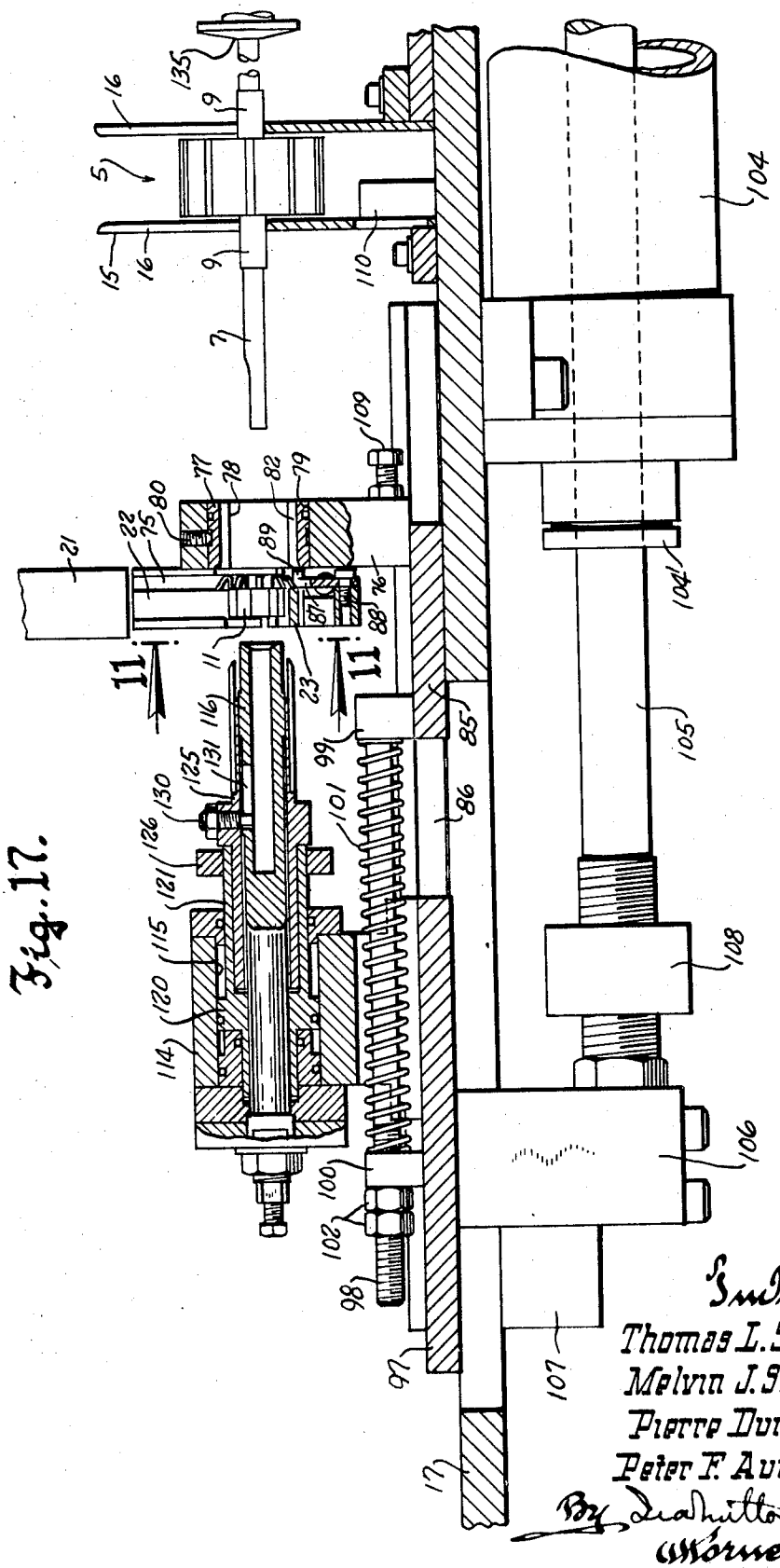


Fig. 17.

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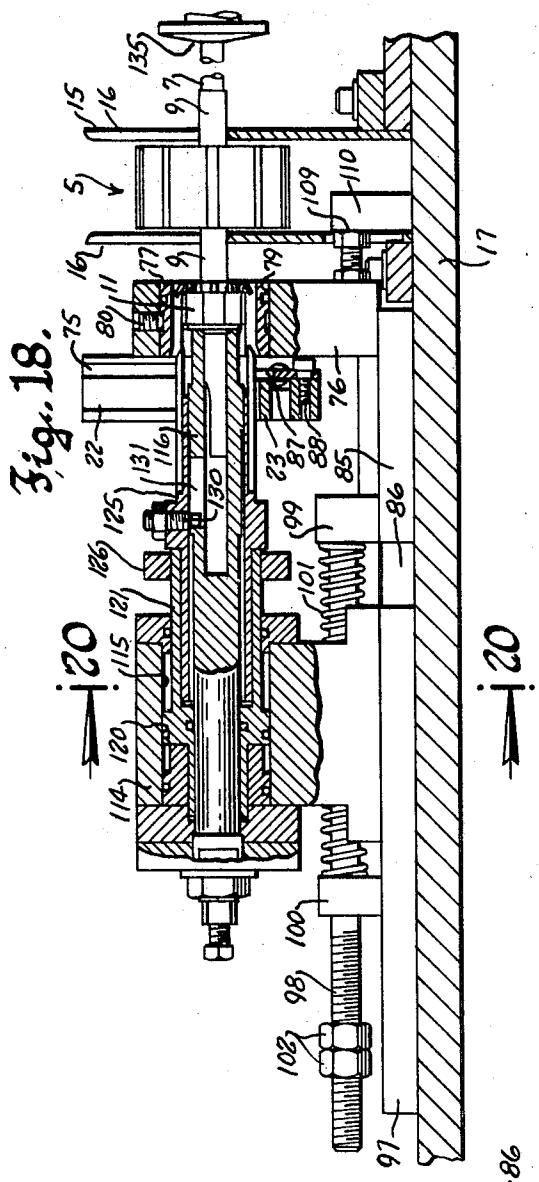


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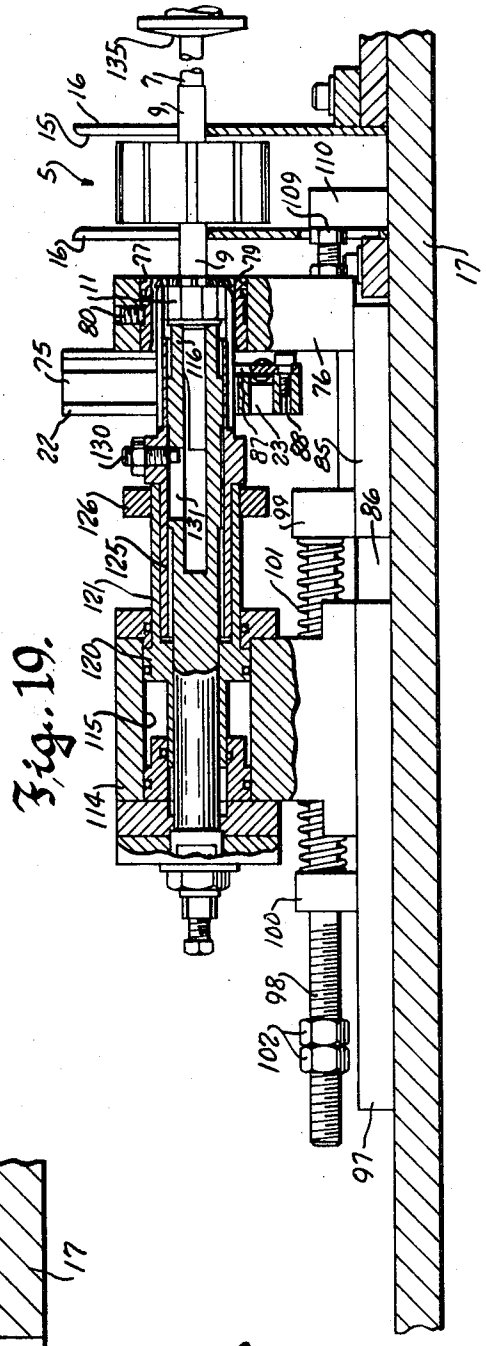


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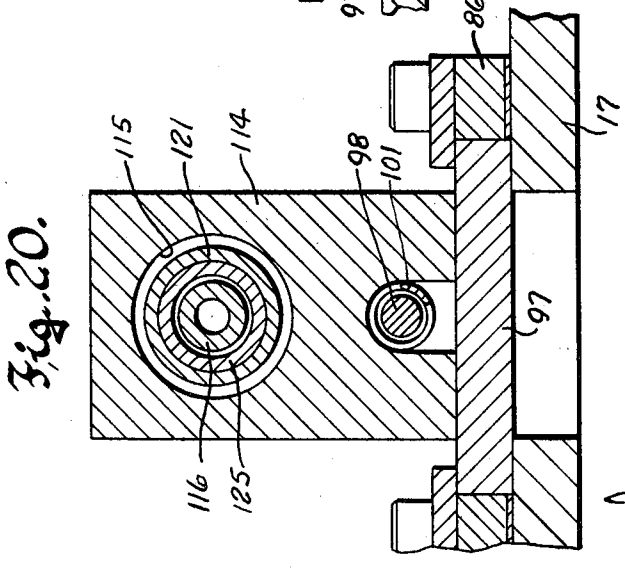
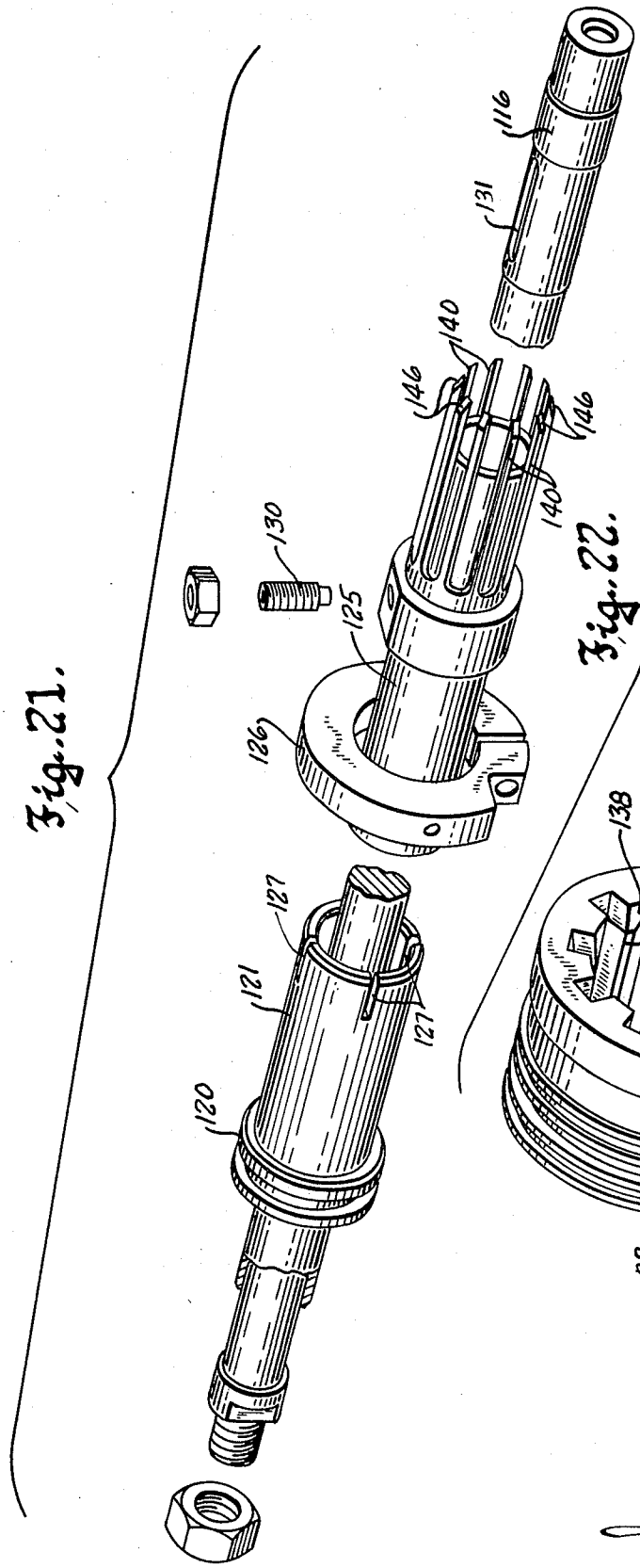
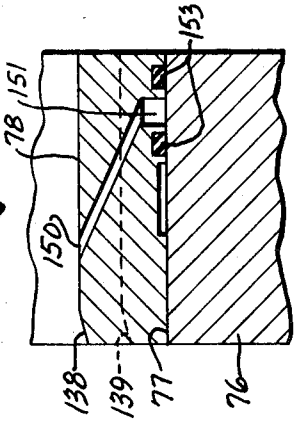
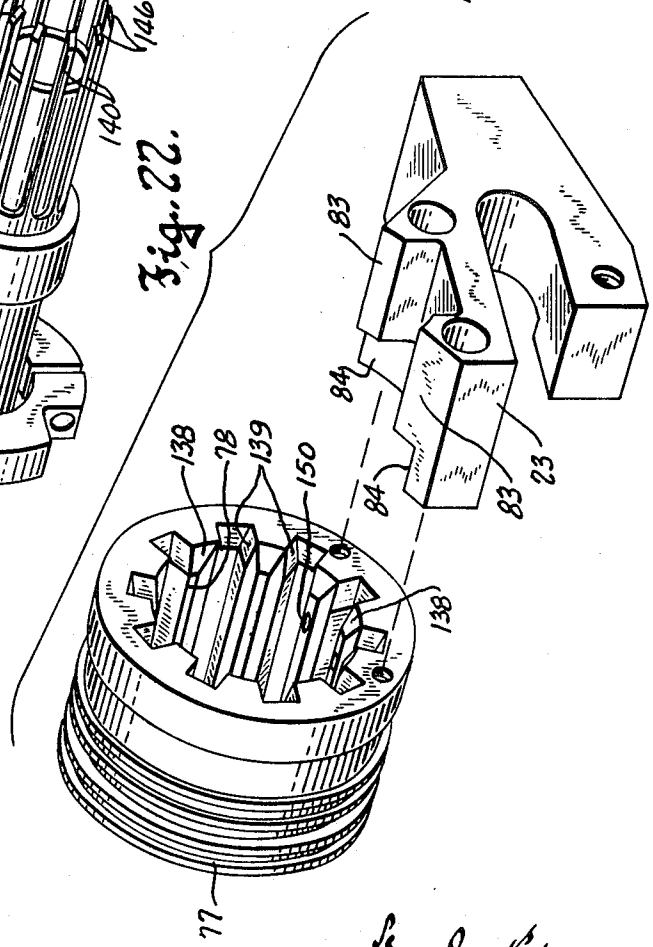


Fig. 20.

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Fig. 25.

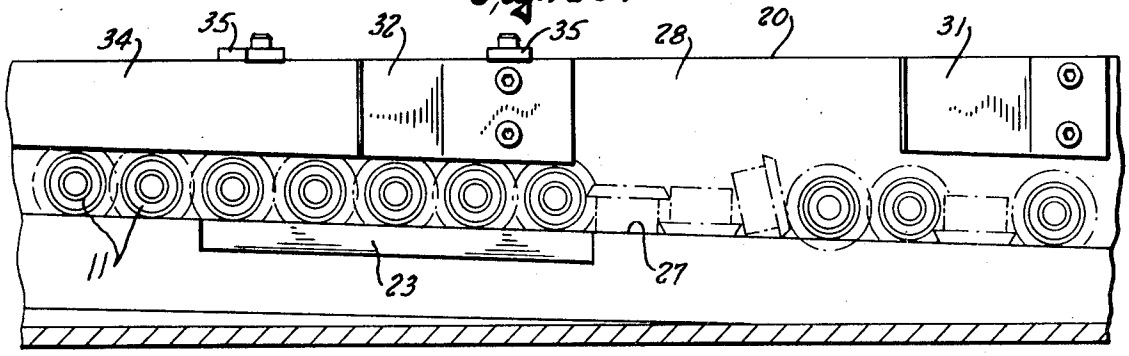
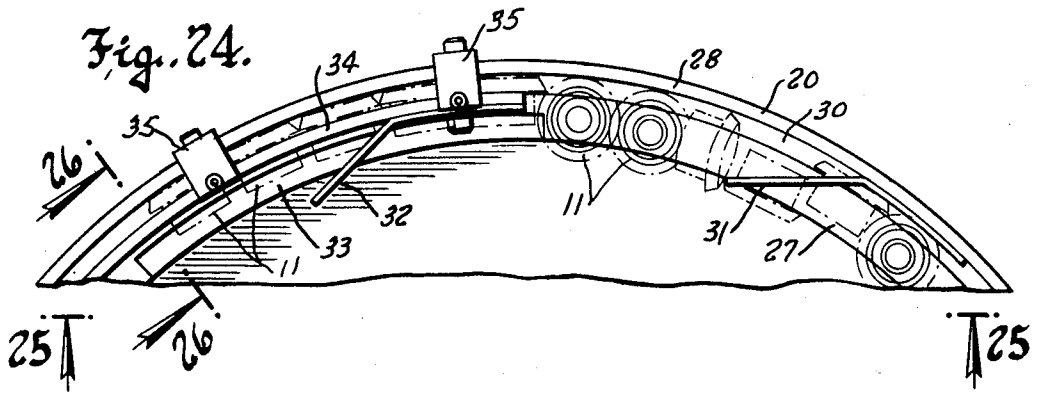


Fig. 24.



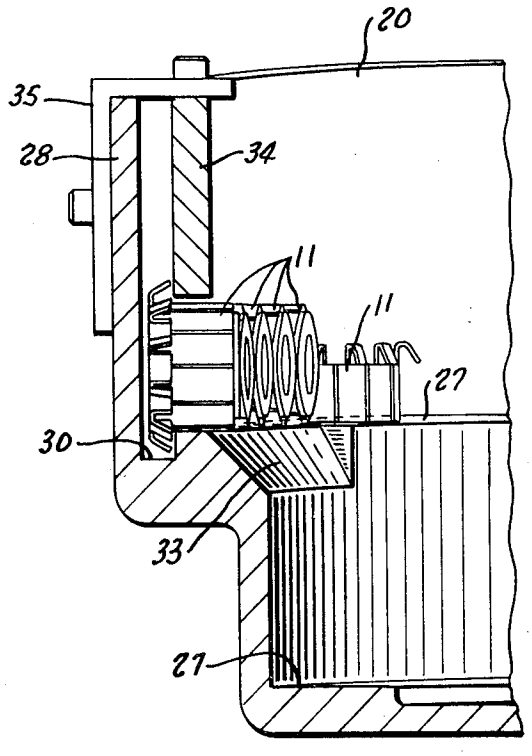


Fig. 26.

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Fig. 27.

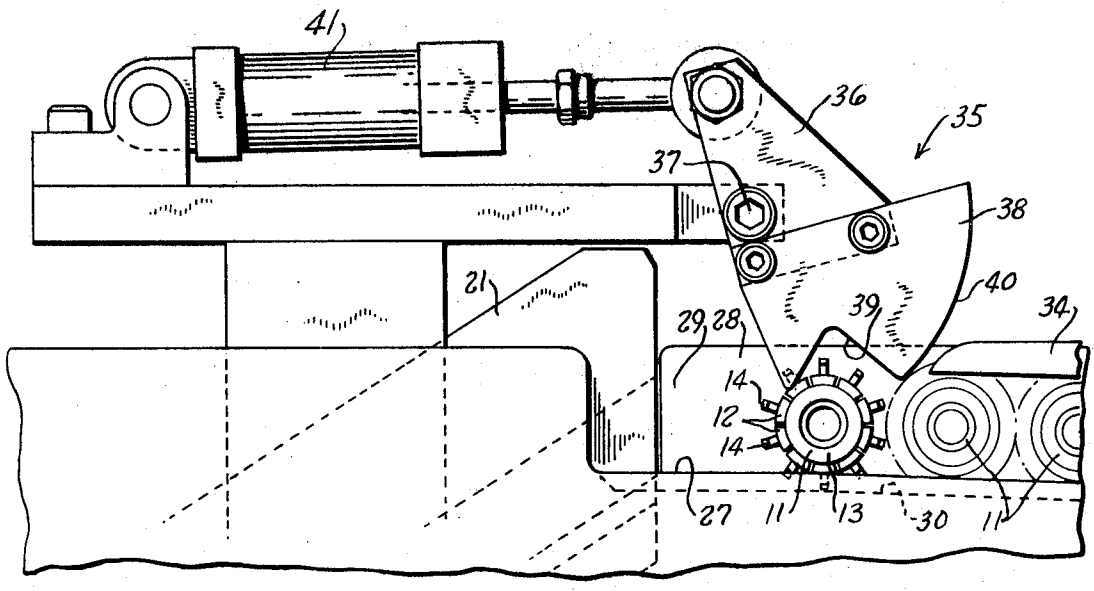
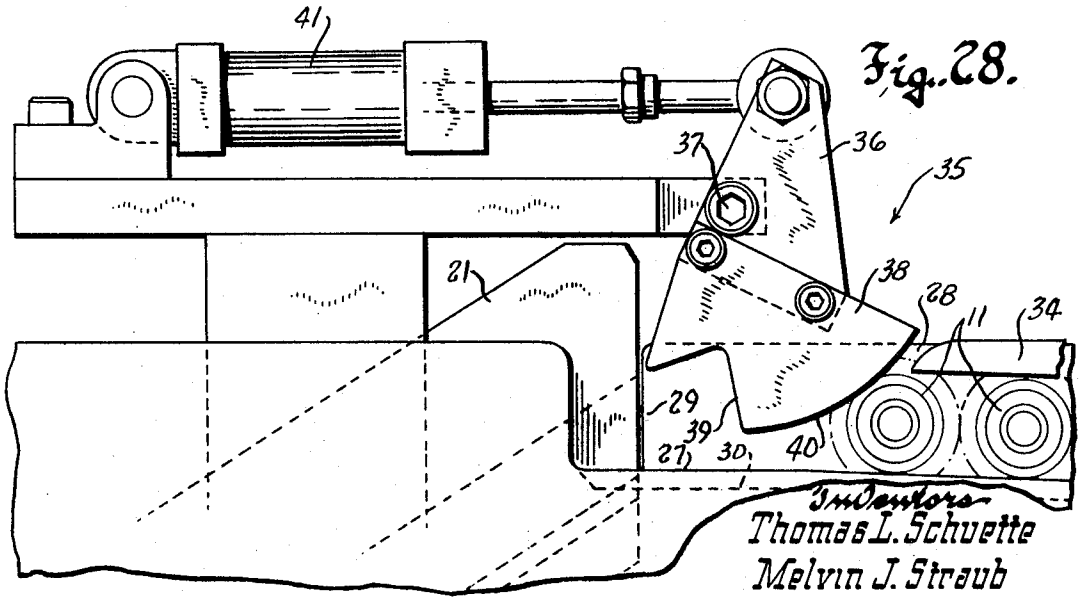


Fig. 28.



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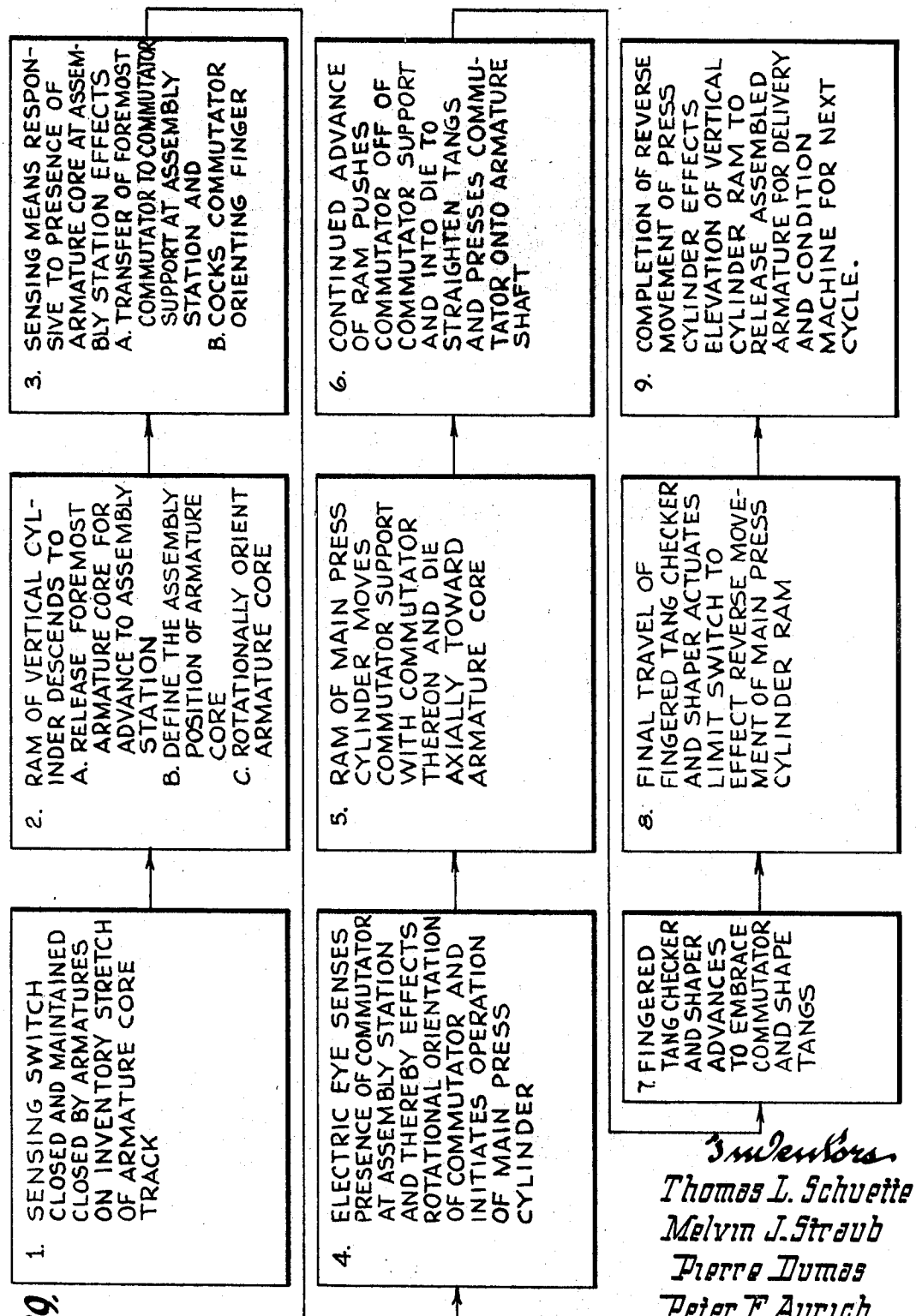


Fig. 29.

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MACHINE FOR AUTOMATICALLY ASSEMBLING ARMATURE CORES AND COMMUTATORS THEREFOR

This invention relates broadly to machines for assembling parts of electric motors, and refers more particularly to a machine for assembling commutators which have circumferentially spaced terminal tangs at one end thereof, onto armature cores of the type comprising a stack of laminations with circumferentially spaced winding receiving slots, solidly mounted upon a shaft. When properly assembled, the commutator and armature core are so oriented that the terminal tangs of the commutator are in predetermined relationship with respect to the winding slots of the armature core, both angularly and axially. This relationship may be such that for each winding slot there is a single terminal tang in line therewith, as in the assembly specifically illustrated herein; or there may be two or even more terminal tangs for each slot, depending upon the nature of the windings to be applied to the core. Also, the tangs are not necessarily in line with the winding slots, even where there is only one tang per slot.

The purpose and object of this invention is to provide a machine for automatically assembling commutators and armature core more efficiently, more reliably, and faster than heretofore possible, regardless of the numerical relationship between the winding slots of the armature core and the terminal tangs on the commutator.

It has been customary to press-fit the commutators onto the shaft of the armature. In the past (as shown for instance by U.S. Pat. No. 1,690,322) this was done manually by placing each armature core and its commutator in an arbor press, in the correct angular orientation to one another, and then, by actuation of the arbor press, forcing the commutator onto the shaft of the armature. Needless to say, production rates by this method were quite limited.

Although there have been efforts prior to this invention to automate the assembly of armature cores and their commutators, all known earlier machines for this purpose left much to be desired. One of the principal objections to the known prior machines was their inability to satisfactorily cope with commutators on which the terminal tangs are bent askew or otherwise improperly disposed. As a result, many of the assembled units were defective and had to be rejected. By contrast, the machine of this invention has reduced the rate of rejects by 90 percent and has done so despite its unprecedented production rates of 600 to 700 assemblies per hour. To illustrate, in the past it was not unusual that as many as 50 out of 1000 armatures would have to be rejected because of defective terminal tangs. This constituted a 5 percent reject rate. The 90 percent reject rate reduction brought about by the machine of this invention, has reduced rejects to no more than 5 per 1000 armatures.

To a large degree, the very high production rates made possible by the machine of this invention result from the fact that the straightening and shaping of the terminal tangs of the commutator takes place while the commutator and armature core are being assembled—in other words, all operations upon both the commutator and the armature core are performed at one station in the machine.

To accomplish this objective, the machine of this invention has means for continuously and successively transferring armature cores and commutators from sources thereof to an assembly station in the machine where the commutators and armature cores are paired and, when thus paired, are rotated relative to one another to bring them into proper angular orientation with the terminal tangs of the commutator aligned with or otherwise properly disposed with respect to the winding slots of the armature core. This takes but a fraction of a second. The commutator core is then moved axially toward the armature core and pressed onto its shaft, and during this assembling operation the terminal tangs of the commutator are straightened and formed into hooks of uniform shape.

In the event one or more of the terminal tangs of the commutator have been deformed to the extent that they cannot be straightened and properly shaped, sensing mechanism which

utilizes the tang-shaping means, initiates the functioning of a reject mechanism so that when the assembled armature core and commutator with the defective terminal tang or tangs leave the assembling station of the machine, it is shunted into a reject path, as distinguished from the path traveled by assemblies that are proper in all respects, and which may lead to other machines where additional operations are performed.

With these observations and objects in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings. This disclosure is intended merely to exemplify the invention. The invention is not limited to the particular structure disclosed, and changes can be made therein which lie within the scope of the appended claims without departing from the invention.

The drawings illustrate one complete example of the physical embodiment of the invention constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

FIG. **1** is a perspective view of an armature core and commutator of the type the machine of this invention is designed to assemble into the rotor unit shown in FIG. **2**;

FIG. **3** is an overall perspective view of the machine;

FIG. **4** is essentially a top plan view of the entire machine, some of its upper structure having been omitted for sake of clarity;

FIG. **4***a* is a detail sectional view through FIG. **4** on the plane of the line **4***a*–**4***a*.

FIGS. **5**, **6** and **7** are elevational views generally taken on the plane of the line **5**–**5** in FIG. **3**, illustrating the mechanism by which the armature cores are successively and individually presented to the assembly station of the machine, the mechanism being shown in different positions in the succeeding views;

FIG. **5***a* is a detail sectional view through FIG. **5** on the plane of the line **5***a*–**5***a*;

FIG. **7***a* is a detail sectional view through FIG. **7** on the plane of the line **7***a*–**7***a*;

FIGS. **8**, **9** and **10** are detail views illustrating that part of the mechanism shown in FIGS. **5**, **6** an **7**, by which an armature core at the assembly station is rotated to a position in which its winding slots are in a predetermined orientation with respect to a fixed vertical plane passing through the axis of the core;

FIGS. **11**, **12** and **13** are vertical elevational views generally taken on the plane of the line **11**–**11** in FIG. **17**, illustrating the mechanism by which a commutator is held at the assembly station in coaxial alignment with an armature core thereat, and by which the commutator is positively rotated into correct angular orientation with respect to the armature core, preparatory to being assembled therewith, said views illustrating the commutator rotating mechanism in different positions;

FIG. **14** is a perspective view of the commutator holding and rotating mechanism shown in FIGS. **11**—**13**, inclusive, and the die by which the tangs on the commutator are straightened as the commutator is press-fitted onto the shaft of the armature core, the die being shown displaced from its correct position for sake of clarity, and an armature core being illustrated in position to receive a commutator;

FIG. **15** is a perspective view of an armature core and commutator in the act of being assembled, and in broken lines illustrating the commutator holding structure and the tang-straightening die;

FIG. **16** is a perspective view of the assembled armature core and commutator and illustrating the mechanism by which the tangs are shaped;

FIG. **17** is a sectional detail view through the mechanism at the assembly station of the machine, said view illustrating an armature core and its commutator in coaxial, axially spaced relation preparatory to being assembled;

FIG. **18** is a view similar to FIG. **17**, illustrating most of the structure shown therein, but with the parts thereof in the positions they occupy directly after the commutator has been pressed onto the shaft of the armature core and before the tang-shaping mechanism has functioned;

FIG. 19 is a view similar to FIG. 18, but showing the parts in the positions they occupy when the tang-shaping mechanism has functioned;

FIG. 20 is a detail cross-sectional view through FIG. 18 on the plane of the line 20–20;

FIG. 21 is an exploded perspective view of part of the mechanism by which the commutator is pushed onto the shaft of the armature core, and part of the mechanism by which the tangs of the commutator are shaped;

FIG. 22 is a perspective view of the tang-straightening die and the basketlike support or holder in which the commutator sets while it is rotationally adjusted in preparation to being pushed onto the shaft of the armature core, attention being directed to the fact that in this FIG. 22 the parts illustrated are viewed from the direction opposite that of FIGS. 14, 15 and 16;

FIG. 23 is a fragmentary detail sectional view through FIG. 14 on the plane of the line 23–23;

FIG. 24 is a top plan view of a portion of the hopper or bowl in which a supply of the commutators is maintained for transfer to the assembly station of the machine;

FIG. 25 is a vertical sectional view through the commutator supply hopper, taken generally on the plane of the line 25–25 in FIG. 24;

FIG. 26 is a cross-sectional view through the sidewall of the commutator supply hopper, taken on the plane of the line 26–26 in FIG. 24;

FIGS. 27 and 28 are elevational views of the gate mechanism which controls transfer of the commutators from the supply hopper to the assembly station of the machine, showing the same in different positions; and

FIG. 29 is a flow sheet depicting the successive operations which the machine performs.

Referring now particularly to the accompanying drawings in which like parts are identified by like reference characters, in FIGS. 1 and 2 the numeral 5 designates generally an armature core of the type with which this invention is concerned, and which comprises a stack of laminations 6 firmly mounted upon a shaft 7. The stack of laminations has equicircumferentially spaced winding receiving slots 8 opening to its peripheral boundary surface, and insulating sleeves 9 embrace the portions of the shaft 7 adjacent to the opposite sides of the stack. Beyond one of these sleeves the shaft has swedged ribs 10 projecting from its surface to bite into the bore of a commutator 11 when the same is press-fitted onto the shaft.

The commutator 11, as is customary, comprises circumferentially spaced segments 12 solidly mounted upon a body of insulation 13 to collectively present a cylindrical surface upon which brushes ride when the armature is assembled in a dynamoelectric machine. Each of the segments 12 has a hooklike terminal tang 14 at the end thereof facing the armature core, there being one segment 12 and one tang for each of the winding slots 8, in the specific armature structure shown. However, as noted hereinbefore, and as is well known to the art, there may be two or even more commutator segments and terminal tangs for each winding slot.

Since the winding of armatures is done on automatic machines, it is important that the terminal tangs be properly shaped and correctly positioned with respect to the winding slots 8 and the cylindrical surface of the commutator. This requirement for proper positioning and shaping of the terminal tangs presents a most difficult problem, and in prior attempts to automate the assembly of commutators and armature cores this problem either proved to be an insurmountable obstacle, or it unduly limited production rates. By contrast, the machine of this invention not only straightens and properly shapes the terminal tangs, but does so in a most reliable and expeditious manner while the commutators are being assembled onto the armature cores, so that the straightening and shaping of the tangs requires practically no additional time. This significant advantage is gained notwithstanding the fact that the commutators are very haphazardly handled, it being understood that the commutators, like the armature cores, are produced on other machines and must be transported to the assembling machine of this invention.

With reference now directed particularly to the general overall machine shown in FIGS. 3 and 4, the assembly station where the actual assembly of the armature core and its commutator takes place is identified by the reference character "S." The armature cores 5 reach this assembly station by rolling down a track 15 formed by two inclined rails 16 mounted upon a base 17 for adjustment toward and from one another to accommodate armature cores of different sizes. The base 17 constitutes part of the general frame structure of the machine.

The commutators 11 are dumped haphazardly into a vibratory bowl 20 from which they pass to a downwardly inclined track or chute 21 which leads to a vertical guideway 22 down which the commutators fall onto a basketlike support 23—FIGS. 11—14. The cross-sectional shape of the inclined track or chute 21 is such that the commutators are free to roll therealong. Accordingly, the bottom 24 of the track or chute has a depression 25 adjacent to one side thereof to accommodate the tangs 14. The receiving and discharge end portions of the inclined track or chute 21 are preferably covered.

The vibratory bowl 20, which is essentially a conventional piece of apparatus, has an upwardly inclined track 27 formed in its sidewall 28 onto and along which the commutators crawl due to the vibratory action of the bowl. As they travel along the track 27, improperly positioned commutators are knocked off the track and only correctly positioned commutators reach the discharge port 29 of the vibratory bowl, through which they pass onto the inclined track or chute 21.

As shown in FIG. 26, the track 27 has a groove 30 adjacent to the sidewall 28, to accommodate the tangs 14 of commutators that are properly positioned on the track, and to assure proper disposition of the commutators on the track 27, deflectors 31 and 32 project into the bowl from its sidewall above the track. The deflector 31 will dislodge commutators that tend to pile one upon the other, and the deflector 32 coacts with a downwardly sloping portion 33 which extends for a distance along the length of the track 27 ahead of the discharge port, to dislodge commutators not properly positioned on the track.

As seen in FIG. 26, properly positioned commutators ride along the track 27 with their tangs in the groove 30 and also between the sidewall of the bowl and a guard rail 34. The rail 34 is removably supported from the sidewall of the bowl by brackets 35; the removability of the guard rail 34 and the manner of its securement enabling the structure to be adjusted to handle commutators of different sizes.

At the discharge port 29, a gate, indicated generally by the numeral 35, functions to successively transfer individual commutators to the feed track or chute 21, and through control of the opening and closing of the gate the advance of the commutators is timed to assure that a commutator will arrive at the assembly station of the machine in time to be paired with an armature core that arrived at the assembly station by rolling down the track 15. The gate 35 consists of a lever 36 mounted to swing about a fixed pivot 37 and having a sector-shaped plate 38 detachably fixed thereto. A notch 39 in the outer arcuate edge 40 of the plate accommodates only a single commutator so that—assuming the presence of a commutator in the notch 39—rocking of the lever in the clockwise direction to its position shown in FIG. 28, results in the foremost of the row of commutators moving along the track 27 being transferred to the track or chute 21, while the next and succeeding commutators are held back by the curved edge 40 of the plate 38.

Rocking of the gate lever 36 in the opposite direction to its position shown in FIG. 27, enables the next commutator to enter the notch 39 and be held thereby until the gate is again opened. An air cylinder 41 opens and closes the gate by rocking the lever 36 from one position to the other.

The detachability of the sector-shaped plate 38 enables the gate 35 to be adapted to different sized commutators.

Successive presentation of the armature cores to the assembly station is controlled by a gate mechanism, indicated generally by the numeral 45 and shown particularly in FIGS. 5, 6 and 7.

The gate mechanism **45** comprises a lever **46** mounted to rock about a fixed horizontal pivot **47** at the lower end of a leg **48** which depends from a platform **49** that constitutes part of the fixed frame structure of the machine. Detachably secured to the lower end of the lever **46** is a plate **50** from which a pair of parallel horizontally disposed pins **51** and **52** project. As seen in FIG. **5***a*, the lever **46** and the plate **50** secured to its lower end, are located to one side of the inclined track **15**, but the pins **51** and **52** project over the track and are so spaced with respect to the axis of the pivot **47** and the track **15** that one or the other of the pins, depending upon the position of the lever **46**, will always block movement of armature cores along the track. It should, of course, be understood that the diameter of the armature cores must be taken into account, and for this purpose, the plate **50** is replaceable by virtue of its being detachably mounted on the lever **46**.

A tension spring **53** connected between the lever **46** and the platform **49** yieldingly holds the lever—and hence the plate **50**—in the position shown in FIG. **5**, in which the pin **51** blocks further descent of the armature cores down the track.

Comparison of FIGS. **5** and **6** illustrates how rocking of the lever **46** in opposition to the force of the spring **53** releases the leading armature core for continued travel down the track **15** and, at the same time, restrains the succeeding armature cores from following the released core. Such rocking motion is imparted to the lever **46** by downward motion of a cam **54** which engages a cam follower **55** fixed to the upper end of the lever **46**.

The cam **54** is actuated by the ram **56** of an air cylinder **57** which is mounted on and projects upwardly from the platform **49** substantially in line with the track **15**. A block **58** fixed to the lower end of the ram has the cam **54** secured thereto and also has a pair of spaced-apart yokes **59** and **60** depending therefrom.

As shown in FIG. **7***a*, these yokes are so positioned with respect to the axis of the ram and the track **15** that as the ram descends the yoke **59** moves across the outer face of one of the track rails **16**, while the yoke **60** moves along a vertical path substantially equispaced between the rails. This of course entails constraining the ram against turning, which may be done in any suitable manner as by a guide rod **58'** projecting up from the block **58**, and slidably received in a hole through the platform **49**.

The yoke **59** has a long leg **61** and a shorter leg **62**, the latter being at the upstream side of the yoke—with respect to the track **15**. Hence, as the yoke is lowered, its long leg first projects below the level of the track to stop an armature core rolling down the track, and then as the yoke continues to descend, the shorter leg **62** also projects below the level of the track whereupon the armature core shaft is embraced by the legs of the yoke. In this manner the armature core is positioned and held at the assembly station.

It should of course be understood that the functioning of the air cylinder **57** to cause the ram **56** to descend is so timed with the opening of the gate mechanism **45** that the long leg **61** will be in a position to stop the released armature core when it arrives at the assembly station.

By the time the ram has descended far enough to stop the approaching armature core (FIG. **6**), the portion of the cam **54** then engaged by the cam follower **55**, being vertical, will no longer impart motion to the lever **36**. Hence, continued descent of the ram does not affect the condition of the gate mechanism **35** which remains in its condition shown in FIGS. **6** and **7** to hold back the armature cores on the track **15**.

The yoke **60** is of a size and shape to straddle the stack of laminations of the armature core when the shaft thereof is embraced by the yoke **59**, see FIGS. **7** and **7***a*. Not only does the straddling of the core by the yoke **60** properly locate the core, but it also makes it possible for the descent of the yoke to rotate the core to a predetermined position in which its winding slots occupy a specified angular relationship with respect to a fixed plane containing the axis of the armature core. FIGS. **8**, **9** and **10** illustrate this feature of the invention. These figures view the illustrated structure from the side thereof opposite that seen in FIGS. **5**—**7**.

As seen in FIGS. **8**, **9** and **10**, the legs of the yoke **60** have pawls **63** medially pivoted thereto as at **64**. These pawls are yieldingly biased to positions in which beaks **65** on their lower extremities project into the space between the legs of the yoke **60** to enter the mouths of the winding receiving slots **8** in the armature core as the yoke **60** approaches the armature core at the assembly station. It is this engagement of the beaks **65** with the armature core during descent of the yoke **60** by which the core is rotated to its proper position.

To accommodate the pawls **63**, the yoke **60** has pockets or recesses **66** in the face thereof remote from the yoke **59**. These pockets or recesses are of a size to contain all but the beak portions **65** of the pawls. Compression springs **67** confined between the inner sidewalls **68** of the recesses and the upper end portions of the pawls yieldingly hold the pawls in their operative positions defined by adjustable stops **69**.

The stops **69** are so adjusted that the distance between the beaks **65** of the pawls is sufficiently less than the diameter of the armature core that as the beaks approach the core, at least one of them will contact the upwardly facing edge of one of the winding slot mouths as seen in FIG. **9**. During completion of the descent of the yoke **60**, the thus engaged pawl beak imparts torque to the armature core and rotates it sufficiently to enable the other pawl beak to engage the upwardly facing edge of a winding slot at the opposite side of the core, whereupon the two pawls coact during the final stage of their descent to positively bring the core into its desired rotational orientation, and hold the same against accidental displacement therefrom as long as the ram **56** remains in its lowered position.

A spring pressed plunger **70** mounted in the bight portion of the yoke **60**, engages the top of an armature core being held at the assembly station jointly by the yoke **59** and the pawls **63**, to assure against having the core lifted off the track **15** by the ascent of the pawls as the ram **56** rises.

Attention is directed to the fact that one of the legs of the yoke **60**, specifically the one farthest down the inclined track **15**, has a magnetic detector **71** mounted thereon to detect the presence or absence of core at the assembly station. Response of this detector to the presence of a core initiates the functioning of the gate **35** by which the feeding of commutators to the assembly station is controlled. Hence, unless an armature core is in position at the assembly station, no commutator will be released. The circuitry through which the magnetic detector performs its function has not been illustrated since it constitutes no part of the invention, and moreover would be well within the skill of any electrical engineer. For the same reason, no attempt has been made to illustrate the various limit switches and their circuits by which the sequence of events in the operation of the machine are initiated and controlled.

As perhaps best seen in FIG. **14**, the vertical guideway **22** by which the commutators are directed onto the basketlike support **23**, is formed by a pair of rails **75** each generally U-shaped in cross section. These rails are detachably secured to one face of an upright wall **76** with their open sides facing one another. The basketlike support **23** is also detachably secured to the wall **76**, but indirectly so, since it is actually affixed to a die member **77** which in turn is mounted in the wall **76**.

The die member **77** is a barrel with a hole or bore **78** axially therethrough, see FIG. **22**. It is inserted into a round hole **79** in the wall **76** and held there by a setscrew **80**. The hole or bore **78** through the die member is of a diameter to slidably accept the commutators, and to accommodate the tangs on the commutators the boundary surface of the hole has circumferentially equispaced parallel grooves **82** of a size just large enough to permit the tangs to slide therethrough.

The axial length of the die member is equal to the thickness of the wall **76** so that the ends of the die member are flush with the opposite faces of the wall, and the basketlike support **23** is detachably secured to that end of the die member which is flush with the face of the wall to which the vertical rails **75** are secured. Accordingly, the support **23** is positioned across the bottom of the vertical guideway **21**.

The support **23** is shaped to provide a pair of parallel horizontal rails **83** with transversely curved top surfaces, the curvature of which coincides with the boundary surface of the hole **78** in the die member. Hence, a commutator dropped onto the basketlike support **23** will be coaxially aligned with the die member. To accommodate the tangs of a commutator seated on the rails **83**, the end portions of the rails adjacent to the die member are cut away as at **84** (FIGS. **14** and **22**). This relief permits the commutator to be rotated.

The wall **76** in which the die member is fixed and by which the support **23** and the vertical guideway **21** leading thereto are carried, is mounted on a carriage **85** which in turn is slidably mounted between guides **86** on the base **17** that forms part of the frame structure of the machine (see FIG. **17**). It is important to observe that the guides **86** constrain the carriage **85** to reciprocation along a path parallel to the axis of an armature core at the assembly station, and that a commutator seated on the basketlike support **23** is coaxial with the armature core. Hence, since the support **23** holds the commutator axially aligned with the die member, displacement of a commutator off of the support **23** and through the die member results in assembly of the commutator onto the armature core, provided the carriage **85** has been moved far enough towards the armature core.

However, before a commutator on the support **23** is displaced therefrom, it must be properly angularly oriented with respect to the armature core onto which it is to be assembled—that is, rotated to a predetermined position. The mechanism by which such rotation is imparted to the commutator comprises a finger **87** pivotally mounted on the support **23** by a stud **88** screwed into a tapped hole in the lower portion of the support. The upper free end of this pivoted finger has a pin **89** projecting laterally therefrom and located between the end portions of the rails **83** which are cut away to accommodate the tangs on the commutators. Hence the pin **89** is in position to be received between the lowermost pair of adjacent tangs of a commutator dropped onto the support **23**. Rocking the finger about its pivotal mounting thus will rotate the commutator through a limited angle.

The finger **87** is moved to a "cocked" position shown in FIG. **12** by an air cylinder **90** which is secured to the support **23** and projects horizontally from one side thereof. The ram **91** of this cylinder passes through the interbeing portion of the support and is connected to the finger as at **92**.

Suitable biasing means not shown, yieldingly urges the finger **87** toward a defined limit of motion shown in FIGS. **11** and **13**, so that regardless of the position of rotation the commutator might be in when it drops onto the support **23**, the release of the finger **87** by relief of pressure in the cylinder **90** results in the commutator being rotated to a definite position with each tang thereof in its proper angular relationship with its associated winding receiving slots of the armature core, which in this instance is exact angular alignment.

When the commutator has been thus rotationally oriented, it is shoved off the support **23** and into the die member, and to permit such displacement of the commutator, the flanges **93** of the vertical rails **75** that lie flat against the wall **76** are cut away, as at **94**; in fact, the opposite flanges **93'** are likewise cut away, as at **94'**, but for another reason.

As noted hereinbefore, guides **86** constrain the carriage to reciprocation along a path parallel to the axis of an armature core at the assembly station. A second carriage **97** is also movable along the guides **86**, the two carriages being connected to move in unison as well as with respect to one another. The connection between the carriages comprises a rod **98** projecting from a boss **99** on the carriage **85** and passing slidably through a hole in a boss **100** on the carriage **97**, and a compression spring **101** on the rod **98** confined between the bosses **99** and **100**. The spring yieldingly holds the two carriages spaced apart a distance determined by the adjustment of a pair of nuts **102** threaded on the rod and engaging the boss **100**.

Motion is imparted to the connected carriages by an air cylinder **104** mounted under the base **17** with its ram **105** positively connected to the carriage **97** through an arm **106** depending from the underside of the carriage. The stroke of the ram and hence the travel of the carriage **97** is defined by a fixed stop **107** with which the arm **106** collides and an adjustable stop nut **108** on the ram and engageable with an abutment **104'** which is fixed with respect to the cylinder. During projection of the ram **105**, i.e. during its motion towards the left in FIGS. **17**, **18** and **19**, the collision of the arm **106** with the fixed stop **107** limits travel of both carriages. However, in the opposite direction, motion of the carriage **85** is stopped before the retraction of the ram is arrested, travel of the carriage **85** in this direction being limited by the collision of an adjustable stop **109** on the carriage with a fixed stop **110** on the base **17**.

The carriage **97** has mounted thereon the mechanism for pressing the commutators onto the armature core shafts and also the structural elements by which the tangs are shaped. This structure, which is best shown in FIGS. **17** through **20**, comprises a cylinder block **114** mounted on the carriage **97** and having a bore **115** coaxially aligned with the die member **77** and an armature core at the assembly station. Fixed to the cylinder block and projecting coaxially from its bore towards the wall **76** is a pusher bar **116**. During operation of the machine this bar shoves a commutator off the support **23** and onto the shaft of the armature core.

Encircling the bar **116** and slidable in the bore **115** is a piston member **120** with a tubular extension **121** projecting from the cylinder in telescoping relation with the pusher bar **116**. A tang-shaping sleeve **125** encircling the pusher bar, extends into the tubular extension **121** and is detachably secured thereto by a split-clamping ring **126**, the end of the tubular extension on which the clamping ring is mounted having slits **127** to facilitate the clamping action, see FIG. **21**.

Relative axial motion between the pusher bar **116** and the piston member **120** is limited by the engagement of the inner unthreaded end of a screw **130** screwed into the sleeve **125**, with the opposite ends of a longitudinally extending slot **131** in the pusher bar. Since the commutator must be pushed a substantial distance beyond the end of the armature shaft during its assembly with the armature core, the outer end of the pusher bar **116** is hollow to telescope over the armature shaft.

Obviously, of course, as the commutator is pushed onto the armature shaft, the armature core must be supported against axial displacement. This can be done in different ways, but is conveniently accomplished by mounting a stop **135** on the base **17** in position to be engaged by the adjacent end of the shaft of an armature core at the assembly station. This stop should be adjustable to accommodate armature shafts of different lengths, and as shown in FIGS. **3** and **4** can be simply an enlarged head on a screw **136** threaded into a block **137** projecting up from the base **17**. In FIGS. **17**, **18** and **19**, the stop **135** is diagrammatically portrayed.

An important feature of the machine is its provision for straightening the commutator tangs during the assembly of the commutator onto the armature core. This is accomplished by the transfer of the commutator from the basketlike support **23** into the die member **77**. It will be recalled that the bore **78** through the die member is of a size to slidably accept the commutator, and that its grooves **82** are of a size to permit the tangs to slide therealong, but for this to occur all of the tangs must be correctly aligned with the axis of the commutator—that is, they must be symmetrical to radial planes containing the axis of the commutator and bisecting the fixed ends of the tangs. It follows, therefore, that any tang which is askew or displaced to one side or the other of its proper position, will be brought into proper position—will be straightened—as the commutator is pushed into the die member by the advance of the pusher bar **116**.

To facilitate entry of the commutators into the bore of the die member, the ends of the lands between its grooves are bevelled, as at **138**, and to facilitate entry of the tangs into the grooves, the mouths of the grooves are flared, as at **139**, see FIG. **22**.

The displacement of the commutators off of the support **23** and into the die member requires movement of the carriage **97** towards the carriage **85** and hence does not occur until the advance of the latter carriage is stopped by collision of its stop **109** with the stop **110**. By the time these stops engage, the die member will have embraced the shaft of the armature core and will be in the position shown in FIGS. **18** and **19**. Continued advance of the carriage **97** with respect to the now stationary carriage **85** compresses the spring **101** and thus firmly holds the carriage **85** in its advanced position. It also causes the pusher bar **116** to engage the commutator on the support **23** and push it therefrom into the die member and onto the armature shaft. The advance of the pusher bar is stopped by the collision of the adjustable stop **108** on the ram with its cooperating fixed stop **104'** which positively limits the motion of the ram and accurately locates the commutator on the armature shaft. By adjustment of the stop **108** the commutator can be brought to its desired position on the armature shaft, as for instance just contacting the end of the adjacent insulating sleeve **9**.

It should be noted that when the commutator reaches its selected position on the armature shaft, the commutator is still in the die member with its tangs in the discharge ends of the grooves **82**. The cylinder **115** is now pressurized to move the piston **120** and advance the tang-shaping sleeve **125**. As best seen in FIGS. **16** and **21**, this sleeve has circumferentially equispaced fingers **140** which telescope over a commutator in the die member and move endwise along the grooves **82**, it being understood that there is one such finger for each groove and that the fingers are aligned with the grooves. To permit the fingers **140** to telescope over a commutator in the bottom of the guideway **21** and enter the grooves in the die member, is the reason for cutting away part of the flanges **93'** as at **94'**. The extremities of the fingers **140** are wedge or chisel shaped with the edges thereof at the radially inner surface of the fingers. The ends of the fingers thus present radially outwardly and rearwardly sloping cam surfaces **146** which engage under the tangs and lift those thereof that are not sufficiently spaced from the underlying cylindrical surface of the commutator, as the sleeve arrives at its foremost limit of motion. Though it is not mandatory that the fingers **140** lift all of the tangs to exactly the same height, this can be assured and all of the tangs can be given the same hook-shaped formation by so dimensioning the fingers that they lift the tangs engaged thereby against the bottoms of the grooves.

In the event one or more of the tangs is so deformed that its free end is tight against the underlying cylindrical surface of the commutator so that the edge of the approaching finger **140** can not engage under the tang to lift it, advance of the sleeve **125** is arrested. This interruption in the advance of the sleeve **125** is used to initiate the functioning of reject mechanism by which imperfect commutator-armature core assemblies are shunted from the path taken by the "good" assemblies leaving the machine.

The reject mechanism can take any desired form. Thus, as shown in FIG. **3**, it may consist of a "trap door" **147** in the discharge portion of the track **15** down which the commutator-armature core assemblies roll from the assembly station. Opening of the trap door permits an approaching unit to drop into a reject bin, not shown. Such opening of the trap door may be effected by any suitable mechanism (not shown) in response to detection by one of the fingers **140** of a defectively shaped tang.

The machine is equipped with many refinements which, though of lesser importance than the features described, contribute to its completeness. For instance, to assure against premature displacement of a commutator off of the support **23**, an air blast is projected into the lower end of the guideway **21** and against a commutator therein. For this purpose, the die member has one or more air discharge ports **150** leading from an annular groove **151** in its periphery to the bore **78** of the die member, with the mouths of the discharge ports facing toward the guideway **21**. The groove **151** registers with a port **152** in the wall **76** (FIG. **14**) with which an air supply line connects, and O-rings **153** flanking the groove **151** guard against passage of air from the groove except through the ports **150**.

Another detail resides in the provision of means for checking whether or not the armature cores approaching the assembly station are in proper endwise orientation. For this purpose, a pair of rodlike stops **155** embraces the track **15**. These stops are so spaced and positioned with respect to the track that properly oriented armature cores roll down the track without contacting them, while improperly endwise oriented armature cores collide with one or the other of the stops. This arrests advance of the improperly oriented armature core with the result that the machine stops due to the absence of a core at the assembly station.

The machine is also stopped when a photocell **160** mounted on the vertical guideway **21** senses the absence of a commutator on the support **23** when one should be there.

Since the machine is intended to handle armature cores and commutators of different sizes and styles, all portions of the machine which have some contact with either the armature core or the commutator, and which thus may be considered "tooling" are either detachably mounted to permit replacement thereof with different sized counterparts, or are adjustable. For the most part, this interchangeability and adjustment has been recognized in the foregoing description, and where not specifically mentioned is to be understood.

OPERATION

Although the operation of the machine is believed to be clear from the foregoing description, a brief summary thereof along with the flow sheet—FIG. **29**—may be helpful.

Starting with the premise that the vibratory bowl **20** contains a supply of commutators and that a row of armature cores is on the upper end portion of the track **15** which may be considered an inventory track, actuation of the appropriate controls on the control panel **170** of the machine initiates its operation. The cycle begins with descent of the ram **56** of the top cylinder **57**. This actuates the gate mechanism **45** to release the foremost or leading armature core on the inventory track for advance to the assembly station, and at the same time restrains the next and succeeding armature cores on the inventory track from further advance.

The descent of the ram **56** also brings the yokes **59** and **60** into their operative positions to stop the advancing armature core and hold it at the assembly station. During final descent of the ram **56**, the beaks **65** of the pawls **63** that are carried by the yoke **60** engage the armature core and rotate it to a definite position.

The presence of an armature core at the assembly station is sensed by the magnetic detector **71** and as a result the gate **35** functions to transfer or kick the leading commutator in the row thereof leaving the vibratory bowl, onto the inclined track or chute **21**, while holding back the next and succeeding commutators. Response of the magnetic detector **71** also causes the air cylinder **90** to "cock" the commutator rotating finger **87**.

The commutator rolling down the inclined track or chute **21** drops down the vertical guideway **22** onto the basketlike support **23**. As it does, the electric eye **160** senses the presence of a commutator at the assembly station and, acting through appropriate circuitry, relieves pressure in the air cylinder **90** to allow the bias on the finger **87** to swing the same to a defined position and in so doing rotationally orients the commutator into proper relation with the armature core at the assembly station.

The response of the electric eye also initiates the operation of the main press cylinder **105** to effect retraction of its ram **105**. During part of the retraction of the ram the commutator support **23** with commutator thereon, and the die member **77** move with it towards the armature core; but before the retraction stroke of the ram is complete the advance of the commutator support and die member is arrested. The continued advance of the ram, acting through a pusher bar **116**, shoves the

commutator off the support **23** and into the die member. As it does, any tangs of the commutator that are not properly positioned with reference to radial planes containing the commutator axis and bisecting the fixed ends of the tangs, are straightened by the entry of the tangs into the grooves **82** in the bore of the die member. The advance of the pusher bar **116** also presses the commutator onto the shaft of the armature core.

Upon completion of the retraction of the ram **106** the cylinder **115** is pressurized to project the tang checking and shaping fingers **140** over the commutator and into the grooves **82** in the die member. As the fingers **140** move into the grooves, their chisel- or wedge-shaped extremities contact and lift the tangs, preferably against the bottom of the grooves, and thus properly shape all of the tangs.

Completion of the advance of the fingered tang checker and shaper acting through limit switch-controlled circuitry causes the main press cylinder to move the ram **105** in the opposite direction, i.e. to project it from the cylinder. This restores the commutator support and the die member and all associated parts to their original positions ready to receive and act upon the next commutator, and completion of this stroke of the ram effects elevation of the ram **56** of the vertical top cylinder **57** to release the assembled commutator and armature core for delivery, and also conditions the machine for its next cycle.

In the event any one of the commutator tangs is so deformed that it cannot be lifted by its respective shaping finger **140**, the resulting interference with the advance of the fingered tang checker and shaper, acting through appropriate circuitry actuates reject mechanism, depicted by the "trap door" **147** in the delivery track, to keep imperfect commutator-armature core assemblies from being delivered along with the satisfactory units.

From the foregoing description taken with the accompanying drawings, it should be apparent to those skilled in the art, that this invention will significantly reduce the cost of assembling commutators onto armature cores.

We claim:

1. A machine for automatically assembling commutators with armature cores of the type comprising a shaft with a stack of laminations thereon, the stack of laminations having circumferentially spaced winding receiving slots and the commutators having circumferentially spaced terminal tangs at one end thereof, each of which must be in a definite location with respect to at least one of the winding receiving slots of the armature core and form a hook of predetermined shape overlying the cylindrical surface of the commutator, said machine comprising the combination of:

A. feeding means for successively transferring commutator and armature cores, each from a source thereof, to an assembly station;

B. receiving means at the assembly station for receiving and holding commutators and armature cores in coaxial paired relation with the end of the commutator at which its tangs are located facing but spaced from the armature core;

C. pressure applying means operable upon a paired armature core and commutator being held by said receiving means to effect relative axial movement thereof towards one another, to thereby press the commutator onto the shaft of the armature core; and

D. tang-straightening means positioned to be engaged by the commutator tangs during relative movement of the commutator and the armature core toward one another.

2. A machine for automatically assembling commutators with armature cores of the type comprising a shaft with a stack of laminations thereon, the stack of laminations having circumferentially spaced winding receiving slots and the commutators having circumferentially spaced terminal tangs at one end thereof, each of which must be in a definite location with respect to at least one of the winding receiving slots of the armature core and form a hook of predetermined shape overlying the cylindrical surface of the commutator, said machine having

1. feeding means for successively transferring commutators and armature cores, each from a source thereof, to an assembly station,

2. receiving means at the assembly station for receiving and holding commutators and armature cores in coaxial paired relation with the end of the commutator at which its tangs are located facing but spaced from the armature core,

3. pressure applying means operable upon a paired armature core and commutator being held by said receiving means to effect relative axial movement thereof towards one another to thereby press the commutator onto the shaft of the armature core,

said machine being characterized by:

tang-straightening means positioned to be engaged by the commutator tangs during relative movement of the commutator and the armature core toward one another.

3. The machine of claim **2**, further characterized by

tang-shaping means positioned to be coaxially aligned with a paired commutator and armature core at the assembly station, and operable upon actuation to engage the tangs on the commutator and impart a predetermined shape thereto.

4. The machine of claim **3**, further characterized by power-driven actuating means for said tang-shaping means, timed to effect operation of said tang-shaping means directly after the commutator has been pressed onto the shaft of the armature core and while the assembled commutator and armature core are still at the assembly station.

5. The machine of claim **1**, wherein said tang-straightening means comprises a die member with a hole therethrough of a size and shape to axially slidably accept the commutator, the boundary surface of said hole having circumferentially spaced longitudinally extending grooves of a size to slidably accommodate the tangs,

and means mounting said die member in a position to lie between a paired commutator and armature core at the assembly station,

so that during relative movement thereof towards one another, the commutator is pushed into the hole and the tangs move along the grooves and in so doing become centered with respect to planes containing the axis of the commutator and bisecting the attached ends of the tangs, and the maximum radial projection of the tangs from the commutator is defined by engagement of the tangs with the bottoms of said grooves.

6. The machine of claim **2**, wherein said tang-straightening means comprises a die member with a hole therethrough of a size and shape to axially slidably accept the commutator, the boundary surface of said hole having circumferentially spaced longitudinally extending grooves of a size to slidably accommodate the tangs,

and means mounting said die member in a position to lie between a paired commutator and armature core at the assembly station,

so that during relative movement thereof towards one another, the commutator is pushed into the hole and the tangs move along the grooves and in so doing become centered with respect to planes containing the axis of the commutator and bisecting the attached ends of the tangs, and the maximum radial projection of the tangs from the commutator is defined by engagement of the tangs with the bottoms of said grooves.

7. The machine of claim **5**, further characterized by

tang-shaping means comprising an axially reciprocable sleeve coaxial with said hole in the die member and having circumferentially spaced parallel fingers projecting from one end thereof to telescope over the commutator and enter the grooves in the boundary surface of the hole behind the tangs upon axial advance of the sleeve toward said die member,

the inner surfaces of the fingers being positioned to ride upon the cylindrical surface of the commutator, and the ends of said fingers being wedge-shaped with the

apex of the wedge at the inner surfaces of the fingers so as to engage under the tangs in the grooves and lift the same towards the bottoms of the grooves,
whereby the wedge-shaped ends of the fingers and the bottoms of the grooves can coact to define the maximum distance the tangs project above the cylindrical surface of the commutator.

8. The machine of claim 7, further characterized by
power means for imparting axial movement to the sleeve, said power means being timed to advance the sleeve after the commutator has been pushed into the hole.

9. The machine of claim 6, further characterized by
tang-shaping means comprising an axially reciprocable sleeve coaxial with said hole in the die member and having circumferentially spaced parallel fingers projecting from one end thereof to telescope over the commutator and enter the grooves in the boundary surface of the hole behind the tangs upon axial advance of the sleeve toward said die member,
the inner surfaces of the fingers being positioned to ride upon the cylindrical surface of the commutator, and the ends of said fingers being wedge-shaped with the apex of the wedge at the inner surfaces of the fingers so as to engage under the tangs in the grooves and lift the same towards the bottoms of the grooves,
whereby the wedge-shaped ends of the fingers and the bottoms of the grooves can coact to define the maximum distance the tangs project above the cylindrical surface of the commutator.

10. The machine of claim 9, further characterized by
power means for imparting axial movement to the sleeve, said power means being timed to advance the sleeve after the commutator has been pushed into the hole.

11. A machine for automatically assembling commutators with armature cores of the type comprising a shaft with a stack of laminations thereon, the stack of laminations having circumferentially spaced winding receiving slots and the commutators having circumferentially spaced terminal tangs at one end thereof which must be in predetermined positional relationship with respect to the winding receiving slots when the assembly is completed and form hooks of predetermined shape overlying the cylindrical surface of the commutator, said machine having

1. means to receive and hold an armature core and a commutator in coaxial spaced relationship with the end of the commutator at which the tangs are located facing the armature core,
2. positioning means engageable with the coaxial armature core and commutator and operable to bring the same into such angular orientation relative to one another that the tangs and winding slots are in predetermined positional relationship, and
3. pressure applying means operable upon the coaxial armature core and commutator to effect relative axial movement thereof towards one another to thereby press the commutator onto the shaft of the armature core,
said pressure applying means including a pressure applying member constrained to reciprocate along a defined axis,

said machine being characterized by:

A. tang checking and shaping means coaxial with said reciprocably movable pressure applying member, comprising
cooperating relatively movable members adapted to clamp the tangs of the commutator therebetween upon relative movement of said members in one direction while a commutator and armature core are in the grip of said pressure applying means, to sense the posture of the tangs with respect to the cylindrical surface of the commutator and to lift all of the tangs at least a predetermined minimum distance above the cylindrical surface of the commutator if none of the tangs has its free end bearing against the surface of the commutator; and

B. impositive power means for effecting such relative movement of said cooperating members, whereby
the movement thereof in said direction is arrested by any tang which has its free end bearing on the cylindrical surface of the commutator, to provide an initiating signal for actuation of reject mechanism, while completion of such relative motion lifts the tangs at least to said predetermined minimum distance above the cylindrical surface of the commutator.

12. Apparatus for assembling commutators having terminal tangs onto armature cores of the type having a stack of laminations fixed upon a shaft, comprising:

A. armature core-holding means adapted to receive and hold an armature core in a definite axially fixed position;
B. tandem arranged first and second slidably mounted carriages constrained to travel along a path parallel to the axis of an armature core held by said holding means;
C. a commutator support on the first carriage to receive and hold a commutator in coaxial alignment with an armature core held by said holding means;
D. a bored die member on the first carriage positioned to at all times be between the armature core-holding means and the commutator support with the axis of its bore coaxial with an armature core held by said holding means, the bore of the die member being of a size to accept the commutator and having circumferentially spaced longitudinally extending grooves in its wall to slidably accommodate the terminal tangs on the commutator;
E. yieldable motion transmitting means connecting the carriages for travel in unison while permitting relative movement therebetween;
F. power means connected with the second carriage to effect simultaneous advance of both carriages towards the armature core-holding means;
stop means for interrupting the advance of the first carriage when the same has moved far enough to cause the shaft of an armature core held by said armature core-holding means to project through the bore of the die member; and
H. a pusher bar on the second carriage operable upon continued advance of the second carriage after the advance of the first carriage has been interrupted to shove the commutator off its support, into the bore of the die member and onto the shaft of the armature core,
the passage of the tangs along the grooves in the die member as the commutator moves into the die member straightening any tangs that may be askew.

13. The apparatus of claim 12 further characterized by
a tang-shaping sleeve telescoped over the pusher bar and having circumferentially spaced parallel fingers, one for each groove in the die member, to embrace a commutator in the die member and enter the grooves therein upon advance of the sleeve with respect to the pusher member and the die member,
the extremities of said fingers being shaped to lift the tangs towards the bottom of the grooves and thereby shape the tangs, and
power means to advance the tang-shaping sleeve with respect to the pusher bar and into the die member.