

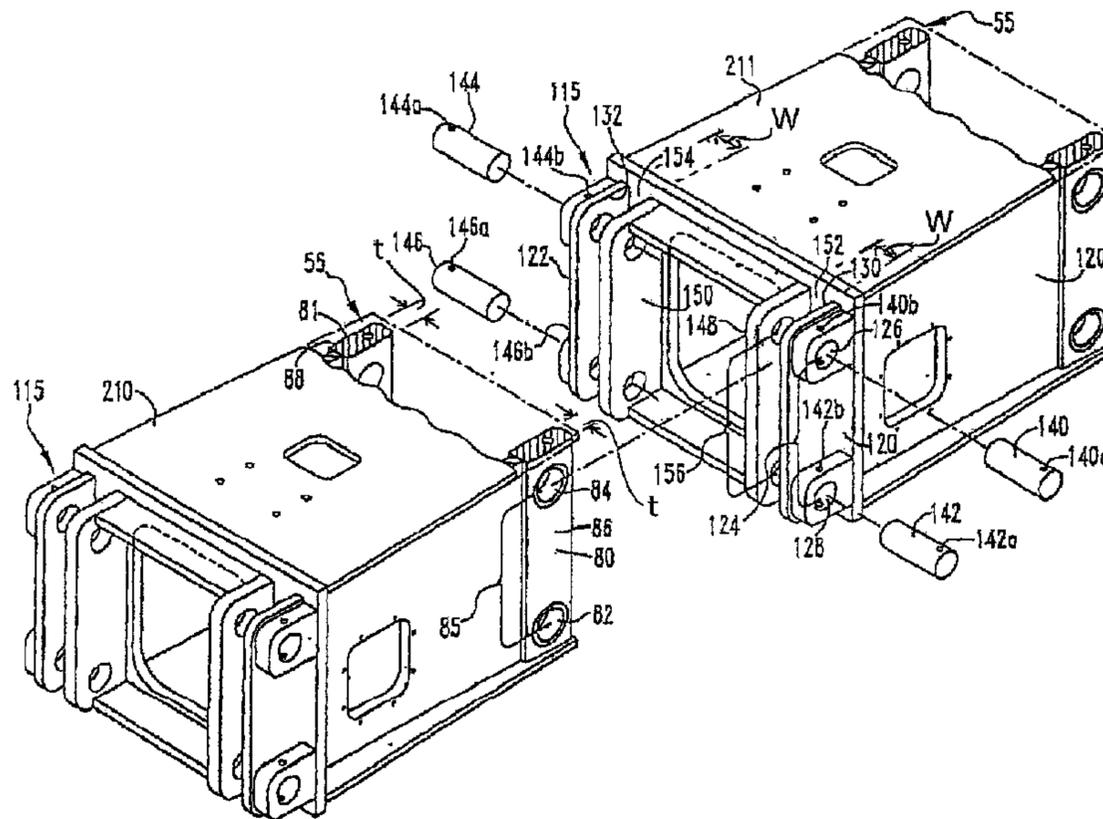


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(54) Title: MODULAR SYSTEM FOR CONNECTING ATTACHMENTS TO A CONSTRUCTION MACHINE



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A modular system for connecting attachments to the extension arm of a construction machine, wherein each module has a standardized coupling arrangement. As a result, each module is compatible with another module to provide great versatility in configuring the machine. Additionally, the system includes a variety of different modules.

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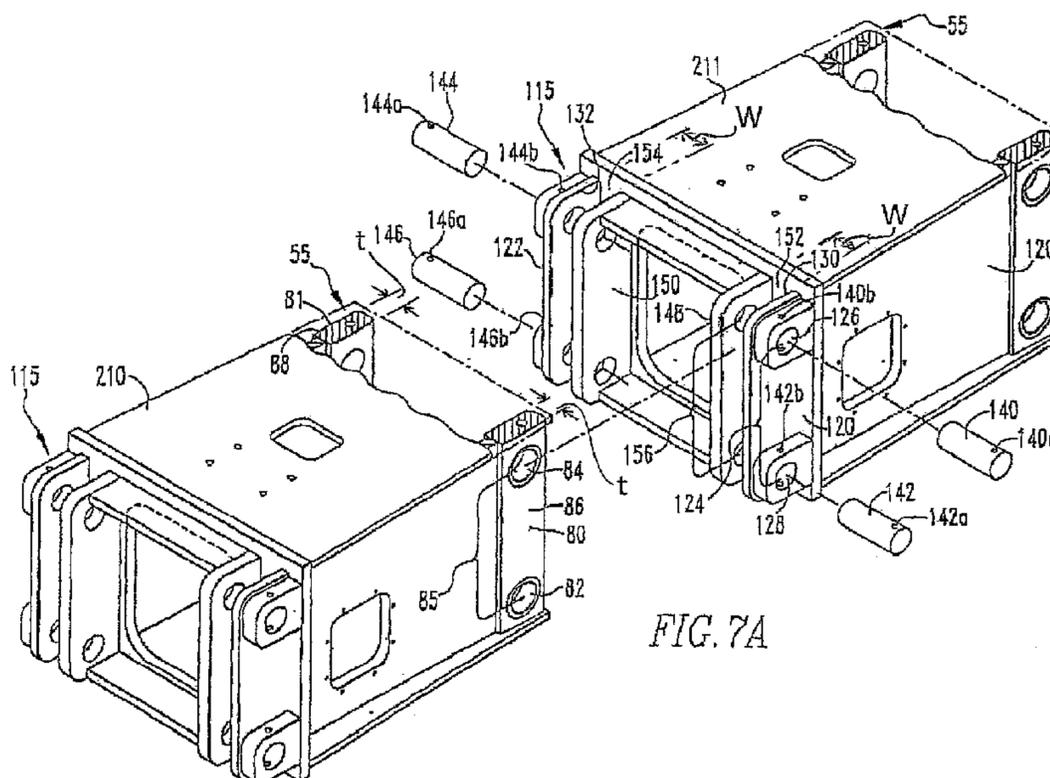
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(54) Title: MODULAR SYSTEM FOR CONNECTING ATTACHMENTS TO A CONSTRUCTION MACHINE



(57) Abstract: A modular system for connecting attachments to the extension arm of a construction machine, wherein each module has a standardized coupling arrangement. As a result, each module is compatible with another module to provide great versatility in configuring the machine. Additionally, the system includes a variety of different modules.

**MODULAR SYSTEM FOR CONNECTING ATTACHMENTS
TO A CONSTRUCTION MACHINE**

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a modular system for construction or demolition equipment which is adapted to be attached to a backhoe for attaching multiple tools, such as a heavy-duty metal cutting shear, a plate shear, a claw, a hammer, a bucket, a grapple, or a concrete crusher.

[0002] While the discussion hereafter will make reference to construction equipment, such equipment is also referred to as demolition equipment, scrap handling equipment, and the like. The description of construction equipment is not intended to be restrictive of the equipment being referenced. Demolition equipment, such as heavy-duty metal cutting shears, plate shears, claws, hammers, buckets, grapples, and concrete crushers have been mounted on backhoes powered by hydraulic cylinders for a variety of jobs in the demolition field. This equipment provides for the efficient cutting and handling of scrap. For example, in the dismantling of an industrial building, metal scrap in the form of various diameter pipes, structural I-beams, channels, angles, sheet metal plates, and the like, must be efficiently severed and handled by heavy-duty metal shears. Such metal shears can also be utilized for reducing automobiles, truck frames, railroad cars, and the like. The shears must be able to move and cut the metal scrap pieces regardless of the size or shape of the individual scrap pieces and without any significant damage to the shears. In the demolition of an industrial building, concrete crushing devices, such as a concrete pulverizer or concrete crackers, are also used to reduce the structure to manageable components which can be easily handled and removed from the site. A grapple is often utilized where handling of debris or work pieces is a primary function of the equipment. Historically, all these pieces of equipment represent distinct tools having significant independent capital costs. Consequently, the demolition industry has tended to develop one type of tool that can have the greatest possible utility and application.

[0003] In general, construction equipment, such as a backhoe, is made up of a tractor having attached thereto a hydraulically operated boom and attached to the boom is a hydraulically operated stick. Each manufacturer of construction equipment provides a variety of attachments for their equipment, however, these attachments fit on only that manufacturer's equipment. As a result, the purchasing of such attachments not only requires a dedicated commitment to a single manufacturer of construction equipment, but furthermore,

puts the equipment owner at a significant disadvantage if the particular equipment manufacturer does not provide a particular attachment which may be needed by the equipment owner. It is inefficient and costly for an equipment owner to own and maintain two separate construction machines because certain attachments are made by one manufacturer and certain other attachments are made by another manufacturer.

[0004] Additionally, different construction tasks require different configurations of the construction machine and, depending upon the equipment manufacturer, there may be only a limited number of configurations possible for a specific construction machine. In the event that the machine owner desires a different configuration, then it may be necessary to approach the equipment manufacturer and ask for the specialized services associated with a customized part. This may become prohibitively expensive.

[0005] A design is needed that will provide the machine owner with the flexibility of a single set of attachments that may be suitable for use with any of a variety of construction machines from different manufacturers. Furthermore, a design is needed whereby a machine owner may have the flexibility to configure the attachments in any desirable sequence, thereby maximizing the efficiency of the construction machine. Finally, a design is needed whereby it is possible for the machine owner to maximize the versatility of a construction machine by utilizing a plurality of different attachments that may be attached to the construction machine.

SUMMARY OF THE INVENTION

[0006] A modular system for connecting a module to an extension arm of a construction machine has a wing secured to the end of the extension arm, wherein the wing at an end opposite the extension arm has one of a standardized proximal mounting arrangement with a pair of spaced-apart parallel plates or a standardized distal mounting arrangement with two pairs of spaced-apart parallel plates. The two pairs each have two closely spaced plates defining a slot therebetween, wherein the width of the slot is approximately the thickness of one of the plates associated with the standardized proximal coupling arrangement. The system also has a module made up of a modified stick having a first end adapted to be secured to the wing and has the other of the standardized distal coupling arrangement or the standardized proximal coupling arrangement adapted to be coupled to the coupling arrangement on the wing so that the module may be interchangeably secured to the wing. Each of the plates associated with the wing is positioned adjacent a plate associated with the module. At least one common mating hole extends through each wing plate and the adjacent

module plate. A pin adapted to slide into at least one mating hole to restrict translation of the wing plate and the module plate relative to one another in a direction parallel to the plates. The modified stick has a longitudinal axis and a hydraulic cylinder mounted to the stick. The standard proximal coupling is pivotally attached to hydraulic cylinder. The modified stick may be secured to the wing with the cylinder on top such that extending the cylinder drives any member attached to the modified stick in a downward direction. The modified stick may be secured to the wing with the cylinder on the bottom, such that extending the cylinder drives any member attached to the modified stick in an upward direction.

[0007] Another embodiment is directed to a modular system for connecting any one of a plurality of modules to an extension arm of a construction machine. The system has a wing secured to the end of the extension arm, wherein the wing at an end opposite the extension arm has one of a standardized proximal mounting arrangement with a pair of spaced-apart parallel plates or a standardized distal mounting arrangement with two pairs of spaced-apart parallel plates. The two pairs each have two closely spaced plates defining a slot therebetween. The system also has a plurality of modules, wherein each module has a first end adapted to be secured to the wing and comprises the other of a standardized proximal coupling arrangement or a standardized distal coupling arrangement adapted to be coupled with the coupling arrangement of the wing. As a result, each module may be interchangeably secured to the wing. The width of the slot is approximately the thickness of one of the plates associated with the standardized proximal coupling arrangement and each of the wing plates associated with one of the proximal mounting arrangement or distal mounting arrangement is positioned adjacent to one of the pair of module plates associated with the other of the distal mounting arrangement or the proximal mounting arrangement. At least one common mating hole extends through each wing plate and the adjacent module plate. A pin is adapted to slide into at least one mating hole to restrict translation of the wing plate and the module plate relative to one another in a direction parallel to the plates.

[0008] Yet another embodiment is directed to a modular system for connecting any one of a plurality of structural extension modules to another structural extension module on a construction machine. The system has a proximal coupling adapter module having a first end with a standardized proximal coupling arrangement with a pair of spaced-apart parallel plates and a second end with a standardized proximal coupling arrangement with a pair of spaced-apart parallel plates. The spaced-apart plates each have a width. A connection module has at one end a distal coupling arrangement having two pairs of spaced-apart parallel plates. The two pairs each have two closely spaced plates defining a slot therebetween for each pair,

wherein the width of the slot is approximately equal to the thickness of one of the plates associated with the standardized proximal coupling arrangement. Each plate of the pair of plates in the standardized proximal coupling arrangement at one end of the adapter module is positioned adjacent and within the slot of a pair of plates associated with the standardized distal coupling arrangement of the connection module. At least one common mating hole extends through each plate of the adapter module and the connector module. A pin is adapted to slide into mating holes of adjacent plates of the standardized proximal coupling arrangement and the standardized distal coupling arrangement to restrict translation of the adapter module and the connecting module relative to one another in a direction parallel to the plates.

[0009] Yet another embodiment is directed to a modular system for connecting any one of a plurality of structural extension modules to another structural extension module on a construction machine. The system has a distal coupling adapter having, at a first end, a standardized distal coupling arrangement and having, at a second end, a standardized distal coupling arrangement. Each standardized distal coupling arrangement has two pairs of spaced apart parallel plates, wherein the two pairs each have two closely spaced plates defining a slot therebetween for each pair. A connector module has a first end with a standardized proximal coupling arrangement with a pair of spaced-apart parallel plates, wherein the spaced-apart plates each have a width and, wherein the width of the slot between the plates of the standardized distal couplings is approximately equal to the thickness of one of the plates associated with the standardized proximal coupling arrangement. Each plate of the pair of plates in the standardized proximal coupling arrangement at one end of the connector module is positioned adjacent and within the slot of a pair of plates associated with the standardized distal coupling arrangement of the adapter module. At least one common mating hole extends through each plate of the adapter module and the connector module. A pin is adapted to slide into mating holes of adjacent plates of the standardized proximal coupling arrangement and the standardized distal coupling arrangement to restrict translation of the adapter module and the connecting module relative to one another in a direction parallel to the plates.

[0010] In yet another embodiment, a split boom extends from the base of a construction machine. The split boom has a lower boom portion with a first end secured to the base of the construction machine and one of a standardized proximal coupling arrangement or a standardized distal coupling arrangement attached at the second end of the lower boom portion. The standardized proximal coupling arrangement has a pair of spaced-apart parallel

plates, wherein the spaced-apart plates each have a width and, wherein the standardized distal coupling arrangement has two pairs of spaced-apart parallel plates. The two pairs each have two closely spaced plates defining a slot therebetween for each pair. An upper boom portion has a first end with the other of the standardized proximal coupling arrangement or the standardized distal coupling arrangement. Each plate of the pair of plates in the standardized proximal coupling arrangement at one end of either the lower boom portion or upper boom portion is positioned adjacent and within the slot of a pair of plates associated with the standardized distal coupling arrangement of the other of the lower boom portion or upper boom portion. At least one common mating hole extends through each plate of the lower boom portion and the upper boom portion. A pin is adapted to slide into mating holes of adjacent plates of the standardized proximal coupling arrangement and the standardized distal coupling arrangement to restrict translation of the lower boom portion and the upper boom portion relative to one another in a direction parallel to the plates.

[0011] These and other advantages of the present invention will be clarified in the description of the preferred embodiments, wherein like reference numerals represent like elements throughout.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0012] Figure 1 is a schematic of a construction machine with the stick positioned to receive an attachment;

[0013] Figure 2 is a schematic of the construction machine in Figure 1 with a stick wing mounted to the stick;

[0014] Figure 3 is a schematic of a construction machine with the boom positioned to receive an attachment;

[0015] Figure 4 is a schematic of the construction machine in Figure 3 with a boom wing attached to the boom;

[0016] Figures 5A and 5B are a side view and a front view of a stick wing;

[0017] Figures 6A and 6B are a side view and a top view of a boom wing;

[0018] Figure 7A is an exploded isometric view of one embodiment of the coupling arrangement in accordance with the subject invention;

[0019] Figure 7B is an assembled isometric view of the coupling arrangement illustrated in Figure 7A;

[0020] Figure 8 is a side view of an alternate embodiment of the coupling arrangement in accordance with the subject invention;

- [0021] Figure 9 is a side view of another alternate coupling arrangement in accordance with the subject invention;
- [0022] Figure 10 is an exploded view of a stick wing and a portion of an adapter;
- [0023] Figure 11 is the view of the stick in Figure 10 along lines "XI – XI" in Figure 10;
- [0024] Figure 12A is a view of the adapter illustrated in Figure 10 along lines "XII-XII" with the tie bars extended;
- [0025] Figure 12B is a view of the adapter in Figure 12A with the tie bars retracted;
- [0026] Figures 13A-13C illustrate the sequential steps for securing the stick wing to the adapter;
- [0027] Figures 14A, 14B, and 14C are front, top, and left end views, respectively, of an adapter;
- [0028] Figures 15, 16, 17, and 18 are exploded side views of different configurations of modules possible utilizing the design in accordance with the subject invention;
- [0029] Figure 19 is an assembled view of the exploded element in Figure 18 excluding the multi-tool;
- [0030] Figures 20A and 20B are side views of a folding adapter, in different positions, in accordance with the subject invention, whereby the folding member and the adapter member are integral with one another;
- [0031] Figures 20C and 20D are side view of the folding module and adapter module illustrated in Figures 20A and 20B but includes a removable coupling between the two parts;
- [0032] Figures 21A-21D are sequential side views of the motion possible utilizing the arrangement in accordance with Figure 18;
- [0033] Figure 22 is an exploded side view of a bucket associated with a stick wing and a rotator module therebetween;
- [0034] Figure 23 is a side view of the arrangement illustrated in Figure 22 but in an assembled configuration;
- [0035] Figures 24-26 are a side view, a left end view, and a right end view of a rotator module in accordance with the subject invention;
- [0036] Figure 27 is an exploded side view similar to that of Figure 22, however, without the rotator module between the stick wing and bucket;
- [0037] Figure 28 is a side view of an assembled configuration of the elements in Figure 27;
- [0038] Figure 29 is an exploded side view of a claw associated with a stick wing;
- [0039] Figure 30 is a side view of the arrangement in Figure 29, but in an assembled configuration;

- [0040] Figure 31 is an exploded side view of a hammer associated with a stick wing;
- [0041] Figure 32 is the hammer illustrated in Figure 31, but assembled and mounted upon the stick of a construction machine;
- [0042] Figures 33 and 34 are a side view and a top view, respectively, of a reducer module;
- [0043] Figures 35 and 36 are a side view and a top view of an enlarger module;
- [0044] Figure 37A is a schematic of a construction machine, whereby a supplemental extension arm has been added to the stick for a system designed to be utilized with an electric magnet for retrieving scrap;
- [0045] Figure 37B is a schematic of a construction machine, whereby a modified stick has been added in place of the stick illustrated in Figure 37A;
- [0046] Figure 37C is a schematic of a construction machine, whereby a second modified stick has been added in place of the supplemental extension arm illustrated in Figure 37B;
- [0047] Figures 38 and 39 are a top view and a side view, respectively, of the supplemental extension arm illustrated in Figure 37A;
- [0048] Figure 40A is a modified stick having a squared-off coupling end;
- [0049] Figure 40B is a modified stick similar to the modified stick illustrated in Figure 40A, but with an angled coupling end;
- [0050] Figures 41A-41E illustrate a sequence of motion possible utilizing the elements illustrated on the construction machine in Figure 37A;
- [0051] Figure 42 is a schematic of a construction machine, whereby the supplemental extension member has been added to the boom for a system designed to be utilized with an electric magnet for retrieving scrap;
- [0052] Figures 43A-43C illustrate, in different positions, a telescopic adapter module mounted to the boom of a construction machine
- [0053] Figure 44 is an exploded top view of a stick wing and a portion of an adapter;
- [0054] Figure 45 is a side view of the stick wing illustrated in Figure 44;
- [0055] Figure 46 is an assembled top view of the arrangement illustrated in Figure 44, with the locking pins retracted;
- [0056] Figure 47 is an assembled top view similar to the arrangement illustrated in Figure 46, but with the locking pins extended to engage the adapter;
- [0057] Figure 48 is a side view of a multi-tool secured to a universal adapter plate suited for mounting upon a skid steer;
- [0058] Figure 49 is a perspective view of the universal adapter plate illustrated in Figure 48.

[0059] Figure 50 is a schematic similar to that illustrated in Figure 37C, wherein the modified extension arm is oriented such that the cylinder is beneath the modified extension arm to provide lift to an attachment mounted thereupon;

[0060] Figure 51 is a schematic similar to that illustrated in Figure 2, wherein in Figure 51 the stick wing has a standardized distal coupling arrangement;

[0061] Figures 52A and 52B are similar to that illustrated in Figures 5A and 5B, however, now a standardized distal coupling arrangement is located where, originally, the standardized proximal coupling arrangement was located;

[0062] Figure 53 illustrates an arrangement similar to that in Figure 4, however, the boom wing now has a standardized proximal coupling arrangement as opposed to the standardized proximal coupling arrangement illustrated in Figure 4;

[0063] Figures 54A and 54B illustrate schematics similar to those found in Figures 6A and 6B, however, now a standardized distal coupling arrangement is located where, originally, the standardized proximal coupling arrangement was located;

[0064] Figures 55, 56, and 57 illustrate a perspective view, an end view, and side view, respectively, of an adapter with a standardized proximal coupling arrangement at each end;

[0065] Figures 58, 59, and 60 illustrate a perspective view, an end view, and a side view, respectively, of an adapter with a standardized distal coupling arrangement at each end;

[0066] Figures 61, 62, and 63 illustrate an exploded, a cut-away, and an assembled view of the adapter found in Figure 55 arranged to show its relationship with other attachments;

[0067] Figure 64 is a schematic of a side view of a construction machine with a split boom with the lower boom portion illustrated;

[0068] Figure 65 illustrates the split boom of Figure 64 with the upper boom portion extension having a cylinder which is oriented for lifting; and

[0069] Figure 66 is similar to the arrangement illustrated in Figure 65, however, now the boom extension has been rotated such that it is now best suited to impart a downward force to the extension, which in one application it may be used for digging.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0070] Figure 1 illustrates a construction machine 10, including a tractor 12, having an extension arm or boom 15 mounted thereupon and pivoted upon the tractor 12 with a hydraulic cylinder (not shown). Attached to the boom 15 is an extension arm or stick 20 operated by a hydraulic cylinder 25 attached between the boom 15 and the stick 20. A stick pivot attachment point 30, in conjunction with a stick linkage attachment point 35, provides

points of attachment through which other tools and accessories may be attached to the stick 20. A hydraulic cylinder 40, in conjunction with a connecting linkage 45, acts to move the stick linkage attachment point 35 to manipulate any accessory attached thereto. It is important to note that the stick pivot attachment point 30 and stick linkage attachment point 35 may significantly differ from one manufacturer to another, such that one accessory or tool from a particular manufacturer may not be compatible to mount upon the stick of another manufacturer.

[0071] Directing attention to Figure 2, the subject invention is intended to overcome this deficit by providing a modular system comprised of different functional modules that may be attached to the stick 20 through the use of a stick wing 50. The proximal end 51 of the stick wing 50 is connected to the stick 20 at the stick pivot attachment point 30 and at the stick linkage attachment point 35. The distal end 52 of the stick wing 50 includes a standardized proximal coupling arrangement 55 which may be used as a base for mounting any number of modular accessories or tools.

[0072] Additionally, directing attention to Figures 3 and 4, which illustrate a construction machine 10 having a tractor 12 with only a boom 15 extending therefrom, a boom pivot attachment point 60 and a boom linkage attachment point 65, driven by the hydraulic cylinder 25, may be used as attachment points to receive the proximal end 71 of a boom wing 70 (Figure 4). Once again, a distal end 72 of the boom wing 70 has a standardized proximal coupling arrangement 75 adapted to receive a variety of different modular accessories and tools.

[0073] Through the use of the stick wing 50 and the boom wing 70 it is possible to adapt a large variety of different construction machines to accept a plurality of standardized attachments and tools, thereby providing the maximum versatility for a construction machine 10 in the event a manufacturer does not provide a full complement of such attachments and/or tools, or, in the event a machine owner wishes to maximize the capacity of the machine.

[0074] In particular, the proximal end 51 of the stick wing 50 or the proximal end 71 of the boom wing 70 may be customized to accommodate the stick attachment points or the boom attachment points of any variety of different designs.

[0075] Figures 5A and 5B illustrate a front and side view of a stick wing 50. In particular, the stick wing 50 is comprised of at least two plates 80, 81, each having at least two holes 82, 84 extending therethrough and spaced apart to define a hole pattern 85. The at least two opposing plates 80, 81 have mounting surfaces 86, 88 thereupon. It is the location of these

plates 80, 81 and the associated holes 82, 84 which define the proximal coupling arrangement associated with the stick wing 50. The opposing plates 80, 81 are connected together through the use of a connecting member 90.

[0076] Additionally, each opposing plate 80, 81 has therethrough connecting bores 92, 94 spaced apart from one another on each plate 80, 81. It is the location and design of each of these connecting bores 92, 94 which provide a connection to the stick wing 50 of one manufacturer or another manufacturer. The stick wing 50 may be designed such that the size and the location of the connecting bores 92, 94 accommodate the attachment of the stick for different construction machines. While it may be necessary for a machine owner to have in inventory a variety of different stick wings 50, each designed to adapt for different construction machinery, it will not be necessary for the machine owner to purchase customized tools for each construction machine because, as will be seen, the modular system, in accordance with the subject invention, permits the use of a single set of tools upon machines from different manufacturers.

[0077] Figures 6A and 6B illustrate a side view and a top view of a boom wing 70 having the standardized proximal coupling arrangement 75 and connecting bores 100, 102 extending through plates 104, 106 designed to be connected to the boom pivot attachment point 60 and boom linkage attachment point 65 illustrated in Figure 3. The standardized proximal coupling arrangement 75 is identical to the standardized proximal coupling arrangement 55 previously described in association with the stick wing 50. Additionally, the connecting bores 100, 102 may be sized and spaced appropriately to accommodate the attachment points for booms from manufacturers of different construction machines. Just as with the stick wing 50, the boom wing 70 may be comprised of at least two opposing plates 104, 106 and each of these opposing plates 104, 106 may have mounting surfaces 108, 110.

[0078] A typical configuration for the proximal coupling arrangement and distal coupling arrangement herein discussed is illustrated in Figures 7A and 7B. Directing attention to Figure 7A, an adapter 210 having a standardized proximal coupling arrangement 55 is illustrated in an exploded isometric view relative to the standardized distal coupling arrangement 115 of another adapter 211. In particular and using reference numbers already used with respect to the stick wing 50 and the boom wing 70, the proximal coupling arrangement 55 is comprised of opposing plates 80, 81 with a hole pattern 85 defined by holes 82, 84 which extend through both plates 80, 81. Each plate 80, 81 has a mounting surface 86, 88.

[0079] The standardized distal coupling arrangement 115 is also comprised of at least two opposing plates 120, 122 with a hole pattern 124 defined by spaced-apart holes 126, 128. Each opposing plate 120, 122 has a mounting surface 130, 132 each of which is generally aligned with a mounting surface 86, 88 of the distal coupling arrangement 55. The opposing plates 80, 81 of the proximal coupling arrangement 55 are spaced in complimentary relationship with the opposing plates 120, 122 of the distal coupling arrangement 115, such that when the plates 80, 81 and 120, 122 are merged, the mounting surfaces 86, 130 and 88, 132 are adjacent to one another. Additionally, the hole pattern 85 of the distal coupling arrangement 55 identified by holes 82, 84 match the hole pattern 124 of the distal coupling arrangement 115 defined by holes 126, 128. As a result, the proximal coupling arrangement 55 is mated with the distal coupling arrangement 115 and the hole patterns 85, 124 align, such that the retention pins 140, 142, 144, 146 may be inserted within the holes, thereby securing the proximal coupling arrangement 55 within the distal coupling arrangement 115, as illustrated in Figure 7B. The retention pins 140, 142, 144, 146 each have bores 140a, 142a, 144a, 146a extending diametrically therethrough to accept locking pins (not shown) which are engaged through the bores 140a, 142a, 144a, 146a and through matching bores 140b, 142b, 144b, 146b extending through the adapter.

[0080] It is also possible, as illustrated in Figure 7A, for the distal coupling arrangement 115 to further include with each opposing plate 120, 122, a reinforcement plate 148, 150 spaced next to the opposing plate 120, 122 to define slots 152, 154 therebetween. Each reinforcement plate 148, 150 has an identical hole pattern 156 to that of the hole pattern 124 associated with the opposing plate within the slot 152.

[0081] From inspection of Figure 7A, it should be appreciated that each adapter module 210, 211 has a standardized proximal coupling arrangement 55 and a standardized distal coupling arrangement 115 at each end. As a result, a plurality of adapter modules 210, 211 may be connected to one another in a string of modules. As will be discussed, each different type of module hereinafter discussed will have one or both of the proximal coupling arrangement 55 and the distal coupling arrangement 115. As a result, these modules may be selected and matched with one another to provide a nearly limitless combination of different modules.

[0082] Although throughout this application a specific configuration is described, with respect to each distal coupling arrangement and each proximal coupling arrangement, it is entirely possible for the configuration associated with one coupling arrangement to be associated with the other configuration. In particular, with respect to Figure 7A, it is entirely

possible for the distal coupling arrangement to be associated with reference number 115 and the proximal coupling arrangement to be associated with reference number 55.

[0083] Directing further attention to Figures 7A and 7B, the standardized distal mounting arrangement 115 illustrated therein on adapter 211 includes two pairs of spaced-apart parallel plates 120, 122. Opposing plate 120 forms with reinforcement plate 148, a slot 152, having a width W in the adapter 211. The plate 80 on adapter 210 has a thickness t which is approximately equal to but less than, the width W of the slot 152.

[0084] Additionally, the opposing plate 122 on adapter 211 forms with the reinforcement plate 150 a slot 154 having a width W in the adapter 211.

[0085] This same relationship exists with respect to the opposing plate 122 and the reinforcement plate 150 of the adapter 211 which form the slot 154 having a width W and the plate 81 of the adapter 210, which has a thickness t . Common mating holes 126, 128 extend through the pairs of spaced-apart parallel plates 120, 122 and plates 148, 150 in the adapter 211 and the plates 80, 81 in the adapter 210. Pins 140, 144 extend through the common hole 126, while pins 142, 146 extend through the common hole 128 to restrict translation of the adapter 210 and the adapter 211 relative to one another in a direction parallel to the plates. Depending upon the configuration, it is possible for a single bore through the plates and a single pin extending therethrough to limit the translation of the adapter 210 and the adapter 211 relative to one another.

[0086] While Figure 7A illustrates a standardized proximal coupling arrangement 55 on one side of the adapter 210 and a standardized distal coupling arrangement 115 on one side of the adapter 211, it is entirely possible to switch the standardized proximal coupling arrangement 55 and the standardized distal coupling arrangement 115 so that, while the same coupling occurs between the adapters 210, 211, the standardized proximal and standardized distal coupling arrangements are reversed between the adapter 210 and the adapter 211. Although this coupling reversal is discussed with respect to adapter 210 and adapter 211 illustrated in Figures 7A and 7B, this type of alternate arrangement may be applied to any of the configurations discussed herein.

[0087] Although the proximal coupling arrangement and mating distal coupling arrangement heretofore disclosed will be the typical arrangement discussed throughout this application, it should be appreciated that there are multiple other coupling arrangements which may be used with the subject invention. In particular, as illustrated in Figure 8, a standardized distal coupling arrangement 155 is mateable with a standardized proximal coupling arrangement 215, whereby the arrangement 155 is comprised of a hooking plate 160

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with a hole 162 therethrough and a spaced-apart hook 164. The proximal coupling arrangement 215 is comprised of a hooked plate 166 with a spaced-apart hole 168 therethrough and a pivot pin 170, such that the hook 164 of the hooking plate 160 may engage the pivot pin 170 of the hooked plate 166 and the spaced-apart holes 162, 168 aligned to receive a support pin 172 extending therethrough, thereby providing a secure coupling between the distal coupling arrangement 155 and the proximal coupling arrangement 215.

[0088] Figure 9 illustrates yet another coupling arrangement, whereby a distal coupling arrangement 175 is connected to a proximal coupling arrangement 180. In particular, the distal coupling arrangement 175 is comprised of a plate 185 having a hole 187 extending therethrough and a wide protruding end 188. A projection 189 extends transversely to the end 188. The proximal coupling arrangement 180 is comprised of a plate 195 having a hole 197 extending therethrough and a matching wide receiving end 198. A recess 199 complimentary in shape to the projection 189 extends transversely within the end 198 in a direction corresponding to the projection 189. The wide protruding end 188 of the distal coupling arrangement 175 is brought into abutment with the matching wide receiving end 199 of the proximal coupling arrangement 215, wherein the holes 187, 197 are aligned and the projection 189 is engaged with the recess 199. A retention bolt 201 is then placed within the holes 187, 197 to provide a secure coupling between the two coupling arrangements 175, 180.

[0089] What has so far been described is a distal mounting arrangement secured to a proximal mounting arrangement through the use of pins which are secured within mating hole patterns between the proximal mounting arrangement and the distal mounting arrangement. While it is entirely possible to manually secure these pins within the holes of the matching hole patterns, it is also possible to automate this function so that the pins may be hydraulically activated to be engaged or disengaged from the matching holes of the proximal mounting arrangement and distal mounting arrangement.

[0090] In particular and directing attention to Figures 10-13C, an automatically actuated coupling system 300 will be discussed. For purposes of discussion, as shown in Figure 10, a stick wing 305 will be attached to an adapter 310. The stick wing 305 is comprised of a base 312 having at least one plate 314 with at least two holes 316, 318 extending therethrough defining a hole pattern 319.

[0091] Directing attention to Figures 10 and 12A, and focusing on one half of a coupling arrangement 305, 310, at least two locking posts 320, 322 are aligned with the holes 316, 318 and secured to a tie bar 324. When the stick wing 305 is aligned with the adapter 310, the

posts 320, 322 are slidable within the holes 316, 318 of the base plate 314. The adapter 310 is a module having a plate 328 with a hole pattern 330 extending therefrom matching that hole pattern 319 of the base plate 314 when the adapter 310 is positioned next to the stick wing 305. A manipulator rod 335 (Figure 11) is moved back and forth by an actuator 340. Figure 11 illustrates the manipulator rod 335 in a retracted position. The actuator 340 may be, among other things, a hydraulic cylinder or an electric solenoid capable of moving the manipulator rod 335 from a retracted position, illustrated in Figure 11, to an extended position, illustrated in Figure 13A. The manipulator rod 335 extends from the stick wing 305 to engage a slot 342 in the tie bar 324, as illustrated in Figures 10 and 13A. As illustrated in Figure 13B, once the manipulator rod 335 engages the slot 342 within the tie bar 324 the manipulator rod 335 may be retracted, which at the same time will pull the tie bar 324 toward the adapter plate 328 thereby moving the locking posts 320, 322 (Figure 12A) into the holes 316, 318 (Figure 10) of the wing 305 to secure the adapter 310 within the wing 305. Figures 12A and 13A illustrate the adapter 310 with the tie-bar 324 and the pins 320, 322 in the extended position, while Figure 13C illustrates the stick wing 305 secured to the adapter 310 when the tie bar 324 is positioned in the retracted manner. As a safety precaution, directing attention to Figure 13C, locking pins 344, 346 may be used to secure the manipulator rod 335 within its retracted position relative to the adapter 310. By utilizing such an arrangement, it is possible to automatically actuate retention pins to engage or disengage modules associated with one another.

[0092] It should be noted that in a preferred embodiment, the stick wing 305 and the adapter 310 have been discussed with a single based plate 314 and a single adapter plate 328. However, it should be understood and as illustrated in Figures 10-13C, that each stick wing 305 and adapter 310 has at least a pair of opposing plates to provide an arrangement which is symmetrical about the center of each the stick wing 305 and the adapter 310. It should also be noted that while, with respect to Figures 10 – 13C, only one side of the arrangement was discussed, there are four retention pins in a typical adapter coupling in a symmetric arrangement to pins 320, 322, illustrated in Figure 12A.

[0093] Figures 10-13C illustrate one type of automatically actuated coupling system 300, whereby the locking posts mounted upon the adapter 310 are moved inwardly to engage the holes 316, 318 of the stick wing 305.

[0094] Directing attention to Figures 44-47, it is also possible for the locking posts to move outwardly. In particular, an automatically actuated coupling system 1300 will be discussed. For purposes of discussion as shown in Figure 44, a stick wing 1305 will be attached to an

adapter 1310. The stick wing 1305 is comprised of a base 1312 having at least one plate 1314 with at least two holes 1316, 1318 extending therethrough defining a hole pattern 1319. At least two locking posts 1320, 1322 are aligned with the holes 1316, 1318 and slidably mounted within a guide 1324 attached to the stick wing base. When the stick wing 1305 is aligned with the adapter 1310, the posts 1320, 1322 are slidable within the holes 1316, 1318 of the base plate 1314. The adapter 1310 is a module having a plate 1328 with a hole pattern similar to that of hole pattern 1319 extending therefrom and matching the hole pattern 1319 of the base plate 1314 when the adapter 1310 is positioned next to the stick wing 1305. When the stick wing 1305 is properly positioned adjacent to the adapter 1310, the locking pins 1320, 1322 are expanded outwardly to engage the holes 1316, 1318 from the retracted position, illustrated in Figure 46, to the extended position, illustrated in Figure 47, where the locking posts 1320, 1322 engage the adapter 1310. The locking posts 1320, 1322 may be hydraulically activated within the guide 1324. It should be noted that while the locking posts 1320, 1322 within the guide 1324 are associated with the stick wing 1305, it is entirely possible for the locking posts 1320, 1322 within the guide 1324 to be associated instead with the adapter 1310.

[0095] Briefly returning to Figures 7A and 7B, described therein was a proximal coupling arrangement 55 mateable with a distal coupling arrangement 115. Figures 14A-14C illustrate a single adapter module 350 for connecting to a construction machine, wherein the module 350 has a body 352 with a first end 354 and a second end 356. A proximal coupling arrangement 55 similar to that illustrated in Figure 7A is associated with the first end 354 and a distal coupling arrangement 115 similar to that illustrated in Figure 7A is associated with the second end 356. The reference numbers applied in Figure 7A may also be applied to the elements in Figures 14A-14C. It should be appreciated that other modules having a proximal coupling arrangement 55 on their first end and a distal coupling arrangement 115 on their second end may be arranged with one another and interlocked together in any desirable fashion. It is this interchangeability which provides the machine owner with maximum versatility and maximum efficiency in mixing and matching any number of a variety of different modules each having a proximal coupling arrangement and/or a distal coupling arrangement which are compatible with other modules.

[0096] The module 350 illustrated in Figures 14A-14C, is an adapter module which, as will be discussed, is intended to attach to a multi-tool. The adapter module 350 at its first end 354 includes a sleeve 401 with a longitudinal axis 403 and a passageway 405 extending therethrough along the longitudinal axis 403. The sleeve 401 is adapted to encompass the

hydraulic cylinder portion 362 (Figure 15) on the end of the multi-tool 360, which is used to operate the multi-tool 360.

[0097] Figure 15 is an exploded side view of an arrangement, whereby a stick wing 50 may be secured to an adapter module 350 which itself may be secured to a multi-tool 360. The multi-tool 360 includes a distal coupling arrangement 115 similar to that illustrated in the adapter module 350 of Figures 14A-14C.

[0098] Briefly returning to Figures 14A-14C, the body 352 includes a window 358. When the adapter module 350 is secured to the multi-tool 360, the window 358 provides access for the hydraulic lines which operate the multi-tool 360.

[0099] Figure 16 illustrates the stick wing 50 with the adapter module 350 and a multi-tool 360 adjacent thereto. Between the stick wing 50 and the adapter module 350 is an extension module 365 which is similar to the adapter module 350 but exists purely to provide an extension between the stick wing 50 and another module. The extension module 365 includes a support structure 367 with a proximal coupling arrangement 55 associated with the first end 369 and a distal coupling arrangement 115 associated with the second end 371.

[00100] While the adapter module 350 and the extension module 365 provide rigid structures between the proximal coupling arrangement and the distal coupling arrangement of each of these modules, Figure 17 illustrates a folding module 375 which is capable of pivoting, such that the proximal coupling arrangement 55 and distal coupling arrangement 115 may be oriented relative to one another at different angles. The folding module 375, illustrated in Figure 17, is attached to an adapter module 350 at the first end 377 and to a stick wing 50 at the second end 379. Just as before, the adapter module 350 is connected to the multi-tool 360.

[00101] The configuration illustrated in Figure 18 is identical to the configuration illustrated in Figure 17 with the exception that the stick wing 50 is replaced by the boom wing 70 previously described. With this interchangeability, it should be appreciated that any module that may be attached to the stick wing 50, illustrated in Figure 2, may also be attached to the boom wing 70, illustrated in Figure 4. Nevertheless, returning to Figure 18, the folding module 375 as described with respect to Figure 17 is capable of orienting the proximal coupling arrangement 55 at a different angle relative to the distal coupling arrangement 115.

[00102] Directing attention to Figures 18 and 19, the folding module 375 is comprised of a two-part structure between the first end 377 and the second end 379. Figure 18 illustrates the folding adapter 375 in a straight pattern, while Figure 19 illustrates the folding adapter 375 in

a folded configuration. A first part 380 and a second part 382 are connected at one point 384 by a pivot 386 and are connected at a different point 388 by a driving cylinder 390 with a cylinder rod 392 such that the motion of the cylinder rod 392 changes the angular orientation of the first part 380 relative to the second part 382 and, as a result, changes the angular orientation of the adapter 350 relative to the boom wing 70 or to any other module to which the first part 380 may be attached.

[00103] The arrangements illustrated in Figure 18 and in Figure 19 are a boom wing 70 attached to a folding module 375, which itself is attached to an adapter module 350. To conserve space and to minimize the number of parts, it is entirely possible to consolidate the boom wing 70 and the folding module 375, illustrated in Figures 18 and 19, to generate a folding adapter module 395, illustrated in Figures 20A and 20B. The folding adapter module 395 is comprised of a two-part structure, wherein the first part is an adapter part 397 similar to the adapter module 350 previously described, but now, the adapter part 397 is an integral part of the folding adapter module 395. The adapter part 397 is at the module first end 409.

[00104] The folding adapter module 395 includes a first part 407 which has an adapter at the module first end 409 and includes similar features to the adapter module 350 described with respect to Figures 14A-14C. In particular, the first part 407 at the first end 409 includes a sleeve 401 with a longitudinal axis 403 and a passageway 405 extending therethrough along the longitudinal axis 403. The sleeve 401 is adapted to overlap a hydraulic cylinder portion 362 (Figure 15) on the end of a tool 360.

[00105] The second part is a folding member 411. The first part 407 and the second part 411 are connected to one another at one point 484 by a pivot 486 and at a different point 488 by a driving cylinder 490 with a cylinder rod 492, such that motion of the cylinder rod 492 changes the angular orientation of the first part 407 relative to the second part 411 and, as a result, changes the angular orientation of the boom wing 70 and the first end 409.

[00106] The folding adapter module 395 illustrated in Figures 20A and 20B is comprised of a first part 407, which is an adapter, and a second part 411, which is the folding member. Figures 20C and 20D illustrate a similar arrangement but with a standardized proximal coupling arrangement 55 associated with the folding member 411 adjacent to the first part 407. As a result, the first part 407 includes a standardized distal coupling arrangement 115 such that, in contrast to the arrangement in Figures 20A and 20B, the first part 407 may be easily secured to or removed from the folding member 411. This arrangement is similar to that shown in Figure 19 except now the boom wing 70 (Figure 19) and the second part 382 are unified as a single part. Additionally, with the standardized proximal coupling

arrangement 55 on the folding member 411, any of a variety of other members may be mounted to the folding member 411, as long as those members have a compatible standardized distal coupling arrangement 115.

[00107] Figures 21A-21D illustrate the versatility of a multi-tool 360 attached to a boom wing 70 by way of the folding adapter module 395 just described. Not only may the multi-tool 360 be rotated by the motion of the boom 15 as it is pivoted about the tractor (not shown), but additionally, through the use of the folding adapter module 395, the multi-tool 360 may have an additional joint of rotation such that, as illustrated in the sequence of Figures 20A-20C, the multi-tool 360 may be rotated through an angular range of approximately 135°. While such a rotation may be available utilizing a standard boom/stick combination, the space required for this arrangement coupled with a multi-tool 360 would be prohibitive and, as a result, the folding adapter module 395 provides a solution not heretofore available in previous designs.

[00108] The modular design so far discussed is amenable to both a terminal module with a standardized coupling arrangement at only one end or an intermediate module which includes a standardized proximal coupling arrangement on one end and a distal coupling arrangement on another end.

[00109] Returning attention to Figure 16, the extension module 365 is one example of an intermediate module which, on a first end 369, includes a standardized proximal coupling 55 and, on the second end 371, includes a standardized distal coupling 115, such that the extension module 365 may be secured between two other modules having an identical distal coupling arrangement or proximal coupling arrangement. As illustrated in Figure 16, the stick wing 50 includes a proximal coupling arrangement 55 which is secured to the distal coupling arrangement 115 at one end 371 of the extension module 365 while the proximal coupling arrangement 55 at the other end 369 of the extension module 365 is secured to the distal coupling arrangement 115 of the adapter module 350. As such, the adapter module 350 is also an intermediate module used to accommodate the multi-tool 360.

[00110] In order to accommodate the proximal coupling arrangement 55 of the adapter module 350, the multi-tool 360 has a front end 500 (Figure 15) with a standardized proximal coupling arrangement 115 with the hydraulic cylinder portion 362 extending therefrom. As previously mentioned, the tool adapter 350 includes a sleeve 401 (Figure 14B) with a longitudinal axis 403 and a passageway 405 extending therethrough along the longitudinal axis 403. The sleeve 401 overlaps the hydraulic cylinder portion 362 (Figure 15) and has a standardized proximal coupling arrangement 55 secured to the standardized distal coupling

arrangement 115 of the multi-tool 360. In this arrangement, the multi-tool 360, since it has only a standardized distal coupling arrangement 115, is considered to be a terminal module. On the other hand, the tool adapter 350, since it has both a standardized proximal coupling arrangement 115 and a standardized distal coupling arrangement 55, is considered to be an intermediate module.

[00111] An intermediate module may also be the extension module 365 previously discussed with respect to Figure 16. An intermediate module may furthermore be the folding module 375 discussed with respect to Figures 17 and 18. Additionally, an intermediate module may be the folding adapter module 395 discussed with respect to Figures 19-20B.

[00112] Directing attention to Figures 22 and 23, the intermediate module may also be a rotator module 510 that may, for example, be secured between the stick wing 50 and a bucket 512 having a distal coupling arrangement 115 thereupon. Figure 23 illustrates this arrangement assembled.

[00113] Directing attention to Figures 24-26, the rotator module 510 is comprised of a rotator 514 between a first end 516 and a second end 518. The rotator 514 is comprised of a first part 520 rotatably connected to a second part 522 and further includes a driver 524 to mechanically rotate the first part 520 relative to the second part 522, thereby providing rotation between the module first end 516 and the module second end 518. The driver 524 rotates a driver gear which mates with an engaging gear to provide relative rotation between the first part 520 and the second part 522. The driver 524 may be a hydraulically driven motor or, in the alternative, may be an electric motor. The rotator module has a standardized distal coupling arrangement 115 at the first end 516 and a standardized proximal coupling arrangement 55 at the second end 518.

[00114] Although Figures 22 and 23 illustrate a bucket 512 secured to the stick wing 50 through a rotator module 510, as illustrated in Figures 27 and 28, it is entirely possible to mount the bucket 512 directly to the stick wing 50.

[00115] Figures 29 and 30 illustrate an exploded and an assembled view of a claw 530 secured to the stick wing 50 through a rotator module 510. The claw 530 may be comprised of two tines 532, 534 pivotally secured to the body 536 of the claw and operated by hydraulic cylinders (not shown).

[00116] Figures 31 and 32 illustrate a hammer 540 secured to the stick wing 50 in a typical manner discussed within this application. Depending upon the manufacturer of the hammer, 540, it may be necessary to install a fitting plate 542 which includes a distal coupling arrangement 115 similar to those discussed herein. With such an arrangement, the hammer

540 may be mounted via the stick wing 50 to the stick 20 of a construction machine. Note the hydraulic cylinder 40 (Figure 2) has been removed in Figure 32.

[00117] As previously stated, while a module having a proximal coupling arrangement on one end and a distal coupling arrangement on the opposing end has been referred to as an intermediate module, a module having only a standardized distal coupling arrangement at one end may be referred to as a terminal module. In particular, the multi-tool 360 (Figure 15) may be considered a terminal module as may the bucket 512 (Figure 27), claw 530 (Figure 29), and hammer 540 (Figure 31).

[00118] Note the bucket 512 in Figures 22-23 and 27-28 is comprised of opposing side walls 513a, 513b and a curved bottom 515 connecting the side walls 513a, 513b. The standardized distal coupling 115 is mounted directly to the side wall 513a of the bucket 512. The shape of the bucket 512 in conjunction with the standardized distal coupling 115 mounted directly to the side wall 513a permits the center of gravity of the bucket 512 to be closer to the proximal distal coupling 115, thereby reducing the overhang of the bucket 512 relative to the construction machine. In particular, the hole pattern 156 (Figure 7A) has holes 126, 128 along a line parallel to the side wall 513a of the bucket 512.

[00119] What has so far been discussed are proximal coupling arrangements and distal coupling arrangements all compatible with one another. Such arrangements may typically be associated with a construction machine having a specific design capacity. However, it is entirely possible, depending upon the intended loading of a construction machine, to mate a coupling arrangement of one size with a coupling arrangement of a different size. In particular and with attention directed to Figures 33 and 34, a reducer module 550 is comprised of a first end 552 having a distal coupling arrangement 115 and a second end 554 having a proximal coupling arrangement but proportionately smaller to accommodate a proximal coupling arrangement also proportionately smaller for an adjacent module. In particular, the distance between slots in the distal coupling arrangement 115 is $L1$ and the distance between the center lines of the protrusions 557, 558 for the proximal coupling arrangement 55, which normally would extend within the slots 555, 556, is $L2$ which, as illustrated in Figure 34, is less than $L1$.

[00120] In the alternative, an enlarger module 560 may have a first end 562 with a distal coupling arrangement having a distance between slots 566, 567 of $L3$ with a second end 564 having a distance $L4$ between protrusions 568, 569, wherein $L4$ is greater than $L3$, and the standardized proximal coupling arrangement 55 is proportionately smaller than the standardized distal coupling arrangement 115.

[00121] It should be noted that the size and the spacing of the mounting holes for each adapter will also change depending on the size of the coupling arrangement.

[00122] Figure 37A illustrates a construction machine 12 with a boom 15 and a stick 20 with a stick wing 50 attached thereto and a supplemental extension arm 570 attached to the wing 50. An electric magnet 575 is suspended by cables 577 from the supplemental extension arm 570. The electric magnet must be powered by an electric cable 578 extending all of the way from the tractor 12 to the magnet 575 and, as a result, the electrical cable 578 is exposed not only to the motion of the boom 15 and the stick 20, but furthermore, is exposed to the environment which may include demolition debris contacting or severing the electrical cable 578.

[00123] The supplemental extension arm 570 is illustrated in Figures 38 and 39 and includes a first window 585 providing an entrance to the internal frame and a second window 587 providing an exit from the internal frame, thereby protecting the electrical cable 578 along the length of the supplemental extension arm 570. By doing so, the electrical cable 578 powering the magnet 575 is shielded along the segments of the construction machine where the cable 578 would normally be most vulnerable. The supplemental extension arm 570 has lifting slots 572, 573 extending therethrough suitable to accept the tines of a forklift or suitable to accept a cable sling for lifting.

[00124] In a design similar to that to be discussed with respect to Figures 40A and 40B, the supplemental extension arm 570, as illustrated in Figures 38 and 39, may also have a standardized distal coupling 115 oriented at an angle A perpendicular to longitudinal axis L.

[00125] Figure 37B illustrates an arrangement similar to that arrangement in Figure 37A, except now the stick 20 has been replaced by a modified stick 579. The modified stick 579 is similar to the stick 20 previously described with the addition of the standardized distal coupling 115. The modified stick 579, also illustrated in Figure 40A, may include a first window 581, which provides access to the internal frame of the modified stick 579 to protect the electrical cable, and a second window 583, which together provide an entrance point and an exit point for the electrical cable 578. A hydraulic cylinder 590 is mounted to the modified stick 579 and the standardized proximal coupling 55, in the form of the stick wing 50, is pivotally coupled to the hydraulic cylinder 590. As illustrated in Figure 40A, the standardized distal coupling 115 of the modified stick 579 may be oriented at an angle A perpendicular to a longitudinal axis L extending along the length of the modified stick 579. By providing a standardized distal coupling 115, which forms a perpendicular angle with the longitudinal axis L, it is possible to flip the modified stick 579 so that the hydraulic cylinder

590 is on the bottom of the configuration as opposed to the arrangement in Figures 37B and 40A, with the hydraulic cylinder 590 on the top. As a result, the modified stick 579 may be oriented so that the hydraulic cylinder 590 is on the top or the bottom of the configuration to provide improved performance depending upon whether the modified stick 570 is used to push down on (cylinder on top) or lift (cylinder on bottom) an object. By design, hydraulic cylinders are designed to provide their greatest forces when the piston is extended from the cylinder housing. While the hydraulic cylinder 590 is illustrated on the top of the modified stick 579, the appearance of the modified stick 579 flipped with the hydraulic cylinder 590 on the bottom may be easily envisioned. On the other hand, the standardized distal coupling 115, as illustrated in Figure 40B, may be oriented at a non-perpendicular angle A relative to the longitudinal axis L extending along the length of the arm 570.

[00126] While Figures 37B and 40A illustrate the hydraulic cylinder 590, positioned on the top of the modified stick 579, Figure 50 illustrates the same modified stick 579, but flipped, such that the hydraulic cylinder 590 is on the bottom of the modified stick 579. In this configuration, the modified stick 579 is better suited to lifting objects since the cylinder 590 exerts a much greater force as it is being extended as opposed to retracted. Additionally, a second modified stick 579' may also be added with the hydraulic cylinder 590' on the bottom to provide not only an extension to the construction machine but to also provide that extension with the ability to lift an object. The modified stick 579 has a first end 578A adapted to be secured to the boom wing 70 in a fashion similar to that configuration previously described with respect to Figure 4.

[00127] The modified stick 579 in Figure 40B is identical to that illustrated in Figure 40A and presented in the earlier figures with the exception that now the standardized distal coupling 115 is oriented at a non-perpendicular angle A relative to the longitudinal axis L.

[00128] Figure 37C illustrates an arrangement, whereby a first modified stick 579 may be secured to a second modified stick 579'. While the second modified stick 579' may be identical to the first modified stick 579, it may be preferred for the second modified stick 579' to be smaller than the first modified stick 579. However, in principle, multiple modified sticks may be attached to one another to provide extension to a given machine.

[00129] Figures 41A-41E illustrate the versatility of a construction machine 10 having a hydraulically activated boom 15, a hydraulically activated stick 20, and a hydraulically activated supplemental extension arm 570. As may be seen in the sequence presented in Figures 41A-41E, the end 589 of the supplemental extension arm 570 is capable of being

rotated 360°. Such a range of motion provides a machine operator with tremendous flexibility and versatility.

[00130] Figure 42 illustrates a construction machine 12 with a boom 15 and a boom wing 70 attached thereto. The supplemental extension arm 570 is connected to the boom wing 70. Attached to the supplemental extension arm 570 through a support cable 577, is an electric magnet 575 powered by an electric cable 578. Therefore, it should be apparent that the supplemental extension arm 570 having an electric magnet 575 attached thereto may be secured to either the stick wing 50, as illustrated in Figure 37, or the boom wing 70, as illustrated in Figure 42.

[00131] Figures 43A-43C illustrate a telescopic adapter module 600 secured to the boom wing 70 of a construction machine 12. It should be appreciated that the telescopic adapter module 600 may also be mounted to a stick wing (not shown) or one of the intermediate adapters previously discussed herein.

[00132] The telescopic adapter module 600 is comprised of a base 605 with an axially moving nested segment 610 extending from the base 605. As can be seen in Figures 43A-43B, multiple nesting segments are possible. In particular, Figure 43C illustrates a second nested segment 615 extending from the first nested segment 610. At the furthest end of nested segment 615 is a standardized proximal coupling arrangement 55 of a particular size. A central cylinder 620 may be activated to extend the segments 610, 615 from the base 605. In one embodiment of the subject invention, nested segment 615 is the only segment that includes the standardized proximal coupling arrangement 55. However, in another embodiment, the base 605 includes a standardized proximal coupling arrangement 55 of one size, the first nested segment 610 includes a standardized proximal coupling arrangement 55 of another size and, as mentioned, the second nested segment 615 includes yet another standardized proximal coupling arrangement 55 of yet another size. As a result, the telescopic adapter module 600 functions not only as a telescoping unit, but furthermore, provides the versatility to connect any number of different sized standardized distal coupling arrangements to the telescopic adapter module. As seen in Figure 43C, the standardized proximal coupling arrangement 55 becomes progressively smaller in each segment 610, 615 extending away from the base 605. The embodiment illustrated in Figures 43A-43C includes two nested segments 610, 615 extending from a base 605, wherein the furthest end of each segment 610, 615 has a standardized proximal coupling arrangement 55.

[00133] The subject invention is also directed to a method of interchanging one module with another module to provide versatility to a construction machine. In particular and with

attention directed to Figures 22-23, the rotator module 510 may be secured between the stick wing 50 and the bucket 512 with the standardized coupling arrangements mating with one another. Additionally, with attention directed to Figures 27-28, the bucket 512 may be attached directly to the stick wing 50. As a result, it should be apparent that the modules described throughout this application may be attached in any number of combinations to provide configurations desired by the machine owner. It is also possible to remotely lock and unlock these modules to one another by aligning the hole patterns between a standardized distal coupling arrangement and a standardized proximal coupling arrangement and securing retention pins through the matching holes as described herein.

[00134] The arrangements discussed so far have been directed to the members having one or both of the standardized proximal coupling and a standardized distal coupling associated with a relatively large construction machine. Directing attention to Figures 48-49, a universal adapter plate 1400 which includes a standardized proximal coupling arrangement 55 may be secured to a mounting plate 1410 suitable, for example, for mounting upon a skid steer loader (not shown). As a result, multi-tool 360 secured to an adapter 210, which has a standardized distal coupling arrangement 115, may be secured to the mounting plate 1410. It should be appreciated that the mounting plate 1410 may be configured for attachment to any number of different machines or tools. In such a fashion, the versatility provided by the system described herein may be utilized on other construction equipment, such as the skid steer loader.

[00135] The discussion associated with Figures 7A and 7B highlighted that, depending upon the configuration of the system, for a given module, the standardized proximal coupling arrangement 55 at one end may be switched to a standardized distal coupling arrangement 115 at the same end.

[00136] Briefly directing attention to Figure 2, attached to the stick 20 is a stick wing 50 having at its distal end 52 a standardized proximal coupling arrangement 55. Figures 5A and 5B provide details of the stick wing 50 with the standardized proximal coupling arrangement 55 shown in Figure 5A with a pair of spaced-apart parallel plates 80, 81. This arrangement is suitable to receive a standardized distal coupling arrangement.

[00137] Now directing attention to Figures 51, 52A, and 52B, a stick wing 710 has a proximal end 712 pivotally connected to the stick 20 through a stick pivot attachment point 30 and a stick linkage attachment point 35. However, now the distal end 712 of the stick wing 750 includes a standardized distal coupling arrangement 715, whereby, as illustrated in Figures 52A and 52B, the standardized distal coupling arrangement 715 is made up of two

opposing plates 720, 722 with mating holes 726, 728 extending therethrough to define a hole pattern 724. Reinforcement plates 748, 750 are each closely spaced with respective opposing plates 720, 722 defining slots 752, 754 with a width W therebetween, wherein the width W of the slots 752, 754 are approximately equal to the thickness t of, for example, a plate 80 (Figure 7A) from a standardized proximal coupling arrangement 55 intended to be placed within the slot 152 and secured therein using pins. The proximal end 712 of the stick wing 750 is similar to the proximal end illustrated in Figures 5A and 5B.

[00138] What has just been described is a stick wing 750 having a standardized distal coupling arrangement 715. Briefly directing attention to Figure 4, a boom 15 has attached thereto a boom wing 70 having a standardized proximal coupling arrangement 75.

[00139] Directing attention to Figures 53, 54A, and 54B, the boom 15 may also have a boom wing 760 having a proximal end 761 and a distal end 762. The proximal end 761 is attached to the boom 15 at the boom pivot attachment point 60 and the boom linkage attachment point 65. At the distal end 762 is a standardized distal coupling arrangement 765 which, directing attention to Figures 54A and 54B, is made up of two opposing spaced-apart parallel plates 770, 772 having a hole pattern 774 defined by holes 776, 778. Spaced-apart parallel reinforcement plates 780, 782, which are spaced from opposing plates 770, 772 define slots 784, 786 each having a width W suitable to receive plates 80, 82 (Figure 7A), for example, from a standardized proximal coupling arrangement 55, wherein the plates 80, 82 have a thickness t suitable to fit within the slots 784, 786 and to be secured therein with pins extending through the holes 776, 778. In this fashion, the boom 15 of a construction machine 10 may be equipped with a stick wing or a boom wing, wherein the stick wing and the boom wing may have either of a standardized proximal coupling arrangement or a standardized distal coupling arrangement attached to their distal ends.

[00140] Figures 7A and 7B have illustrated adapters 210, 211 each having at one end a standardized proximal coupling arrangement 55 and, at an opposing end, a standardized distal coupling arrangement 115. Directing attention to Figures 55, 56, and 57, it is also possible to have an adapter 810 having a standardized proximal coupling arrangement 855 at one end and a similar standardized proximal coupling arrangement 855' at an opposing end. The arrangement and the plates are similar to the standardized proximal coupling arrangement 55 described in Figures 7A and 7B.

[00141] Just as the adapter 810 may have standardized proximal coupling arrangements 855, 855' at opposing ends, Figures 58-60 illustrate an adapter 910, similar to that adapter 210 illustrated in Figures 7A and 7B, however, now having at each end standardized distal

coupling arrangements 915, 915' having similar features to the standardized distal coupling arrangement 115 described with respect to Figures 7A and 7B.

[00142] Figures 61, 62, and 63 illustrate the manner which the adapter 810, shown in Figures 55-57, may be mated with two adjacent components. In particular, an adapter 950 may have a standardized distal coupling arrangement 960 that is adapted to mate with the standardized proximal coupling arrangement 855 of the adapter 950 and, additionally, a rotator element 970 may have at one end a standardized distal coupling arrangement 980 suitable to be mated with the standardized proximal coupling arrangement 855' of the adapter 810. Figure 62 shows cut-away portions revealing the manner by which the plates of the couplings mate with one another, while Figure 63 illustrates the parts assembled in a final configuration.

[00143] Figures 64-66 illustrate a construction machine 10 having a split boom 1500 with a lower boom portion 1505 with a first end 1507 secured to the base of the construction machine 10. The second end 1508 has one of a standardized proximal coupling arrangement 1555 similar to standardized proximal coupling arrangement 55 described with respect to Figures 7A and 7B or a standardized distal coupling arrangement 1615 similar to that of standardized distal coupling arrangement 115 described with respect to Figures 7A and 7B. An upper boom portion 1520 has a lower end 1522 having the other of the standardized proximal coupling arrangement 1555 or standardized distal coupling arrangement 1615. As discussed with respect to the standardized proximal coupling arrangement 15 and the standardized distal coupling arrangement 115, at least one common mating hole extends through each plate associated with the couplings and a pin is adapted to slide into the mating holes and adjacent plates of the couplings to restrict translation of the lower boom portion 1505 and the upper boom portion 1520 relative to one another in a direction parallel to the plates.

[00144] As illustrated in Figure 65, the lower boom portion 1505 and the upper boom portion 1520 have longitudinal axes 1506, 1521 that are generally co-axial when the lower boom portion 1505 and the upper boom portion 1520 are assembled together.

[00145] Additionally, while Figures 65 and 66 show the lower boom portion 1505 and the upper boom portion 1520 in the assembled state, it should be appreciated that each of these have two significant differences. First of all, with respect to Figure 65, the upper boom portion 1520 has at its upper end 1525 a boom wing 1570 with a standardized distal coupling arrangement 1575 similar to those described herein. Additionally, the upper boom portion 1520 has a hydraulic cylinder 1580 mounted on one side, wherein the boom wing 1570 is

pivotally attached to the hydraulic cylinder 1580. The hydraulic cylinder 1580 exerts the greatest force when the cylinder rod 1582 is being extended and, for that reason, the configuration illustrated in Figure 65 is optimum for pivoting the boom wing 1570 in a counterclockwise direction for lifting objects.

[00146] Directing attention to Figure 66, because of the symmetry of the standardized proximal coupling arrangement 1555 and the standardized distal coupling arrangement 1615, the entire upper boom portion 1520 may be rotated relative to the lower boom portion 1505 so that the hydraulic cylinder 1580 is flipped or on the opposite side from that illustrated in Figure 65. In this configuration, the stick wing 1590, when the rod 1582 of the hydraulic cylinder 1580 is extended, rotates in a clockwise direction, thereby applying a downward force to a member connected to the stick wing 1590. In this fashion, the hydraulic cylinder 1580 provides a downward motion suitable for digging. It should be noted in the arrangements illustrated in Figures 64-66, that the coupling between the second end 1508 of the lower boom portion 1505 and the first end 1525 of the upper boom portion 1520 are oriented at an angle generally perpendicular to the longitudinal axis 1506 of the lower boom portion 1505. The coupling between the second end 1508 of the lower boom portion 1505 and the first end 1525 of the upper boom portion 1520 may also be oriented at an angle non-perpendicular to the longitudinal axis 1506 of the lower boom portion 1505.

[00147] It should now be appreciated that the system, in accordance with the subject invention, provides tremendous versatility for using the intermediate modules and the terminal modules to assemble from the stick or the boom of a construction machine and almost limitless number of different combinations to accommodate the needs of a machine operator since all of the intermediate modules and the terminal modules are compatible with one another through the standardized coupling arrangements.

[00148] While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. The presently preferred embodiments described herein are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the appended claims and any and all equivalents thereof.

THE INVENTION CLAIMED IS

1. A modular system for connecting a module to an extension arm of a construction machine comprising:
 - a) a wing secured to the end of the extension arm, wherein the wing at an end opposite the extension arm has one of a standardized proximal mounting arrangement with a pair of spaced-apart parallel plates or a standardized distal mounting arrangement with two pairs of spaced-apart parallel plates, wherein the two pairs each have two closely spaced plates defining a slot therebetween, wherein the width of the slot is approximately the thickness of one of the plates associated with the standardized proximal coupling arrangement;
 - b) a module made up of a modified stick having a first end adapted to be secured to the wing, wherein the first end comprises the other of the standardized distal coupling arrangement or the standardized proximal coupling arrangement adapted to be coupled to the coupling arrangement on the wing so that the module may be interchangeably secured to the wing;
 - c) wherein each of the plates associated with the wing is positioned adjacent a plate associated with the module;
 - d) at least one common mating hole extends through each wing plate and the adjacent module plate; and
 - e) a pin adapted to slide into at least one mating hole to restrict translation of the wing plate and the module plate relative to one another in a direction parallel to the plates; and
 - f) wherein the modified stick has a longitudinal axis and a hydraulic cylinder mounted to the stick and, wherein the standard proximal coupling is pivotally attached to hydraulic cylinder and, wherein the modified stick may be secured to the wing with the cylinder on top, such that extending the cylinder drives any member attached to the modified stick in a downward direction or, wherein the modified stick may be secured to the wing with the cylinder on the bottom such that extending the cylinder drives any member attached to the modified stick in an upward direction.

2. The system according to claim 1, wherein the standardized distal coupling of the modified stick is oriented at a non-perpendicular angle relative to the longitudinal axis.

3. The system according to claim 1, wherein the standardized distal coupling of the modified stick is oriented at an angle perpendicular to the longitudinal axis.

4. A modular system for connecting any one of a plurality of modules to an extension arm of a construction machine comprising:

a) a wing secured to the end of the extension arm, wherein the wing at an end opposite the extension arm has one of a standardized proximal mounting arrangement with a pair of spaced-apart parallel plates or a standardized distal mounting arrangement with two pairs of spaced-apart parallel plates, wherein the two pairs each have two closely spaced. plates defining a slot therebetween;

b) a plurality of modules, wherein each module has a first end adapted to be secured to the wing and comprises the other of a standardized proximal coupling arrangement or a standardized distal coupling arrangement adapted to be coupled with the coupling arrangement of the wing so that each module may be interchangeably secured to the wing, wherein the width of the slot is approximately the thickness of one of the plates associated with the standardized proximal coupling arrangement;

c) wherein each of the wing plates associated with one of the proximal mounting arrangement or distal mounting arrangement is positioned adjacent to one of the pair of module plates associated with the other of the distal mounting arrangement or the proximal mounting arrangement;

d) at least one common mating hole extends through each wing plate and the adjacent module plate; and

e) a pin adapted to slide into at least one mating hole to restrict translation of the wing plate and the module plate relative to one another in a direction parallel to the plates.

5. The modular system according to claim 4, wherein the wing is a stick wing attached to the end of a stick, which is attached directly or indirectly to a boom.
6. The modular system according to claim 4, wherein the wing is a boom wing attached directly to the end of a boom.
7. The modular system according to claim 4, wherein one of the plurality of modules is a terminal module having at one end the other of a standardized proximal coupling arrangement or a standardized distal coupling arrangement.
8. The modular system according to claim 4, wherein one of the plurality of modules is an intermediate module having at one end the other of a standardized proximal coupling arrangement or a standardized distal coupling arrangement and, wherein the module further includes a second end comprising the other of a standardized distal coupling arrangement or a standardized proximal coupling arrangement, wherein the intermediate module may be secured between two other modules having a matching standardized distal coupling arrangement or a matching proximal coupling arrangement.
9. A modular system for connecting any one of a plurality of structural extension modules to another structural extension module on a construction machine comprising:
 - a) proximal coupling adapter module having a first end with a standardized proximal coupling arrangement with a pair of spaced-apart parallel plates and a second end with a standardized proximal coupling arrangement with a pair of spaced-apart parallel plates, wherein the spaced-apart plates each have a width;
 - b) a connection module having at one end a distal coupling arrangement having two pairs of spaced-apart parallel plates, wherein the two pairs each have two closely spaced plates defining a slot therebetween for each pair, wherein the width of the slot is approximately equal to the thickness of one of the plates associated with the standardized proximal coupling arrangement;

c) wherein each plate of the pair of plates in the standardized proximal coupling arrangement at one end of the adapter module is positioned adjacent and within the slot of a pair of plates associated with the standardized distal coupling arrangement of the connection module;

d) at least one common mating hole extends through each plate of the adapter module and the connector module; and

e) a pin adapted to slide into mating holes of adjacent plates of the standardized proximal coupling arrangement and the standardized distal coupling arrangement to restrict translation of the adapter module and the connecting module relative to one another in a direction parallel to the plates.

10. A modular system for connecting any one of a plurality of structural extension modules to another structural extension module on a construction machine comprising:

a) a distal coupling adapter having at a first end, a standardized distal coupling arrangement and having at a second end, a standardized distal coupling arrangement, wherein each standardized distal coupling arrangement has two pairs of spaced-apart parallel plates, wherein the two pairs each have two closely spaced plates defining a slot therebetween for each pair;

b) a connector module having a first end with a standardized proximal coupling arrangement with a pair of spaced-apart parallel plates, wherein the spaced-apart plates each have a width and, wherein the width of the slot between the plates of the standardized distal couplings is approximately equal to the thickness of one of the plates associated with the standardized proximal coupling arrangement;

c) wherein each plate of the pair of plates in the standardized proximal coupling arrangement at one end of the connector module is positioned adjacent and within the slot of a pair of plates associated with the standardized distal coupling arrangement of the adapter module;

d) at least one common mating hole extends through each plate of the adapter module and the connector module; and

e) a pin adapted to slide into mating holes of adjacent plates of the standardized proximal coupling arrangement and the standardized distal coupling arrangement to restrict translation of the adapter module and the connecting module relative to one another in a direction parallel to the plates.

11. A split boom extending from the base of a construction machine, wherein the split boom is comprised of:

a) a lower boom portion with a first end secured to the base of the construction machine and one of a standardized proximal coupling arrangement or a standardized distal coupling arrangement attached at the second end of the lower boom portion, wherein the standardized proximal coupling arrangement has a pair of spaced-apart parallel plates, wherein the spaced-apart plates each have a width and, wherein the standardized distal coupling arrangement has two pairs of spaced-apart parallel plates, wherein the two pairs each have two closely spaced plates defining a slot therebetween for each pair;

b) an upper boom portion having a first end having the other of the standardized proximal coupling arrangement or the standardized distal coupling arrangement

c) wherein each plate of the pair of plates in the standardized proximal coupling arrangement at one end of either the lower boom portion or upper boom portion is positioned adjacent and within the slot of a pair of plates associated with the standardized distal coupling arrangement of the other of the lower boom portion or upper boom portion;

d) at least one common mating hole extends through each plate of the lower boom portion and the upper boom portion; and

e) a pin adapted to slide into mating holes of adjacent plates of the standardized proximal coupling arrangement and the standardized distal coupling arrangement to restrict translation of the lower boom portion and the upper boom portion relative to one another in a direction parallel to the plates.

12. The split boom according to claim 11, wherein the second end of the upper boom portion has one of a standardized proximal mounting arrangement with a pair of spaced-

apart parallel plates or a standardized distal mounting arrangement with two pairs of spaced-apart parallel plates, wherein the two pairs each have two closely spaced plates defining a slot therebetween, wherein the upper boom portion mounting arrangement is adapted to receive a member having the other of the standardized proximal mounting arrangement or the standardized distal mounting arrangement such that the member may be secured thereto.

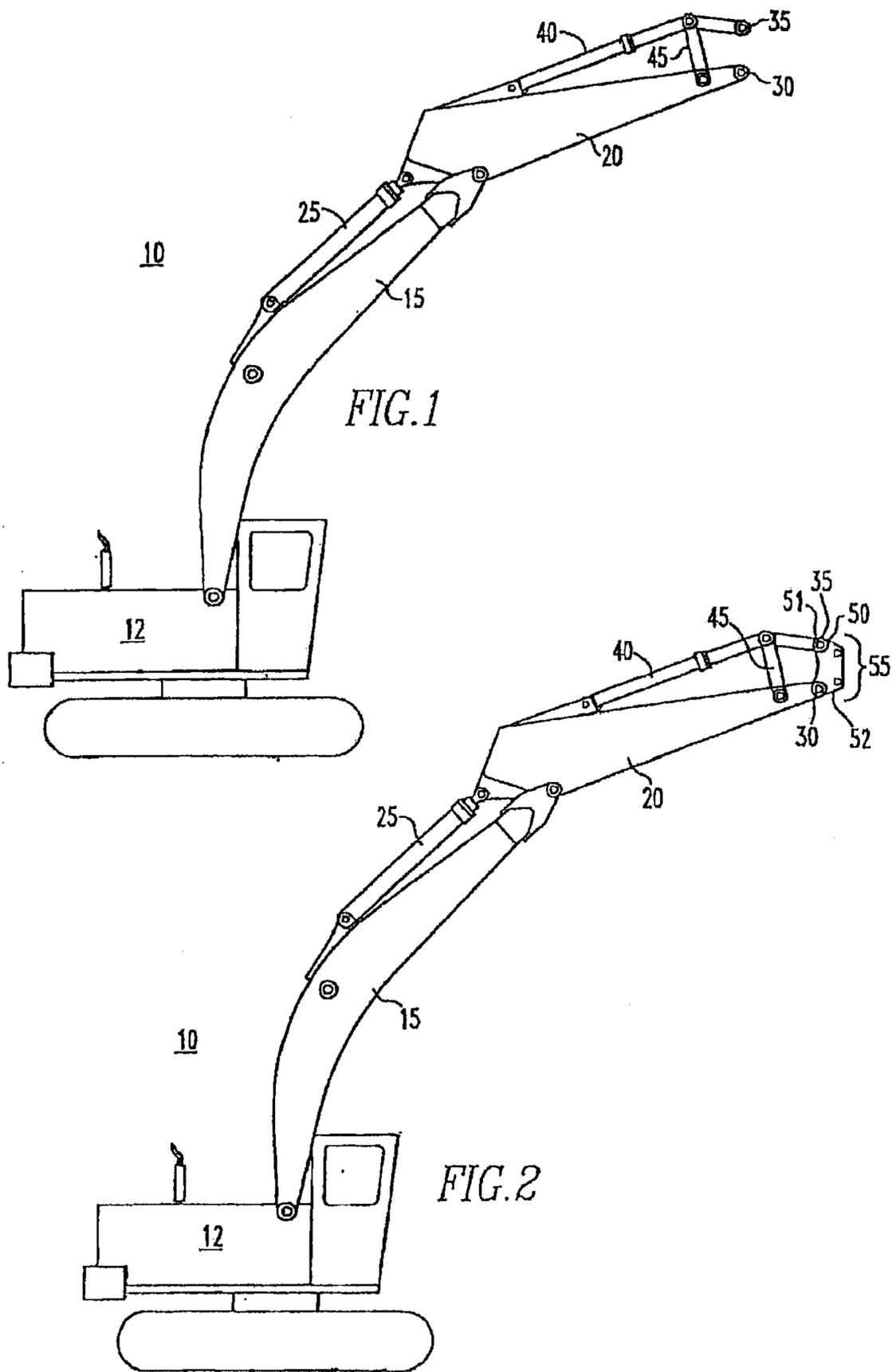
13. The split boom according to claim 11, wherein the lower boom portion and the upper boom portion have longitudinal axes that are generally co-axial when the upper boom portion and the lower boom portion are assembled together.

14. The split boom according to claim 11, wherein the upper boom portion has a longitudinal axis and a hydraulic cylinder mounted on one side and, wherein the coupling arrangement at the second end of the upper boom portion is pivotally attached to the hydraulic cylinder and, wherein the upper boom portion may be mounted upon the lower boom portion so that the orientation of the cylinder is on the top side of the upper boom portion, such that extending the cylinder drives any member attached thereto in a downward direction or, wherein the upper boom portion may be mounted upon the lower boom portion, such that the orientation of the cylinder is on the bottom side of the of the upper boom portion such that extending the cylinder drives any member attached thereto in an upward direction.

15. The split boom according to claim 14, wherein the coupling between the second end of the lower boom portion and the first end of the upper boom portion is oriented at an angle perpendicular to the longitudinal axis.

16. The split boom according to claim 14, wherein the coupling between the second end of the lower boom portion and the first end of the upper boom portion is oriented at an angle non-perpendicular to the longitudinal axis.

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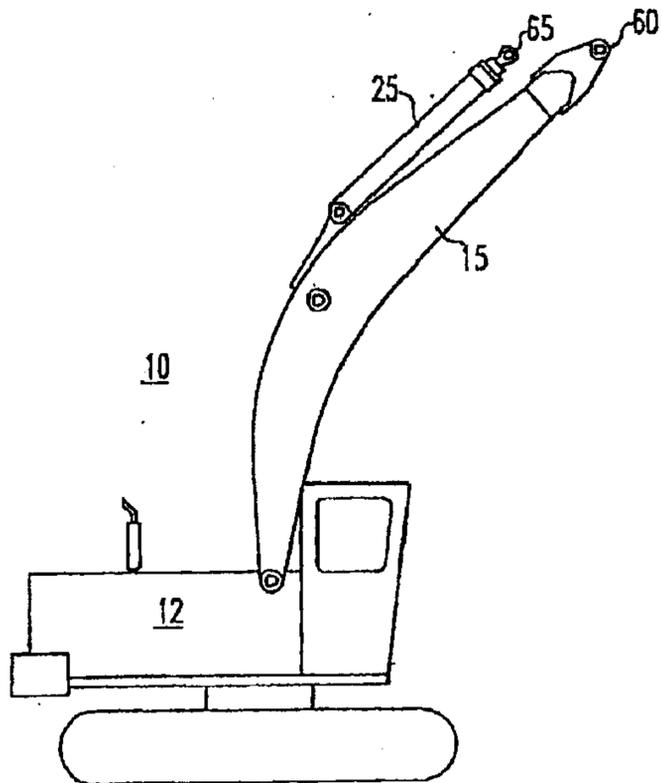


FIG. 3

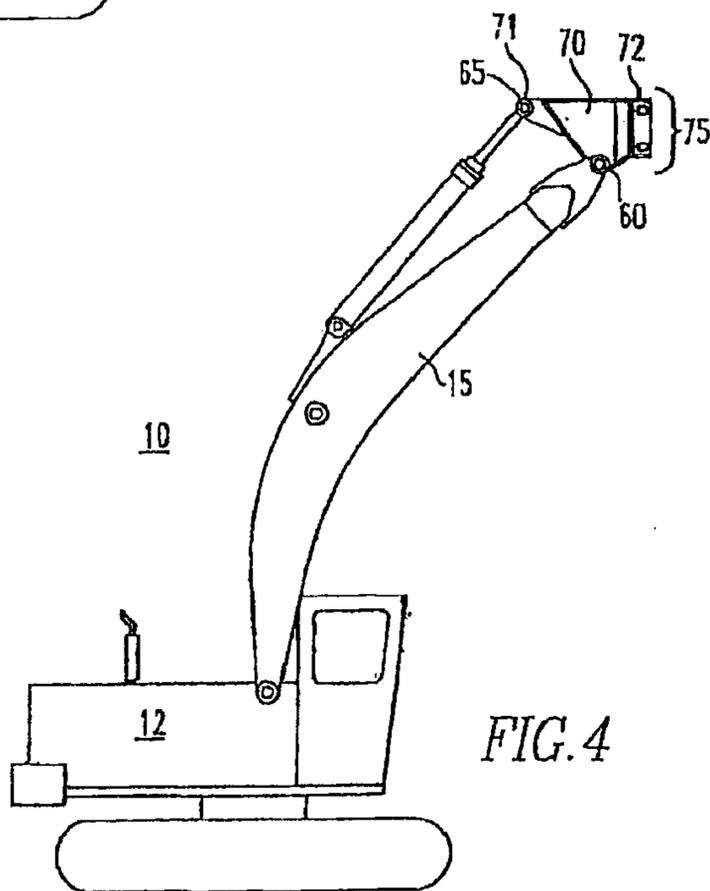
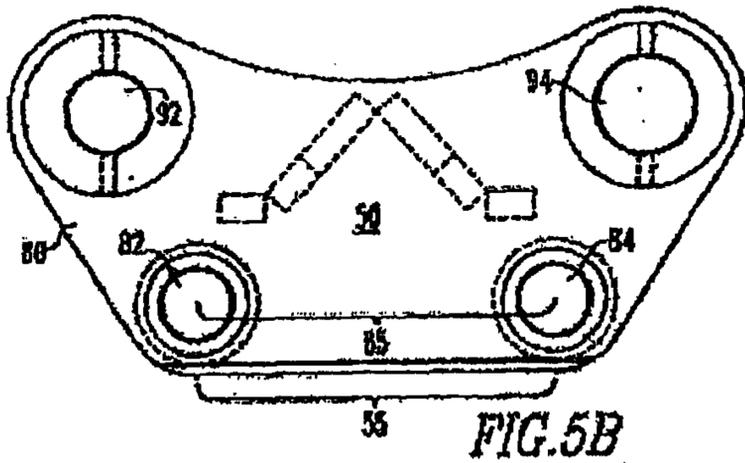
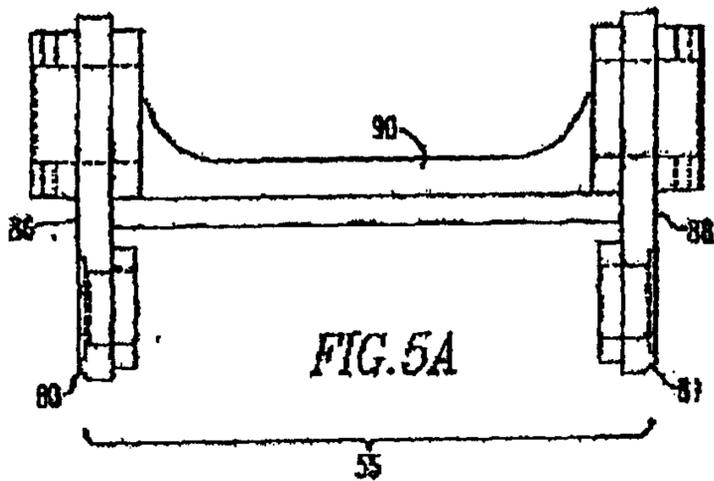
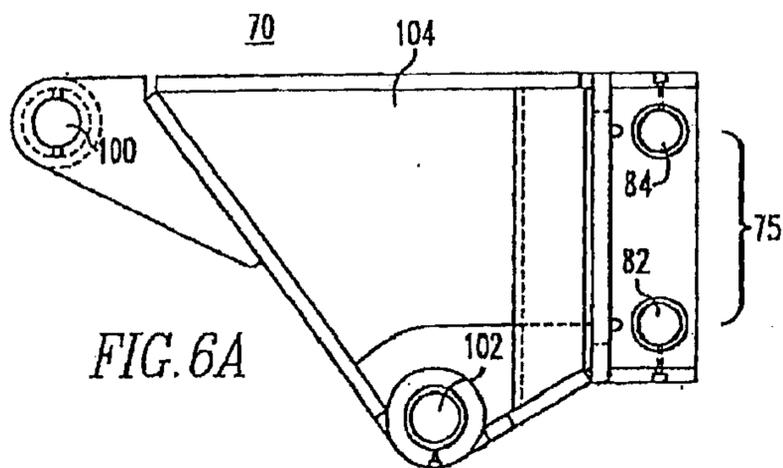
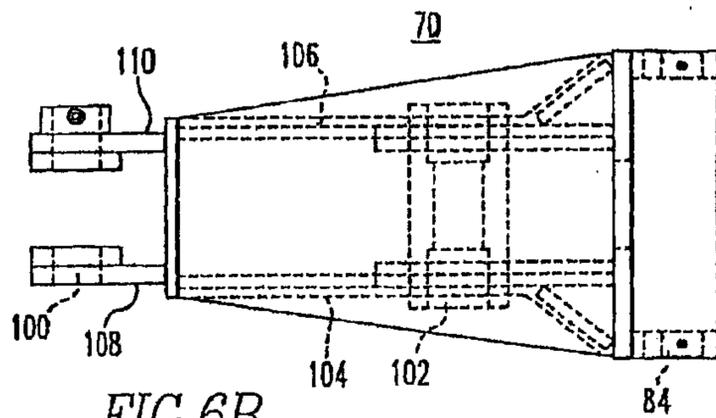


FIG. 4

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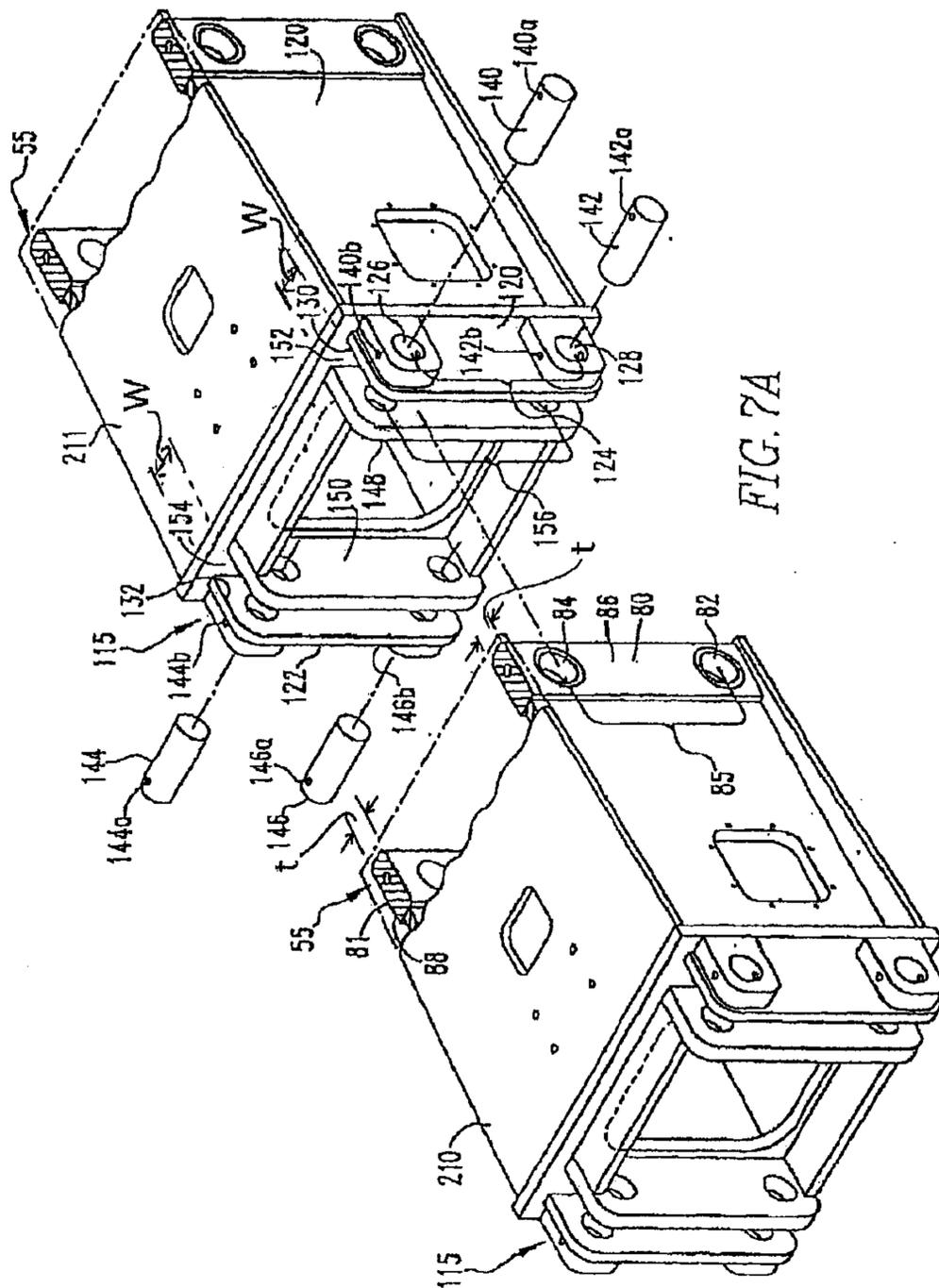
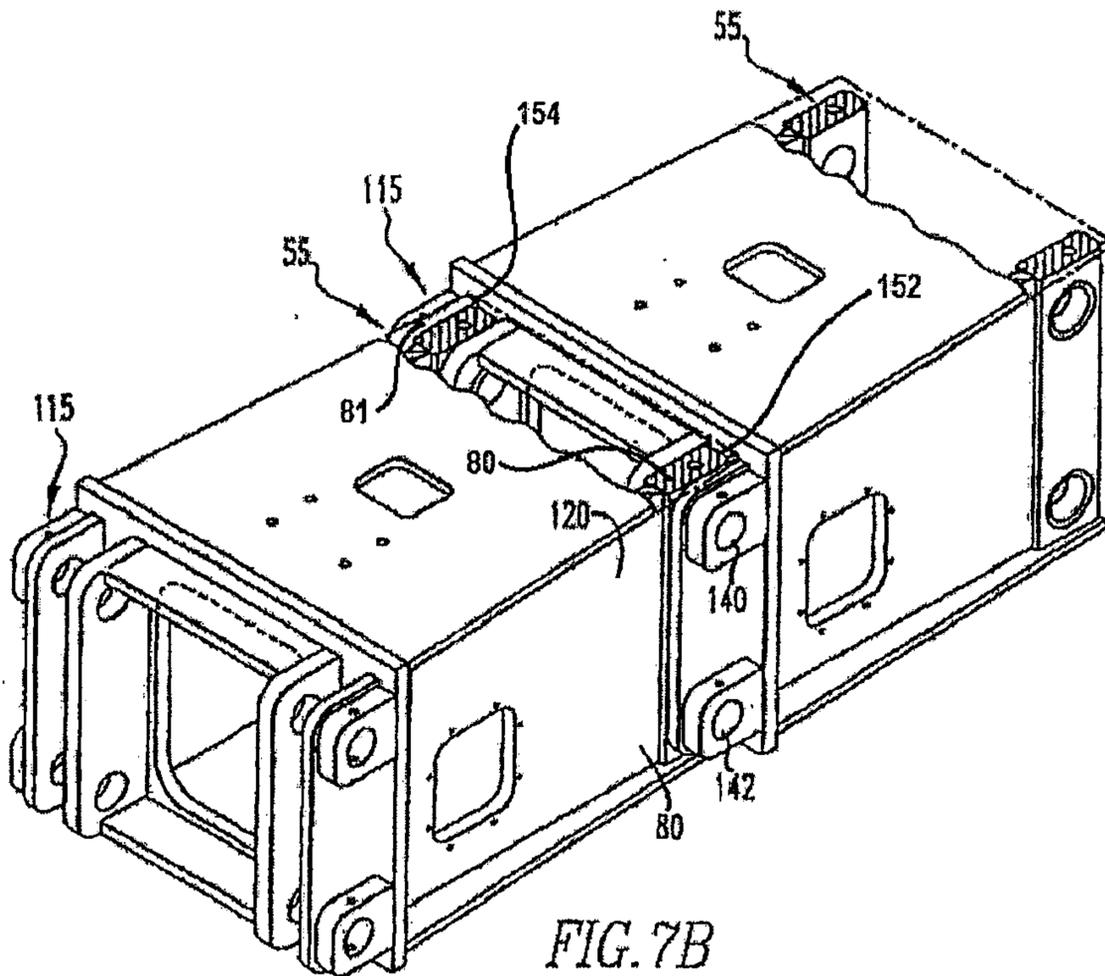


FIG. 7A



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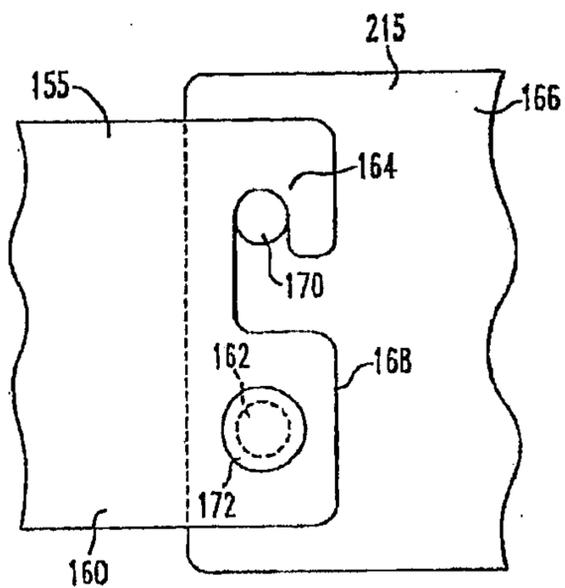


FIG. 8

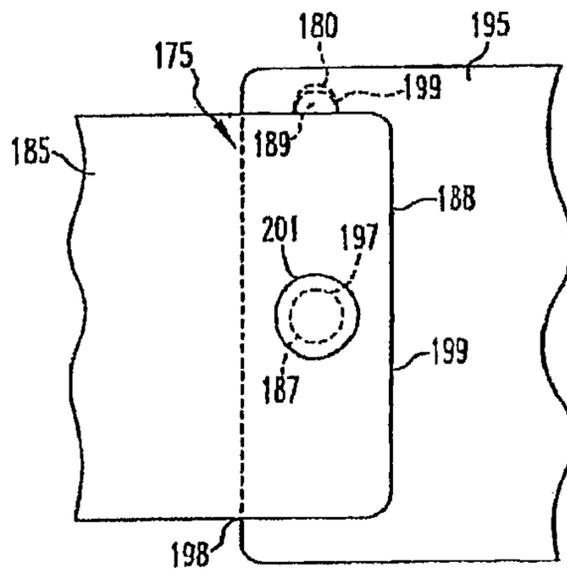


FIG. 9

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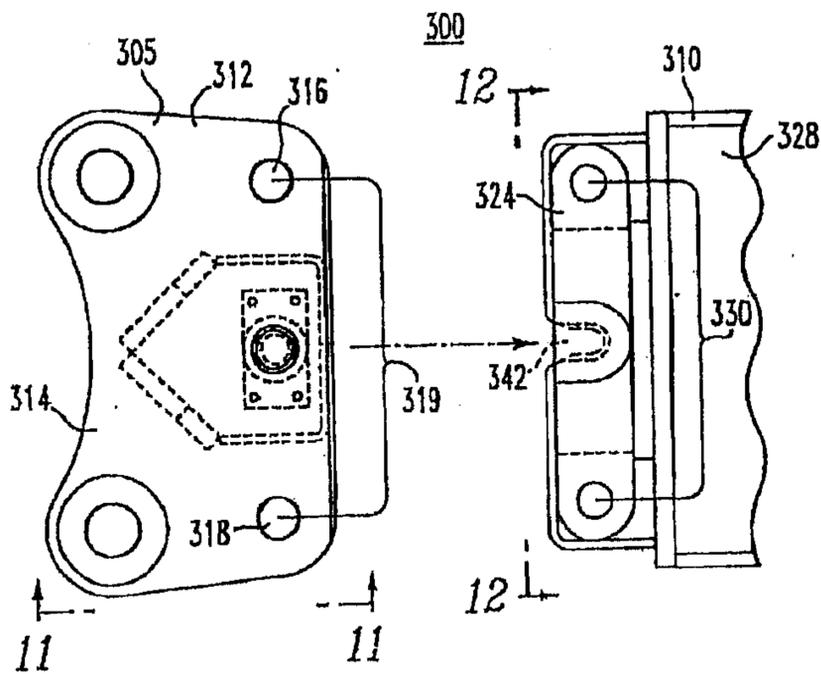


FIG. 10

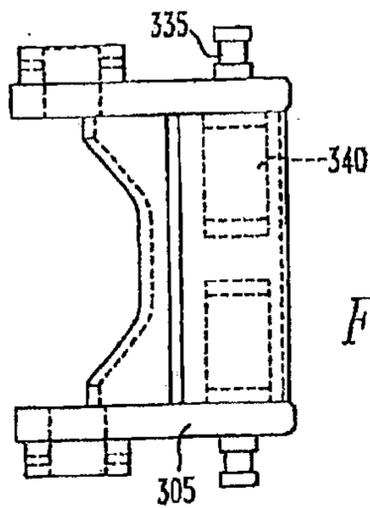
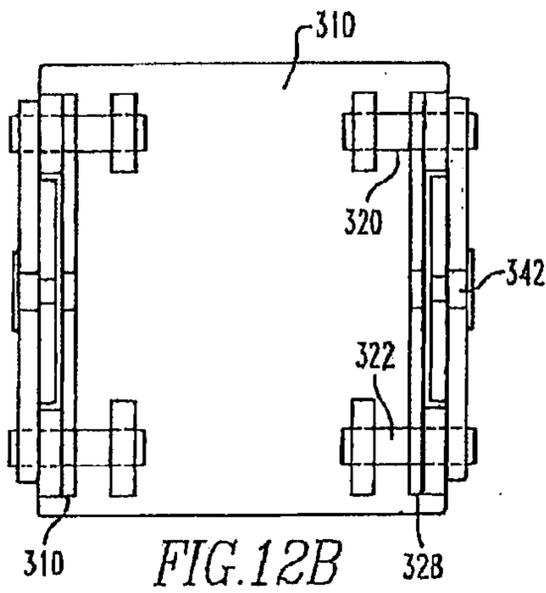
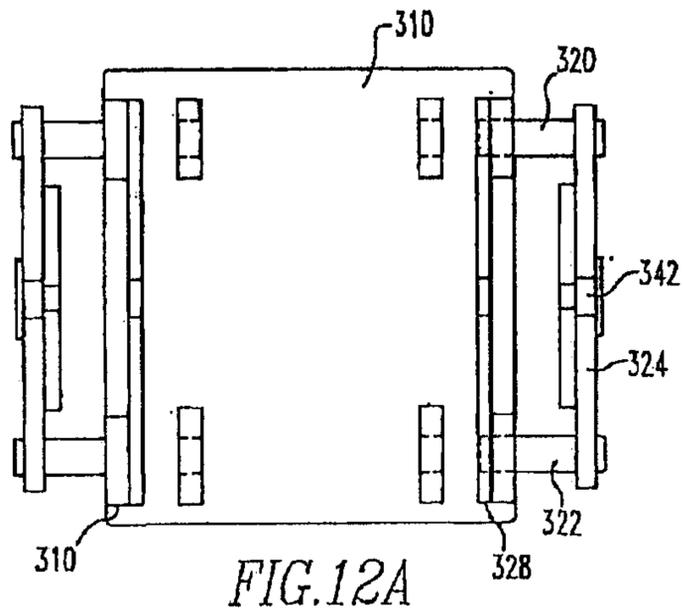


FIG. 11

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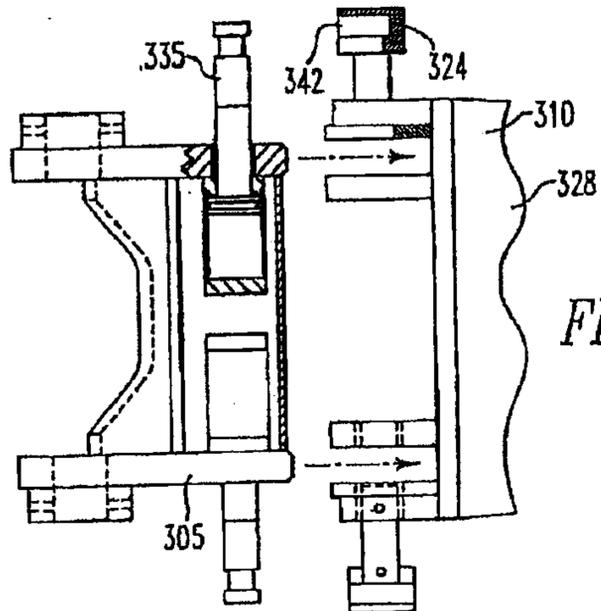


FIG. 13A

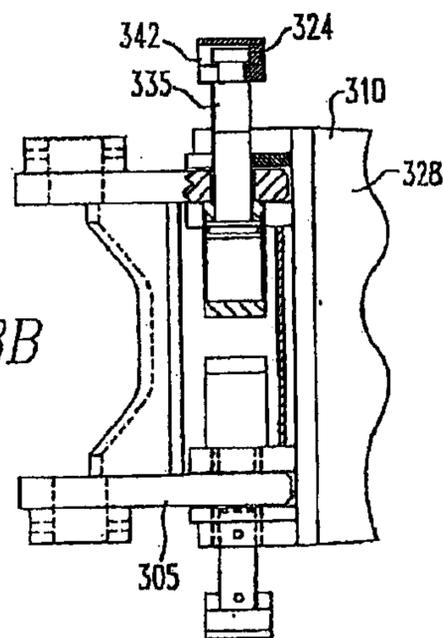


FIG. 13B

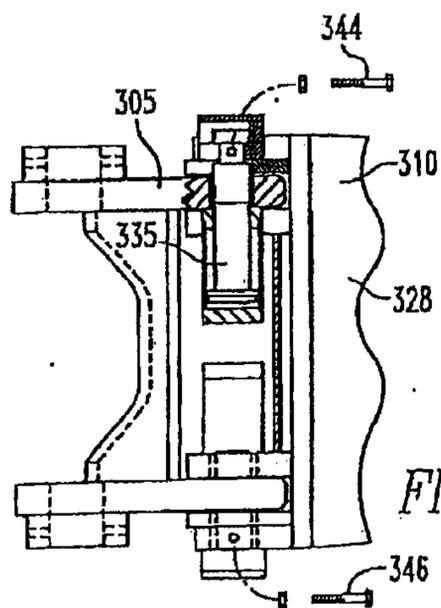
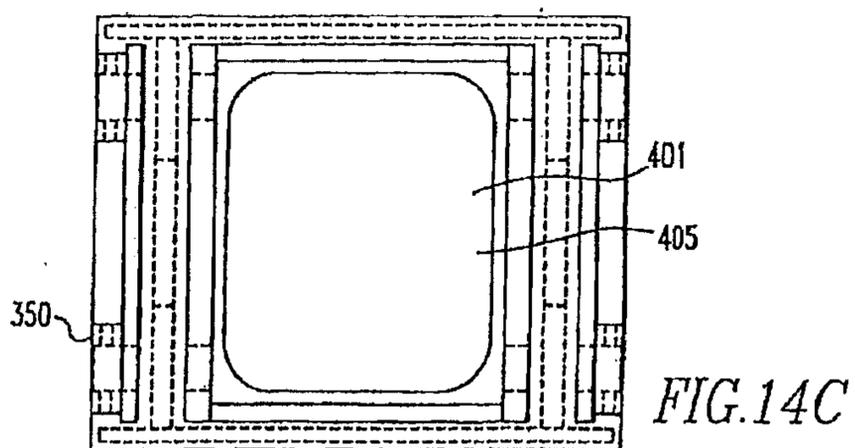
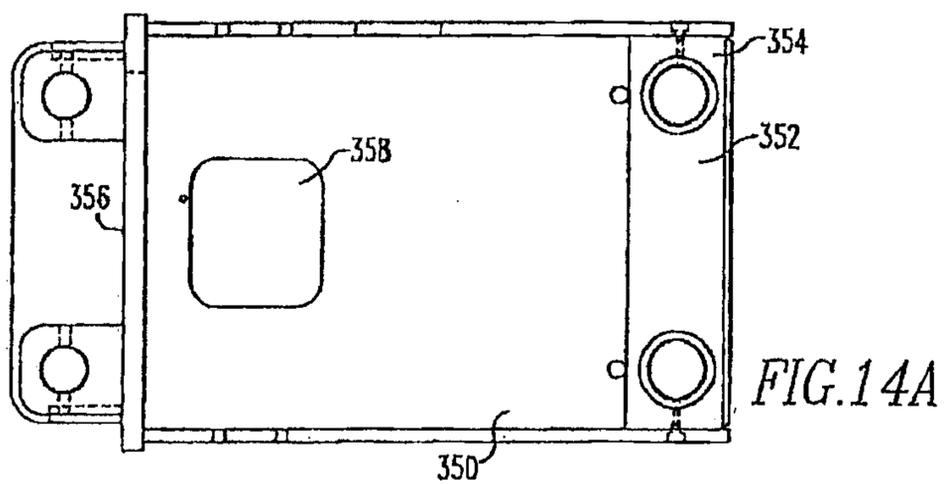
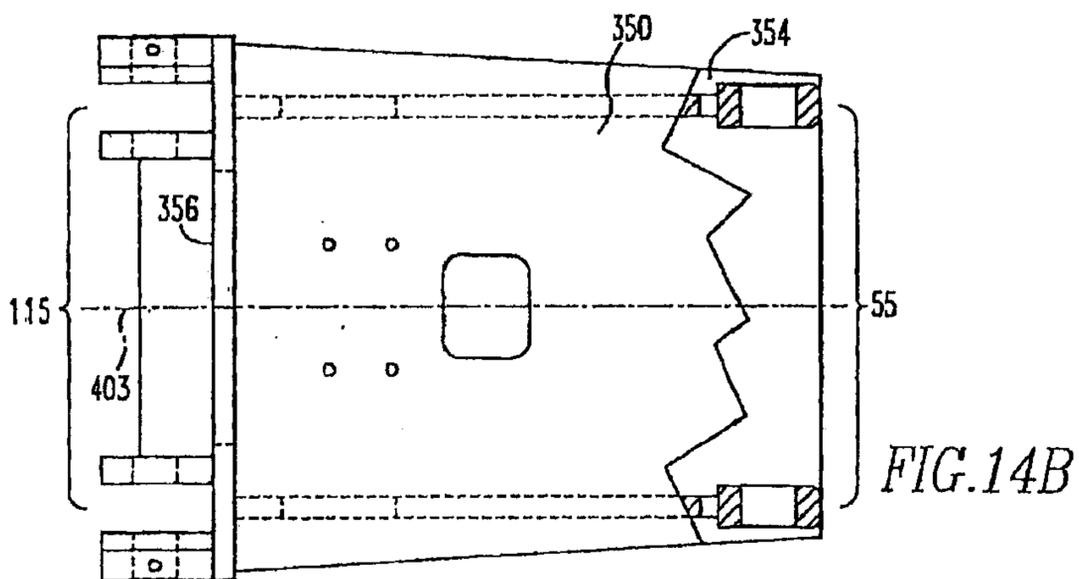


FIG. 13C

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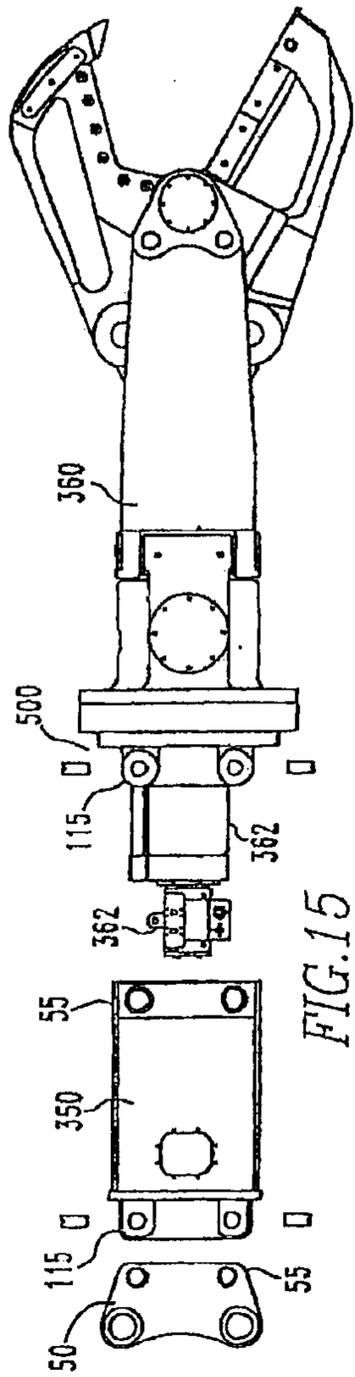


FIG. 15

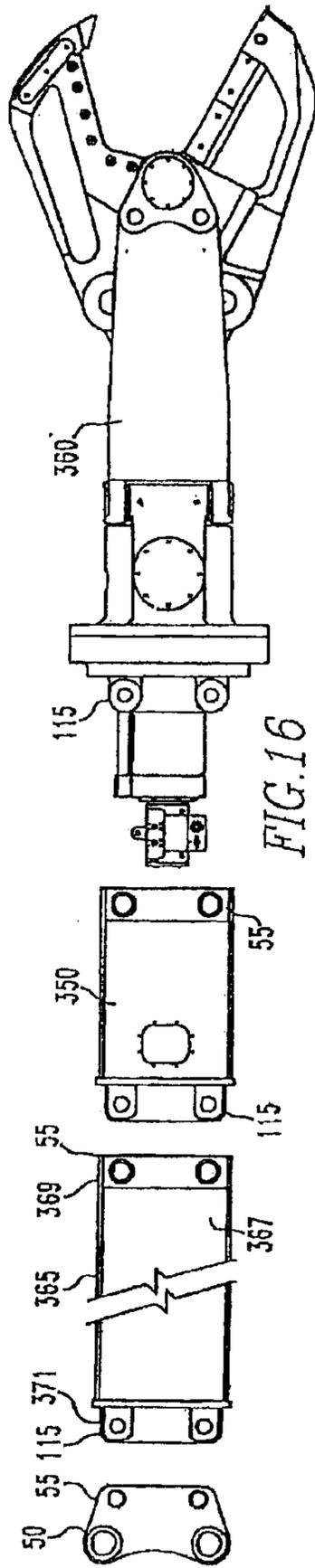


FIG. 16

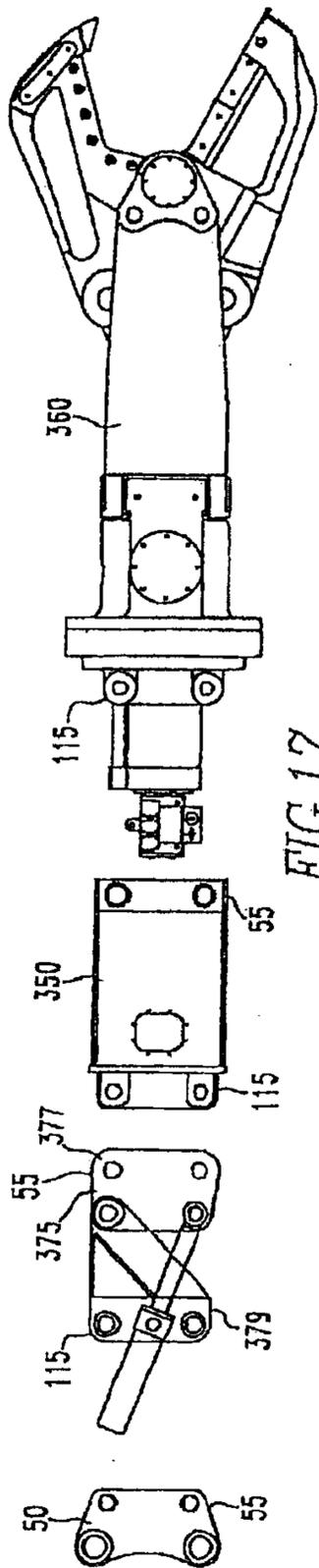


FIG. 17

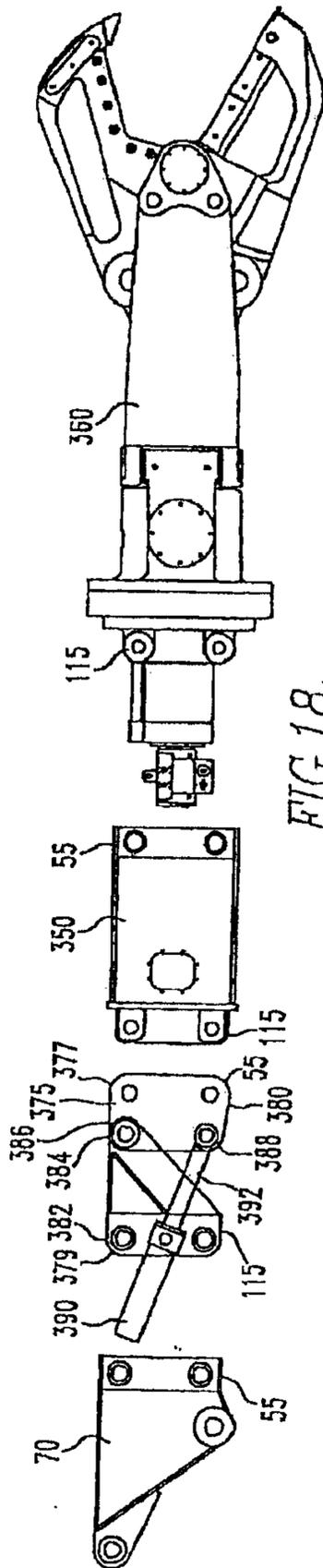
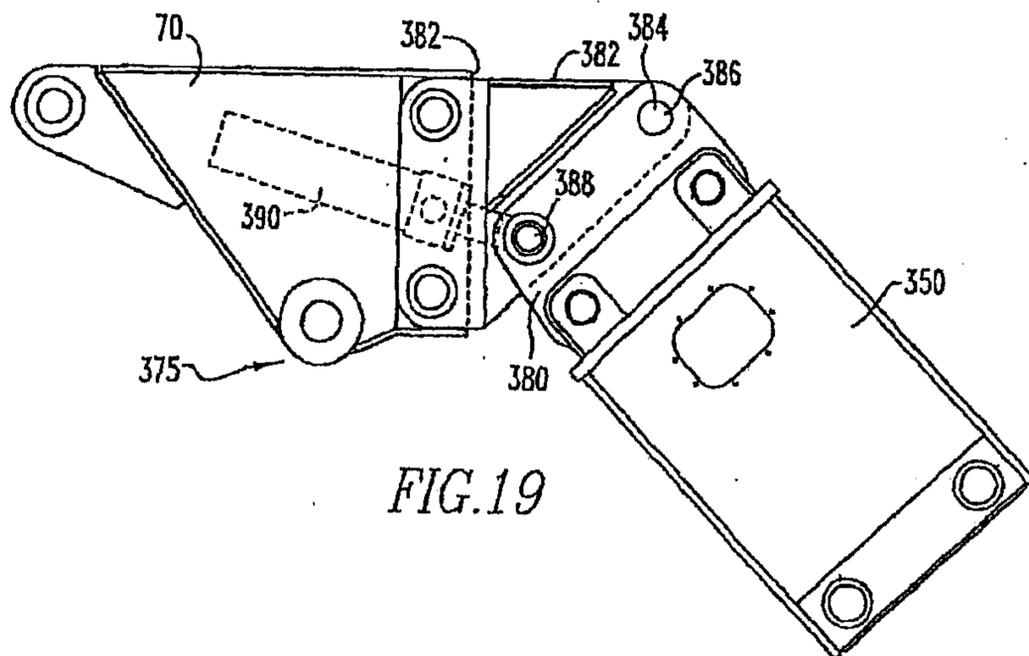
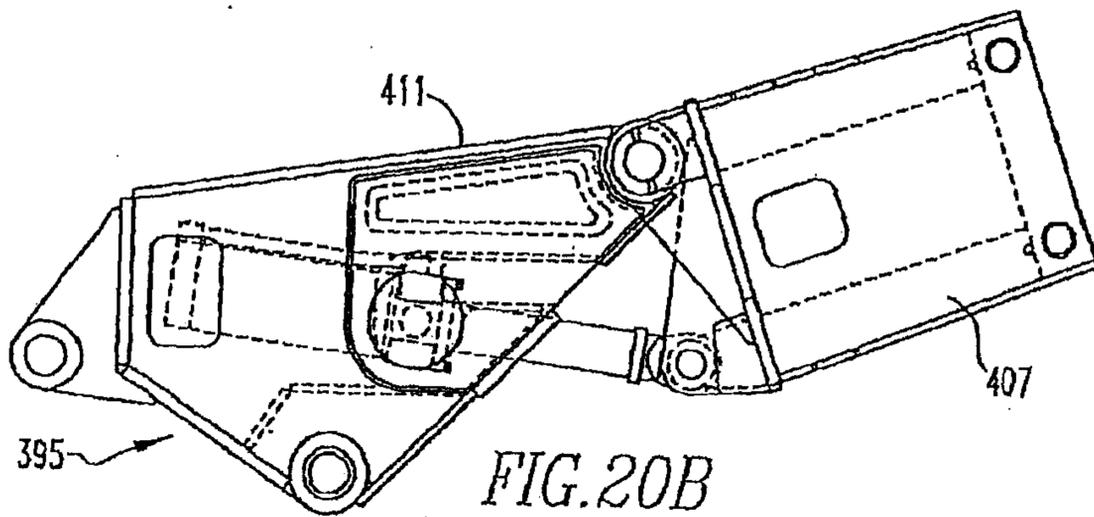
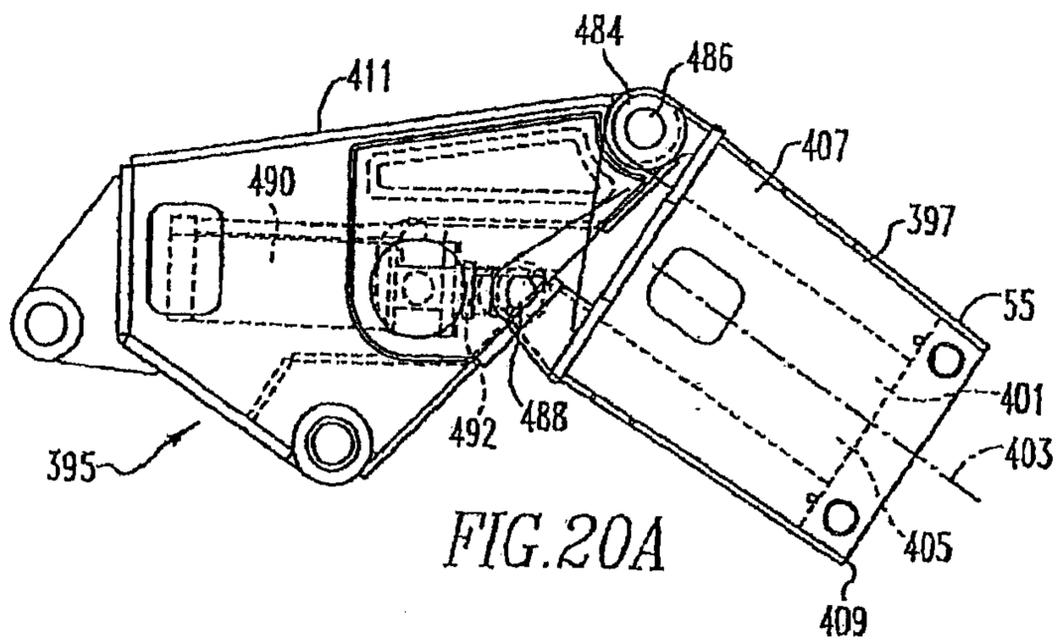


FIG. 18





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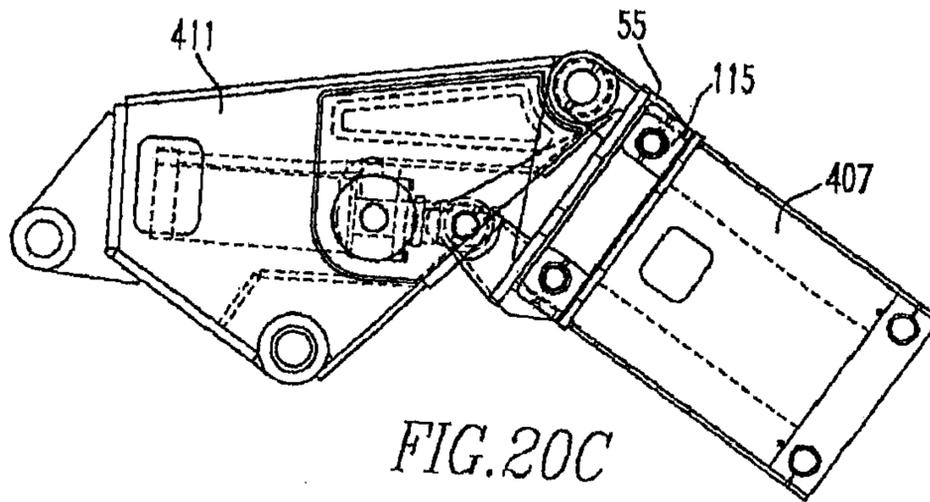


FIG. 20C

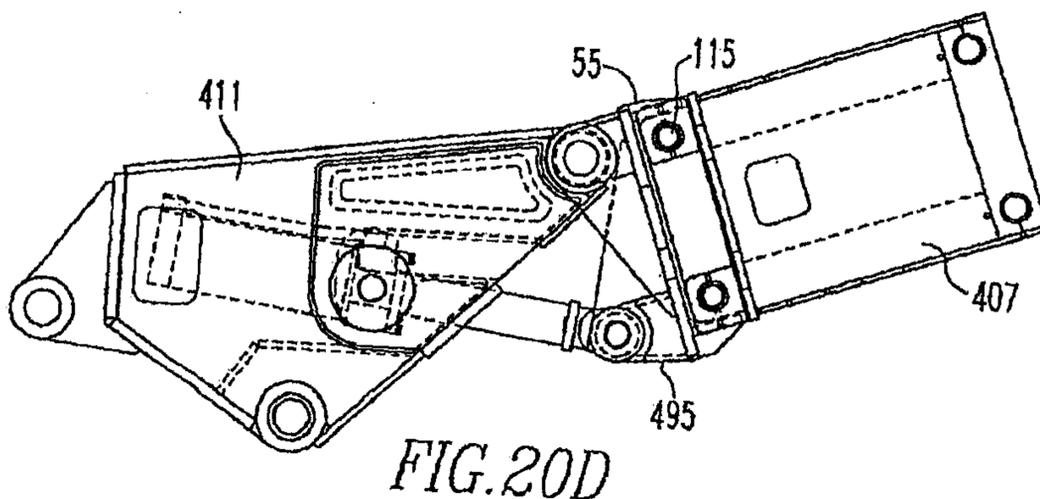
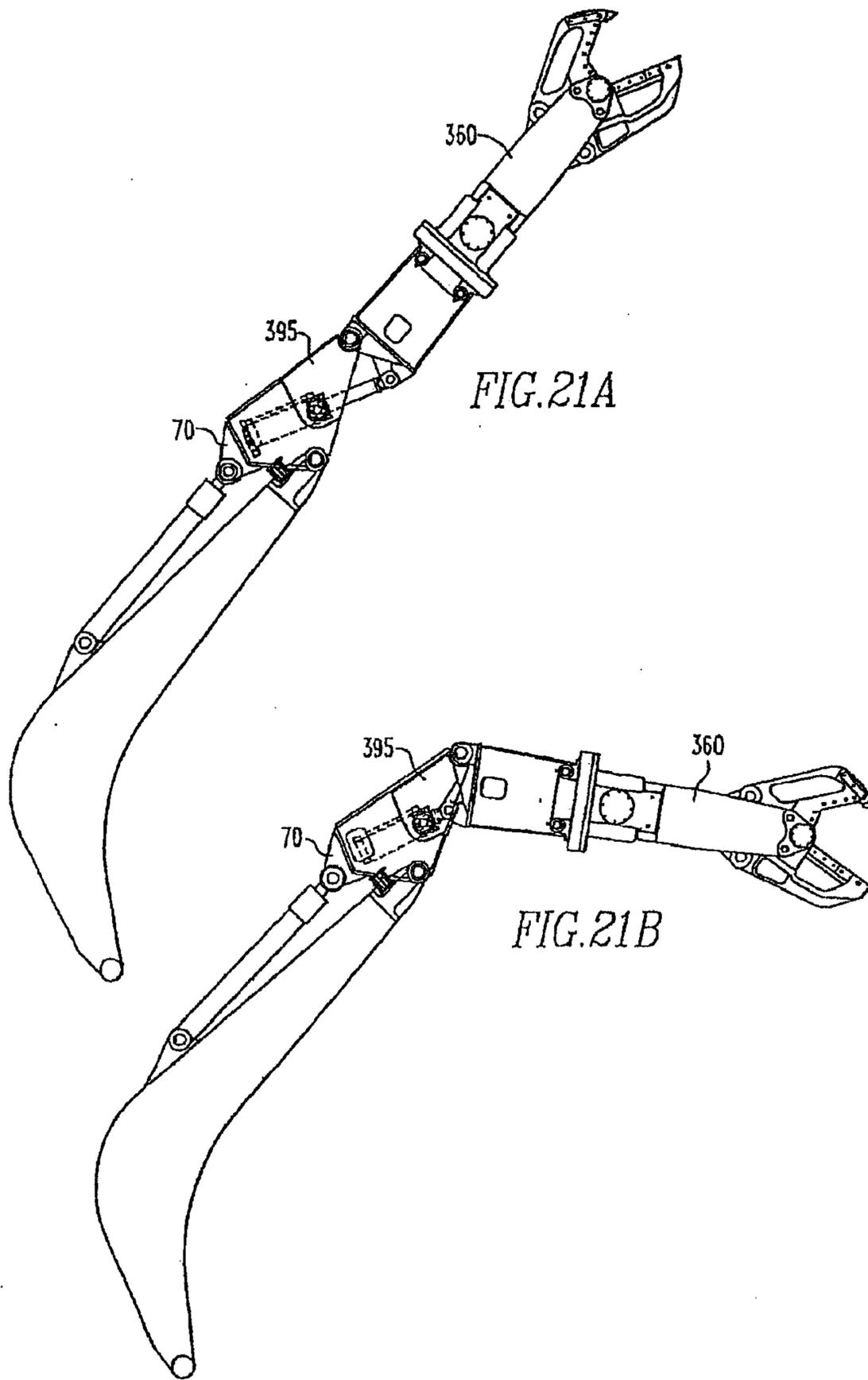


FIG. 20D

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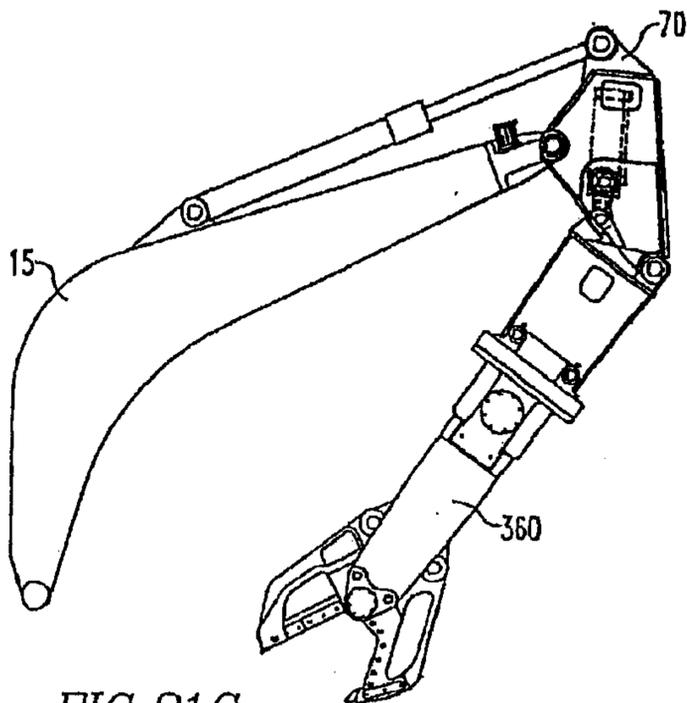


FIG. 21C

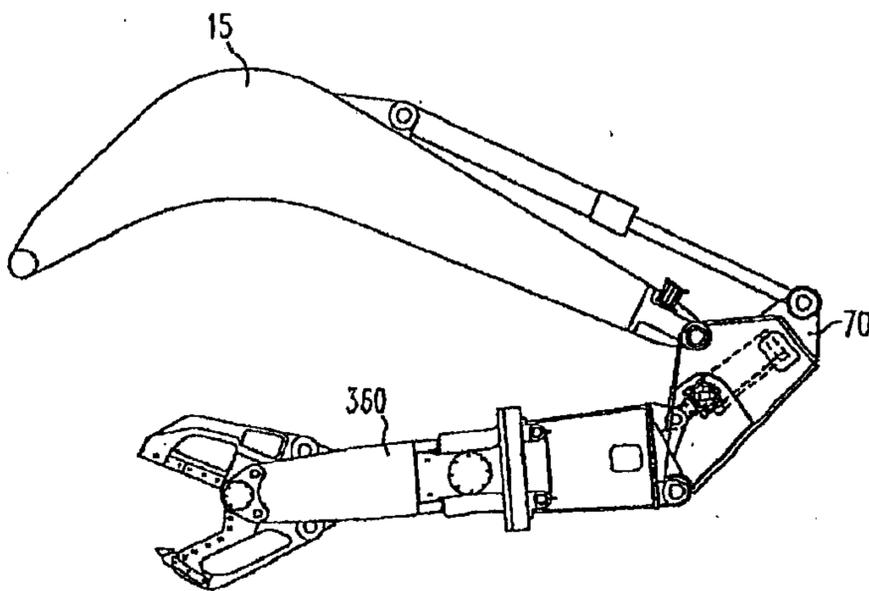


FIG. 21D

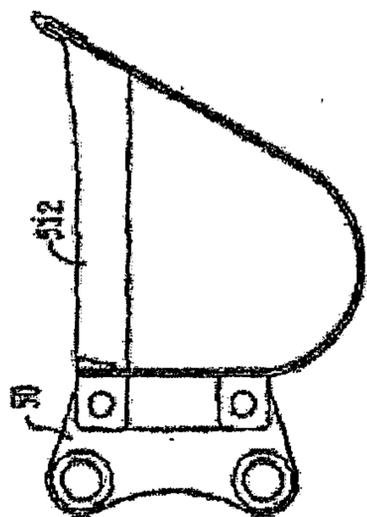


FIG. 28

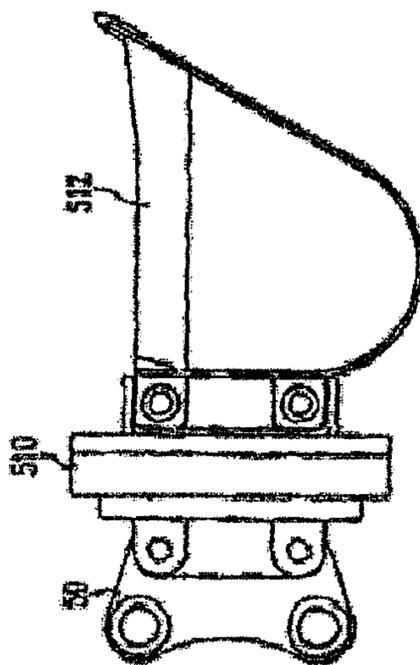


FIG. 29

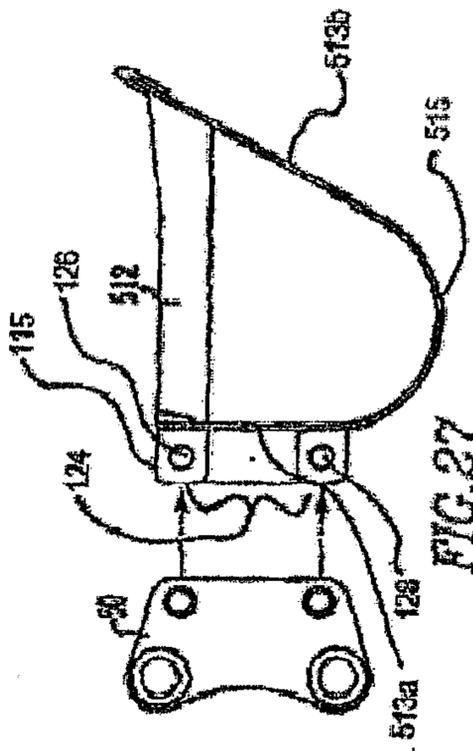


FIG. 27

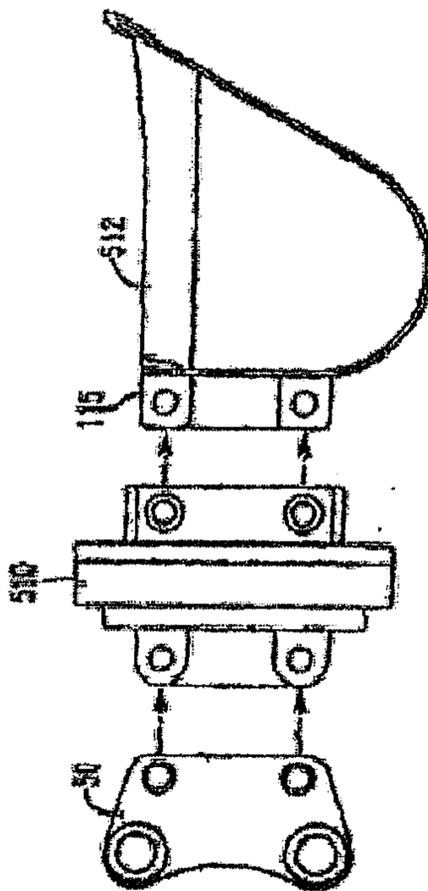


FIG. 22

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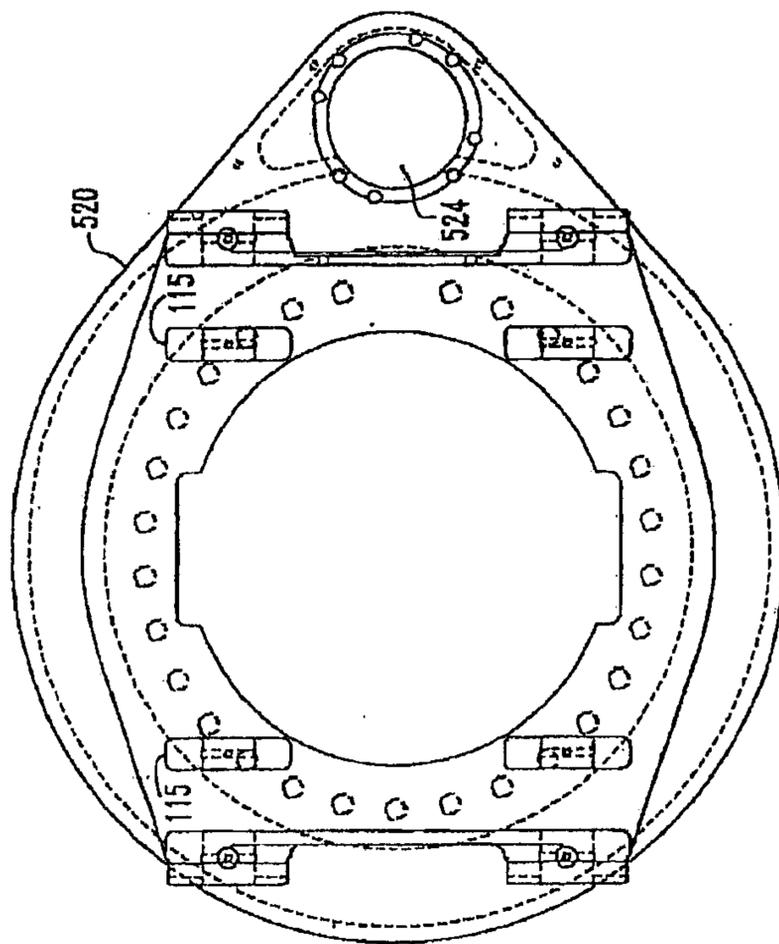


FIG. 25

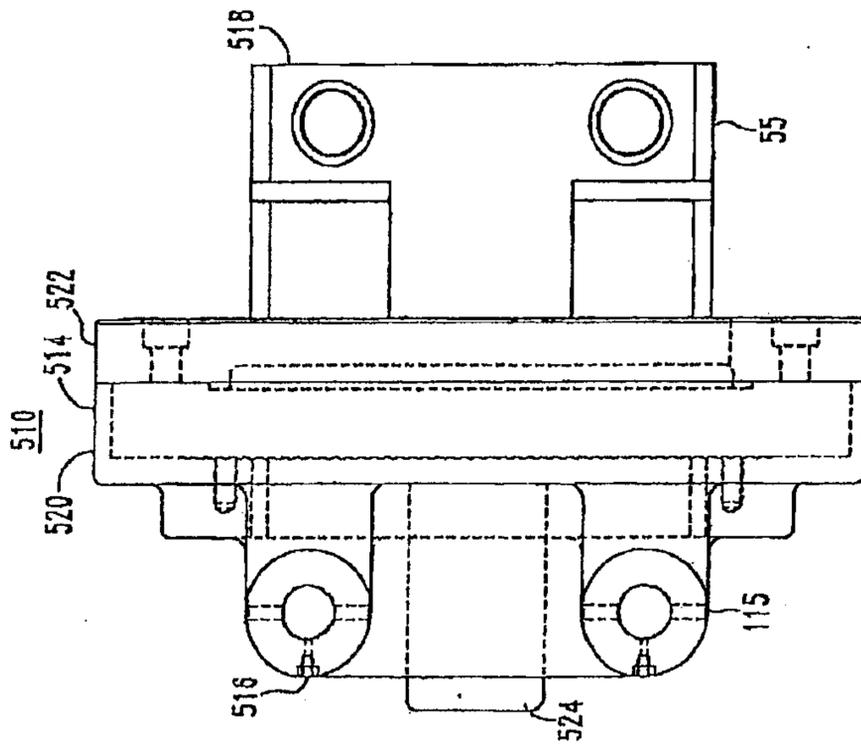


FIG. 24

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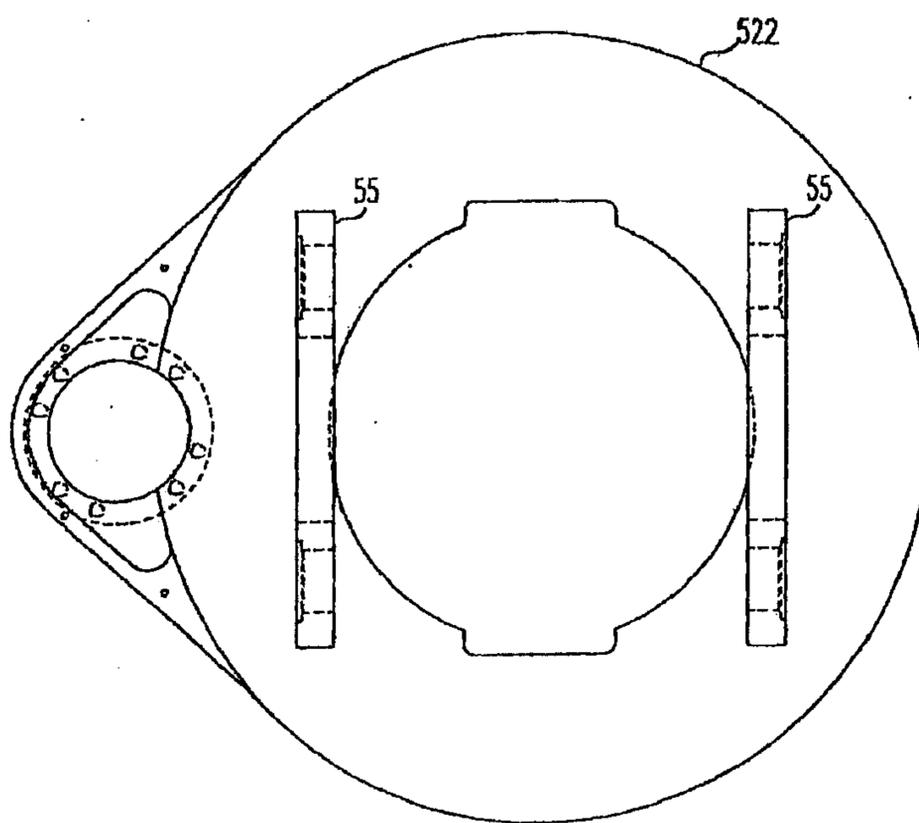


FIG. 26

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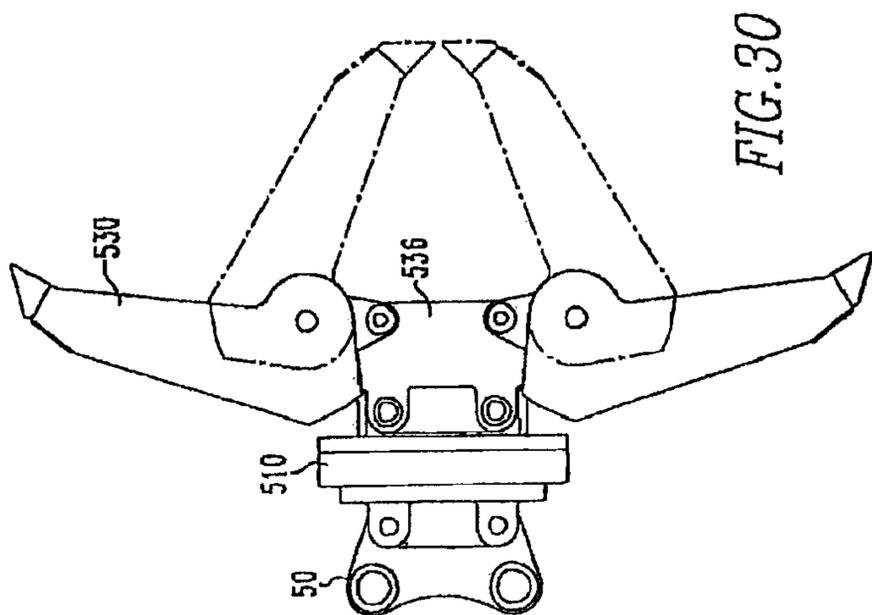


FIG. 30

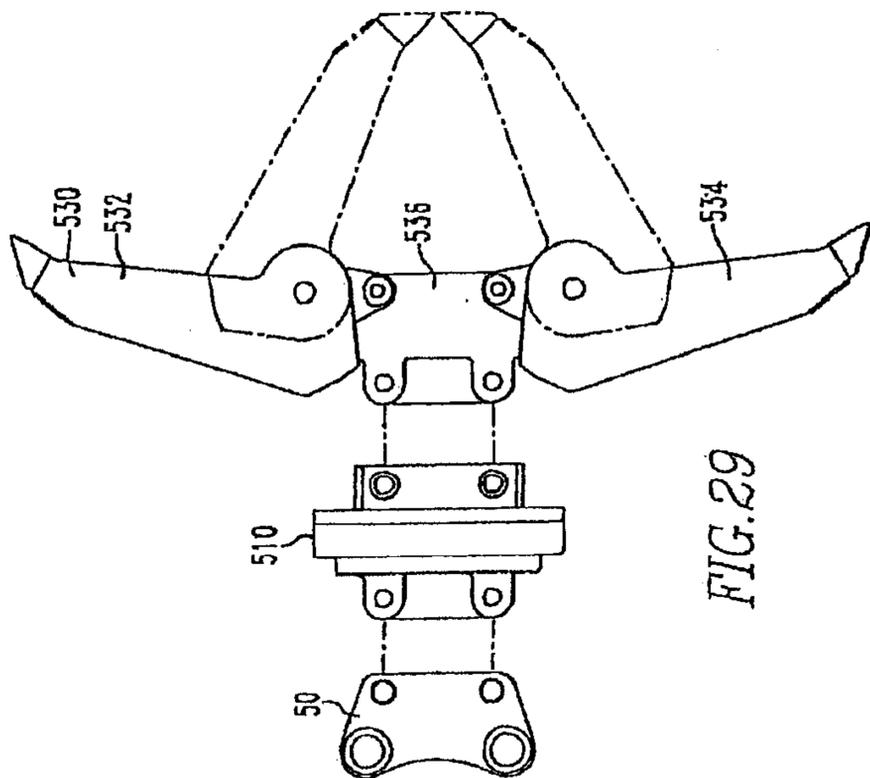
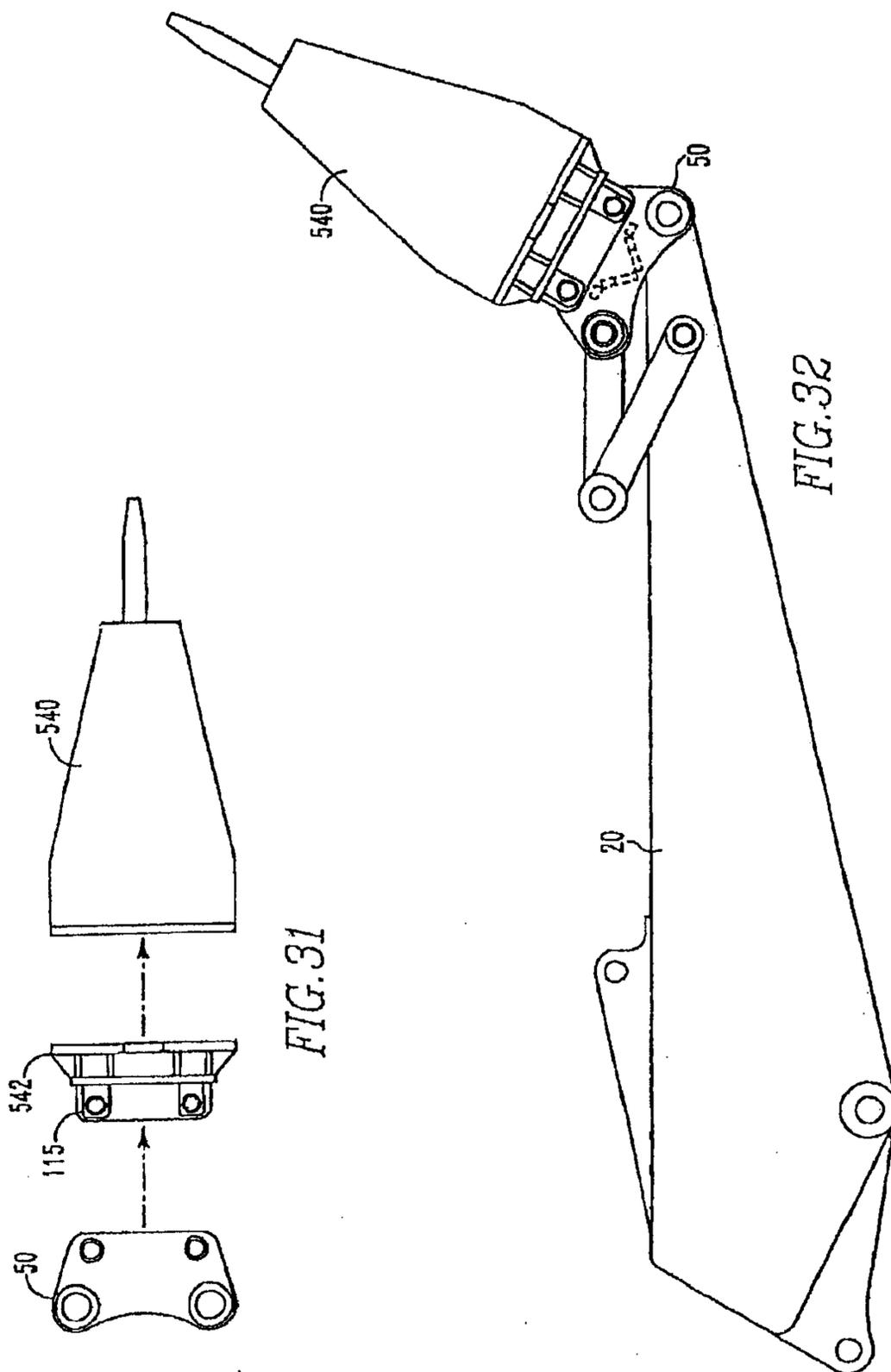
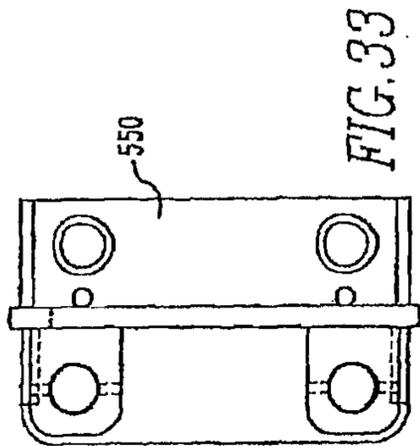
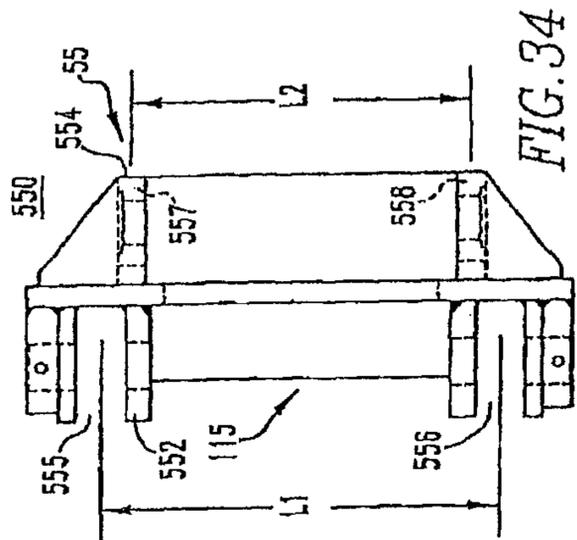
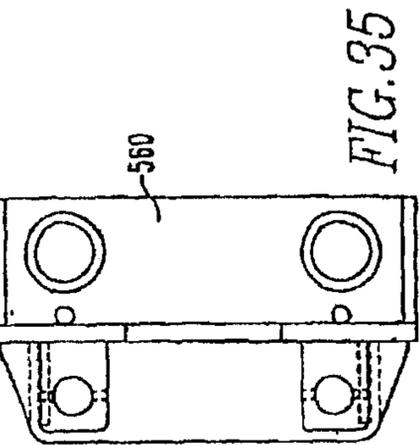
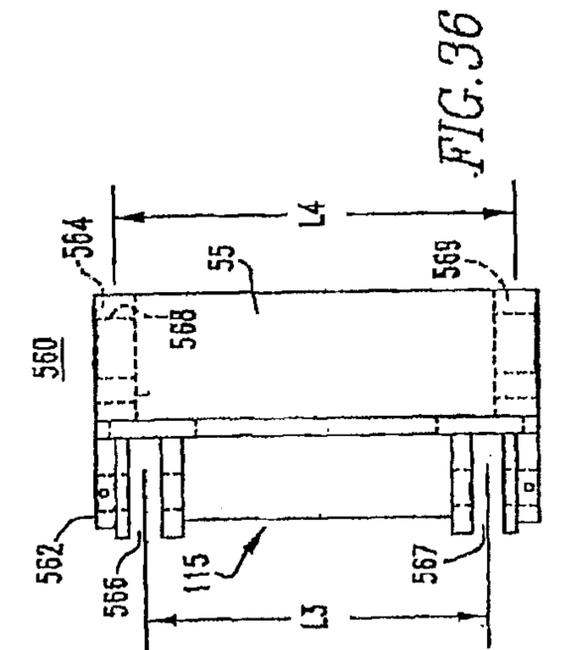


FIG. 29





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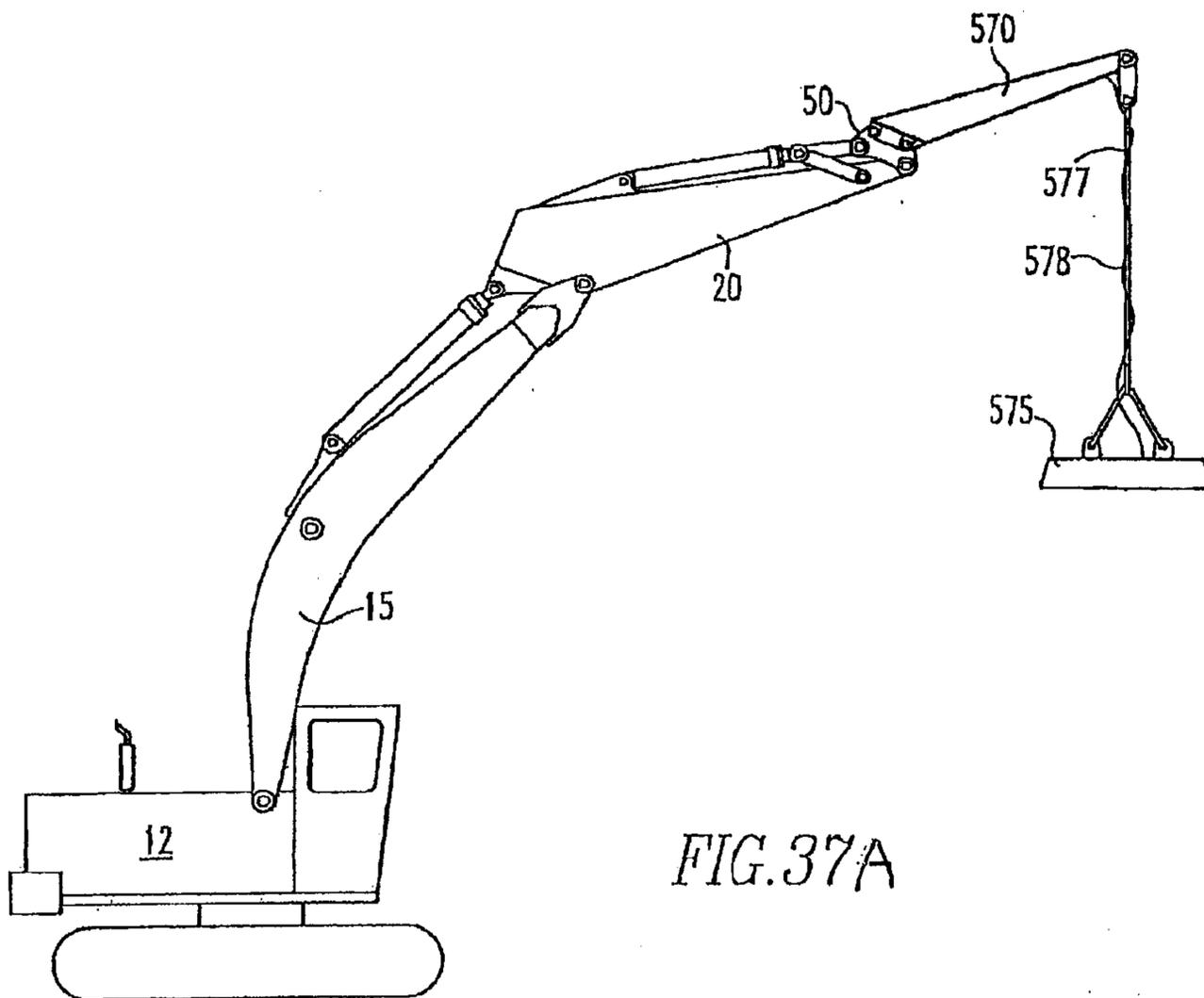
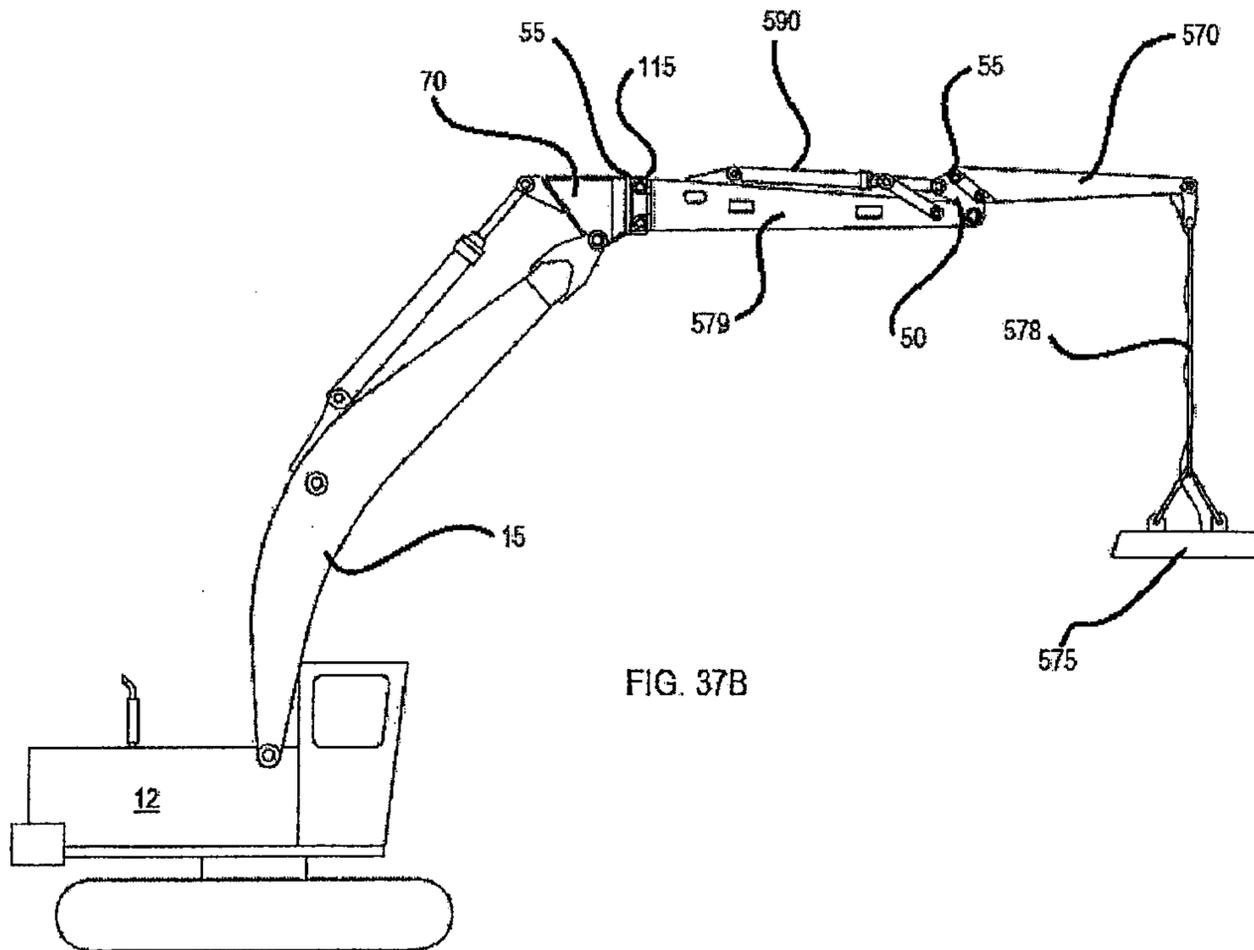


FIG. 37A

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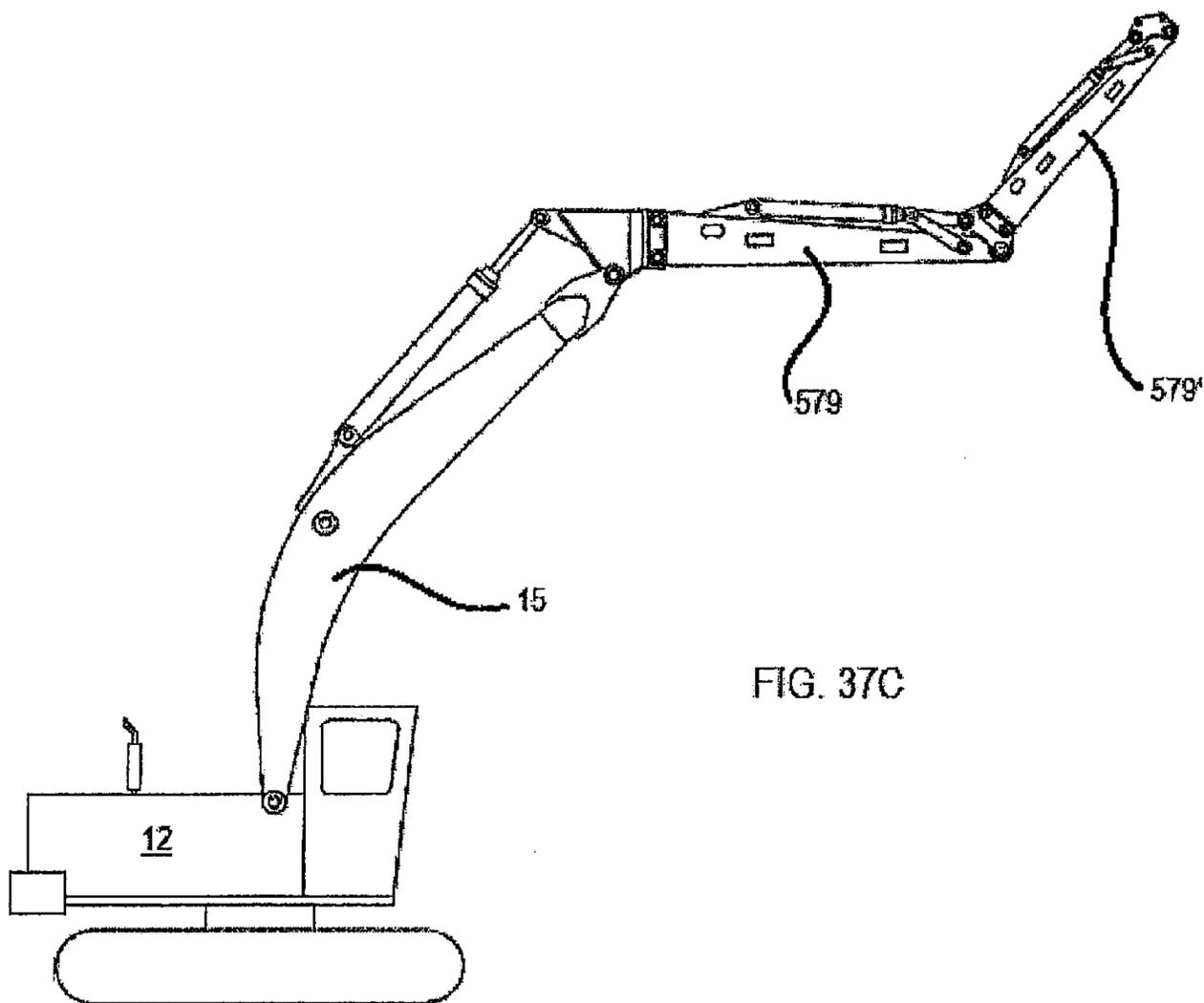
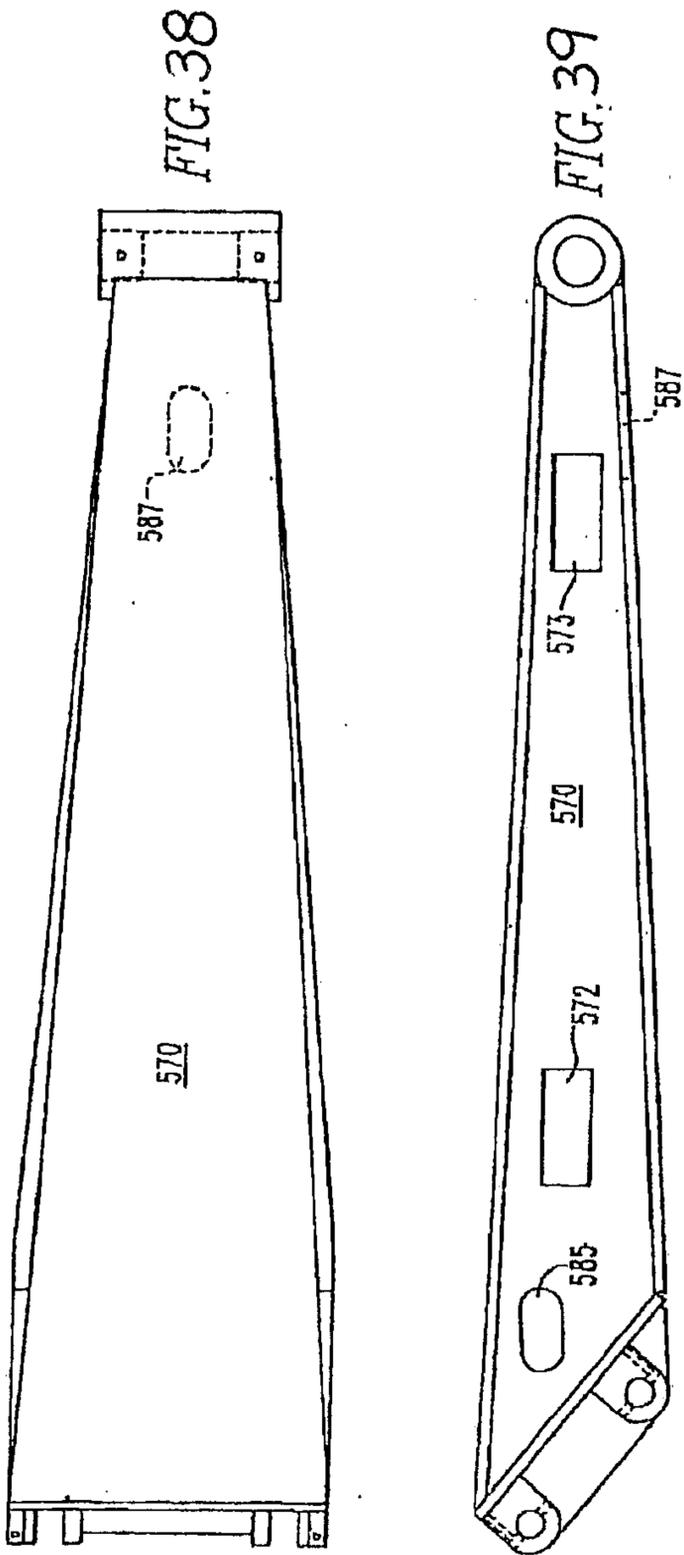


FIG. 37C



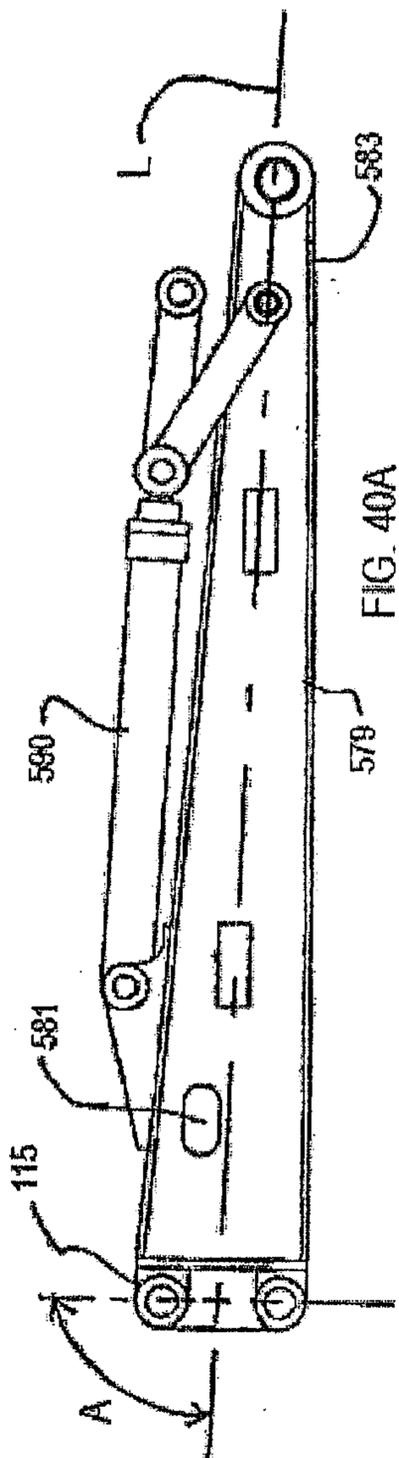


FIG. 40A

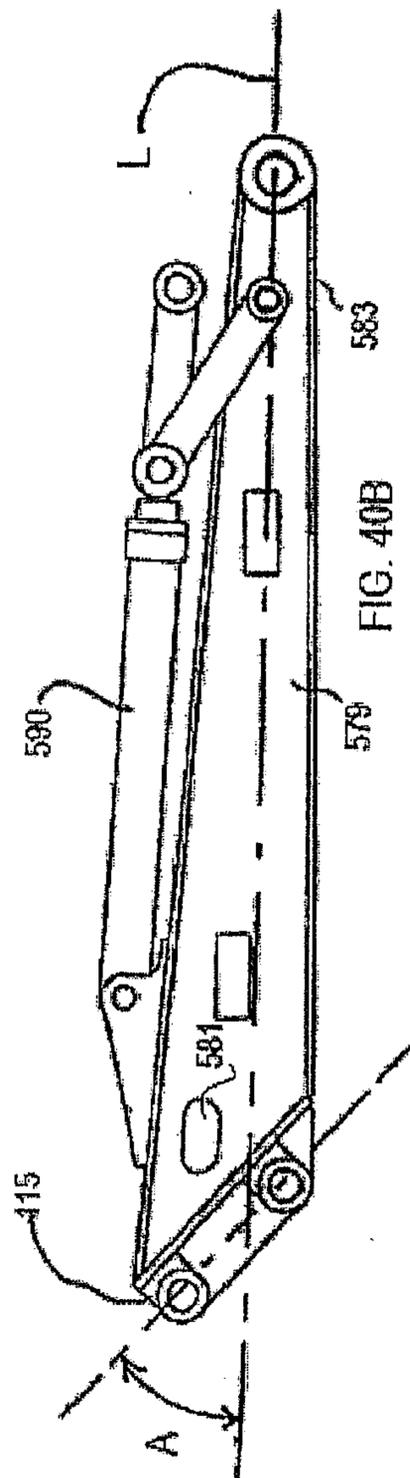


FIG. 40B

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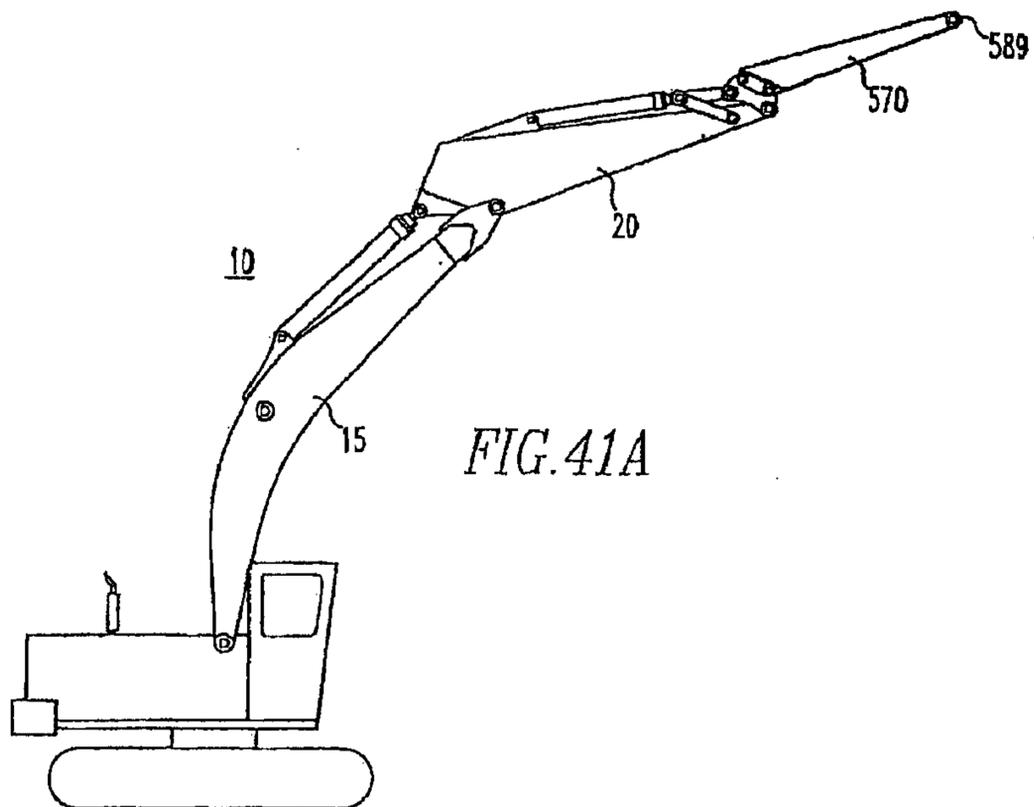


FIG. 41A

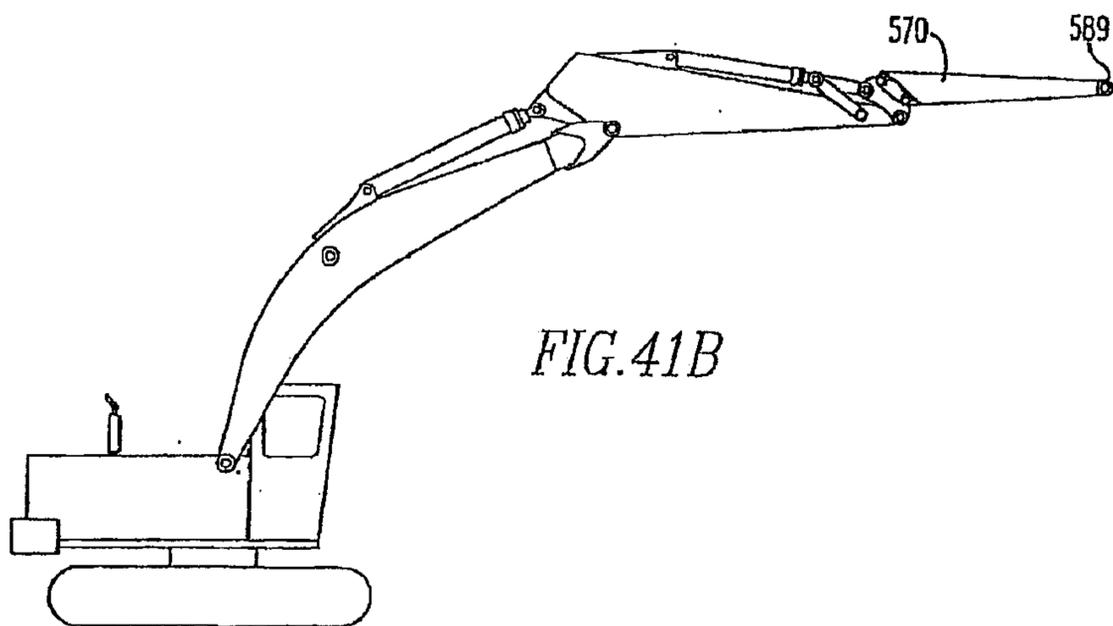
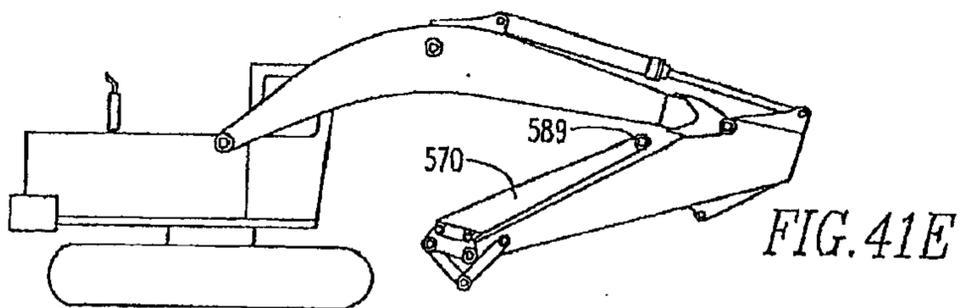
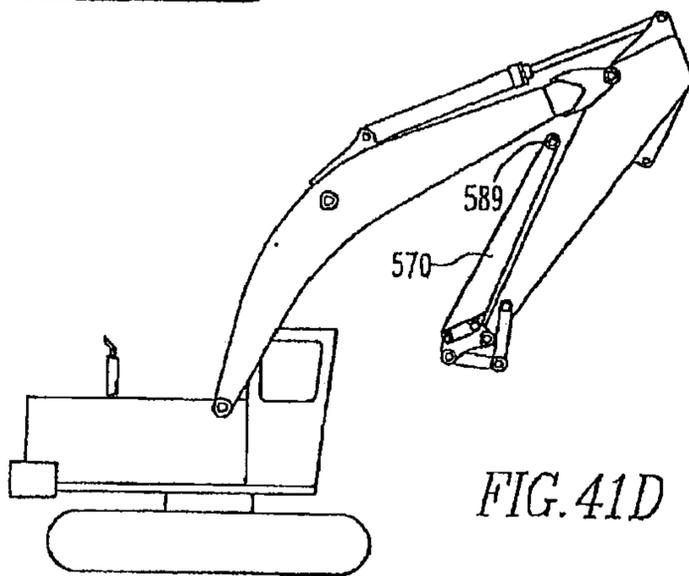
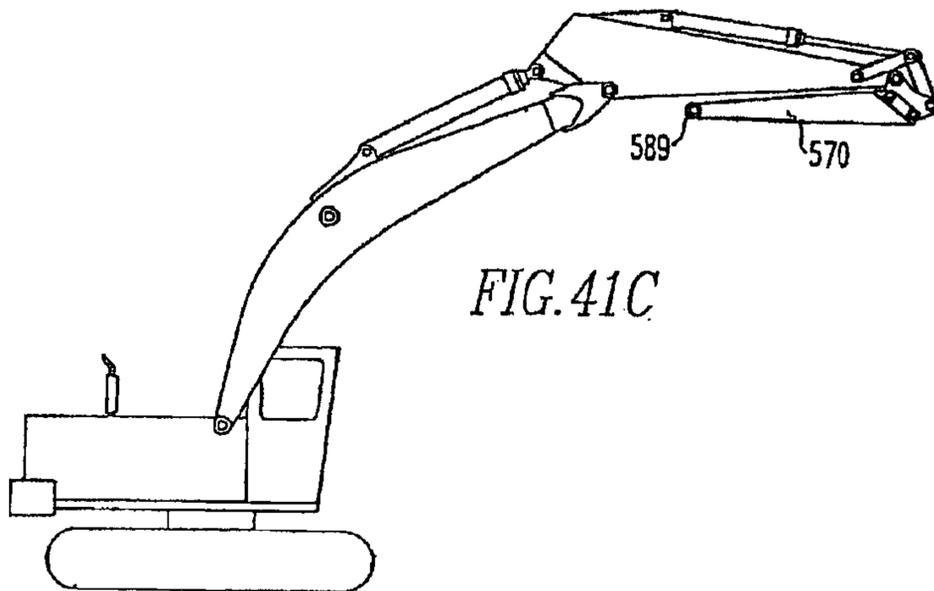


FIG. 41B

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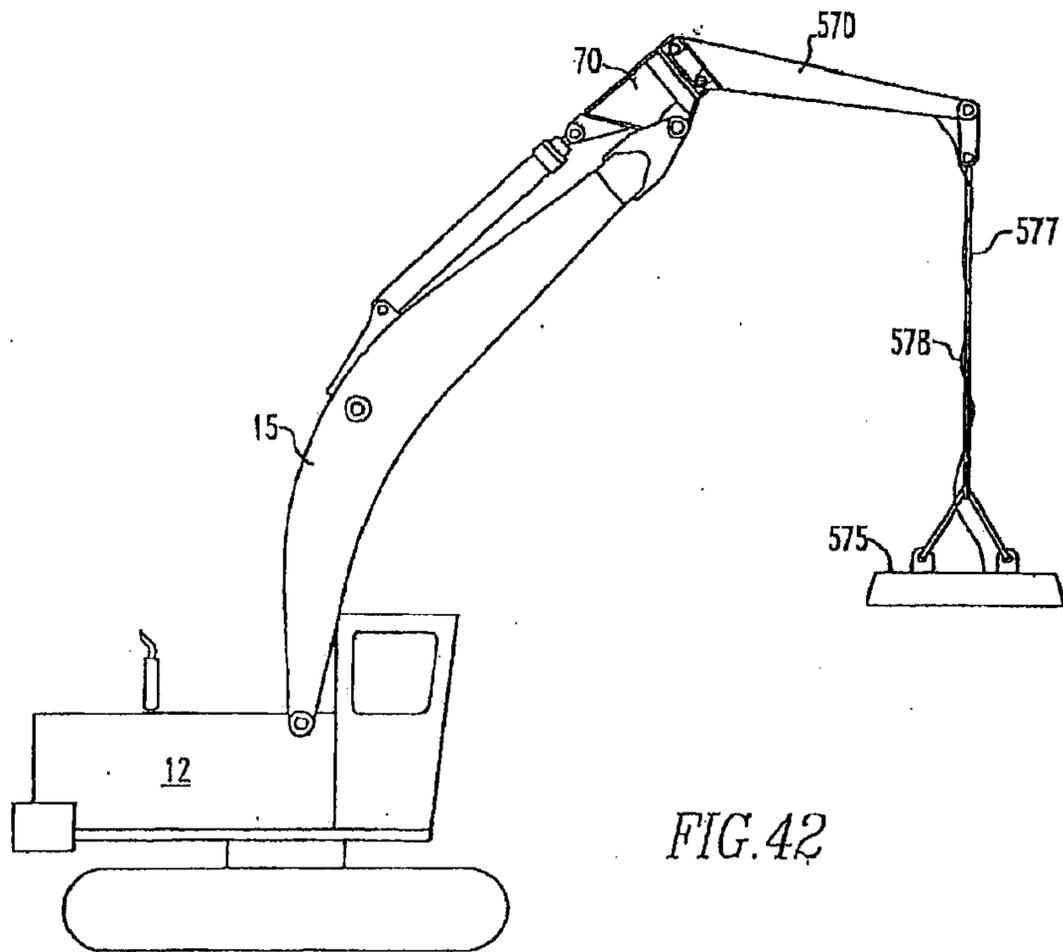


FIG. 42

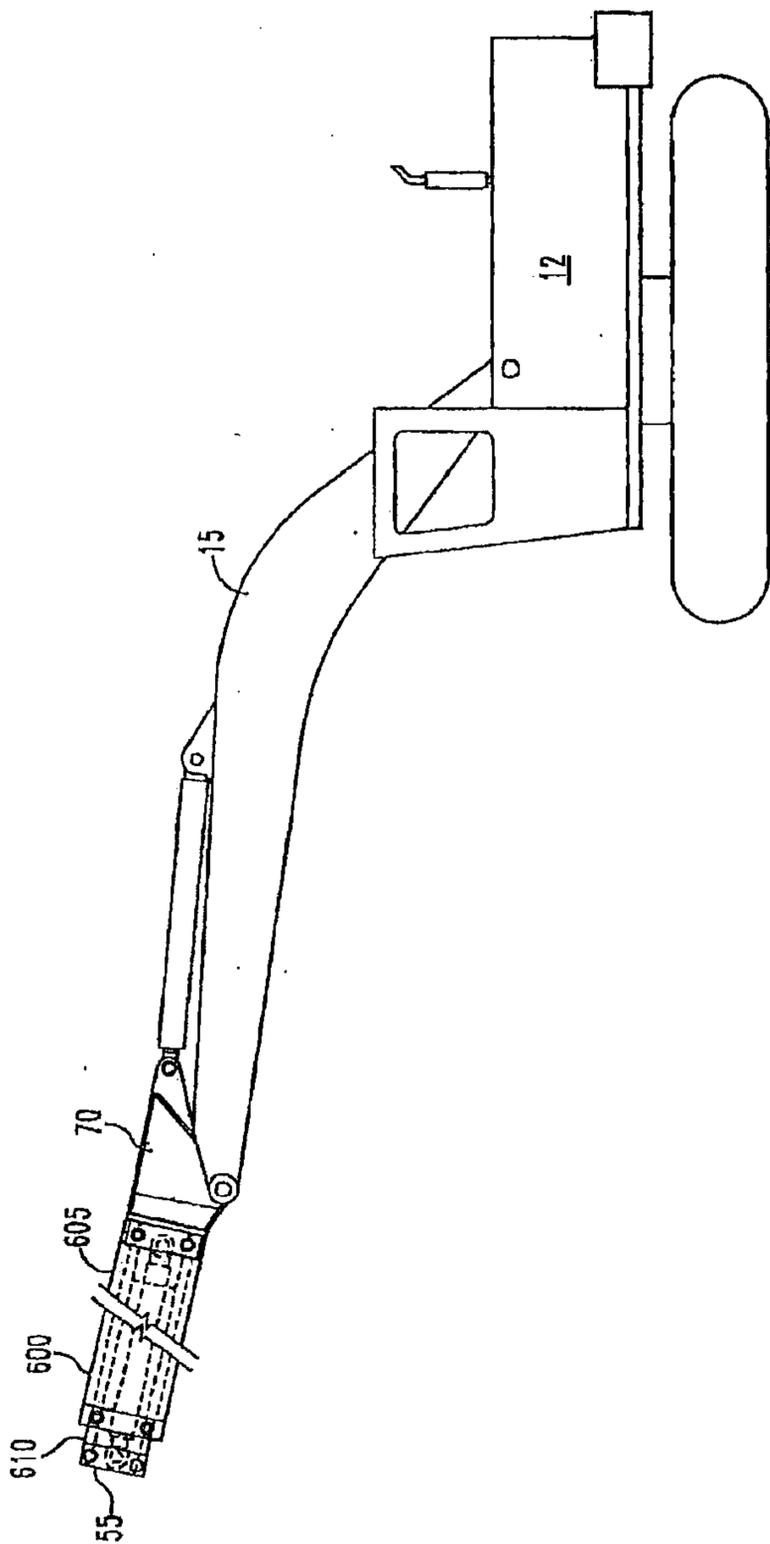


FIG. 43A

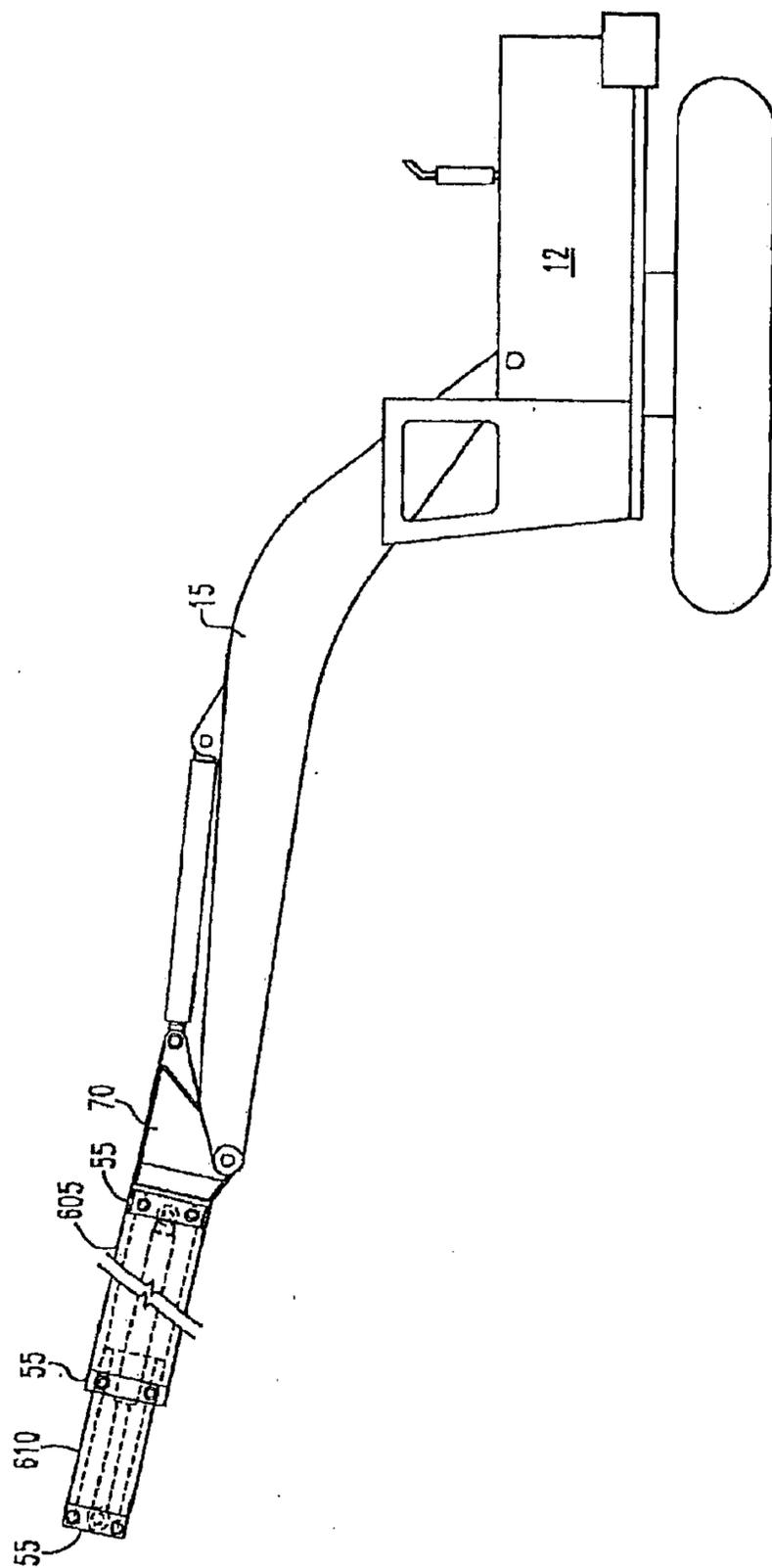
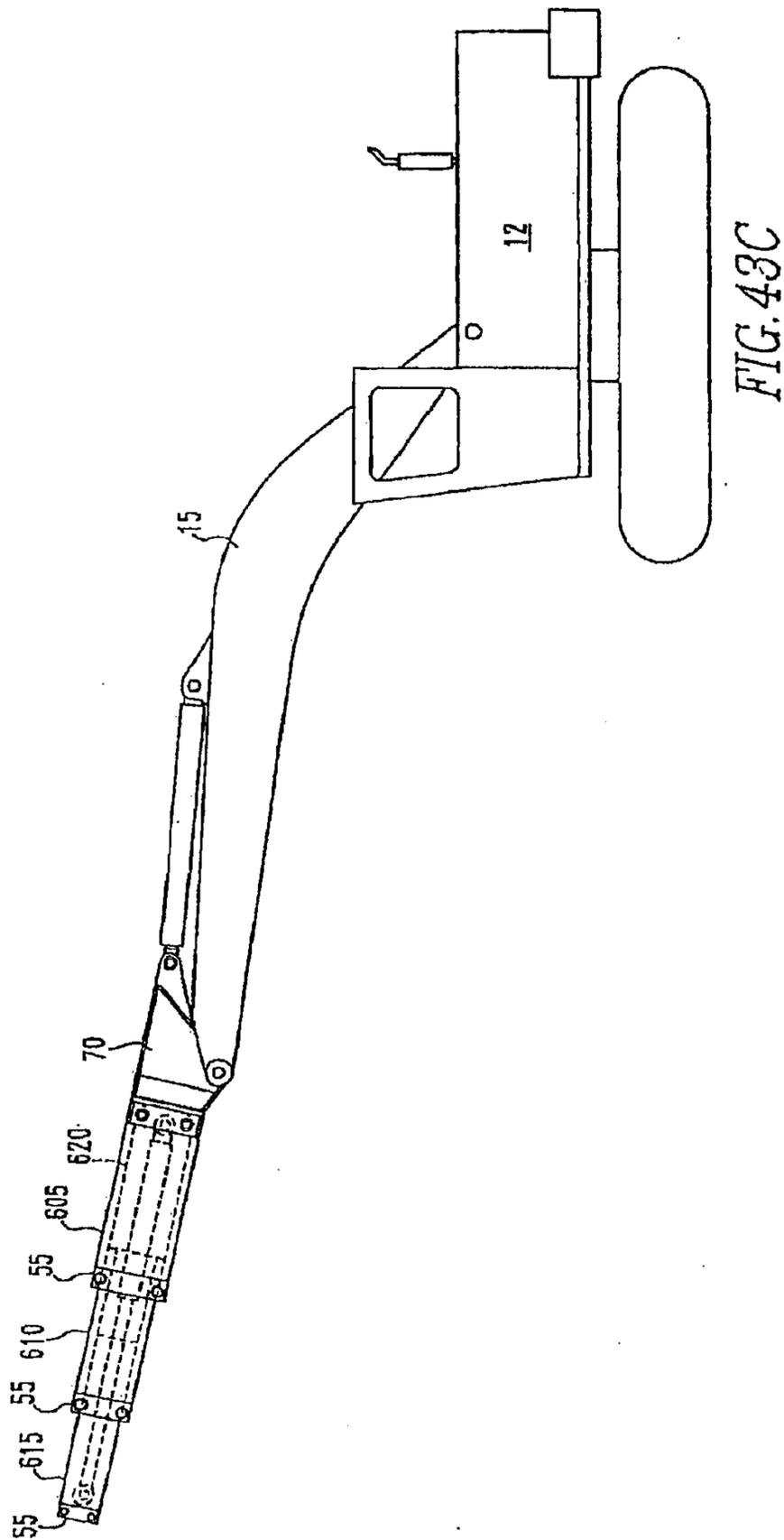
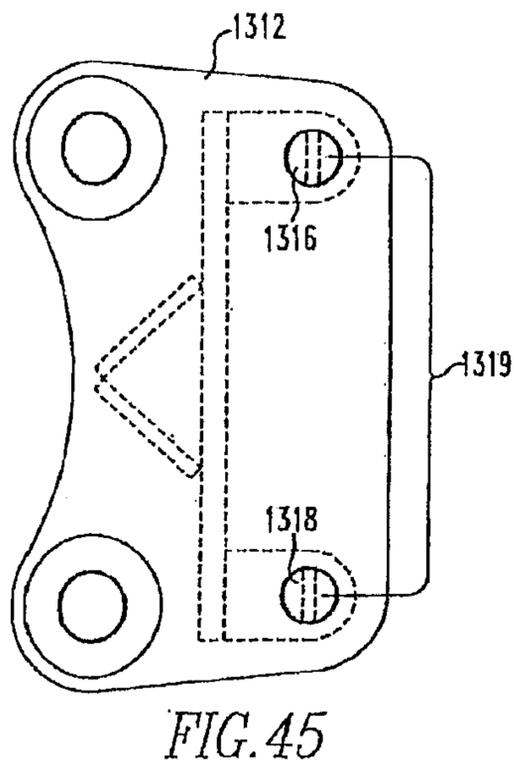
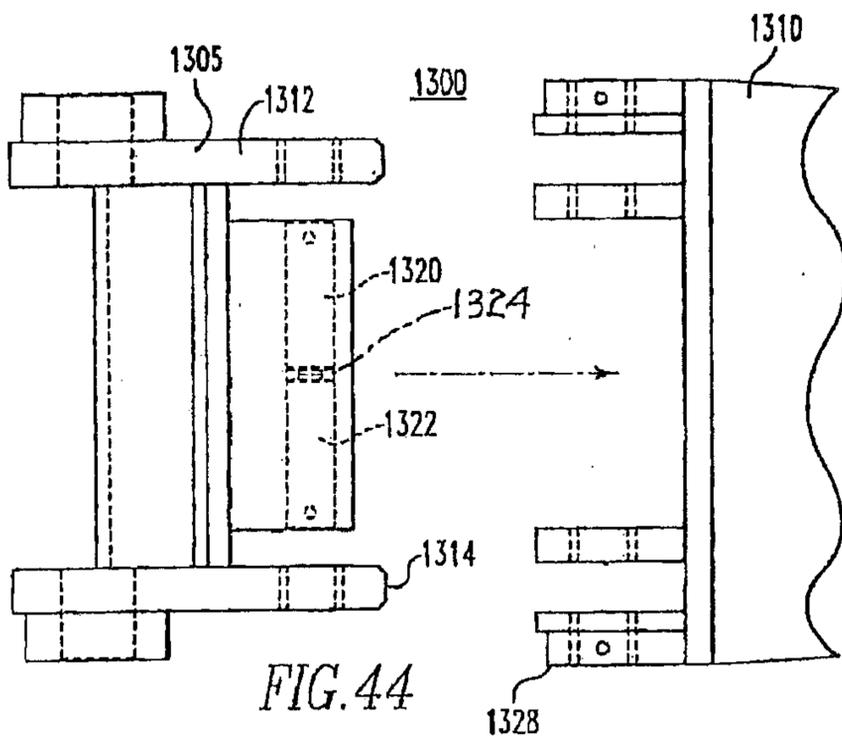


FIG. 43B



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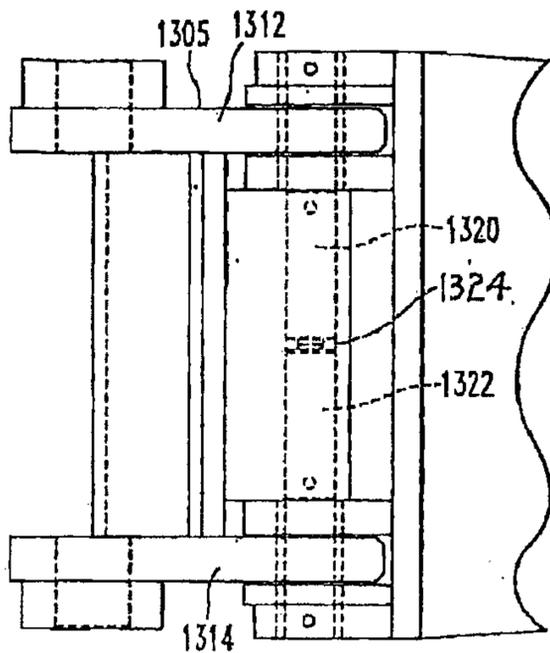


FIG. 46

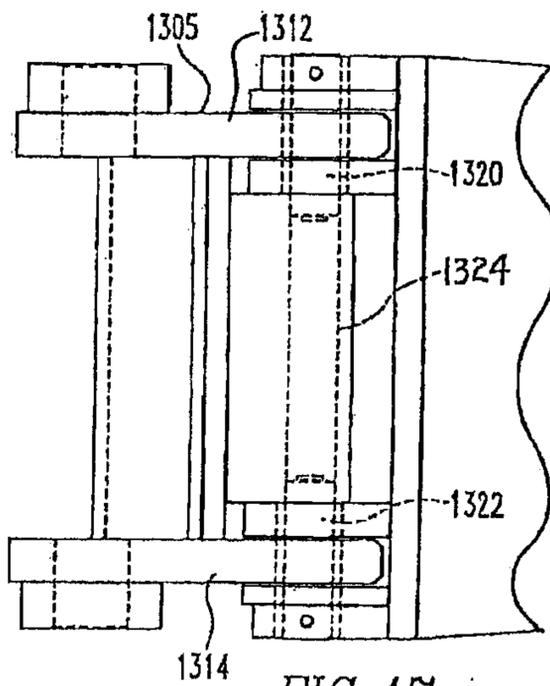


FIG. 47

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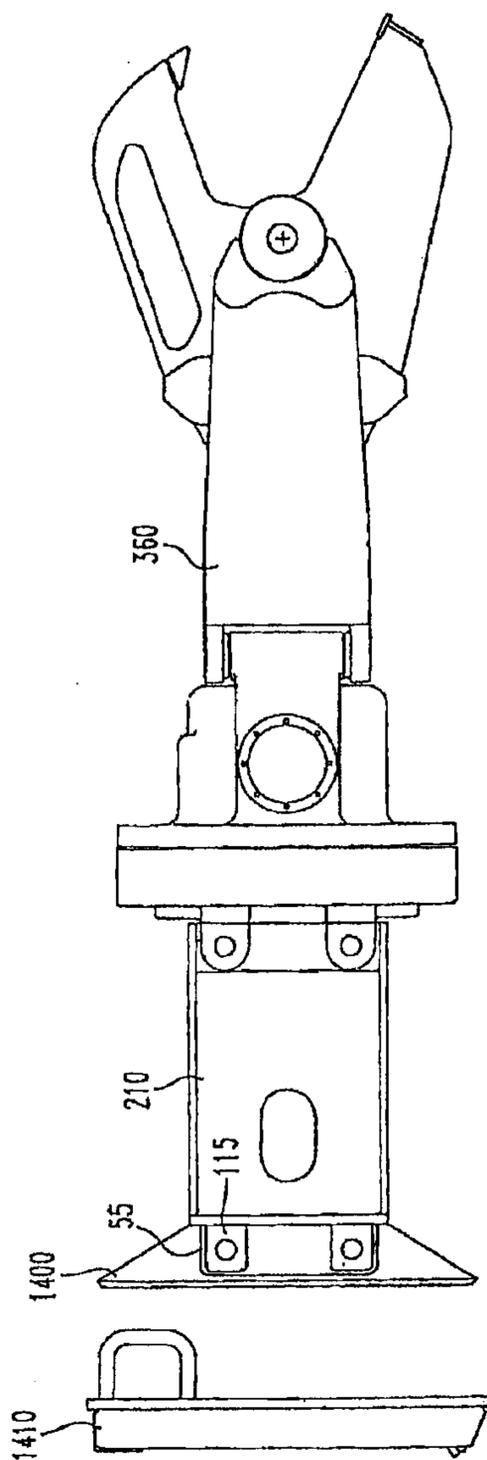


FIG. 48

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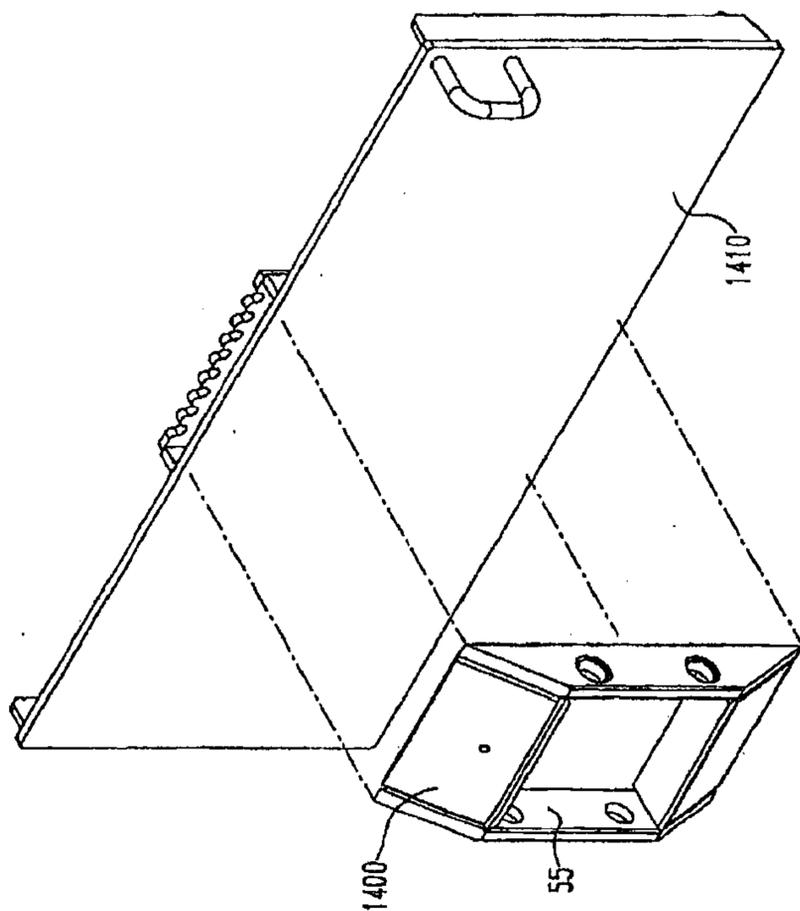


FIG. 49

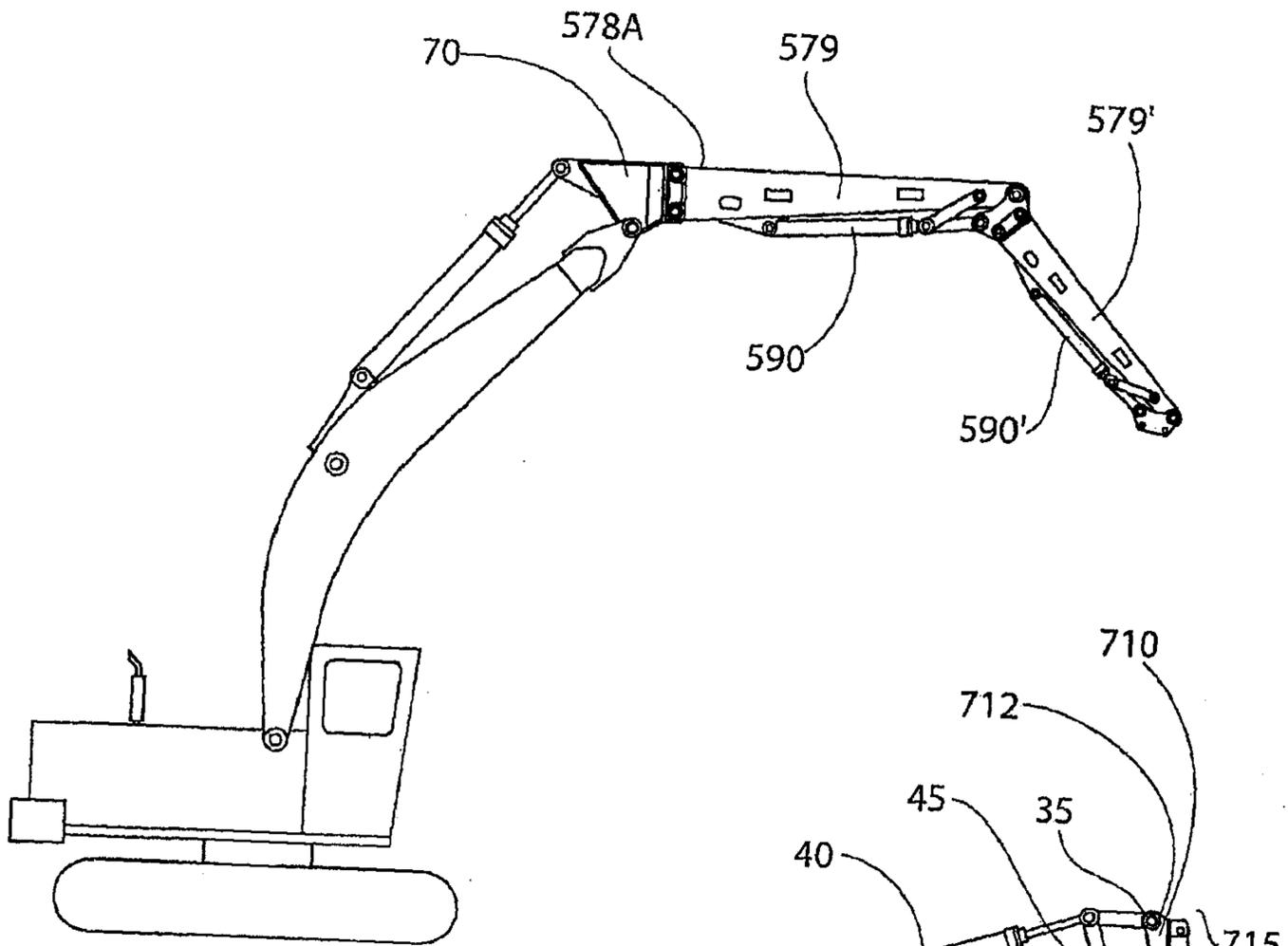


FIG. 50

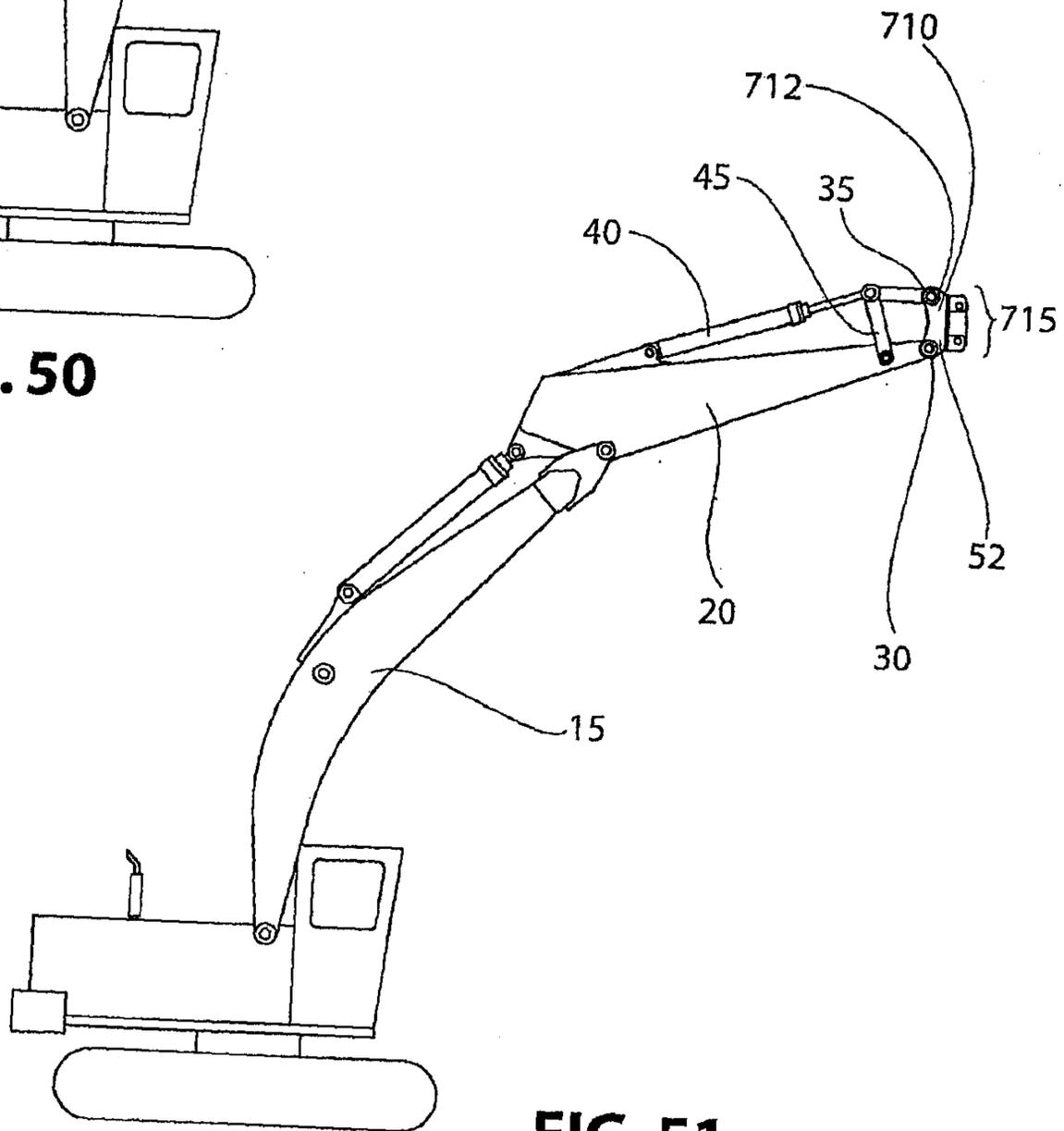
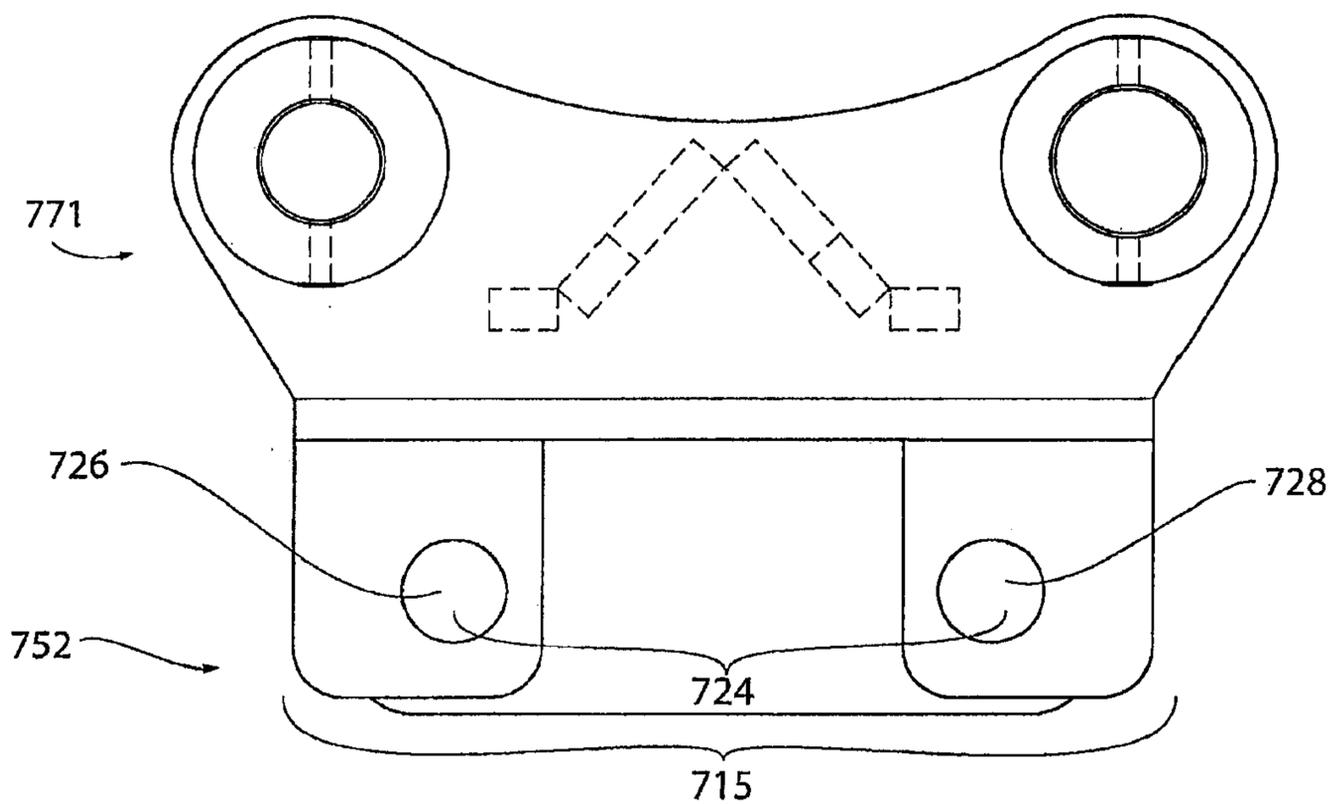
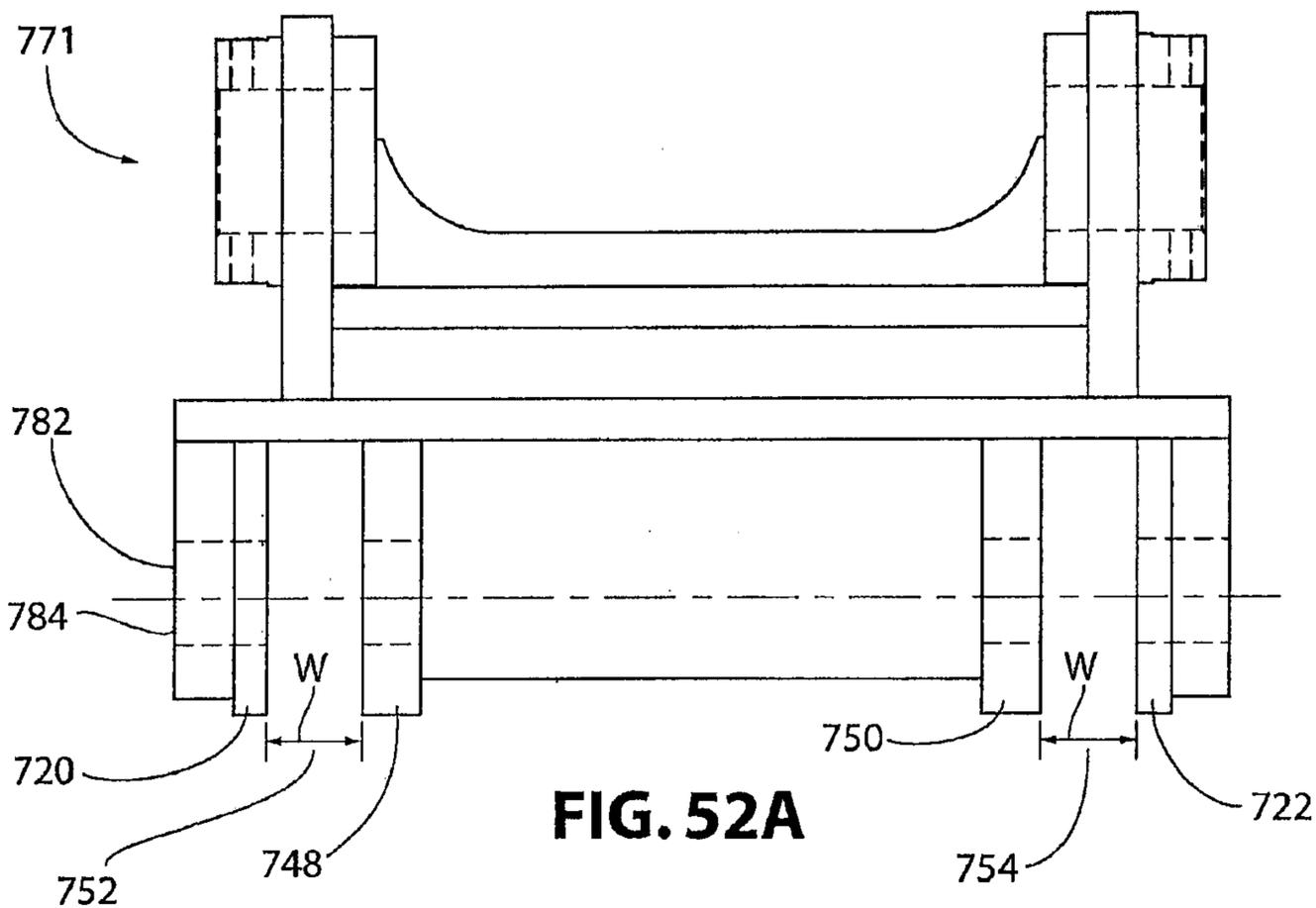


FIG. 51



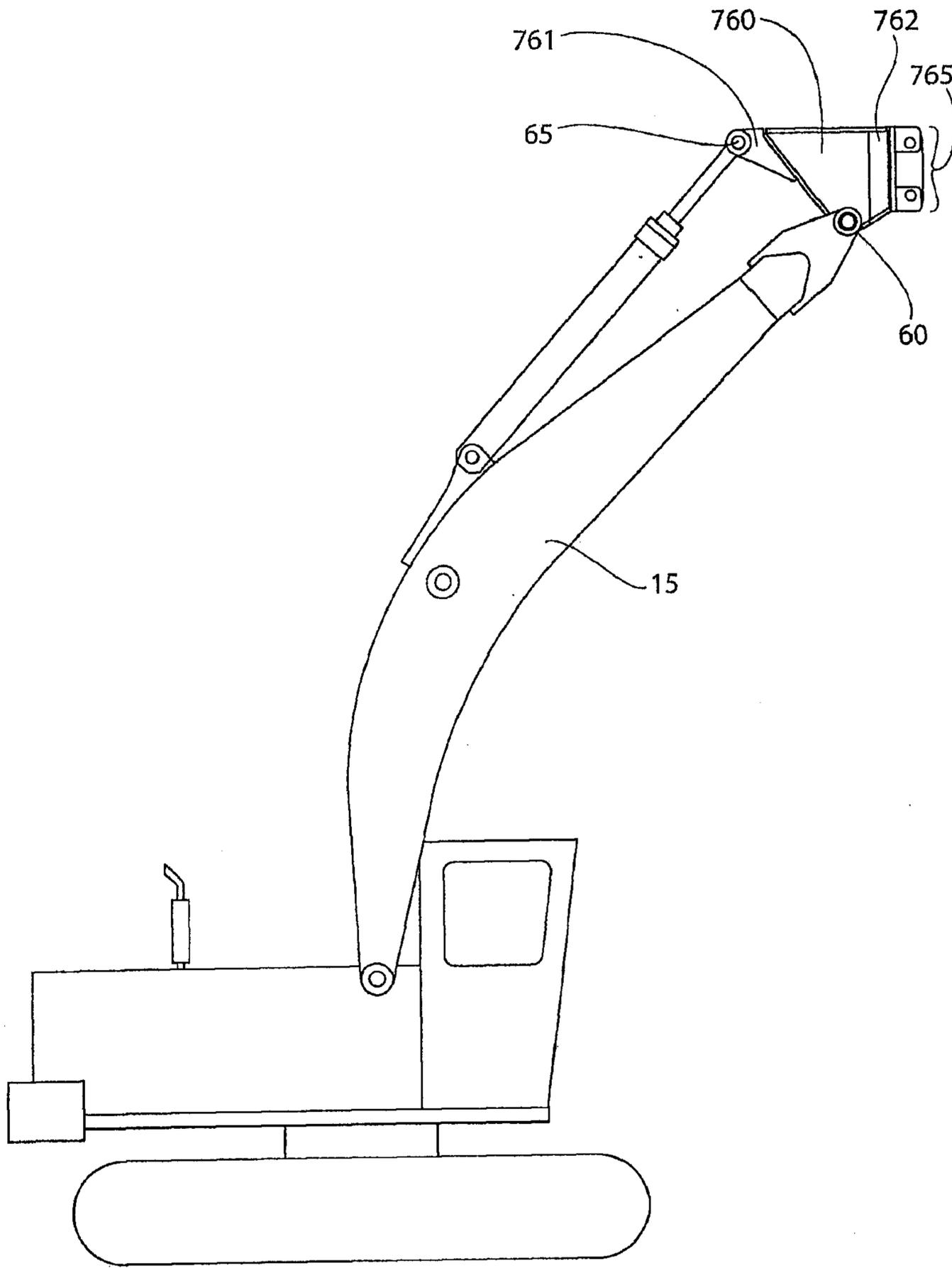


FIG. 53

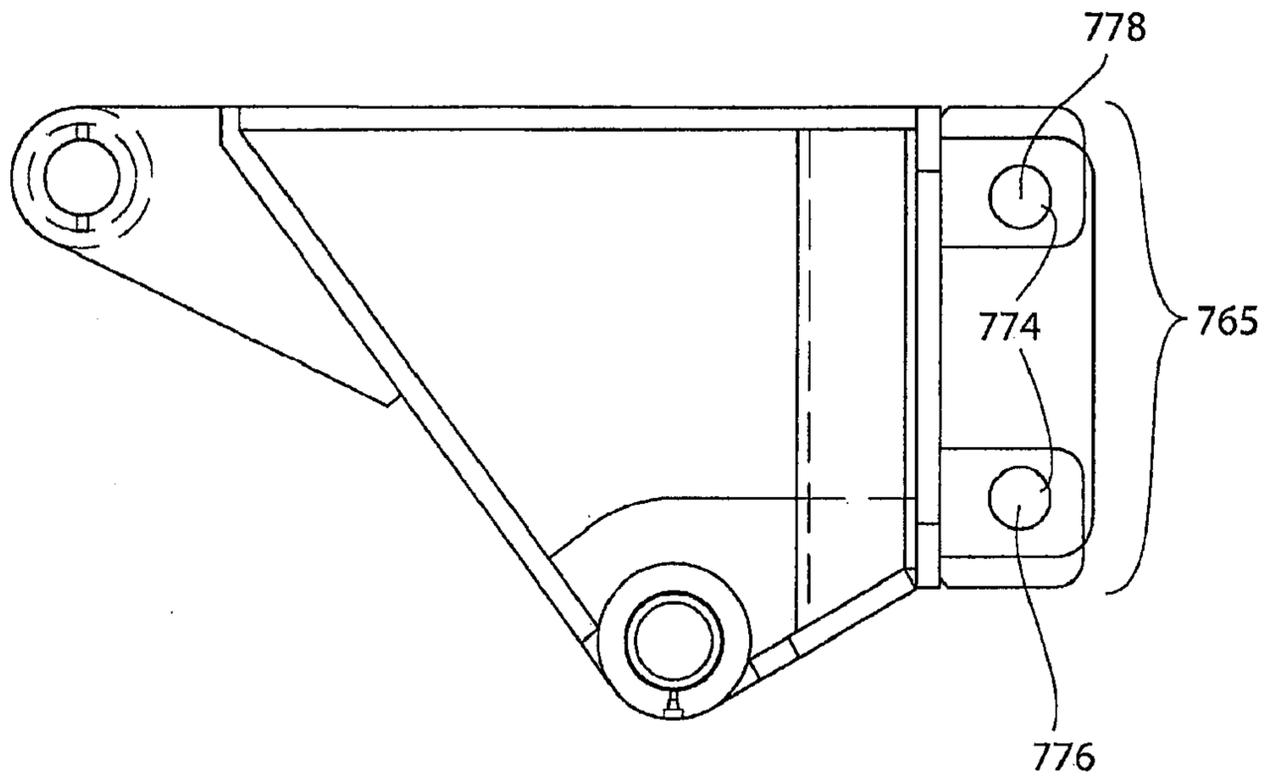


FIG. 54A

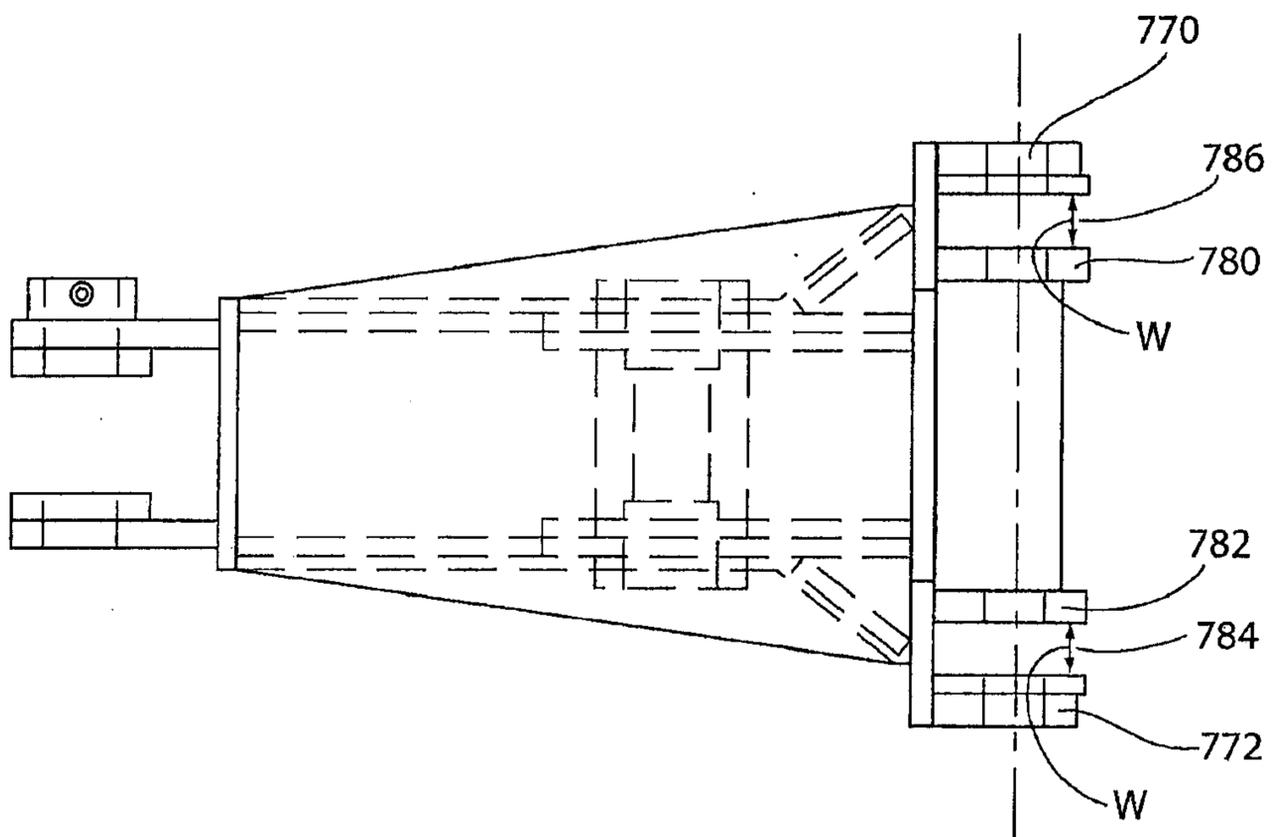
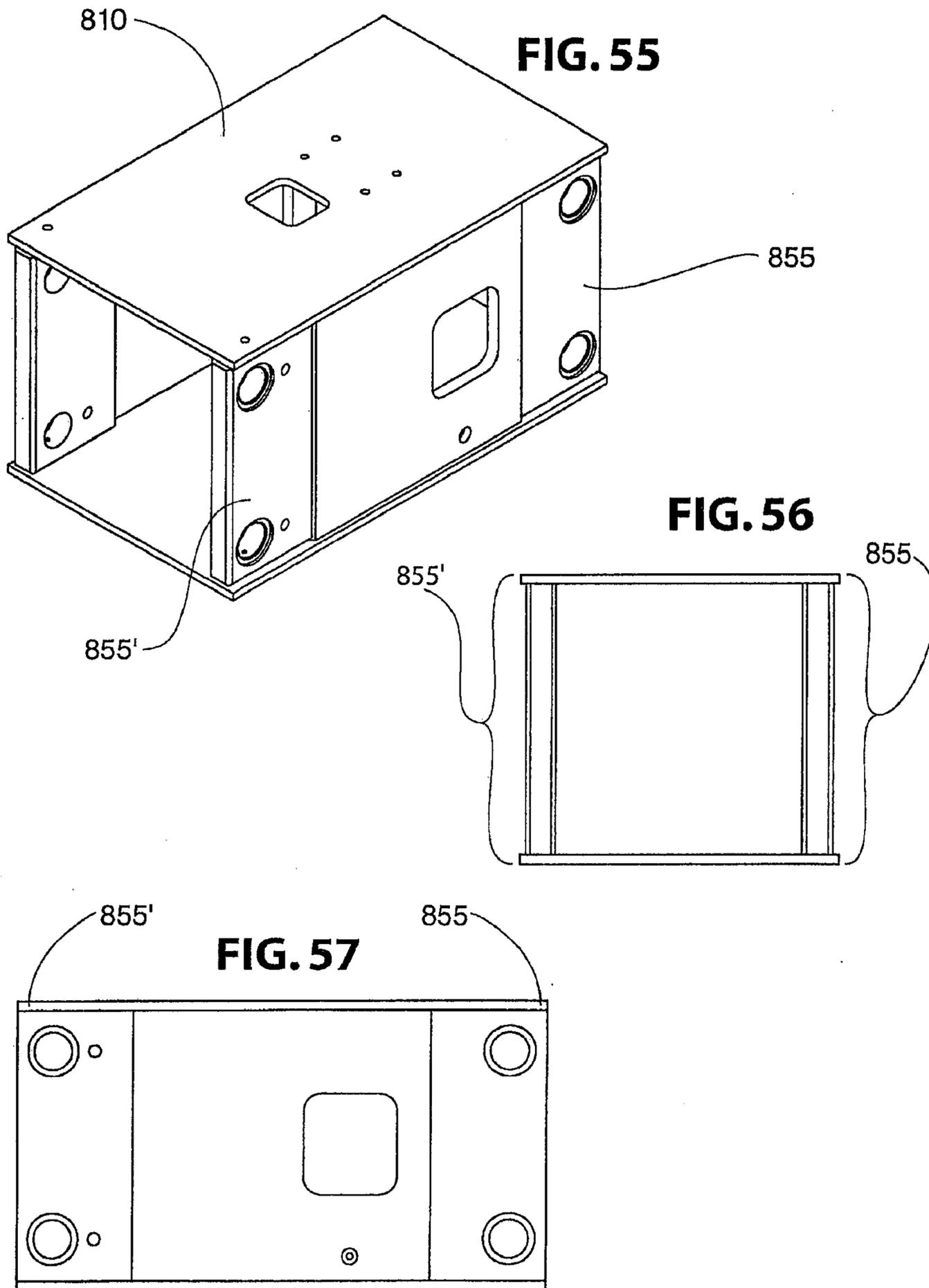


FIG. 54B



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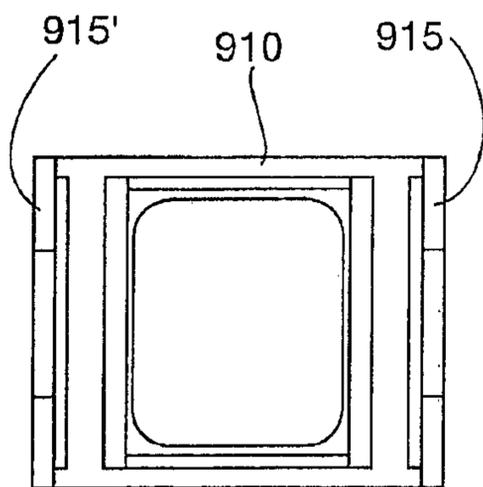
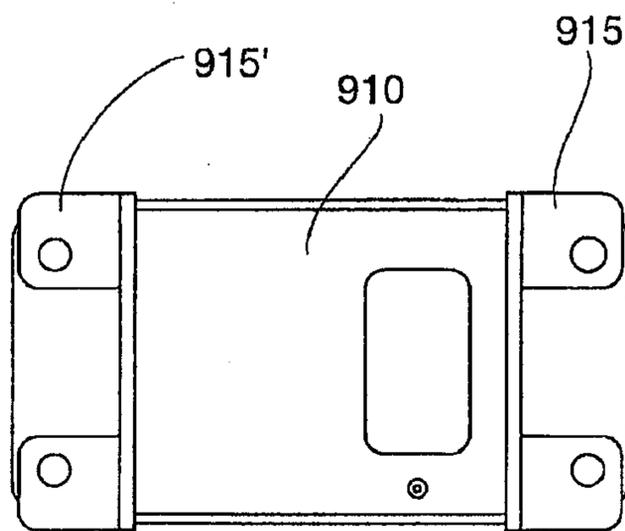
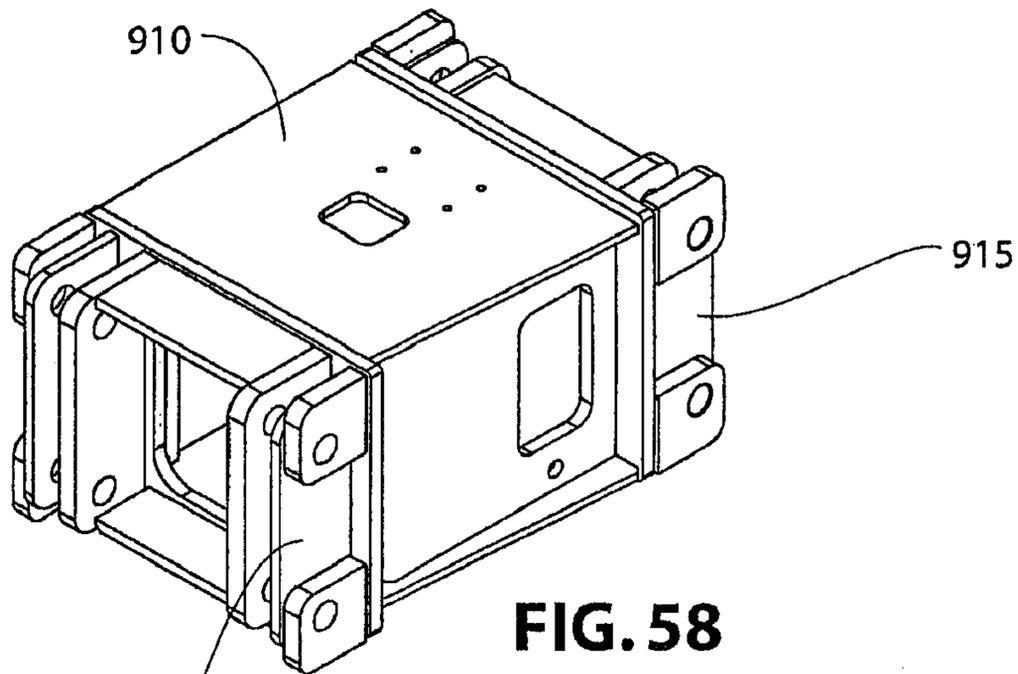


FIG. 60

FIG. 59

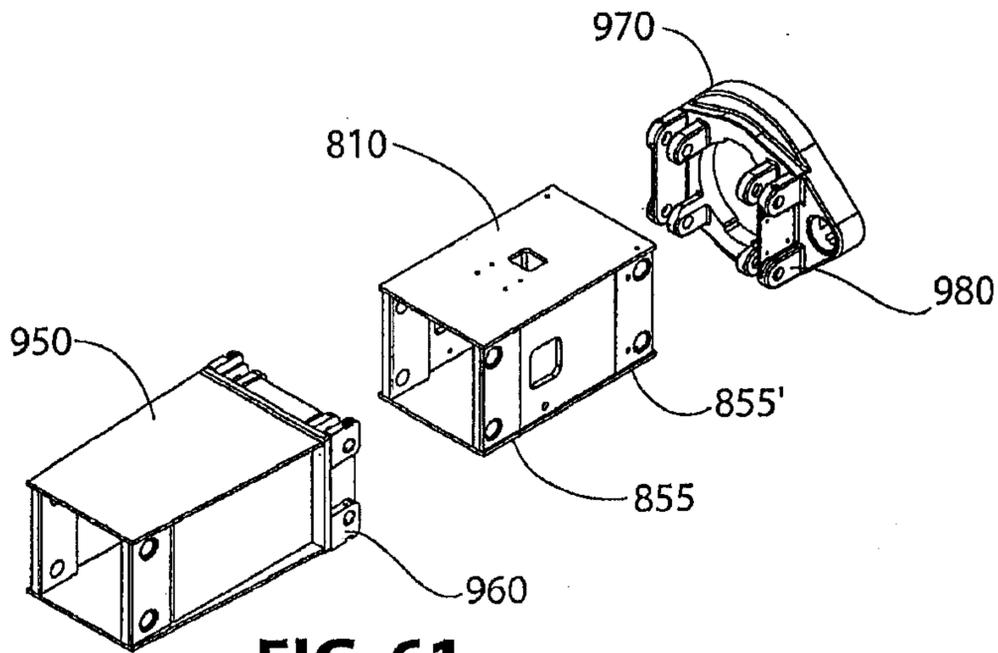


FIG. 61

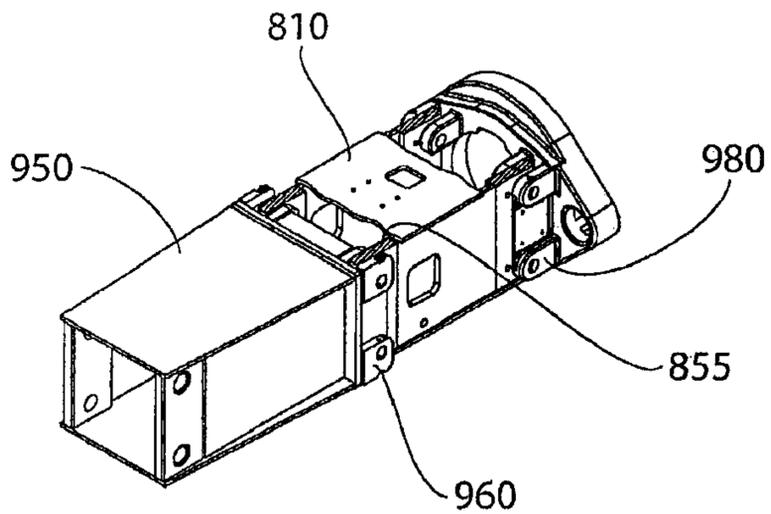


FIG. 62

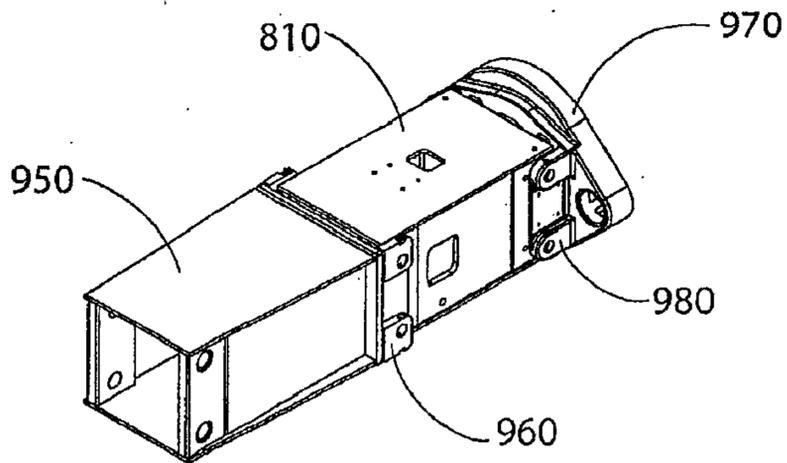


FIG. 63

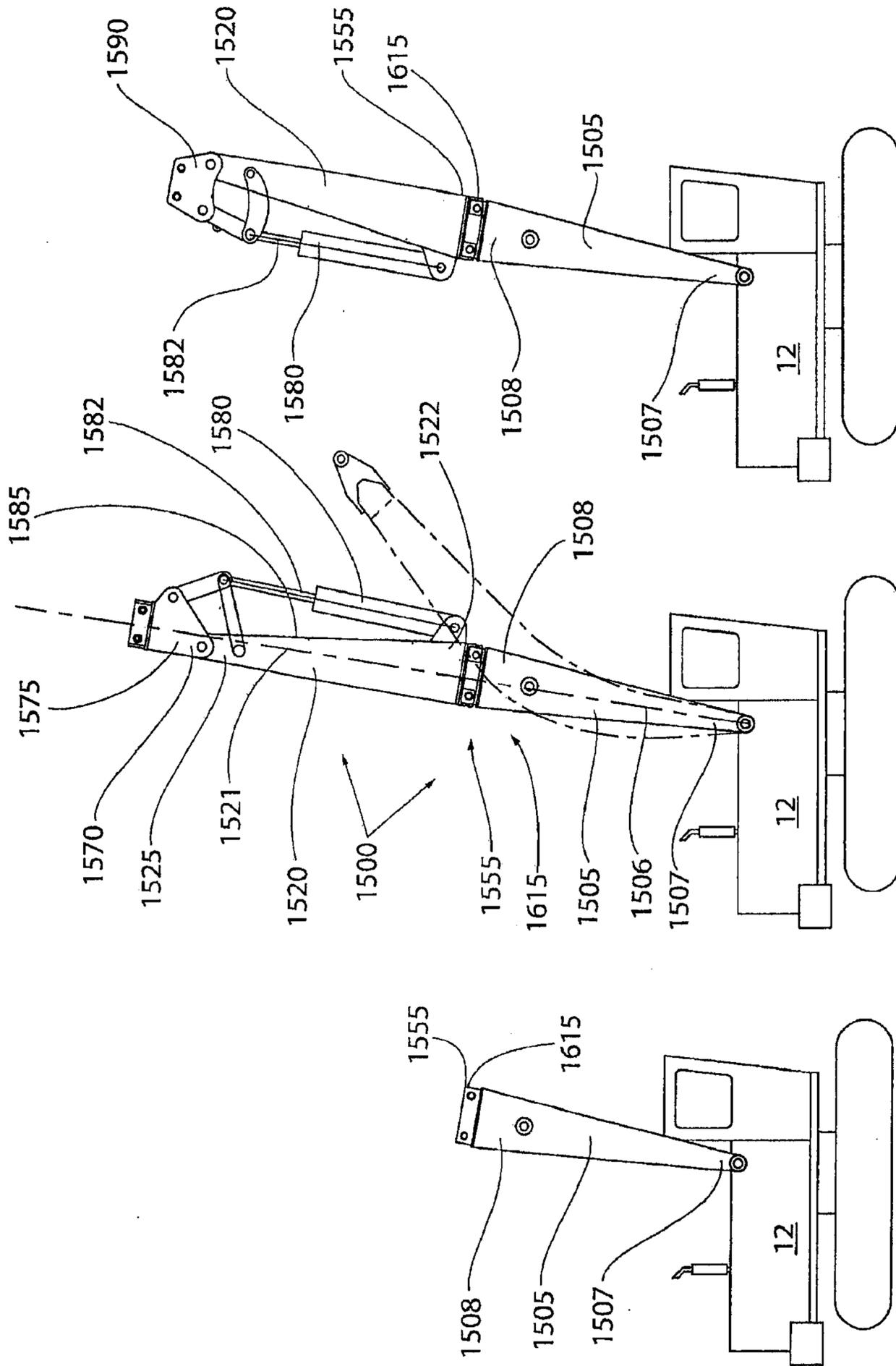


FIG. 66

FIG. 65

FIG. 64

