March 3, 1964 J. L. CHAPMAN, JR., ETAL 3,123,543

METHOD AND APPARATUS FOR FEEDING ARTICLES

Filed Nov. 24, 1961 6 Sheets-Sheet 1

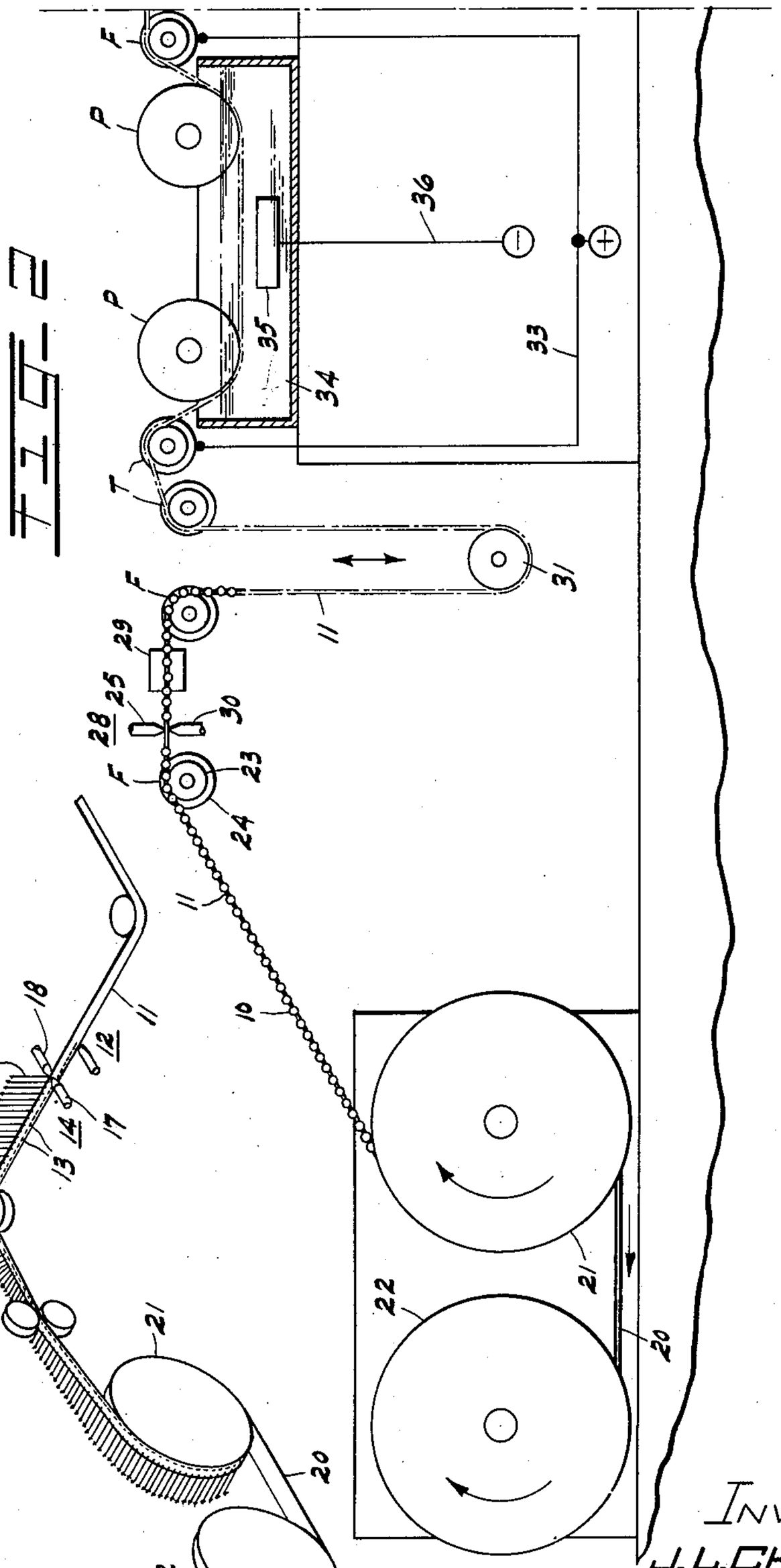

FIG 2

FIG 1

FIG 3 | FIG 4 | FIG 5 | FIG 6

FIG 7

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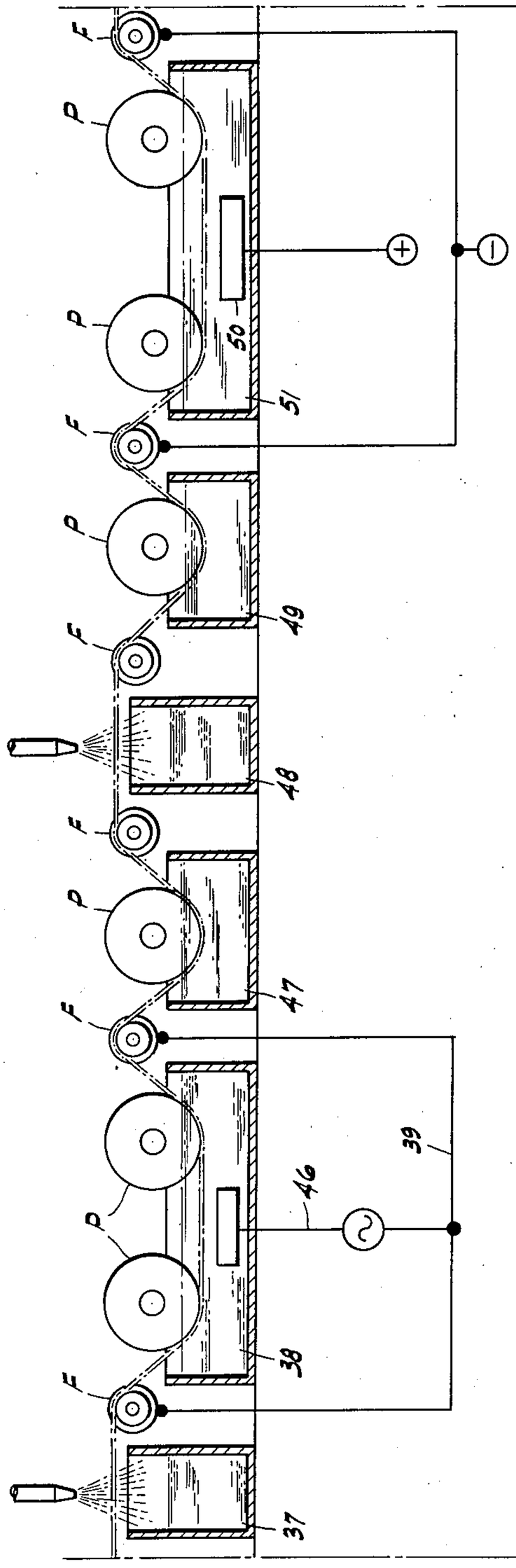

FIG. 5

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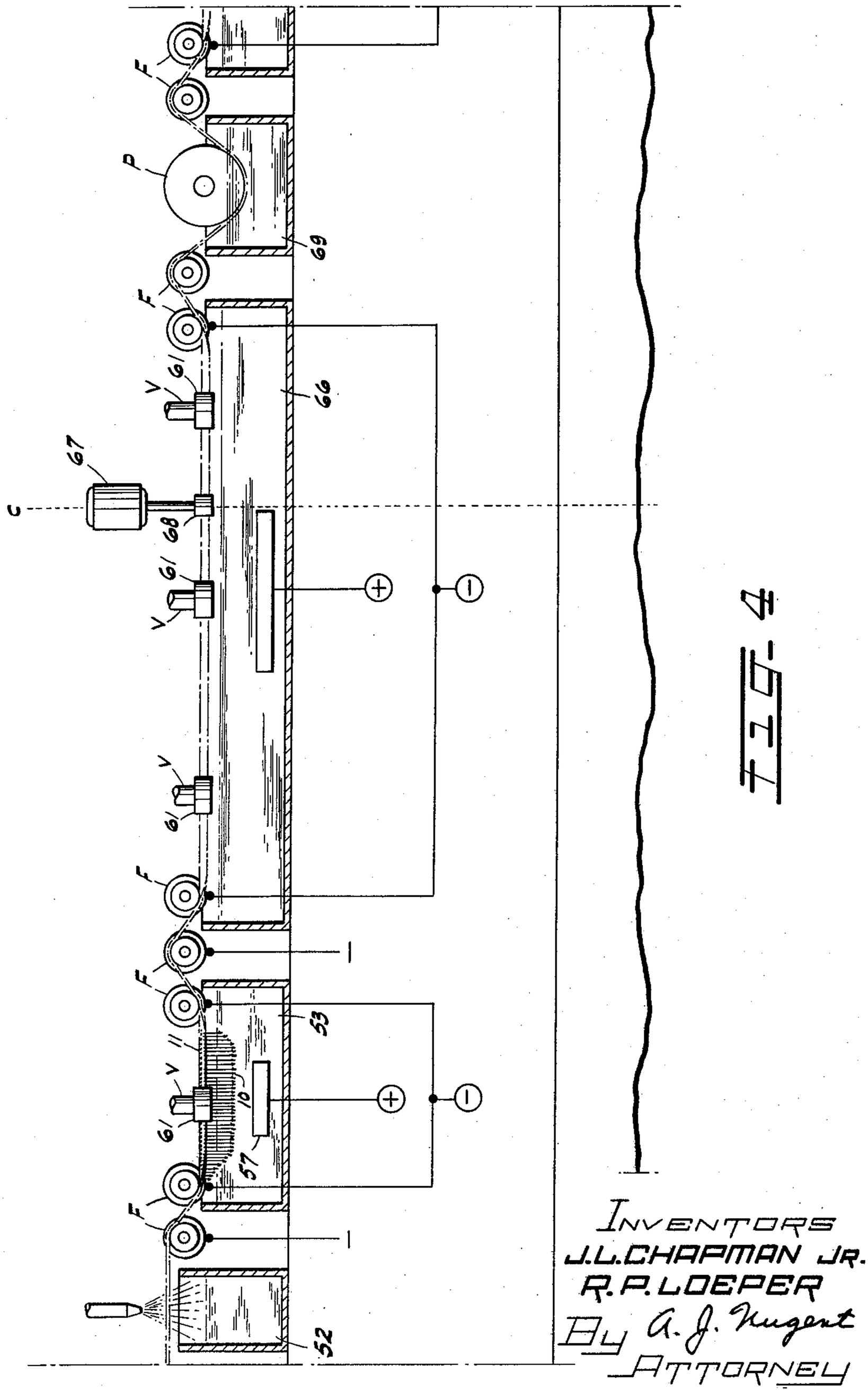

FIG. 4

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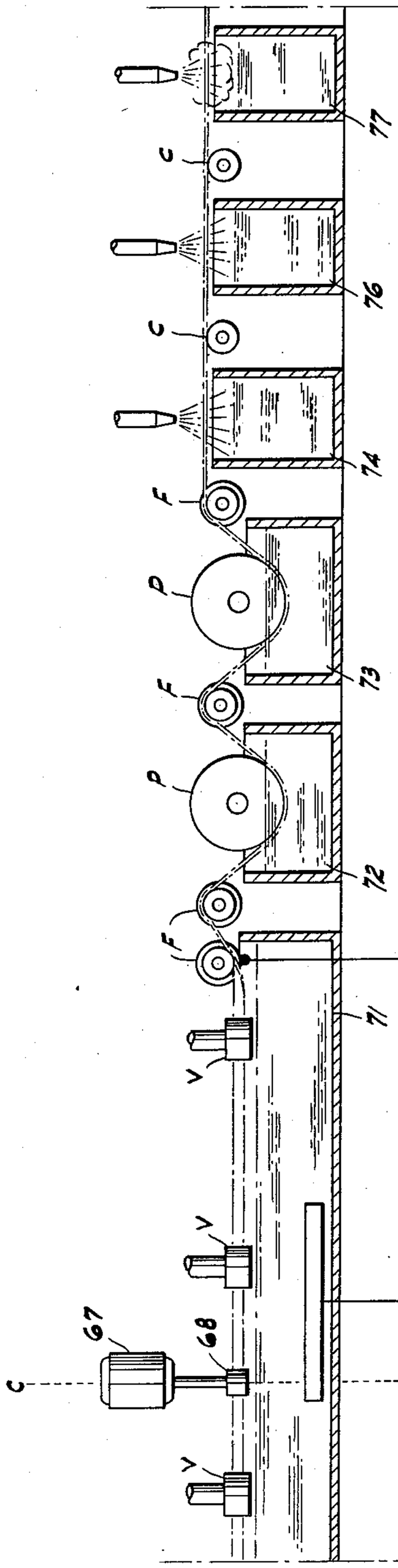

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METHOD AND APPARATUS FOR FEEDING ARTICLES

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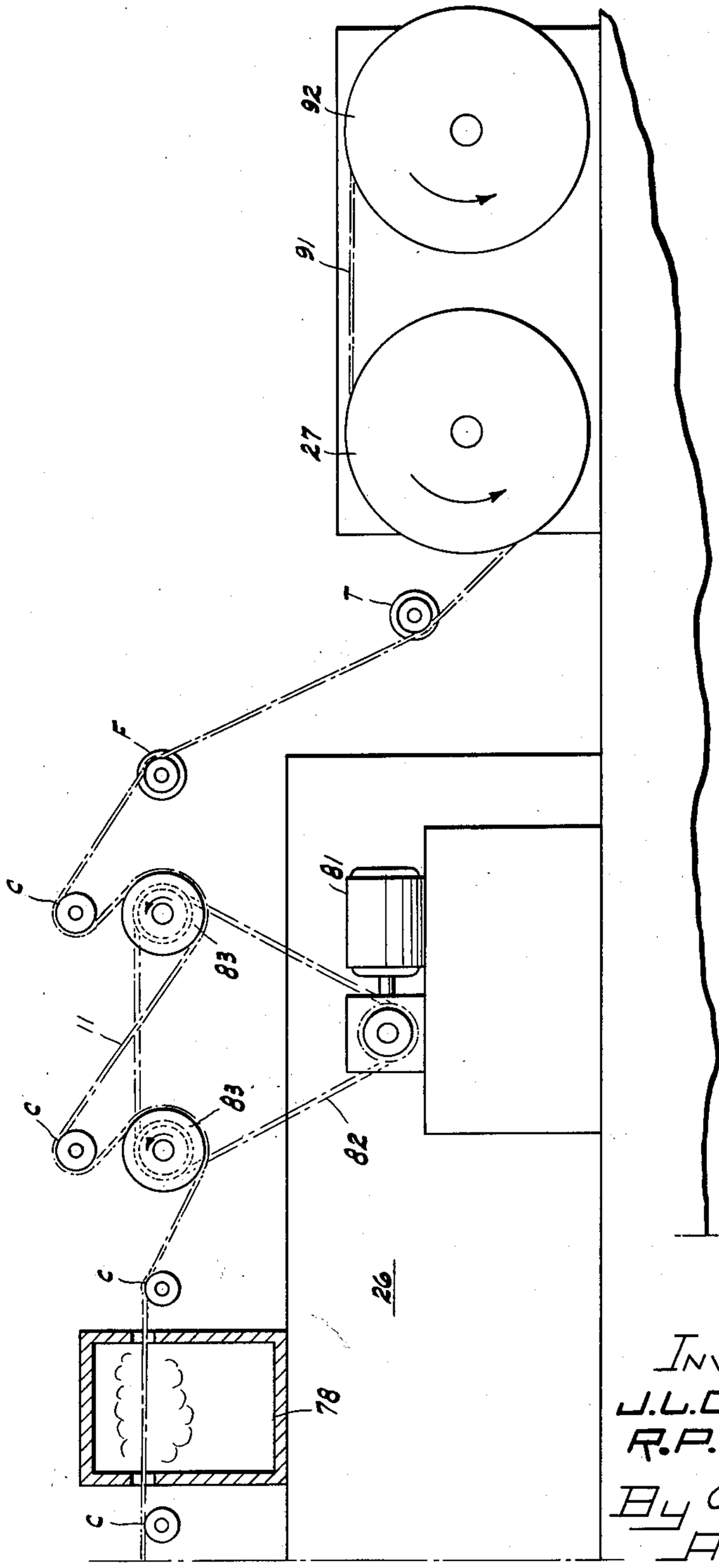

FIG 6

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METHOD AND APPARATUS FOR FEEDING ARTICLES

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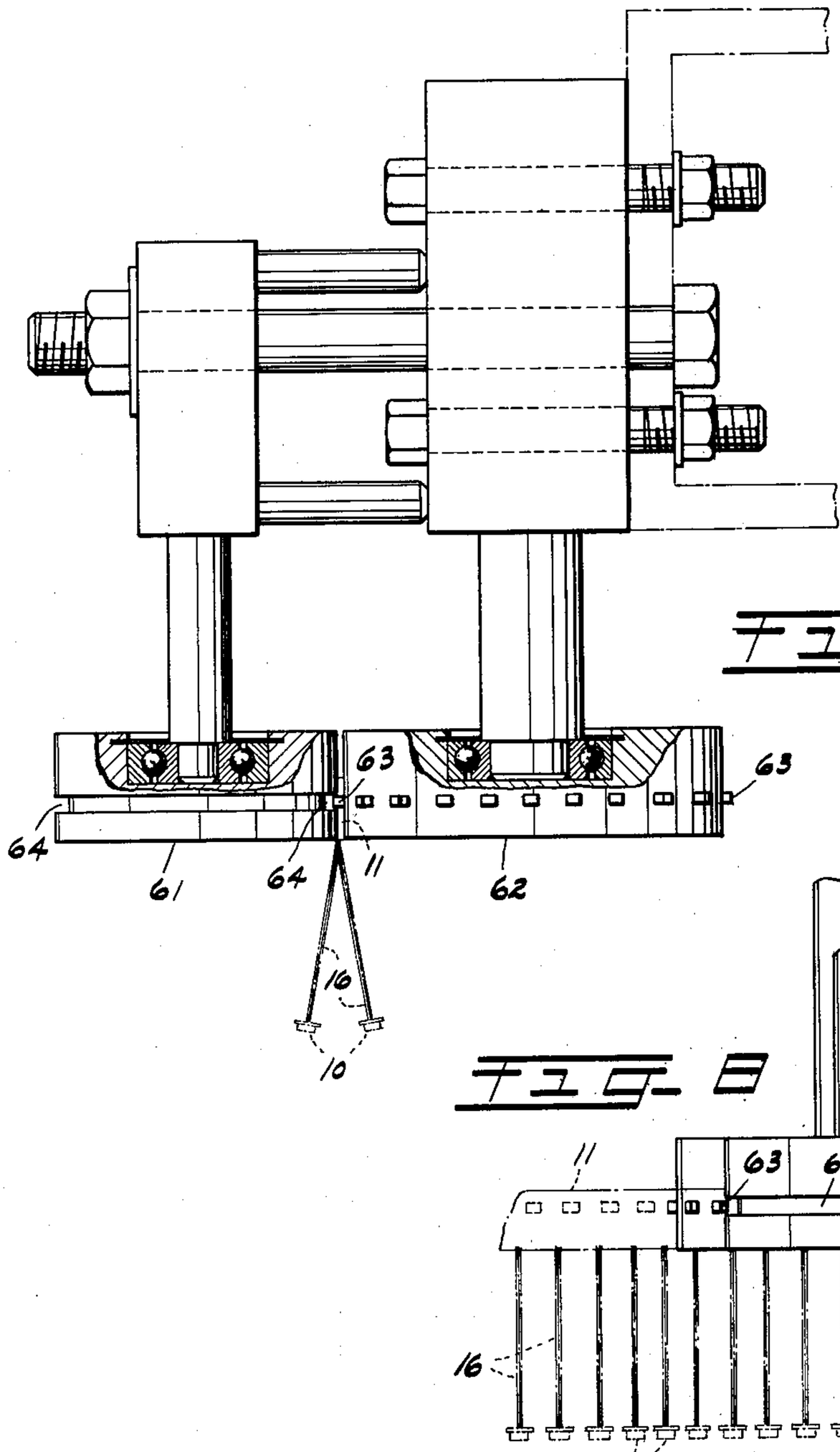

FIG. 9

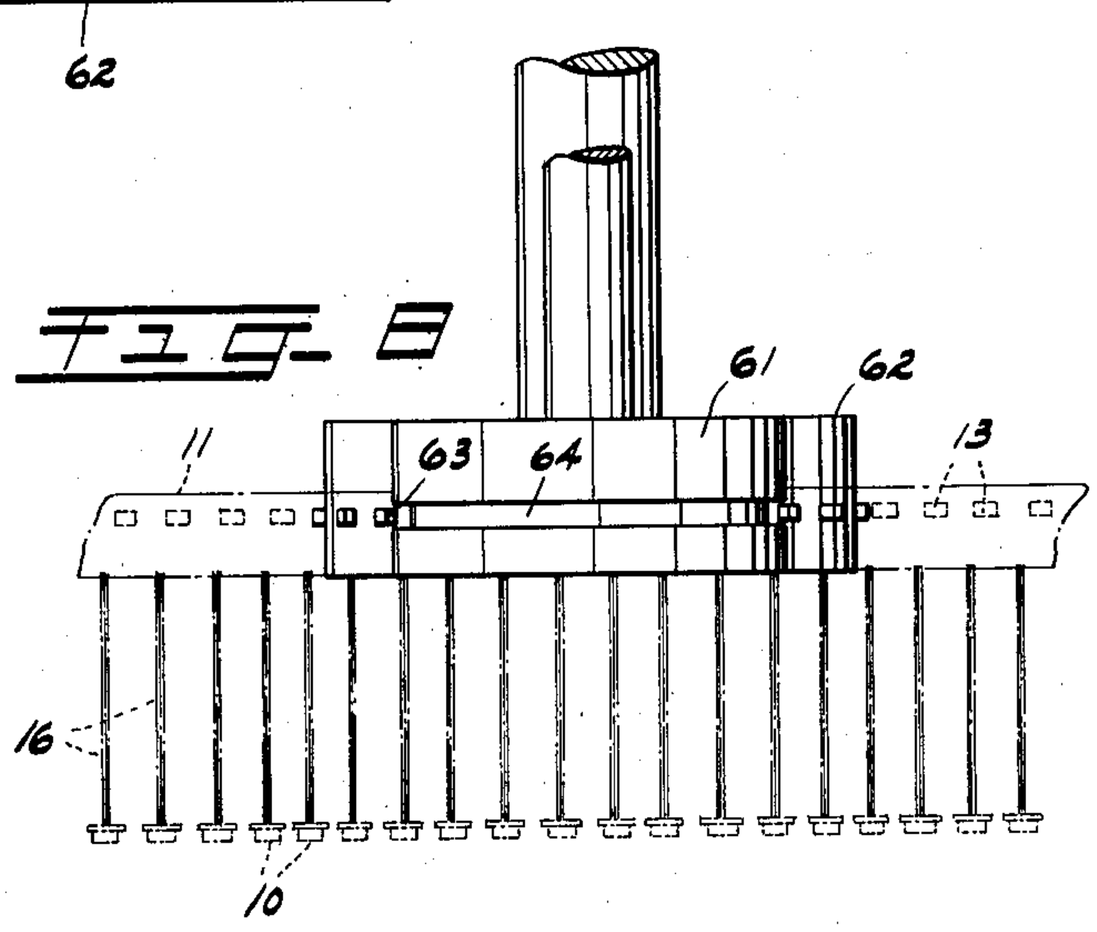

FIG. 8

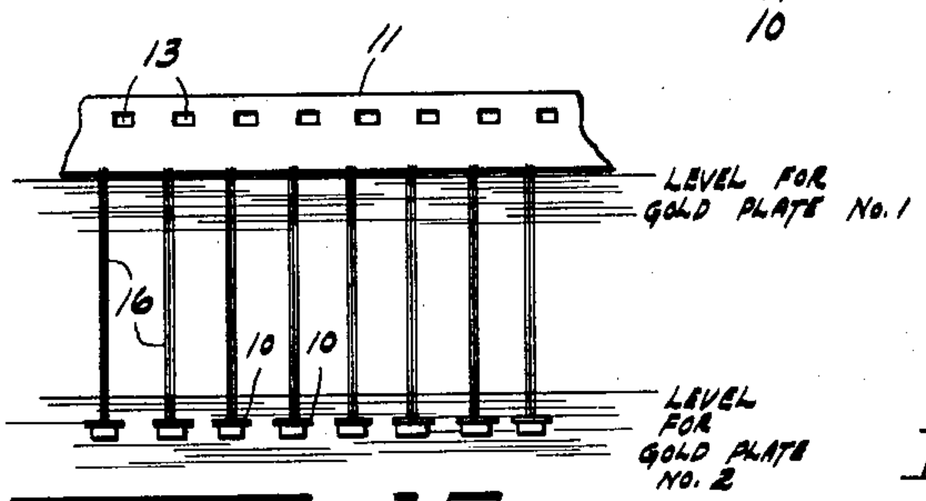

FIG. 10

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3,123,543
METHOD AND APPARATUS FOR FEEDING ARTICLES

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Filed Nov. 24, 1961, Ser. No. 154,744
5 Claims. (Cl. 204—28)

This invention relates to work feeding methods and apparatus and especially to the attachment of piece parts to a flexible strip to facilitate their processing.

The header used in the manufacture of certain transistors comprises a small metallic cup-shaped member wherein the outer surface of the closed end serves as a platform on which the semiconductor wafer is mounted. Customarily, the emitter, base, and collector leads, sealed in the interior of the header by glass, extend through openings in the platform. The open end of the header includes a flange. When assemblage of the header is completed, a can having a flange is placed over the header so that the flanges meet and are welded together. Following the glassing operation, it is required that the header be gold-plated prior to bonding the semiconductor wafer thereto to assure a high standard of electrical performance and reliability. Prior art techniques utilizes a batch-type method of plating, employing plating barrels. Such procedures do not lend themselves to automation wherein it is desirable that articles pass in succession through various work stations. Further, the batch method often resulted in the entangling of the header leads and the use of excess amounts of gold. Rack plating methods are conducive to greater control, but again have the drawback of incompatibility with modern automation techniques for high-scale, efficient production.

In accordance with the present invention, a solution of the problem is attained by the use of a flexible steel tape to which the headers are attached to facilitate their transport through various plating baths and other work locations at different angular positions, the tape providing a direct electrical path to the headers as needed, at least in certain of the plating tanks.

An object of the invention is a method and apparatus for feeding piece parts attached to a flexible strip to a series of work locations.

A more specific object of the invention is a method and apparatus for plating objects by attaching piece parts to a flexible strip and feeding the strip and the piece parts attached thereto at different angular positions as required throughout the plating processes.

Another object of the invention is a method and apparatus for gold plating transistor headers wherein the headers are attached to a flexible steel tape by means of the header leads, the tape then being fed to a series of work positions. The tape itself provides an electrical path to the headers where electrolytic processing is required.

In carrying out the invention, a supply of articles attached to a flexible metal strip is fed to the input of a processing apparatus and the strip and the articles are oriented to different positions as required for feeding and processing at work locations throughout the apparatus, means being provided to feed the strip completely through the apparatus. The strip may serve as an electrical path to the articles where electrical processing is required.

A feature of the arrangement is the provision of a series of rollers for guiding a flexible tape with parts attached to different angular positions.

The invention will hereinafter be described in greater detail with a reference to the drawing, wherein:

FIG. 1 is a schematic of apparatus used in attaching transistor headers to a flexible steel tape;

FIGS. 2 through 6, when laid end to end as shown in FIG. 7, schematically represent a complete cleaning and plating arrangement for transistor headers;

FIG. 8 represents a front elevational view of a set of rollers for twisting the tape to an upright or vertical position;

FIG. 9 is a side view of the rollers partly in section;

FIG. 10 is a graphical representation of the levels of the solution for the gold plating steps.

The apparatus shown in FIG. 1 for attaching the transistor headers **10** to the flexible steel tape **11**, is the subject matter of a co-pending application, R. P. Loeper, Serial No. 154,733, filed November 24, 1961. In accordance with that application, the steel tape **11** is fed from a supply reel, not shown, to a perforating station **12** to perforate feed holes **13** in the tape, and then to a welding station **14** where the leads **16** of the header are attached to the steel tape by means of a pair of electrodes **17—18**. Successive headers have their leads bent in opposite directions by means of bending apparatus **19** in order to assure adequate spacing between adjacent headers during the plating operation. The tape is then wound on a supply reel **21** driven by a suitable motor (not shown) and simultaneously a plastic tape **20** is unwound from the supply reel **22** onto the supply reel **21** to provide spacing between the convoluted layers of transistor headers.

The supply reel **21** is placed in a suitable mount so that the steel tape with the transistor headers attached thereto may be unwound and fed to the plating apparatus. At the same time, the plastic tape **20** is indicated in FIG. 2 is rewound on a reel **22** driven by a suitable motor (not shown). Obviously, if desired, the steel tape with headers attached could be fed directly from the welding and perforating apparatus to the plating apparatus.

In order to facilitate a description of the invention, the following designations are used to identify rollers used repetitively in the process. Rollers F are flanged, stainless steel rollers having a tapered surface of slightly increasing diameter **23** toward the flanged portion **24** to retain the steel tape in position. Rollers P are plastic rollers slightly larger in width than the width of the tape. Rollers C are plain-surfaced, stainless steel rollers.

In commencing a plating operation, a plain steel tape **11** with no headers attached may be threaded about the rollers through the various work locations to the main drive **26** shown in FIG. 6 and anchored to a takeup reel **27** driven through a clutch-type drive by a motor (not shown). Then, as depicted in FIGURE 2, the leading end of tape **11** with the headers **10** attached thereto is fed over a roller F to a welding station **28** and attached, by means of electrodes **25** and **30**, to the trailing end of the plain steel tape **11** which was threaded through the machine. For this purpose, a clamp **29** is provided to temporarily hold the trailing end of the plain tape **11** while it is being joined to the tape **11** with the transistors **10** attached. In order not to delay operation by shutting down the machine, a suitably mounted drop roller **31** engages a slack portion of the tape extending between a roller F and one of a pair of tooth rollers T of stainless steel. Sufficient slack is provided in the tape to allow eight minutes of feed before the drop roller reaches its uppermost position. This affords ample time for the welding operation. It is to be understood, of course, that once a reel of tape with transistor headers attached thereto has been processed, the end of the processed tape will be attached to the leading end of a tape having transistor headers attached for processing.

The actual processing of the transistor headers begins in the alkaline clean tank **34** where any oil or grease on the transistor header is removed by use of a polarized

alkaline cleaning solution. The electrical circuit for this cleaning operation is provided from positive voltage over lead 33 in parallel to the rollers F immediately adjacent opposite ends of the tank 34 and to the steel tape and headers, and from negative source over lead 36 to a cathode 35 in the cleaning solution. Customarily, one of the header leads, such as the collector lead, is bonded to the header platform. While this is done primarily for transistor circuit purposes, it assures electrical continuity during the plating process. Any alkaline solution remaining on the tape and headers is removed at the water spray tank 37 following which the headers move on to an acid cleaning solution in tank 38 containing an equal mixture of hydrochloric acid and water by volume, the tank being held at a suitable temperature. In each tank, the liquid will be held at temperatures conventionally used in plating processes. Electrical current for the acid cleaning procedure is provided from an A.C. source over leads 39 and 46 in the same manner as described in connection with the alkaline cleaning tank 34.

The headers next move through a water rinse tank 47 and past a water spray tank 48, to remove the acid, to a cyanide dip tank 49 to prepare the headers to receive the copper plate undercoating in the tank 51. It should be observed that up to this point the tape, along with the headers, has been fed in a horizontal position. The steel strip now is negative with respect to the anode 50 and becomes in fact a cathode; whereas in the alkaline tank, the steel strip functions as the anode. In this connection, it will be understood that the potentials in each tank are relative to each other and that a constant D.C. reference potential is actually applied to the steel strip. After leaving the copper plate tank 51, the headers move on to the water spray 52 to remove any copper salt which may remain from the copper plating operation. The headers are then fed to the gold flash plating tank 53 and electrical current is provided in the same manner as in the copper plate tank.

It will be observed that in the gold strike tank 53 there is a pair of rollers V shown in detail in FIGS. 8 and 9. The rollers 61 and 62 are respectively the front and rear rollers looking into the drawing in FIG. 4. It is seen that the roller 62 includes toothed portions 63, meshing with complementary openings 64 in the front roller 61 by penetration through the openings 13 of the steel tape 11 transporting the headers 10. Since the rollers 61, 62 are each mounted on a vertical axis, they serve to twist the tape and the headers to a vertical position so that the greater part of the header leads 16 and the header are plated with gold, as clearly indicated in the graphical representation of FIG. 10. By mounting the rollers F overlying the gold strike tank 53 (FIGURE 4) and the rollers V in a precise location and controlling the depth of the gold solution, the upper limit of the gold plate on the leads is rigidly controlled.

As the headers leave the tank 53, the steel strip passes first under an F roller, then over a succeeding F roller, to an F roller overlying the gold plate tank 66. Since each of these F rollers are mounted upon a horizontal axis, the steel tape and the attached headers will now lie in a horizontal direction. In the gold plate tank 66, a plurality of rollers V again orient the steel strip in the vertical position so that the first gold plate applied is to the level indicated in FIG. 10.

While the apparatus is shown arranged along one single line, in actual practice the tanks and the various components of the apparatus are arranged to form a substantially U-shape. Thus, at the points marked C in FIGS. 4 and 5, corners of the apparatus are defined. At these points, auxiliary driving motors 67, driving plastic rollers 68, provide an auxiliary friction feeding device for the main drive 26 shown in FIG. 6. In this type of drive, the tighter the steel tape becomes, indicating a strain on the main drive, the greater is the effectiveness of the friction drive. In other words, when the main drive needs more assistance, the friction drives come more into play. The steel strip, after leaving the gold plate tank 66, enters a gold reclaim tank 69, then into a final gold plate tank 71 (FIGURE 5). In the latter tank, the headers are held in such position by a plurality of rollers V, that only the header proper and only a very small portion of the leads 16 are plated with gold for economy purposes, as is clearly shown in FIG. 10.

Next, the headers pass through a pair of gold reclaim tanks 72 and 73, through a water spray 74, deionized water spray 76, steam blast 77 for blowing off excess water, and a hot air dry tank 78 for drying the headers, to the main drive 26.

The main drive 26 includes a motor 81 driving a belt 82 which, in turn, drives a pair of rubber-coated magnetic rollers 83 which grip and pull the tape completely through the electroplating apparatus except for the assistance offered by the auxiliary motors 67. The steel tape with the gold-plated headers attached may now be wound on the loading reel 27, and between each layer is concomitantly wound the plastic tape 91 from supply reel 92 in the same manner as the tape described in FIG. 1. If desired, the headers could be cut from the steel tape instead of being wound upon the supply reel 27.

Each tank is suitably insulated from the other tanks and from the frame of the machine.

Stripping of gold from the defective headers could obviously be accomplished in the machine by reversing the potential in a gold plating tank.

While the invention has been described in connection with the gold plating of transistor headers, it should be apparent to those in the material feeding art that the principles of the present invention could obviously be extended with equal effectiveness to the feeding of parts generally.

What is claimed is:

1. In an automatic process for cleaning and plating articles attached to and carried by a flexible conductive tape to a succession of various types of confined cleaning and plating solutions, the steps of:

applyng a first reference potential to said articles through said tape,

polarizing said articles as anodes while immersed in a first cleaning solution of said succession of solutions, said polarization being established by the provision of a first electrode submerged in said first solution and biased at a potential which is negative relative to the reference potential applied to said tape,

polarizing said articles alternating as anodes and cathodes while immersed in a second cleaning solution of said succession of solutions, said polarization being established by the provision of a second electrode submerged in said second solution and having an alternating potential applied across said tape and said second electrode,

polarizing said articles as cathodes while immersed in an *n*th plating solution of said succession of solutions, said polarization being established by the provision of at least a third electrode submerged in said *n*th solution and biased at a potential which is positive relative to the reference potential applied to said tape, and

orienting said tape at a predetermined angular position while said articles are biased as cathodes in the region of at least one of said solutions such that only said articles are immersed therein.

2. In an apparatus for transporting articles attached to and carried by an electrically conductive, flexible carrier tape guided by rollers to a succession of various types of confined cleaning and plating solutions,

means for supporting a reel of said tape at the input of the apparatus,

drive means including rollers of magnetic material for

pulling the tape along an extended path to the succession of solutions,

means for applying a reference potential to said tape,

means for polarizing said articles as anodes while immersed in a first cleaning solution of said succession of solutions, said last-mentioned means including a first electrode submerged in said first solution, and voltage means for biasing said first electrode at a potential which is negative relative to the reference potential applied to said tape,

means for polarizing said articles alternately as anodes and cathodes while immersed in a second cleaning solution of said succession of solutions, said last-mentioned means including a second electrode submerged in said second solution, and voltage means for applying an alternating potential across said tape and said second electrode,

means for polarizing said articles as cathodes while immersed in an *n*th plating solution of said succession of solutions, said last-mentioned means including an *n*th electrode submerged in said *n*th solution, and voltage means for biasing said *n*th electrode at a potential which is positive relative to the reference potential applied to said tape, and

means for orienting said tape at a predetermined angular position while said articles are biased as cathodes in the region of at least one of the succession of solutions such that only said articles are immersed therein, said last-mentioned means including at least one roller mounted along a first axis to orient said tape in one plane and further including at least two other rollers mounted along a second axis at a substantial angle to the first axis to orient said tape in a different plane.

3. In an apparatus in accordance with claim 2, wherein said articles comprise semiconductor headers welded to said tape, wherein said tape is perforated, and wherein at least one pair of said other rollers mounted along said second axis includes a roller with teeth for engaging the perforations in said tape and a mating roller having complementary openings into which the teeth project.

4. In an automatic process for gold plating semiconductor headers and the like attached to a flexible, conductive carrier tape, the steps of:

applying a reference potential to the headers through said tape,

immersing said tape with the headers attached thereto into an alkaline cleaning solution,

providing a first electrode submerged in said alkaline solution, and

polarizing said headers as anodes and said first electrode as a cathode to improve the cleaning action of said alkaline solution, said polarization being established by biasing said first electrode at a potential which is negative in relation to the reference potential applied to said tape,

removing said tape from said alkaline solution,

immersing said tape into an acid cleaning solution,

providing a second electrode submerged in said acid solution, and

applying an alternating potential across said tape and said second electrode to improve the cleaning action of said acid solution,

removing said tape from said acid solution,

immersing said tape into a copper plating solution,

providing at least a third electrode submerged in said copper plating solution, and

polarizing said headers as a cathode and said third electrode as an anode to electrolytically deposit the desired amount of copper on said semiconductor headers, said polarization being established by biasing said third electrode at a potential which is positive in relation to the reference potential applied to said tape,

removing said tape from said copper plating solution,

immersing only said headers in a gold plating solution by orienting the planar surfaces of said tape to a vertical position while in the region of said gold plating solution,

providing at least a fourth electrode submerged in said gold plating solution, and

polarizing said headers as a cathode and said fourth electrode as an anode to electrolytically deposit the desired amount of gold on only said headers, said polarization being established by biasing said fourth electrode at a potential which is positive in relation to the reference potential applied to said tape,

removing said headers from said gold plating solution by reorienting the planar surfaces of said tape to a horizontal position,

immersing said tape in a gold reclamation solution to recover any excess gold adhering to said headers, and

removing said tape from said gold reclamation solution.

5. In an apparatus for transporting transistor headers and the like attached to an electrically conductive, flexible carrier tape having perforations therein to a succession of various cleaning and plating baths,

means for supporting a reel of said tape at the input of the apparatus,

drive means including rollers of magnetic material for pulling the tape along an extended path,

auxiliary drive means for enabling said tape to follow a non-linear, horizontal path necessitated by abrupt changes in direction, said last-mentioned means including at each point of abrupt change a roller which makes variable, frictional contact with said carrier tape,

means for applying a reference potential to said tape,

roller means for immersing said tape and transistor headers attached thereto into a first alkaline cleaning bath of said succession of baths,

means for improving the cleaning action of the alkaline solution in said first bath, said last-mentioned means including a first electrode positioned within said first bath, and further including means for polarizing said first electrode as a cathode and said tape as an anode through the biasing of said first electrode at a potential which is negative relative to the reference potential applied to said tape,

roller means for removing said tape from said first bath,

roller means for immersing said tape and said transistor headers into a second acid cleaning bath of said succession of baths,

means for improving the cleaning action of the acid solution in said second bath, said last-mentioned means including a second electrode positioned within said second bath, and further including means for applying an alternating potential across said tape and said second electrode,

roller means for removing said tape from said second bath,

means for immersing only said transistor headers in a third gold plating bath of said succession by varying the angular position of a section of said tape and one or more transistor headers while in the region of said third bath, said last-mentioned means including at least one roller mounted along a first axis to orient said tape in one plane and further including at least two other rollers mounted along a second axis at a substantial angle to the first axis to orient said tape in a different plane, and wherein at least one pair of said other rollers mounted along said second axis includes a roller with teeth for engaging the perforations in said tape, and a mating roller having complementary openings into which the teeth project, and

means for electrolytically depositing the desired amount of gold on said transistor headers while immersed in the gold plating bath, said last-mentioned

means including at least a third electrode positioned within said third bath, and further including means for polarizing said third electrode as an anode and said tape as a cathode through the biasing of said third electrode at a potential which is positive relative to the reference potential applied to said tape.

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