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Elfrink et al.(10) **Pub. No.: US 2006/0185809 A1**(43) **Pub. Date: Aug. 24, 2006**(54) **ACTUATOR SYSTEM FOR USE IN
CONTROL OF A SHEET OR WEB FORMING
PROCESS**

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D21F 13/00 (2006.01)(52) **U.S. Cl.** **162/198; 700/127**(57) **ABSTRACT**

One or more actuator driven devices on a sheet forming machine receive power and engage in bi-directional communications with one or more quality control systems either by having no physically connected cables to transmit the power to the actuators and no physically connected cables used for the bi-directional communications; or contactless power and communication on a power cable; or a cable connected from the power source to the actuators to provide both power and bi-directional communications; or power is provided to the actuators by a cable and the bi-directional communications are wireless.

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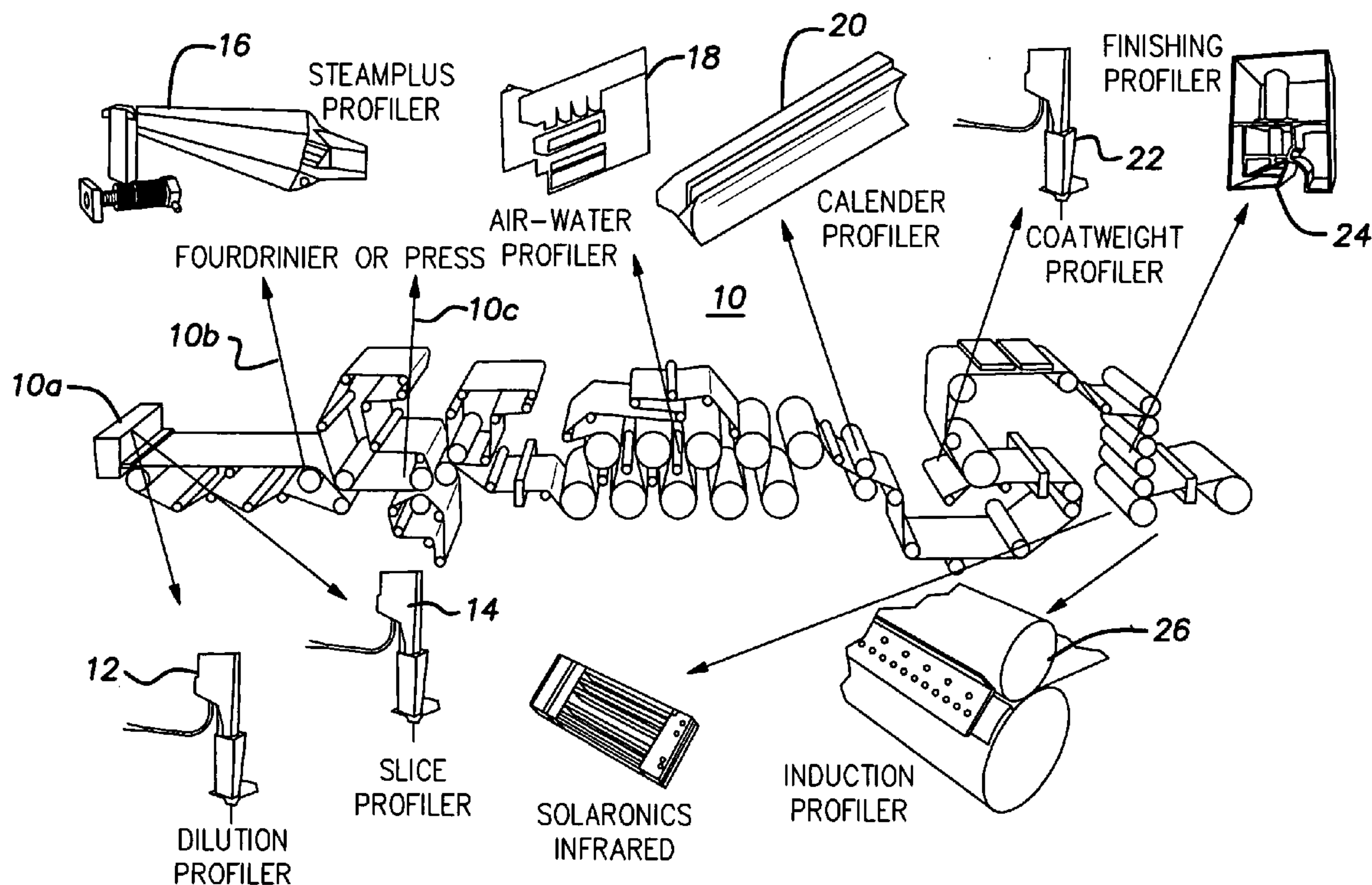
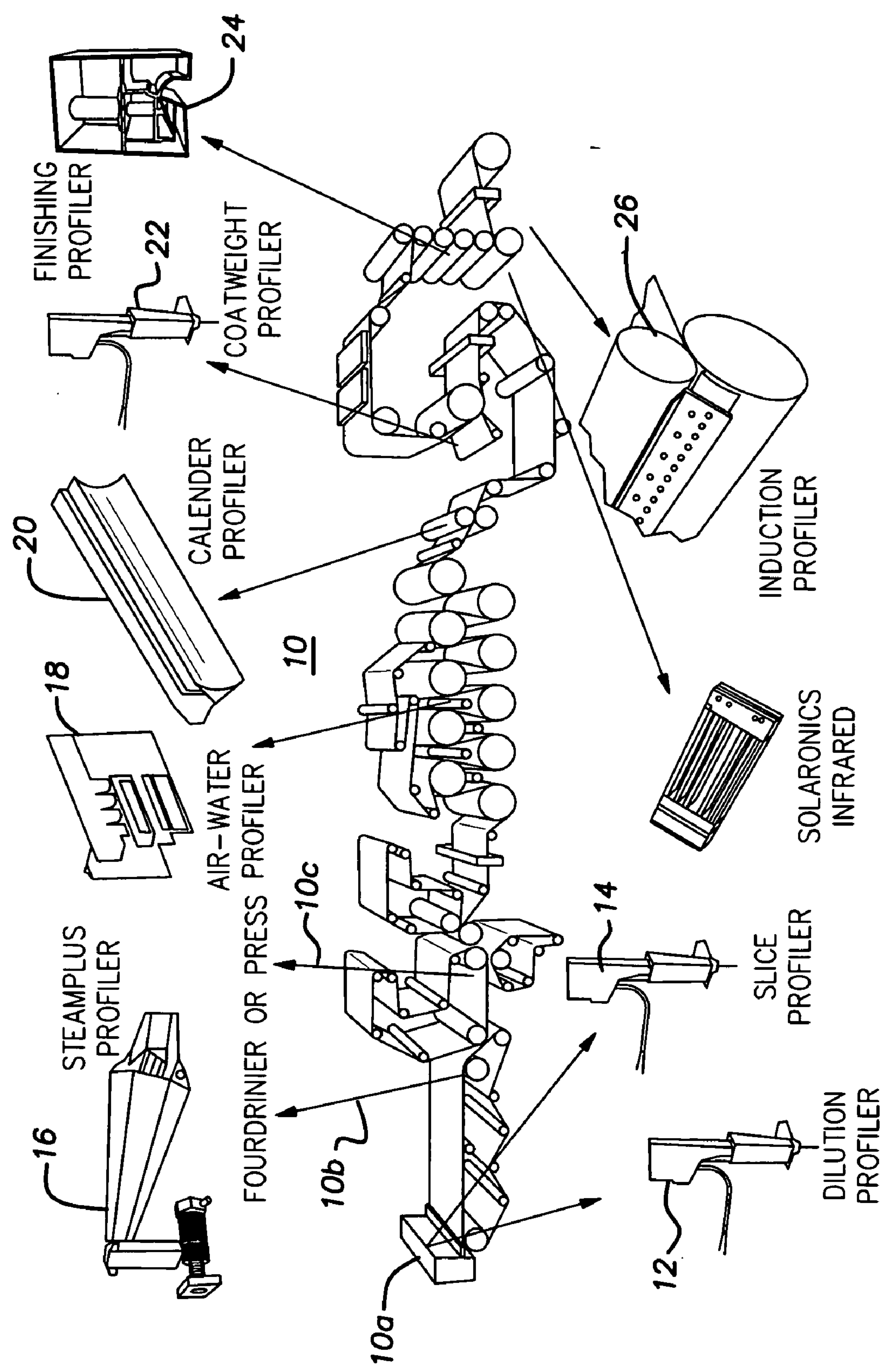
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FIG. 1



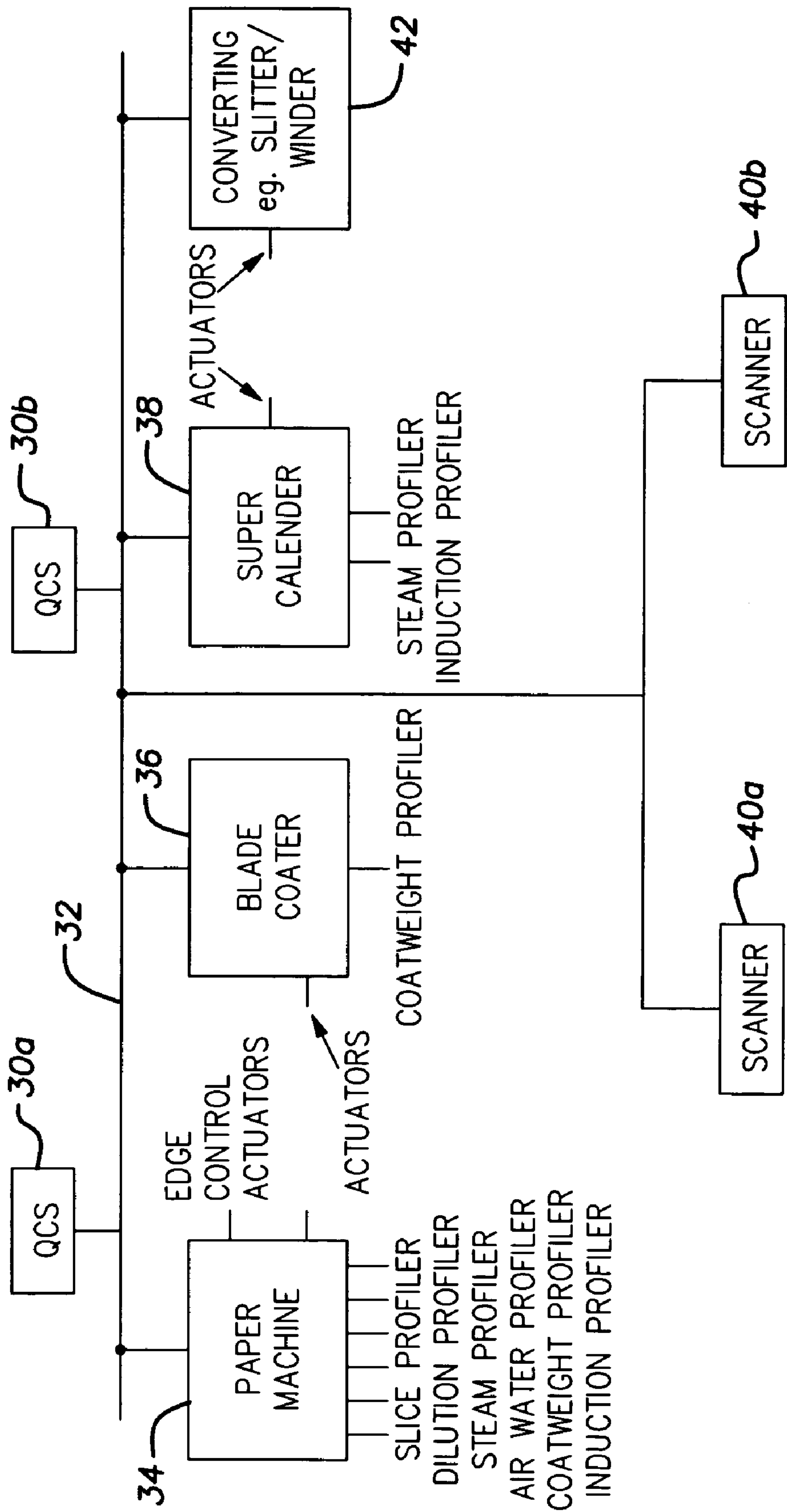


FIG. 2

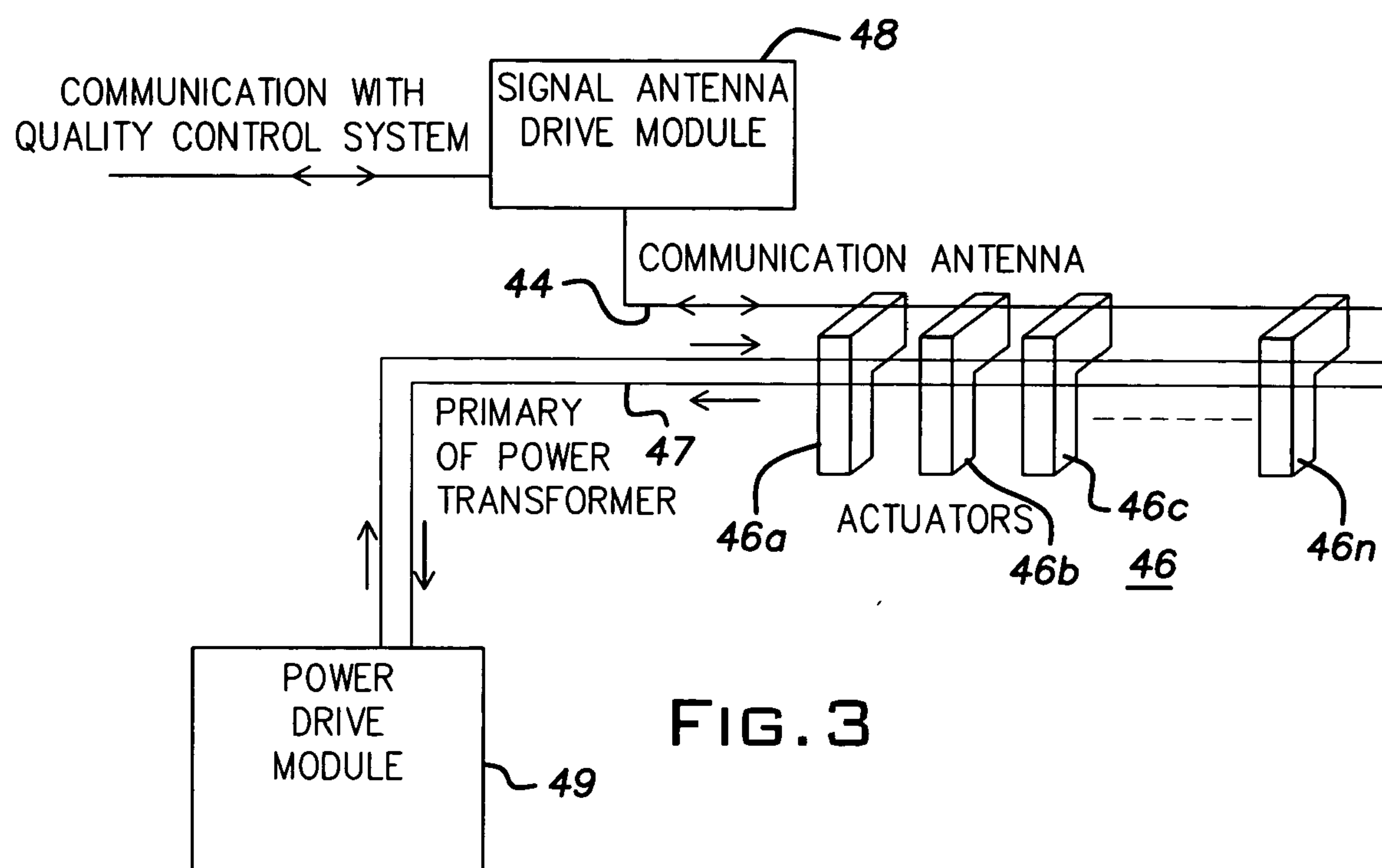


FIG. 3

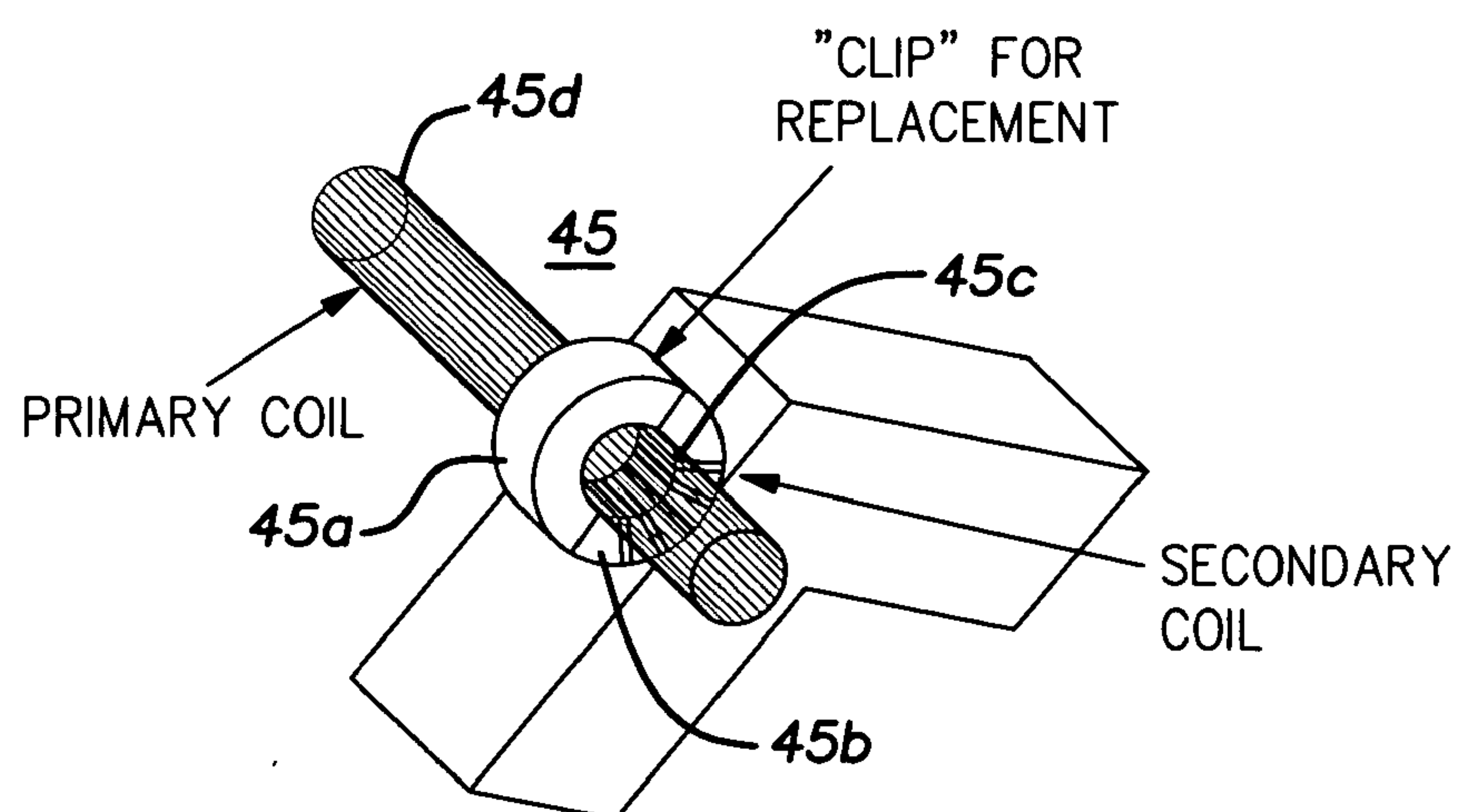
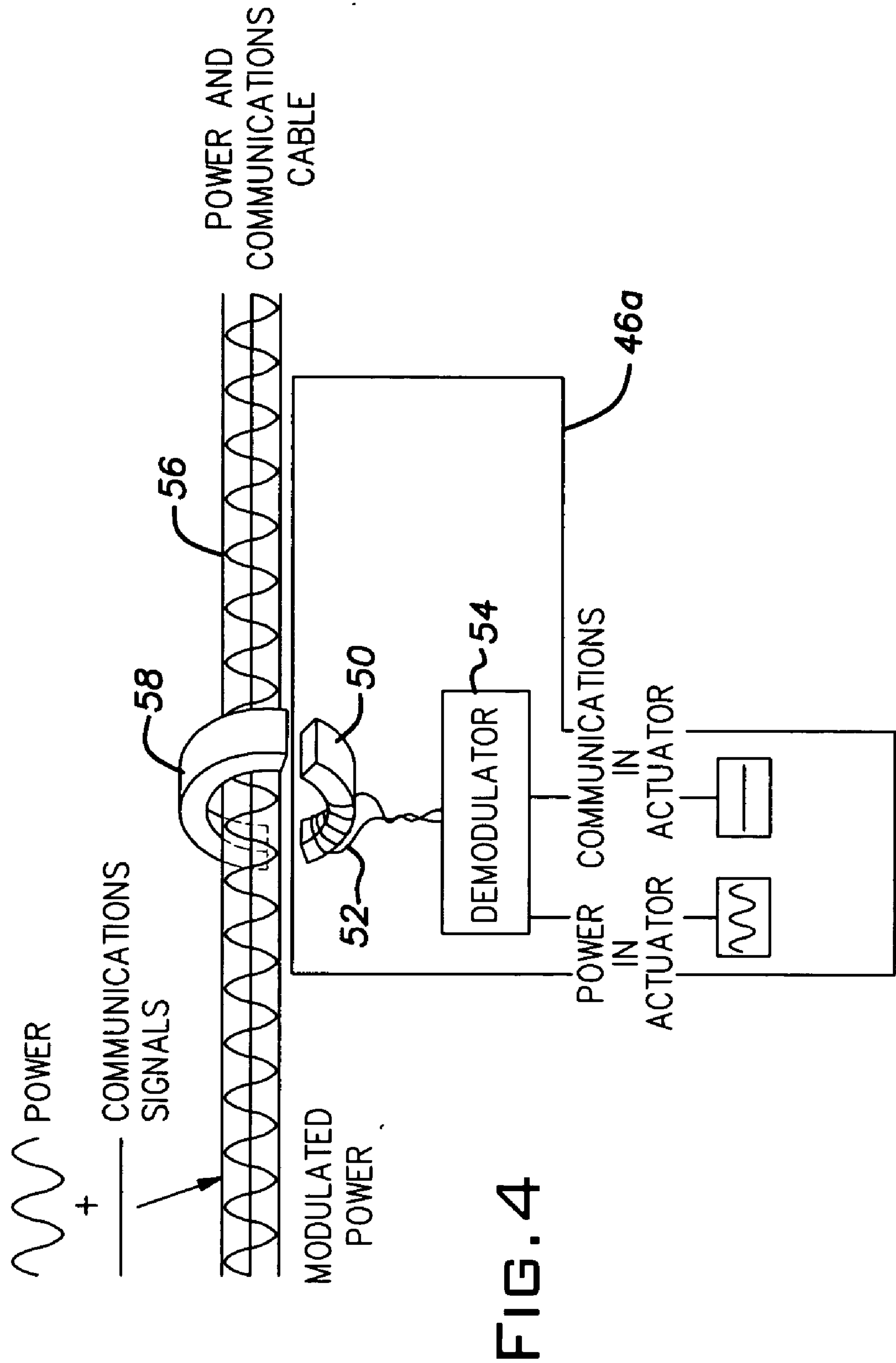


FIG. 3A



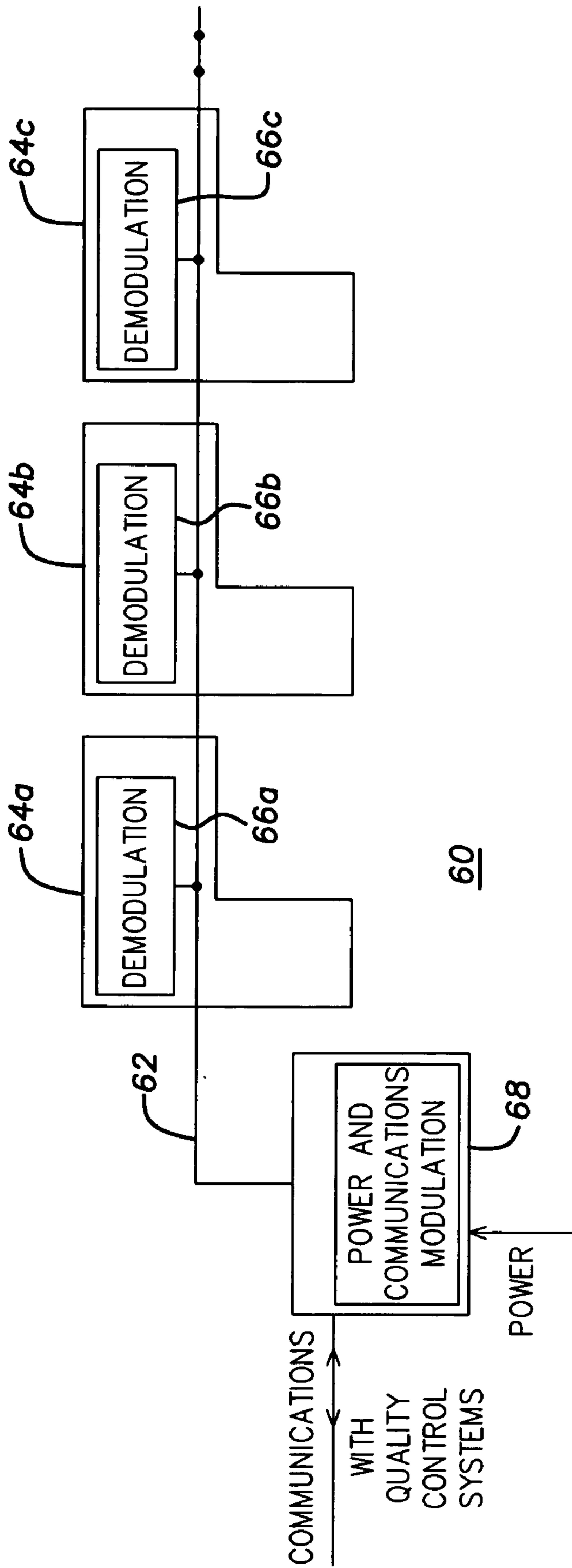


FIG. 5

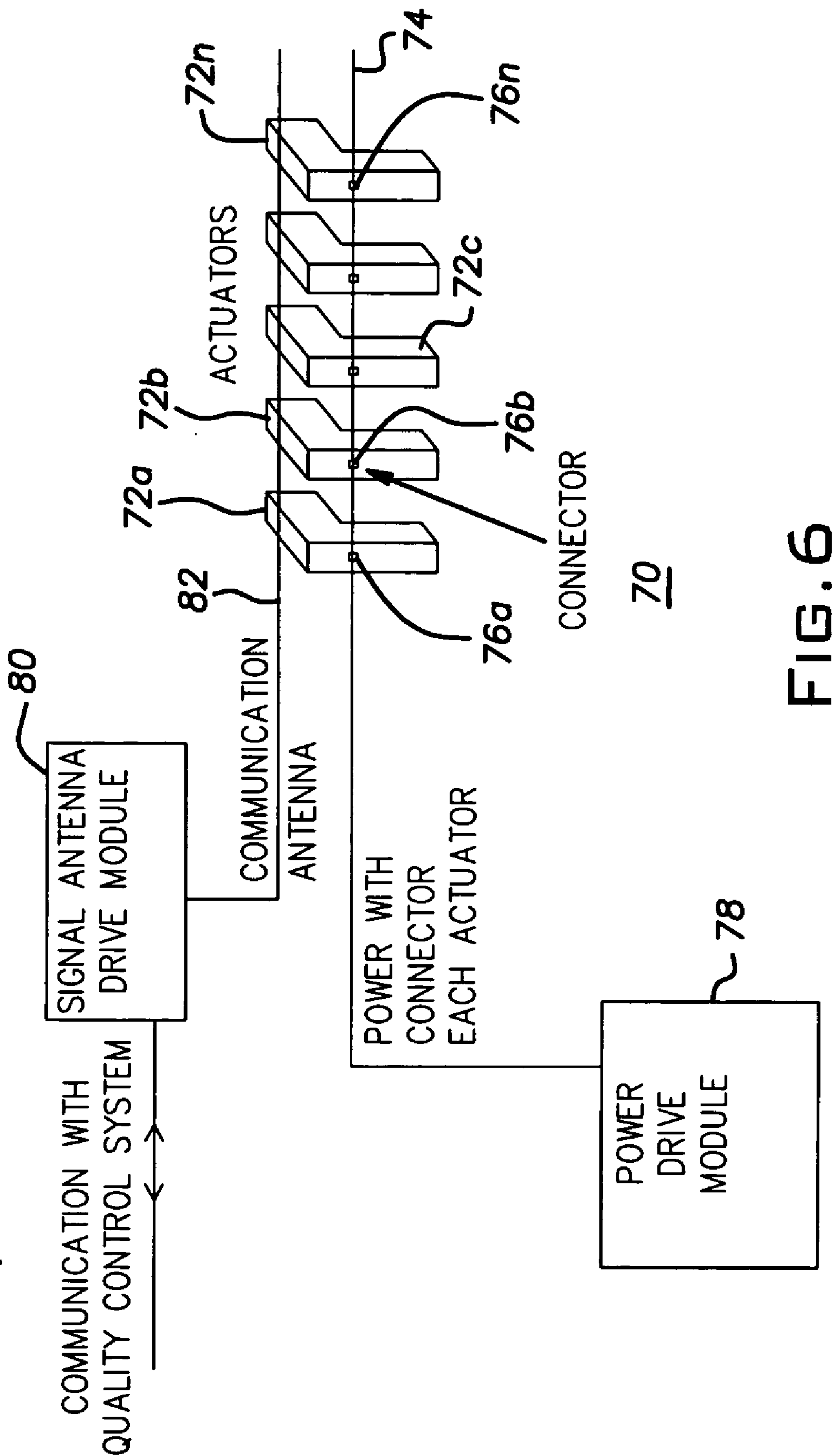


FIG. 6

ACTUATOR SYSTEM FOR USE IN CONTROL OF A SHEET OR WEB FORMING PROCESS

FIELD OF THE INVENTION

[0001] This invention relates to systems for controlling the cross-directional profile of sheet and web materials and more particularly to a cross-directional profile system that uses actuators and in which the power and/or communication to the actuators may be wireless or contactless and/or on the same cable.

DESCRIPTION OF THE PRIOR ART

[0002] It is well known that on-line measurements can be made to detect properties of sheet and web materials during manufacture thereof. For ease of description the term “sheet” is used herein including in the claims to refer to either a sheet or a web. Generally speaking, on-line measurements are made to enable prompt control of sheet and web making processes and, thus, to enhance sheet quality while reducing the quantity of substandard sheet material which is produced before undesirable process conditions are corrected. In the papermaking industry, for example, on-line sensors can detect variables such as basis weight, moisture content, caliper, coating weight, finish, color, and converting of paper sheets during manufacture.

[0003] To detect cross-directional variations in sheet materials, it is well known to use scanning sensors that travel back and forth across the sheet in the cross direction while detecting values of a sheet property along each scan. The term “cross direction” (or “CD”) refers to the direction across the surface of the sheet perpendicular to the machine direction, that is, the direction of travel of the sheet material.

[0004] Measurement information provided by the scanning sensors is assembled for each scan to provide a “profile” of the detected property of the sheet in the cross direction. Each profile thus comprises a succession of sheet measurements at adjacent locations or slices, the profile extending generally in the cross direction. From such profiles, cross directional variations in sheet properties can be detected. Based upon the detected cross directional variations, appropriate control adjustments can be made to the sheet making machine. Such adjustments are made by pluralities of cross directional actuators, such as motor driven slice lip profile control actuators located at the discharge of the headbox of a paper machine; inductive heaters for controlling the diameters of calender and/or other paper machine rollers along the length thereof; and coating blade actuators for controlling the CD weight profiles of coatings applied to one or both surfaces of the paper. Pluralities of cross directional actuators are also used in other industrial sheet forming processes such as plastic extrusion, metal rolling, etc.

[0005] As can be appreciated in all of these sheet forming processes the actuators are used to adjust, flatten and shape the cross direction properties, such as density, moisture content, thickness, and optical properties, of the sheets that are being manufactured. In many cases these cross direction actuators will number from 20 to over 200 at one location on the sheet forming machine. There may be several actuator systems at various locations along the sheet formation process.

[0006] Most of these industrial sheet forming processes operate under severe environments that require actuator designs to be waterproof, corrosion resistant, vibration resistant, high temperature resistant, extremely reliable, as small as possible, and very easy to maintain and service. A critical and expensive portion of any actuator system is the power and communication distribution cables and connectors for the 20 to 200 actuator zones in a typical system extending across the sheet forming machine. Presently only special cables and sealed, industrially hardened, pinned connectors can be used to meet this requirement. Two examples of actuator systems that use power and communication distribution cables and connectors for the actuator zones are shown in U.S. Pat. Nos. 5,771,174 and 5,381,341.

[0007] Thus in order to substantially increase the reliability and serviceability of an actuator system it is desirable to either reduce the number of or eliminate the actuator system cables and connectors. Further reducing the number of or eliminating the actuator system cables and connectors will greatly reduce the cost of the system and the cost and time for system installation.

[0008] There is described in C. Apneseth et al, “Wireless—Introducing wireless proximity switches”, ABB Review 2/2002, pp. 42-49, a wireless proximity switch for use in a cell on an engine assembly line. As is shown in the figure on page 44, there is installed around the cell four primary loops that are fed by two power supplies that set up an alternating current in the loops to thereby produce a magnetic field throughout the cell. Inside the cell is a robot with several wireless proximity switches clustered at the robot gripper. The switches each have small coils that pick up the energy from the magnetic field and convert it to electric power. The switches each also have small radio transceivers and low power electronics that handle the wireless communication link between the switches and an input module outside of the cell. The switches communicate with the input module by way of antennas mounted in the cell.

SUMMARY OF THE INVENTION

[0009] A sheet forming system that comprises:

[0010] one or more quality control systems for use in forming the sheet;

[0011] at least one actuator driven device having a plurality of actuators each associated with formation of the sheet;

[0012] a module for providing power to the plurality of actuators without having a cable connected between the power providing module and the plurality of actuators; and

[0013] a drive signal module connected to at least one of the one or more quality control systems for providing bi-directional communications between the at least one quality control system and each of the plurality of actuators.

[0014] A sheet forming system that comprises:

[0015] a quality control part that has:

[0016] one or more quality control systems for use in forming the sheet;

[0017] a modulator/demodulator associated with at least one of the one or more quality control systems;

[0018] an actuator driven part that has:

[0019] at least one actuator driven device having a plurality of actuators each associated with formation of the sheet, each of the actuators comprising a modulator/demodulator;

[0020] a cable for providing an electric power signal from the quality control part to the actuator driven part, the cable connected to the modulator/demodulator associated with the at least one of the one or more quality control systems for modulating the electric power signal to carry communication signals from the quality control part for the actuator driven part; and

[0021] each of the plurality of actuators further comprising means for receiving the modulated electric power signals from the quality control part without having the cable physically connected to each of the plurality of actuators, the modulator/demodulator associated with each of the plurality of actuators for demodulating the communications signals.

[0022] A sheet forming system that comprises:

[0023] a quality control part that has:

[0024] one or more quality control systems for use in forming the sheet;

[0025] a power and communications module including a modulator/demodulator associated with at least one of the one or more quality control systems;

[0026] an actuator driven part that has:

[0027] at least one actuator driven device having a plurality of actuators each associated with formation of the sheet, each of the actuators comprising a modulator/demodulator; and

[0028] a cable for providing an electric power signal from the quality control part to the actuator driven part, the cable connected to the modulator/demodulator associated with the at least one of the one or more quality control systems for modulating the electric power signal to carry communication signals from the quality control part for the actuator driven part and to each of the actuator modulator/demodulators.

[0029] A sheet forming system that comprises:

[0030] one or more quality control systems for use in forming the sheet;

[0031] at least one actuator driven device having a plurality of actuators each associated with formation of the sheet;

[0032] a module for providing power to the plurality of actuators;

[0033] a cable physically connecting the power providing module to each of the plurality of actuators; and a drive signal module connected to at least one of the one or more quality control systems for providing bi-directional wireless communications between the at least one quality control system and each of the plurality of actuators.

DESCRIPTION OF THE DRAWING

[0034] **FIG. 1** shows a typical sheet forming machine such as a papermaking machine and various actuator driven profilers that may be used on the machine.

[0035] **FIG. 2** shows in block diagram form one or more quality control systems connected to a machine for making a sheet such as paper, one or more scanners and various special function machines associated with the making of the sheet.

[0036] **FIG. 3** shows an embodiment for the present invention in which there are a wireless connection of power and two way communications between a quality control system and one or more actuator driven devices and **FIG. 3a** shows an embodiment in which the connection of power is contactless.

[0037] **FIG. 4** shows an embodiment for the present invention where power is supplied to the actuators and bi-directional communication between the control quality systems and the actuators are both accomplished in a contactless manner over a power cable.

[0038] **FIG. 5** shows an embodiment for the present invention where a single cable is connected to the actuators to provide both electric power and bi-directional communication between the control quality systems and the actuators.

[0039] **FIG. 6** shows an embodiment for the present invention where electric power is provided to all of the actuators over a cable and bi-directional communication between the control quality systems and the actuators is provided by the wireless antenna system of **FIG. 3**.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0040] Referring now to **FIG. 1**, there is shown a typical papermaking machine **10** and various actuator driven profilers **12**, **14**, **16**, **18**, **20**, **22**, **24** and **26** that may be use on machine **10**. More specifically, machine **10** as is well known to those of ordinary skill in the art will include an actuator driven dilution profiler **12** and an actuator driven slice profiler **14** associated with headbox **10a**. The headbox **10a** feeds a pulp suspension onto the initial part of a lower wire (not shown in **FIG. 1**). The actuator driven profilers **12** and **14** and others of the actuator driven profilers described herein are used to control the transverse profile of the suspension.

[0041] Papermaking machine **10** also includes a Fourdrinier table **10b** and a press section **10c** that may include one or more actuator driven steam profilers such as profiler **16** of **FIG. 1**. The moisture profile in the cross-machine direction (CD) is one of many important qualities of paper products. It is not only important that the overall moisture level be controlled, but also that the moisture distribution throughout the sheet be controlled both in the direction that the sheet is moving known as the machine direction (MD) and in the CD. Variation in moisture content of the sheet will often affect paper quality as much or even more than the absolute moisture content.

[0042] Steam showers profilers such as profiler **16** are conventional profiling systems that work by selectively delivering steam onto the paper web during production. Profiling steam showers deliver a variable distribution of steam in zones across the paper web. The amount of steam passing through each zone of a steam shower is adjusted through an actuator located in that zone.

[0043] Steam showers are widely used on the Fourdrinier table **10b** to help drainage and increase production. In the

press section **10c**, steam is added before the press nips to increase the temperature of the web. The added temperature makes the water removal by pressing much more effective as the added moisture removal is much greater than the added moisture due to steam condensation.

[0044] Further downstream machine **10** may also include an actuator driven air water profiler **18**, a calender profiler **20**, a coat weight profiler **22**, a finishing profiler **24** and an induction profiler **26**. Profiling steam showers, such as calender profiler **20**, are also used in the calendaring process to improve gloss and smoothness of the paper products. Moisture spray systems, such as air water profiler **18**, are also conventional profiling systems normally used in the evaporating sections of papermaking machines. The water spray systems are designed to apply a profile of moisture spray in the cross-machine direction to counter an undesirable moisture profile in the paper web. These systems consist of a series of flow-controlling actuators capable of independently adjusting the amount of spray in discrete adjacent zones in the CD. The induction profiler **26** is used for heating the paper roll to provide caliper and gloss control.

[0045] While **FIG. 1** shows a papermaking machine **10** with various actuator driven profilers **12** to **26** it is well known to those of ordinary skill in the art that some of those actuator driven profilers may be used on special functions machines other than machine **10**, such as a blade coater or a supercalender or a slitter winder, that are also associated with papermaking. This use is shown in block diagram form in **FIG. 2**.

[0046] As is shown in **FIG. 2** one or more quality control systems (QCS) **30a** and **30b** are connected by suitable means **32** which may be a physical cable or a wireless connection as described below to a paper machine **34**, a blade coater **36**, a supercalender **38**, one or more scanners **40a** and **40b** and a converter **42**. Paper machine **34** may have edge control actuators and various actuator driven profilers such as the slice profiler, dilution profiler, steam profiler, air water profiler, coat weight profiler and induction profiler shown in **FIG. 1**. Blade coater **36** has an actuator driven coat weight profiler, supercalender **38** has actuator driven steam and induction profilers, and converter **42** has an actuator driven slitter winder.

[0047] In accordance with the various embodiments of the present invention described below the actuators of each of the one or more actuator driven profilers in papermaking machine **10** or the various actuators described in connection with the machines shown in block diagram form in **FIG. 2** receive power and engage in bi-directional communications with the QCS system such as systems **30a** and **30b** of **FIG. 2** as follows:

[0048] a. instead of a cable physically connected to the actuators to transmit power to the actuators and a cable physically connected to the actuators for bi-directional communication between the actuators and with the one or more QCSs **30a**, **30b** this embodiment uses as, is described below, a technique hereinafter referred to as “wireless” to transmit power to the actuators and to provide bi-directional communications between the actuators and with the one or more QCSs—alternatively this embodiment may use a closed magnetic path, hereinafter referred to as “contactless” to transmit

power to each of the actuators—a subset of this embodiment is a cable physically connected between the one or more QCSs and the actuators for bi-directional communications between the actuators and wireless or contactless power;

[0049] b. contactless power and communication on a power cable;

[0050] c. a cable physically connected from the power source to the actuators to provide power to the actuators and bi-directional communication between the one or more QCSs and the actuators using the power cable;

[0051] d. power provided to the actuators through a power cable physically connected to each of the actuators and wireless communication.

[0052] Referring now to **FIG. 3** there is shown in simplified block diagram form the embodiment where no cables are physically connected to the actuators are used to transmit power to the actuators and no cables are physically connected to the actuators are used for bi-directional communication between the actuators and one or more QCSs.

[0053] The embodiment shown in **FIG. 3** uses a technique referred to as “wireless” for both the transmission of power and the bi-directional communications and thus the embodiment as a whole is said to be wireless.

[0054] Bi-directional communication with one or more QCSs such as QCS **30a** and/or QCS **30b** of **FIG. 2** takes place through a primary signal antenna **44** which is in close proximity to the array **46** of actuators **46a**, **46b**, **46c** . . . **46n** and by an antenna (not shown in **FIG. 3**) which is located in each of the actuators. The primary signal antenna **44** interfaces with the one or more QCSs through a signal drive antenna module **48**. Power is transmitted to each of the actuators **46a** to **46n** from power drive module **49** by a transformer arrangement where the secondary side of the transformer is embedded in each actuator **46a** to **46n** and the primary side **47** of the transformer is located outside of the actuator.

[0055] Alternatively as is shown in **FIG. 3a**, a closed magnetic path may be used to transmit power to each of the actuators by using small ring types cores **45** that consist of two half circle parts **45a** and **45b**. One of the half circle parts carries the secondary winding **45c** and the half circle parts can be clipped together around the primary coil wire **45d**. The arrangement shown in **FIG. 3a** uses a technique referred to as “contactless” for the transmission of power.

[0056] Therefore the embodiment shown in **FIG. 3** is wireless as to both transmission of power and bi-directional communications and the embodiment of **FIG. 3a** is wireless as to bi-directional communications and contactless as to the transmission of power as in both embodiments power supplied to and bi-directional communication with each of the actuators **46a** to **46n** does not require the physical connection of a communication cable and a power cable to each of the actuators as in the systems of the prior art.

[0057] A subset of the embodiment shown in **FIG. 3** is where the power is supplied to each of the actuators in the wireless or contactless manner shown in **FIGS. 3** and **3a** and the bi-directional communications between the one or more QCSs and the actuators is accomplished through a cable that is connected to each actuator as is shown in the

aforementioned U.S. Pat. Nos. 5,771,174 and 5,381,341 the disclosures of which are hereby incorporated herein by reference.

[0058] Referring now to **FIG. 4** there is shown in simplified form an embodiment for the present invention wherein power is supplied to all of the actuators and bi-directional communication between the one or more QCSs and all of the actuators are both accomplished in a contactless manner over a power cable. The simplified diagram of **FIG. 4** shows a single actuator such as for example actuator **46a** of **FIG. 3** which has included therein a part of a magnetic core **50** that may be made from ferrite or a similar material with a wire **52** wound on the core. The actuator also includes a modulator/demodulator **54**.

[0059] External to and not connected to the actuators is a power and communication cable **56**. At that end of the system not shown in **FIG. 4** where the one or more QCSs are located and the system for providing power to all of the actuators is also located a modulator/demodulator (not shown in **FIG. 4**) that modulates the AC signal on the power and communication cable **56** to provide communication to all of the actuators and demodulates the communication signals modulated on the AC power signal at the actuators to receive communications from the actuators.

[0060] As is shown in **FIG. 4**, the communication and power cable **56** includes adjacent to each actuator a magnetic core **58** that may be made from ferrite or a similar material which core in combination with the magnetic core **50** embedded in each actuator forms a transformer that allows the modulated AC power signal on cable **56** to be received and demodulated by each actuator. Thus the embodiment shown in **FIG. 4** is also contactless as power supplied to and bi-directional communication with each of the actuators such as actuators **46a** to **46n** of **FIG. 3** does not require the physical connection of a communication cable and a power cable to each of the actuators as in the systems of the prior art.

[0061] Referring now to **FIG. 5**, there is shown in simplified form an embodiment **60** for the present invention wherein a cable **62** is physically connected from the source of power to each of the actuators **64a**, **64b**, **64c** in a manner well known in the art to provide power to all of the actuators and the bi-directional communications between the actuators and the one or more QCSs also occurs using cable **62**. Each actuator **64a**, **64b**, **64c** includes an associated embedded modulator/demodulator **66a**, **66b**, **66c** for bi-directional communications over cable **62** with the one or more QCSs.

[0062] Upstream from the actuators **64a**, **64b** and **64c** is a power and communications module **68** that includes a modulator/demodulator (not shown in **FIG. 5**) that allows power to be transmitted over cable **62** to each of the actuators and the cable to also carry the bi-directional communications between the actuators and the one or more QCSs.

[0063] Referring now to **FIG. 6**, there is shown in simplified form an embodiment **70** for the present invention wherein power is provided to each of actuators **72a**, **72b** . . . **72n** over a cable **74** that is physically connected by associated connector **76a**, **76b** . . . **76n** to each of an associated one of the actuators in a manner well known in the art. A power drive module **78** provides the power to cable **72**.

[0064] Bi-directional communication between each of the actuators **72a**, **72b** . . . **72n** and the one or more QCSs is provided wirelessly by the antenna system described above for the embodiment shown in **FIG. 3**. As previously described a signal drive antenna module **80** is connected between the one or more QCSs and the communication antenna **82**. Antenna **82** is in close proximity to each of the actuators **72a**, **72b** . . . **72n** and each of the actuators include an antenna.

[0065] While the present invention is described herein in connection with a paper making machine it should be appreciated that the present invention in all of the embodiments described herein can be used with any process that uses actuators in connection with a moving sheet or web. Examples of such processes are the forming of textiles and machines that printing on sheets or webs.

[0066] It is to be understood that the description of the preferred embodiment(s) is (are) intended to be only illustrative, rather than exhaustive, of the present invention. Those of ordinary skill will be able to make certain additions, deletions, and/or modifications to the embodiment(s) of the disclosed subject matter without departing from the spirit of the invention or its scope, as defined by the appended claims.

What is claimed is:

1. A sheet forming system comprising:

one or more quality control systems for use in forming said sheet;

at least one actuator driven device having a plurality of actuators each associated with formation of said sheet;

a module for providing power to said plurality of actuators without having a cable connected between said power providing module and said plurality of actuators; and

a drive signal module connected to at least one of said one or more quality control systems for providing bi-directional communications between said at least one quality control system and each of said plurality of actuators.

2. The system of claim 1 wherein power is provided from said power providing module to each of said plurality of actuators by a transformer arrangement comprising a primary side associated with said power providing module and a secondary side associated with each of said plurality of actuators.

3. The system of claim 2 wherein said transformer arrangement primary side runs from said power providing module adjacent to each of said plurality of actuators and said secondary side is embedded in each of said plurality of actuators.

4. The system of claim 1 wherein power is provided by said power providing module to each of said plurality of actuators by a closed magnetic path from said power providing module to each of said plurality of connectors.

5. The system of claim 4 wherein said closed magnetic path comprises a primary wire providing a magnetic field from said power providing module to each of said plurality of actuators and each of said plurality of actuators comprise means connected to said actuator to intercept said magnetic field provided by said primary wire.

6. The system of claim 1 wherein said bi-directional communications is provided by a cable connecting said drive signal module and each of said plurality of actuators.

7. The system of claim 1 wherein said drive module provides bi-directional wireless communications between said at least one quality control system and each of said plurality of actuators.

8. The system of claim 7 wherein said bi-directional wireless communications is provided by an antenna arrangement comprising a primary signal antenna associated with said drive signal module that is in close proximity to each of said plurality of actuators and an antenna located in each of said plurality of actuators.

9. A sheet forming system comprising:

a quality control part comprising:

one or more quality control systems for use in forming said sheet;

a modulator/demodulator associated with at least one of said one or more quality control systems;

an actuator driven part comprising:

at least one actuator driven device having a plurality of actuators each associated with formation of said sheet, each of said actuators comprising a modulator/demodulator;

a cable for providing an electric power signal from said quality control part to said actuator driven part, said cable connected to said modulator/demodulator associated with said at least one of said one or more quality control systems for modulating said electric power signal to carry communication signals from said quality control part for said actuator driven part; and

each of said plurality of actuators further comprising means for receiving said modulated electric power signals from said quality control part without having said cable physically connected to each of said plurality of actuators, said modulator/demodulator associated with each of said plurality of actuators for demodulating said communications signals.

10. The sheet forming system of claim 9 wherein said means for receiving said modulated electric power signals in each of said plurality of actuators comprises a magnetic core embedded in each of said actuators and a magnetic core adjacent to each of plurality of actuators, said cable passing through each of said magnetic cores adjacent to each of said plurality of actuators.

11. A sheet forming system comprising:

a quality control part comprising:

one or more quality control systems for use in forming said sheet;

a power and communications module including a modulator/demodulator associated with at least one of said one or more quality control systems;

an actuator driven part comprising:

at least one actuator driven device having a plurality of actuators each associated with formation of said sheet, each of said actuators comprising a modulator/demodulator; and

a cable for providing an electric power signal from said quality control part to said actuator driven part, said cable connected to said modulator/demodulator associated with said at least one of said one or more quality control systems for modulating said electric power signal to carry communication signals from said quality control part for said actuator driven part and to each of said actuator modulator/demodulators.

12. A sheet forming system comprising:

one or more quality control systems for use in forming said sheet;

at least one actuator driven device having a plurality of actuators each associated with formation of said sheet;

a module for providing power to said plurality of actuators;

a cable physically connecting said power providing module to each of said plurality of actuators; and

a drive signal module connected to at least one of said one or more quality control systems for providing bi-directional wireless communications between said at least one quality control system and each of said plurality of actuators.

13. The system of claim 12 wherein said bi-directional wireless communications is provided by an antenna arrangement comprising a primary signal antenna associated with said drive signal module that is in close proximity to each of said plurality of actuators and an antenna located in each of said plurality of actuators.

* * * * *