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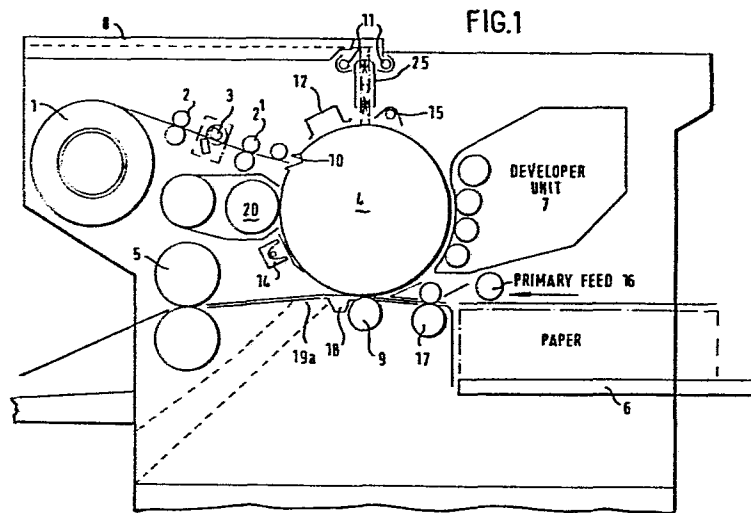
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D-8000 München 80(DE)(54) **Improvements in or relating to electrostatographic copying and duplicating.**

(57) An electrostatographic duplicator in which an original document is duplicated by redeveloping a previously developed and fixed latent image has a rotatory drum 4 for supporting a sheet of electrostatographic recording material releasably clamped thereon. A supply spool 1 carries electrophotographic recording material in web form, and rollers 2 advance the recording material towards the drum 4, after which guillotine 3 cuts an individual sheet of predetermined length from the advancing web. The individual sheet is directed by rollers 2 onto the support member and clamped thereon. A corona charging unit 12 electrically charges the recording material on the support member, an imaging station 11, 25 projects a light image of the original document onto the recording material, a development station 7 applies an insulating toner to an electrostatic latent image on the recording material and a master fixing unit 14 fixes the developed toner image onto the sheet of recording material supported on the drum 4. In duplicating cycles means 16, 17 feeds copy sheets serially towards the support member, a transfer station is located so that copy sheets

pass between an electrically charged transfer member 9 and the recording material on the drum 4 so that an unfixed toner image transfers onto a copy sheet. The copy sheets pass to a copy sheet fixing device 5 and the recording material travels past a cleaning unit 20 before it is re-charged at corona unit 12 and flood exposed at a station 20 in the next duplicating cycle, control means responsive to a start button and a counter records the number of duplicated copies required and controls the operation of all the aforesaid devices so that (I) in a master preparation cycle a sheet of recording material is cut from the material on the supply spool 1 and clamped onto the drum 4 after which a fixed toner image is formed on the master by driving the drum 4 at a first speed, electrically charging the recording material, forming a latent image of the original document thereon, developing 7 the latent image with toner and radiant heat fusing the developed toner image onto the recording material, (II) in subsequent duplicating cycles the drum 4 is driven at a second speed

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higher than the first speed and cyclically the drum is cleaned (20), electrically charged (12), uniformly illuminated (15) and redeveloped with toner (7) and the resulting toner image is transferred onto copy sheets and fixed thereon, and (III) on completion of duplication the used sheet of recording material is ejected from the support member.



IMPROVEMENTS IN OR RELATING TO ELECTROSTATOGRAPHIC COPYING
AND DUPLICATING

The present invention relates to apparatus for electrostatographic copying and fixed image duplicating of
5 an original document.

The idea of electrostatic printing a multiplicity of copies from a non-conductive image or on an electrically conductive printing plate was described by Roland M. Schaffert in U.S. Patent
10 No. 2576047 and a fixed image duplicating cycle was described by Konishiroku Photo Industry Corporation in U.K. Patent Specification No. 1139256 and by Loren E. Shelffo of Addressograph-Multigraph Corporation in U.K. Patent Specification No. 1210666. Konishiroku in their Specifi-
15 cation No. 1139256 describe the use of individual sheets of light sensitive paper taken from a stack by a suitable feeder device. Subsequently Olympus Optical Co. have proposed in U.S. Patent No. 4273438 to provide a latent image duplicator in which a rotatable drum has a photocon-
20 ductive sheet wound around its outer surface from an internal supply roll to an internal take-up roll.

The present invention employs a roll of zinc oxide coated paper or other material remote from the drum, automatically feeds it towards the drum and clamps it onto
25 the drum when demanded. The master can be used for copying and duplicating and it is a particular advantage that the same development unit or station can be used both for master development and for copy development. The drum

or other support for the electrophotographic recording member runs at different speeds depending upon whether the machine is master imaging, copying or duplicating and in order to facilitate this and to enable the parts of the machine to function in correctly timed sequence when the drum is accelerating or decelerating. Timing is preferably carried out by means of a pulse generator rotatable with the support and a decoder that forms part of the control unit that feeds signals denoting the number of cycles completed by the support and its position in the current cycle, selector logic units responding to this information to turn on their associated devices at the appropriate time.

In one aspect the invention provides an electrostatographic duplicator in which an original document is duplicated by redeveloping a previously developed and fixed latent image, comprising in combination:

- (a) a rotary support member for supporting a sheet of electrostatographic recording material releaseably clamped thereon;
- (b) means for rotating the support member;
- (c) a supply spool that carries electrophotographic recording material in web form, means for advancing the recording material towards the support member, cutting an individual sheet of predetermined length from the advancing web, directing the cut sheet onto the support member

and clamping it thereon;

(d) a corona charging unit for electrically charging the recording material on the support member;

5 (e) an imaging station for projecting a light image of the original document onto the recording material;

(f) means for uniformly illuminating the recording material on the support member;

10 (g) a development station for applying an insulating toner to an electrostatic latent image on the recording material;

(h) means for feeding copy sheets serially towards the support member;

15 (i) a transfer station located so that copy sheets pass between an electrically charged transfer member and the recording material on the support members so that an unfixed toner image transfers onto a copy sheet;

20 (j) a master image fixing device located adjacent the support member for fixing a developed toner image onto the recording material;

(k) means for cleaning the recording material on the support member;

25 (l) means for fixing the transferred toner image to the copy sheet; and

(m) control means responsive to a start button and a counter recording the number of duplica-

ted copies required for controlling the
operation of all the aforesaid devices so
that (I) in a master preparation cycle a
sheet of recording material is cut from the
material on the supply spool and clamped onto the
support member after which a fixed toner image is
formed on the master by driving the drum at a first
speed, electrically charging the recording material,
forming a latent image of the original document
thereon, developing the latent image with toner and
radiant heat fusing the developed toner
image onto the recording material, (II) in
subsequent duplicating cycles the drum is
driven at a second speed higher than the first
speed and cyclically the drum is cleaned,
electrically charged, uniformly illuminated and
redeveloped with toner and the resulting toner
image is transferred onto copy sheets and fixed
thereon, and (III) on completion of duplication
the used sheet of recording material is
ejected from the support member if required.

In another aspect the invention provides apparatus
for electrostatographic reproduction of an original
document by copying or fixed image duplicating including a
supply spool that carries electrostatographic recording
material in web form, means for advancing the recording
material towards a rotatory support member, means for
severing the recording material into individual sheets,

means for releasably clamping an individual sheet onto the support member, a master imaging station for forming a light image of an original document on the recording material on said support member, a development station for
5 applying an insulating toner to an electrostatic latent image on the recording material, a master fixing station operable only when in the master fixing stage of the duplicating mode to fix a developed toner image from a master imaging cycle onto the sheet of recording material on the support member
10 for use in subsequent duplicating cycles, a transfer station operable to transfer an unfixed toner image from the recording member to a copy sheet during copying and to transfer a redeveloped toner image from the recording member during duplicating and control means selectively operable to
15 cause the machine to perform copying or duplication and connected to the master imaging to take place only when the master material on the support member does not bear a fixed toner image.

Of course, residual toner is removed by a brush
20 cleaner so that the master is maintained free from unfixed toner that might otherwise interfere with re-imaging or cause ghost images on recycling. Provision is also made for automatic ejection of the master either when a predetermined number of copies have been made and consequently
25 the photoconductive properties are no longer satisfactory or at a predetermined number of copies such that the master is no longer suitable for the duplicating process.

A combined copier/duplicator of the present kind

will normally work at a first speed when copying and at a second speed when duplicating. If copy sheet fixing is carried out by a heated roll fixing unit, then it is necessary for the fixing unit to adapt rapidly to
5 different linear speeds of the copy sheet.

In a third aspect the invention provides a combined electrostatographic copier and duplicator that forms copies by creating a light image of an original document on an electrostatographic recording member at each copy
10 cycle and transfers a developed image to a copy sheet that is discharged at a first linear speed towards a fixing unit comprising a pair of rollers having deformable surfaces, at least one of said rollers being heated, the copy sheet passing between them in order to fix the toner
15 image to the copy sheet and duplicates by forming further toner images on the recording member without creating a new light image and transferring the toner images to copy sheets that are discharged towards the fixing unit at a second linear speed higher than said first linear speed,
20 said fixing unit having means operable to adjust the roller pressure between a first relatively low value for use when copying and a second higher value when duplicating whereby satisfactory toner fixing to the copy sheets at both said first and second speeds can be
25 achieved without alteration of roller temperature.

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic representation of an electrophotographic copying and duplicating machine showing the arrangement of the working components thereof;

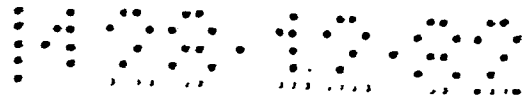
Figure 2 is a schematic diagram of an electronic control system for all cycles of the copying and duplicating machine of Figure 1 in the duplicating mode;

Figure 3 is a diagram showing a pair of rolls of a roller fusing unit; and

Figure 4 is a graph showing nip width against applied roll pressure.

How the machine is constructed and is to operate

In Figure 1, master material in the form of zinc oxide coated paper is held on a spool 1. Its leading edge passes between first and second pairs of feed rollers 2' and 2 between which there is a guillotine 3. The master material then passes a further roller and enters leading edge clamps 10 on the periphery of a rotary drum 4 which is rotated at the same peripheral speed as the linear speed of the master material. The drum 4 has a head clamp 10 and a tail clamp (not shown) for the cut sheet of master material each defined by a transversely directed recess or notch and a set of typically four clamping fingers. The head and tail clamping fingers are supported on common shafts having follower means and are arranged to be lifted as the drum rotates by means of a load cam operated by a solenoid or other suitable means. So when the load cam is in its working position, as the drum rotates the follower means travels over a raised sector



thereby raising and lowering the clamping fingers. The feeding of the master sheet by rollers 2' is synchronised with rotation of the drum so that the leading edge of the master sheet enters into the open head clamp at the appropriate position. As the drum 4 continues to rotate, master material continues to be drawn from the spool 1 until a required length has passed through the guillotine 3 which then operates. The free end of the master material is then drawn onto the drum and the tail clamping fingers are raised and lowered by the load cam in synchronised relationship to the arrival of the cut master sheet to clamp the trailing edge of the master sheet onto the drum and the transfer roller is raised to hold the master taut against the drum surface before the tail clamping fingers come down to retain it permanently in position. Since the tail clamping fingers must rotate in the opposite direction to that of the head clamping fingers they are raised and lowered by similar follower means but via a pair of quadrant gears, the ratio of the quadrant gears being conveniently chosen so that the tail clamping fingers rotate approximately twice the angular movement of the head clamping fingers; this is necessary since the leading edge of the master sheet slides underneath the head clamping fingers whereas the trailing edge describes an involute arc when being clamped.

A second solenoid operated cam 19 (Figure 2) for master ejection is attached to the frame of the machine and has a lobed surface that the follower means follows

when the master eject cam is in its working position. The master eject cam is displaced approximately 270° around the axis of the drum 4 with respect to the clamp 10 and may be used to eject a spent master from the drum. As the head clamps pass the eject cam they are caused to open and two arms attached to the same shaft as the clamping fingers thrust the leading edge of the master sheet away from the drum, and the transfer roller is again raised to drive the ejected master forward into the exit chute. The master is then stripped from the drum and a master exit flap 19a raised to allow the spent master to pass down a disposal chute. The tail clamps are opened by the same cam so that the discarded master is free to fall into the chute.

15 Synchronisation of the loading cycle is achieved by generating a series of clock pulses (256 per drum revolution) as the drum 4 rotates together with a counter reset pulse generated once per drum revolution. These pulses are generated by photo-electric sensors A and B (Figure 2) and slotted discs (not shown). As the drum starts to rotate a counter receives a reset pulse and starts to count clock pulses. These pulses are used to control the sequence of operation of other parts of the machine as more fully described below. This method of
20 timing is a considerable advance on simple microswitches, timing cams or time delay systems because it allows the machine to operate at variable drum speeds and enables a correct timing sequence to be maintained when the drum is

accelerated or decelerated.

When the master material is on the drum, it may be used for copying or duplicating purposes. All the components of the machine are employed in duplicating, whereas
5 some of them are inoperative during copying, so it is convenient to describe the duplicating procedure first. The master sheet is electrically charged by a corona charging unit 12, and then imaged with a light image of a document to be copied. The document to be copied, supported on a platen driven by drive means 8 and illuminated
10 by lamps 11 is conveyed past a strip lens array 25 synchronously with rotation of the drum 4 as described in R.W. Gundlach's US Patent Nos.3584950 and 3584952, in UK Patent Specification No.1200383 and in our copending UK
15 Patent Application No.8136622. Other optical systems than a strip lens can be used. In particular it may be desirable to use a system of mirrors and lenses that permits variable magnification to be used eg. for reduction copying and duplicating. The imaged master sheet then
20 passes to a development station 7 in which a two-component magnetic developer including particles of an insulating and charge retaining toner composition is applied to the latent electrostatic image on the master sheet by means of one or more magnetic brushes. The drum 4 is further
25 rotated to pass the master sheet through a radiant master fuser 14 that fixes the toner image onto the master sheet. The condition of master image fixing is desirably such that the fused toner resin possesses appropriate charge

acceptance and decay properties and should desirably give a fixed master image that typically holds a surface charge of about -450v with a decay of not more than 15% after 0.5 seconds for at least 1000 charge/discharge cycles (see our
5 copending UK Patent Application No.8123328). During the master imaging cycle, the drum 4 is required to travel relatively slowly, typically at about 12 r.p.m.

When the master imaging cycle is complete, the machine switches over to a duplicating cycle mode in which
10 the drum 4 rotates considerably faster, typically at 30 to 100 r.p.m. The master sheet is recharged at the corona charging station 12, flood exposed by means of a strip lamp 15 and redeveloped with toner by means of the developer unit 7. Because of the insulating nature of the fused
15 toner image on the master sheet, it retains its electrical charge on flood exposure, whereas the non-image areas being photoconductive are discharged by the action of lamp 15. The result is to create a new latent image of electrostatic charge in fixed toner image areas of the master
20 sheet, and it is this new latent image that is redeveloped by the developer unit 7. Copy sheets are then advanced, synchronously with drum rotation, from a paper tray 6 by primary feed roller 16 and secondary feed rollers 17 to a transfer station where they pass between drum 4 and a
25 transfer roller 9 where a bias potential is applied to the roller 9 to transfer the toner image onto the copy sheets. The electrical bias to roller 9 is arranged to be switched on only when the leading edge of each copy sheet has

passed a predetermined distance beyond the transfer zone and is switched off when the trailing edge of the copy sheet has passed through the transfer zone. By this means, stripping of the copy from the contact with the master sheet on the drum 4 is facilitated (see UK Patent Specification No.2056914A), and a vacuum unit 18 is provided immediately downstream of transfer roller 9 to ensure that the copy sheets take an appropriate path without the need for mechanical stripping devices that might otherwise interfere with the fixed image. The imaged copy sheets then travel to a copy fixing station where the toner is fixed thereto eg. by passage through a pair of rollers that apply heat and/or pressure thereto. The master traverses a cleaning station where residual toner that has not transferred is removed by a brush 20 and then returns to the corona charging station 12 for another duplicating cycle. When duplicating is complete the master is ejected from the drum 4 and at the next copying and/or duplicating cycle a fresh master sheet is severed from the roll of master material and clamped onto the drum as described above.

In copying cycles, the master sheet on drum 4 is re-used. Downstream of the developer unit 7 the toner image is transferred to copy sheets at transfer roller 9 without being fixed at fuser station 14 which is inoperative. And the platen drive 8 has to operate for each copy that is produced.

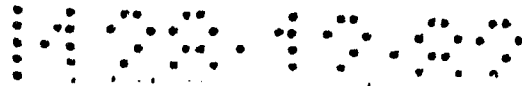
The Control Circuit

In Figure 2, the paper tray 6 is operated by a paper raise and lower button 50 that controls drive motor 51 for the paper tray. An indicator and sensor device 52 is
5 connected to a machine initialising logic unit 53 that forms part of a digital control system for the machine. Also connected to the unit 53 are a toner sensor and indicator 54. Both sensor device 52 and unit 53 pass signals to device 55 that detects a lack of supplies and
10 simulates copy 0 (final sheet) until further supplies are made. A power on-off switch 56 is connected via cover interlock sensor 57 to machine initialising logic unit 53 as also is a master roll located sensor 58 which senses when master material is not present in roll 1 and a platen
15 position indicator and sensor 8'. Where the rollers 5 are hot pressure fusing rollers a heat sensing and control unit 59 is in two-way communication with the initialising logic unit 53 so that the machine is not allowed to operate until the appropriate roller temperature has been
20 attained. The logic unit 53 also communicates via paper misfeed logic unit 60 with paper misfeed sensors and indicator 61 and it outputs to standby indicator 62, to machine/operator interface logic unit 63, to OR gate 64 that enables master roll drive 2', to OR gate 65 that
25 enables guillotine 3 and to the main motor 66 that drives the machine.

The paper misfeed logic unit 60 communicates with a decoder 67 for sensors A and B that outputs to a complete

revolution data bus 68 and a partial revolution data bus 69. The data busses 68, 69 both communicate with a duplicating loop detector logic unit 70, a selector 71, a drum drive selection logic unit 72 that initiates high speed drive to drum 4 (low speed drive is initiated through logic unit 63), and a hot pressure fusing roll drive selection logic unit 73 that is also enabled by the loop detector logic unit 70. So the fuser rolls 5 will not start up until enabled by unit 53 and are thereafter controlled in operation by unit 73 that is enabled by detector 70 and is enabled by selector 73 that receives timing information by busses 68, 69. And the selection logic units in general respond to command signals to initiate operation of the respective device at the correct number and part revolution position of drum 4 signalled through busses 68, 69 to drive their associated device for an appropriate period. The developer unit 7 is controlled by selection logic unit 74 that is also controlled by the loop detector 70 and controls the drive to developer unit 7. The machine/operator interface logic unit 63 enables AND gate 75 that also receives an input from bias voltage unit 76 to apply a bias potential to the developer unit at an appropriate time.

Selection logic units 77, 78 connected to busses 68, 69 respectively supply an input to OR gates 64, 65 that control the master roll drive 2' and guillotine 3. So these units can either be caused to operate when required to do so either in response to initialising logic 53 or to timing signals in busses 68, 69 to



feed a new master onto the drum to prepare for a copying and duplicating cycle. A selector logic unit 79 operates the solenoid for the feed cam 10 and selector logic unit 80 additionally connected to paper feed operation logic unit 81 effects raising and lowering of transfer roller 9 to and from its working position and additionally enables AND gate 82 to apply an EHT potential from unit 83 to roller 9 to bring about transfer of the developed toner image to the copy sheets. Logic unit 81 is also connected to paper misfeed sensor 61 and also duplicating loop detector 70. So a signal to selector logic unit 80 may cause the transfer roller 9 to be raised to its operative position during duplicating cycles and electrically biased at the appropriate time but to be disabled and lowered in the event of a paper misfeed. A first paper sensor 86 connected to a sensor logic unit 87 signals to units 55, 61 and 81 when a misfeed to primary feed rolls 17 takes place and additionally a 3-misfeeds indicator 88 is connected to the line from logic unit 87 to unit 55. Selector logic unit 84 for the drive units for primary and secondary paper feed drives 16, 17 is also connected to the duplicating loop detector unit 70 and also to the copy detection or simulation unit 55. The platen drive 8 is connected to selector logic unit 89 and the vacuum unit 18 is connected to selector logic unit 90 which in addition to inputs from busses 68, 69 receives an enabling input from loop detector unit 70. The selector logic unit 91 for lamps 11 of the imaging station is connected thereto

via a brightness control unit 92. Master eject cam and flap operating system 19 is operated via selection logic unit 93 and selector logic unit 94 enables AND gate 95 that connects EHT unit 96 to the corona unit 12. Master
5 radiant fuser unit 14 is controlled by selector logic unit 97 and the flood illumination heaters and lamp 15 are controlled by selector logic unit 98 that is also electrically connected to loop detector unit 70 as shown.

Connected to machine/operator interface logic unit
10 63 is master eject button and indicator 99 and duplicate button and indicator 100, the copy 0 detector or simulator unit 55 also being connected to the indicator 100 as shown. A keyboard entry unit 102 having a 4-digit copy counter and display is electrically connected to loop
15 detection logic unit 70, copy 0 detector or simulation unit 55 and logic unit 63. Between logic unit 71 and logic unit 63 is a master fitted sensor and indicator unit 103.

The machine is controlled from a range of input
20 signals from a user accessible front panel having the power on/off switch 56; a master eject indicator button 99, the copy or duplicate indicator and button 100, keyboard by which the number of copies/duplicates required can be entered (part of 102) and a stop button not shown,
25 and also from the two sensors A and B that are located on the drum drive mechanism and respectively define drum top dead centre for each revolution (sensor A) and the number of steps that the drum has moved from its top dead centre

position (sensor B). The position count is reset to zero every time the drum 4 passes the top dead centre position. It is possible to locate the position of the drum accurately at any time that it is rotating and to cause
5 other parts of the machine to operate synchronously with the drum from a combination of the number of times that the drum has passed its top dead centre position and the measured angular position thereof within the current drum cycle.

10 Operation of the machine

When the machine is first turned on by connection to an appropriate primary source of the power, the main motor
66 starts, turning the cleaning brush 20 and the hot pressure fuser rollers 5 and also commencing to heat these
15 up. The machine initialising logic initiates no further action for a short period eg. of 0.5 second duration in order that internal power supplies may stabilise. A master roll located sensor checks then that the free end of master roll 1 is correctly located in the nip of
20 guillotine 3. If not, logic unit 53 signals OR gate 64 to drive the master roll drive 2' a short distance, after which it signals OR gate 65 to bring about operation of the guillotine to correctly locate the edge of the master material. If after this sequence is completed, no master
25 material is present in the guillotine a misfeed is indicated and the machine will do no further work until the situation is corrected. When the leading edge of the master roll has been found to be correctly located, checks

are made to ascertain whether the machine is ready to start duplication. These include checking that paper is present in feed tray 6 and ready to feed via sensor 52, checking via sensor 54 that toner powder is present and in the appropriate concentration in the developer unit 7 and via sensor 8 checking that the platen is in the appropriate position for copying of all correctly sized originals. Indicators tell the operator to take action if these items are unsatisfactory. Heat sensors 59 tell the machine when the fuser rollers 5 have reached the appropriate temperature. When the master material is found to be present, the other checks have been satisfactory and the fuser rollers 5 have warmed up, the initialising logic unit 53 places the machine in a standby mode ready to receive further instructions.

Once the machine is on standby the operator can initiate the duplicating process. To do this the number of copies required must be entered via the control panel keyboard (part of 102). If an old master has inadvertently been left on the drum 4 it must first be ejected and an indication to the operator to do so appears at 99. The machine is now ready for use on depression of the duplicate button 100.

When a duplicate signal is correctly received by interface logic unit 63 the drive to drum 4 is engaged so that it commences to turn first at slow speed. Gate 75 is enabled to apply bias voltage to the developer unit 7. As the drum passes top dead centre the transfer roller 9 is

raised through selector unit 80 to facilitate wrapping the master around the drum. Then at an appropriate time selector 77 is energised to advance the master sheet by drive roller 2 and selector 79 is energised to move the load clamp 10 to its working position. The leading edge of the master material is fed into the head clamp. When the drum 4 has rotated the correct amount, selector 78 enables guillotine 3 which cuts the master to the required length, after which the drive to feed rolls 2' is discontinued.

10 Failure to load the master correctly will stop further operation of the machine.

At the appropriate point of continued drum rotation, selector 89 causes the platen drive to advance platen 8 and selector 91 turns on the lamps 11. The platen 8 advances synchronously with drum 4 and a light image of an original document placed thereon is projected onto the master sheet through optical system 13. The master has previously been charged by corona unit 12 enabled by selector 94 and gate 95 and the master bearing the resulting charged image passes through the developer unit 7, which deposits toner on the master. Selector 80 causes transfer roller 9 to be lowered to prevent disturbance or transfer of the images or contamination of the transfer roller. The radiant fuser 14 is energised by selector 97 and as drum continues to rotate fuses the toner onto the master. When the platen 8 has completed its travel, selectors 91, 94 turn off lamp 11 and corona unit 12 and the platen returns to its original position.

In the duplicating cycle heaters in flood illumination fluorescent tubes 15 are turned on by selector 98 enabled by logic unit 70. Master fuser 14 is turned off and the drum 4 is accelerated to its higher speed by selector unit 72. Pressure on rollers 5 is increased via control unit 73. A sheet of paper from tray 6 is fed via primary and secondary feed rollers 16, 17 enabled via selector 84 and selector 90 enabled by logic unit 70 causes the vacuum unit 18 to be turned on. Also selector 94 turns corona unit 12 on again and the machine now enters a loop appropriate for duplicating cycles, which loop will continue until the required number of copies have been duplicated.

The duplicating loop consists of the following actions carried out in the correct sequence related to the position of drum 4 at any given moment which is determined by sensors A and B. Selector 80 raises transfer roller 9 and a copy sheet approaches secondary feed rollers 17 being fed through the machine in the correct position. The paper advances through the rollers 17 and the transfer station 4/9 and is again detected by another sensor near vacuum unit 18. The selector 94 turns off the voltage to corona unit 12 whilst the portion of drum 4 not covered by master sheet passes and then turns it back on again. The selector 80 enables gate 82 to apply the appropriate EHT to the transfer roller D at the required time as described above. The sheet of paper is advanced past vacuum unit 18 towards hot pressure fuser rollers 5 and is detected by

another sensor close to rollers 5. Selector 80 now turns off the voltage applied to transfer roller 9 and the duplicating loop is complete ready to recommence.

When the copy counter 102 registers zero, paper feed
5 16, 17 is disabled by selector 84 and the machine completes its last duplication cycle. At the end of this loop, developer unit 7 is turned off, vacuum is removed from unit 18 and the flood illumination lamp 15 is turned off. Drum 4 rotates a little further to ensure that the
10 last sheet of paper has left the machine, after which the drive to drum 4 is turned off by selector 72 and the pressure on hot fuser rollers 5 is reduced by selector 73.

One of the purposes of the sensors close to vacuum unit 18 and master fusing rollers 5 is to detect copy
15 sheet misfeeds. If a copy sheet is not sensed at the correct time by sensors at vacuum unit 18 and fuser roller 5, the machine is immediately turned off and can only be restarted when the paper misfeed has been remedied. Sensor 86 close to secondary feed rolls 17 detects when a
20 sheet of paper has not been fed from tray 6. When this occurs, selector 80 immediately lowers transfer roller 9 to prevent damage to the master, and the two sensors near vacuum unit 18 and fuser roller 5 are inhibited for the remainder of the duplicating cycle in which the missing
25 sheet occurs. If sheets are missing in three successive cycles, misfeed indicator 88 signals to logic unit 55 to interrupt the duplicating process and the machine stops in an orderly fashion as if the last copy had been

5 duplicated.

All the sensors have associated indicators to inform the operator when a fault has occurred. In addition to unit 88 stopping the machine prematurely when three successive
 5 missing sheets occur, the machine will stop similarly without waiting for three misfeeds if it runs out of paper, if the toner in unit 7 runs out and if the heated fuser rollers 5 are not at the required temperature. The machine can be similarly interrupted by the operator on
 10 further depression of the duplicate button 100. When the machine has stopped it is possible to alter the number of copies required on the copy counter 102 after which further depression of the button 100 enables the duplicating cycle to continue.

15 When the machine has reached its last required copy it stops as described above. If the copy counter reads zero, logic unit 63 enables drum drive 4 at slow speed and at the appropriate time selector 93 enables the master eject cam, lifting flap 19a to expose the master eject path and
 20 enabling the clamp 10 to release the leading edge of the master sheet. Once the drum 4 has completed a revolution the master sheet has been removed, after which the eject mechanism has disengaged and the drum 4 stops. The machine is now ready to duplicate another original. The
 25 button 99 is provided so that the master can be ejected at any time.

Various safety features are included to ensure correct machine operation. It is not possible to copy or

duplicate without a master present on the drum 4, nor is it possible to load a master with one already fitted. All the covers must be correctly fitted to ensure operator safety and the removal of any cover will immediately stop
5 the machine.

By using some of the functions described above, a single copy can be produced without fusing the image onto the master. The sequence described above is broadly followed but master fuser 14 is not
10 enabled. The cleaning brush 20 ensures that the master is kept clean and can be reused. If used in this manner the master is not automatically ejected when copy counter 102 reaches zero.

Fusing the Toner to the Copy Sheets

15 The use of heated deformable rollers for fusing toner images onto plain paper is well known in the art. A schematic configuration of such a fusing module is shown in Figure 3. In this example, there is an upper heated roller 301 consisting of a hollow aluminium core 302 with
20 a thin outer layer of deformable material 303 and a heater 304 in the centre of the hollow compressed against a back-up roller 305 consisting of a similar hollow aluminium core 306 with a thicker layer of deformable material 307. The thinner outer layer of the deformable material allows
25 for a relatively rapid response time to the heater, which is switched cyclically in response to a temperature control device 59 (Figure 2) which monitors the surface temperature of the heated roller 301 and maintains it

within the operating limits. These limits are determined by the cold offset temperature and hot offset temperature at which toner transfers from the paper to the roller and the temperature at which the surface has to be maintained
5 to fuse the toner to the paper. The width between points W_1 and W_2 is dependent upon the pressure and deformability of the material.

The correct fusing conditions for a given toner are determined by a combination of roller surface
10 temperature, pressure, nip width and paper speed. Some of the parameters are discussed by C.C. Wilson in J.P.S.E. 1979: 5:3:148-156. The choice of roller material establishes other important parameters such as offset characteristics and roller life.

15 For any given material and thickness a relationship can be derived between applied pressure and nip width. One example of this is shown in L. Shelffo U.S. Patent 3627523, column 8 lines 22-35. This table is plotted as a graph in Figure 4, and is used to illustrate the
20 principles of this invention. The nip width and speed determine the factor described by C.C. Wilson as residence time. By a careful study of the various factors involved it is possible to calculate the optimum operating conditions for such a fusing system for a copier or the
25 like working at a standard copy speed.

In our U.K. Patent Application No.2056914A there is described a high speed electrostatic duplicator in which a master sheet is imaged, then used to form toner images at

high speed without further generation of latent charge images. Such an apparatus is capable of forming one image as well as multiple images. In the former case, where it is used as a conventional copier, as is possible in the
5 copier described herein, the image is re-created for each copying cycle. One of the features of such a machine is that the speed for creating an image is relatively slow and the speed for duplicating relatively fast. Typically, the linear speed for the copying mode would be 20 cm
10 per second and for the duplicating mode, 100 cm per second. For the convenience of the operator, it is desirable to be able to switch from one mode to the other immediately, particularly when the copy mode is used for proofing before committing to duplicating.

15 Where there is a requirement of this nature to operate at variable fusing speed, the hitherto employed copy fusing devices with a single set of predetermined parameters cause problems which make such devices commercially non-viable.

20 It would, of course, be theoretically possible to accelerate the copy paper in the copy mode to a duplicating speed for fusing, but this would generate paper handling problems of an unacceptable magnitude. It would not be possible at all to slow down the fusing in the
25 duplicating mode, since this would create a backlog of waiting copy which could not be handled at all.

 If the temperature remains the same, at the temperature required for high speed fusing, the copy would

almost certainly scorch and the toner offset onto the roller if the speed was reduced to a copy speed. Conversely, if the temperature was set for low speed use, the toner image would not fuse at all when fed at a high speed.. Control of temperature rather than speed would not only be costly, by requiring a duplicate temperature monitoring system with related controls, but the response time, particularly when cooling, is too slow to make it acceptable.

10 As described above, the copy sheet fixing unit preferably has means operable to adjust the roller pressure between a first relatively low value when copying and a second higher value when duplicating whereby satisfactory toner fixing to the copy sheets can be
15 achieved without alteration of roller temperature.

 This method is explained by reference to the graph in Figure 4. For a pressure of 5.5 lbs/sq.in. the nip width is .10 in. At a linear speed of 100 cms per second, the residence time is 2.5 millisecs. If the speed is
20 reduced to 20 cms per second, then the residence time is 12.5 millisecs. However, if the pressure is reduced to 0.6 lbs per sq. in. then the nip width becomes .02 inch and the residence time at the slower speed of .20 cms/sec reverts to 2.5 millisecs, so that the same conditions
25 apply as for high speed operation at a speed of 100 cms per second. In practice a correction factor has to be applied, because fusing results from a combination of pressure and residence time, and because there is a slight

surface temperature rise with an increase in speed. But the principle remains that in order to achieve the dual speed function the unit is designed so that there are two operative pressure positions.

5 This brings an added benefit. Where only a single pressure is applied, it has been found desirable to cam open the two rollers when not in use in order to prevent the formation of a flat along the nip contact. Modern materials are sufficiently resilient to allow this flat to
10 restore in continuous use, but nonetheless its presence can result in the formation of bands of unfused toner when the machine is first started up. In this invention, the pressure applied for slower speed use is sufficiently low to avoid the formation of such a flat. Consequently in a
15 two-speed function no mechanisms are needed additional to those employed in the hitherto state of the art. And furthermore, even in the low-pressure position, there is sufficient contact for the lower roller to be driven, thus ensuring that, even at the lower speed, there is
20 contact between the rollers when idling thus avoiding a sudden drop of temperature due to a heat sink effect when the two rollers are cammed into high speed operating pressures.

Of course, if it is wished, the same principle could
25 be applied to give a multi-speed function if required.

CLAIMS:

1. An electrostatographic duplicator in which an original document is duplicated by redeveloping a previously developed and fixed latent image, comprising in combination:
 - (a) a rotatory support member for supporting a sheet of electrostatographic recording material releasably clamped thereon;
 - (b) means for rotating the support member;
 - (c) a supply spool that carries electrophotographic recording material in web form, means for advancing the recording material towards the support member, cutting an individual sheet of predetermined length from the advancing web directing the cut sheet onto the support member, and clamping it thereon;
 - (d) corona charging unit for electrically charging the recording material on the support member;
 - (e) an imaging station for projecting a light image of the original document onto the recording material;
 - (f) means for uniformly illuminating the recording material on the support member;
 - (g) a development station for applying an insulating toner to an electrostatic latent image on the recording material;
 - (h) means for feeding copy sheets serially towards the support member;
 - (i) a transfer station located so that copy sheets pass

- between an electrically charged transfer member and the recording material on the support member so that an unfixed toner image transfers onto a copy sheet;
- (j) a master image fixing device located adjacent the support member for fixing a developed toner image onto the recording material;
 - (k) means for cleaning the recording material on the support member;
 - (l) means for fixing the transferred toner image to the copy sheet; and
 - (m) control means responsive to a start button and a counter recording the number of duplicated copies required for controlling the operation of all the aforesaid devices so that (I) in a master preparation cycle a sheet of recording material is cut from the material on the supply spool and clamped onto the support member after which a fixed toner image is formed on the master by driving the drum at a first speed, electrically charging the recording material, forming a latent image of the original document thereon, developing the latent image with toner and radiant heat fusing the developed toner image onto the recording material, (II) in subsequent duplicating cycles the drum is driven at a second speed higher than the first speed and cyclically the drum is cleaned, electrically charged, uniformly illuminated and re-developed with toner and the resulting toner image is transferred onto copy sheets and fixed thereon,

and (III) on completion of duplication the used sheet of recording material is ejected from the support member.

2. A duplicator according to claim 1, wherein the electrical potential is applied to the transfer member in each duplicating cycle only when the leading edge of the copy sheet has passed.

3. A duplicator according to claim 2, further comprising a vacuum unit proximately following the transfer station in the direction of advance of the copy sheets.

4. A duplicator according to any preceding claim further comprising pulse generation means rotatable with the support member, decode means that receives and decodes pulses from the generator means to supply to data bus means signals denoting the number of cycles that the support member has completed and its position in the current cycle, selector means severally associated with the aforesaid devices causing them to operate in synchronism with rotation of the drum.

5. An electrostatographic duplicator substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

6. Apparatus for electrostatographic reproduction of an original document by copying or fixed image duplicating including a supply spool that carries electrostatographic recording material in web form, means for advancing the recording material towards a rotatory support member, means for severing the recording material into individual sheets, means for releasably clamping an individual sheet onto the support member, a master imaging station for forming a light image of an original document on the recording material on said support member, a master fixing station operable only when in the master fixing stage of the duplicating mode to fix a developed toner image from a master imaging cycle onto the sheet of recording material on the support member for use in subsequent duplicating cycles, a transfer station operable to transfer an unfixed toner image from the recording member to a copy sheet during copying and to transfer a redeveloped toner image from the recording member during duplicating and control means selectively operable to cause the machine to perform copying or duplication and connected to the master imaging station and the master fixing station to permit imaging to take place only when the master material on the support member does not bear a fixed toner image.

7. A combined electrostatographic copier and duplicator that forms copies by creating a light image of an original document on an electrostatographic recording member at each copy cycle and transfers a developed image to a copy

sheet that is discharged at a first linear speed towards a fixing unit comprising a pair of rollers having deformable surfaces, at least one of said rollers being heated, the copy sheet passing between them in order to fix the toner image to the copy sheet and duplicates by forming further toner images on the recording member without creating a new light image and transferring the toner images to copy sheets that are discharged towards the fixing unit at a second linear speed higher than said first linear speed, said fixing unit having means operable to adjust the roller pressure between a first relatively low value for use when copying and a second higher value when duplicating whereby satisfactory toner fixing to the copy sheets at both said first and second speeds can be achieved without alteration of roller temperature.

FIG. 1

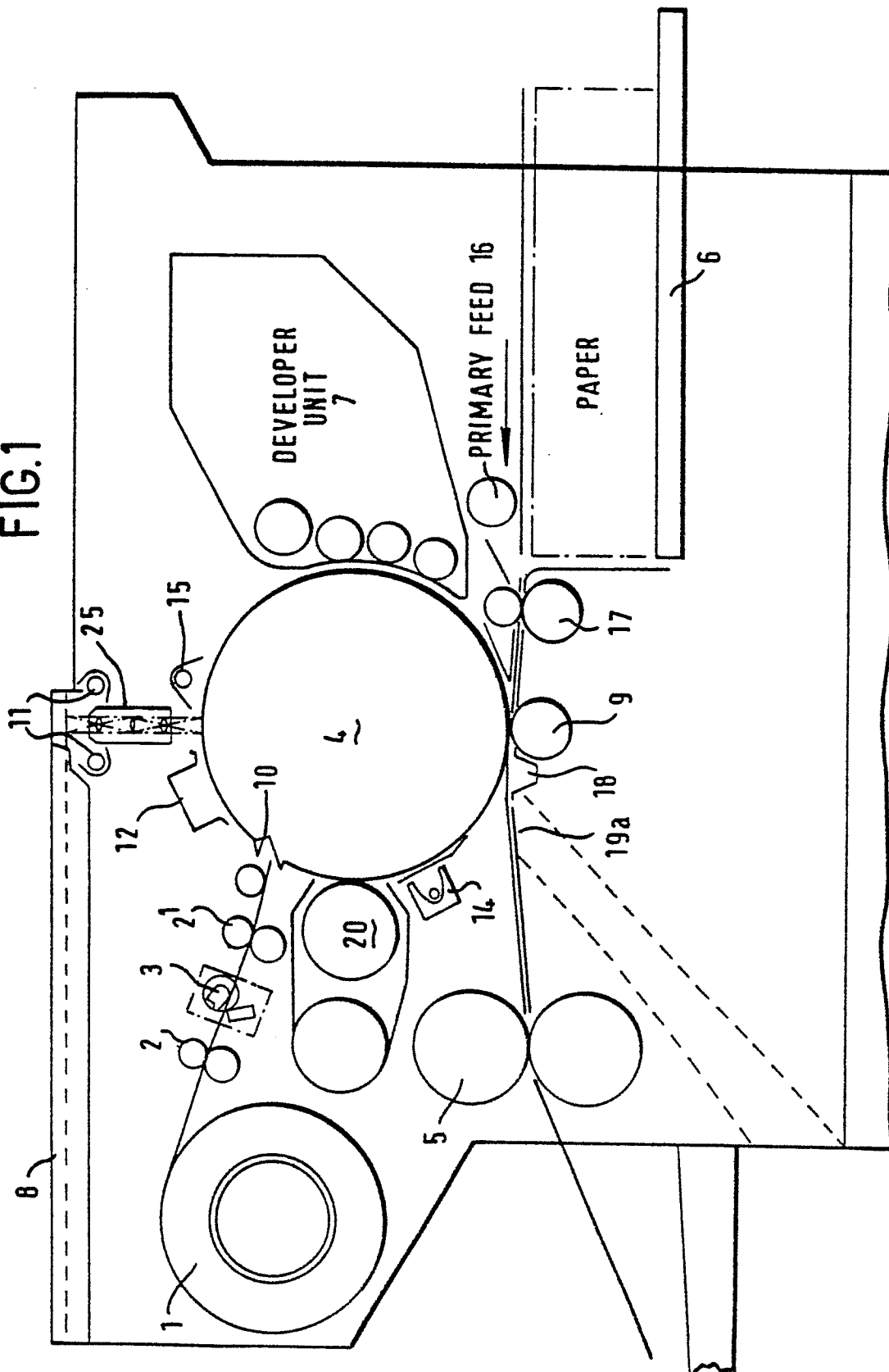


FIG.2

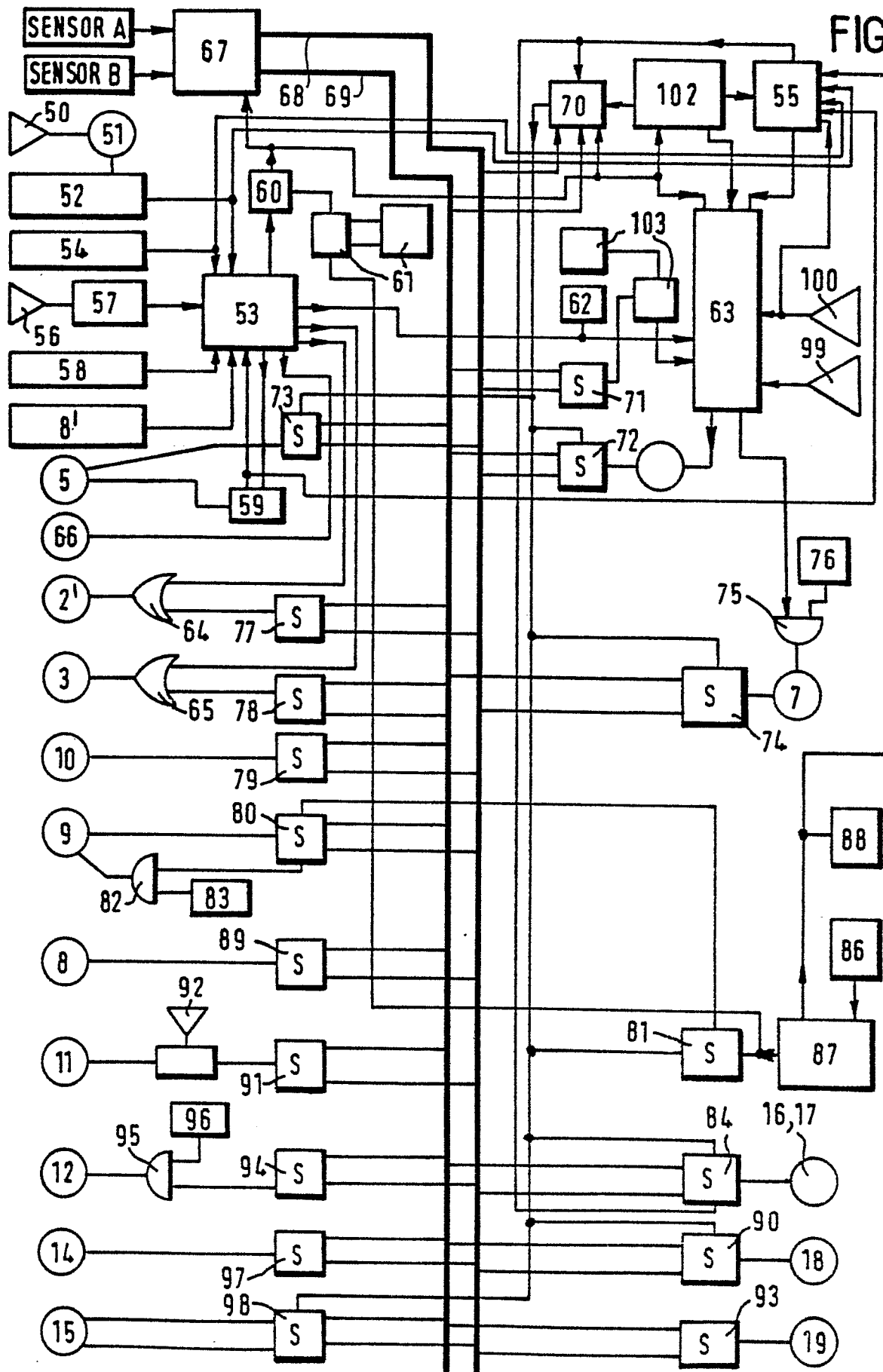
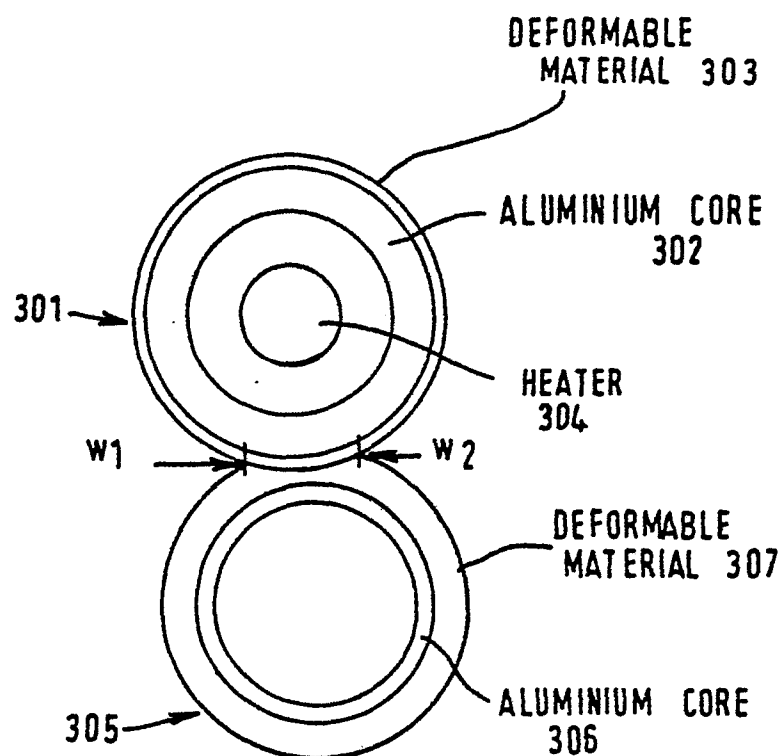


FIG.3



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FIG.4

