

March 1, 1960

E. A. O'MARA
COPYING MACHINE

2,927,210

Filed May 21, 1958

FIG. 1

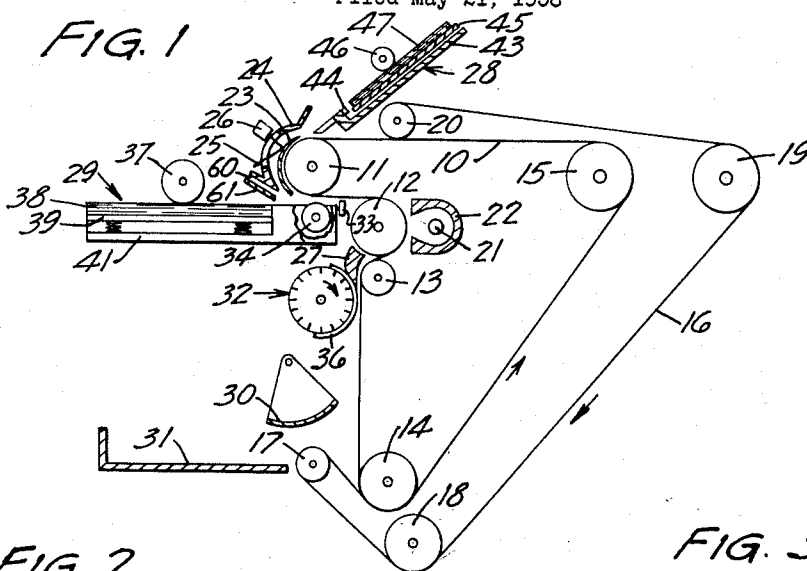


FIG. 2

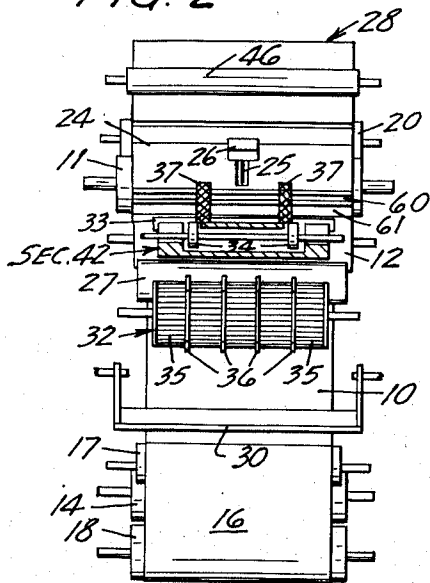


FIG. 3

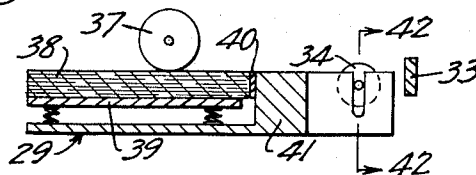


FIG. 4

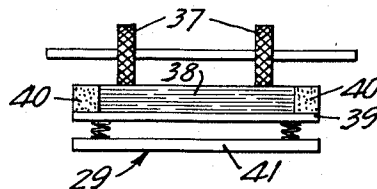


FIG. 5

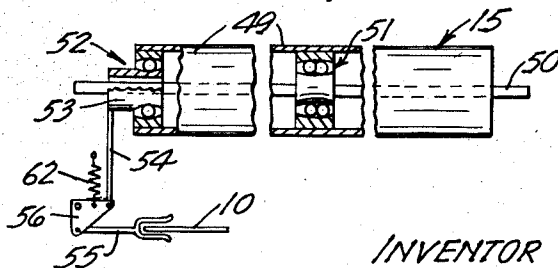
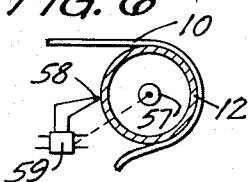


FIG. 6



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1

2,927,210

COPYING MACHINE

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Application May 21, 1958, Serial No. 736,799

12 Claims. (Cl. 250—49.5)

This invention relates to the multiple reproduction or duplicating art. While not restricted thereto, it has particular reference to the duplication, on heat-sensitive copy-paper, of graphic originals such as printed or typewritten pages, sketches, drawings or the like as provided on thin paper or equivalent sheet material. In such sheet materials the image and background areas are significantly different in their ability to absorb high-intensity radiations, particularly in the infra-red region but also at other frequencies, with resultant formation, when suitably irradiated, of a corresponding heat-pattern which is then utilized to produce a visible image on a heat-sensitive copy-paper. The principle has been described in Miller Patent No. 2,740,896. Effective heat-sensitive copy-papers have been described in a number of patents, see in particular Miller et al. Nos. 2,663,654—7.

Apparatus for accomplishing the thermographic copying process has also been described; see Miller Patent No. 2,740,895. In the method and with the apparatus there described, the graphic original and heat-sensitive copy-paper are smoothly supported as a two-ply combination in mutually heat-conductive pressure-contact and protected from external heat-loss, and the original is then strongly and briefly irradiated. A single copy is produced. Repetitive hand manipulation is necessary if additional copies of the same original are required.

Duplicating processes involving physical transfer of ink, dye, or other image-forming material from a master copy to a paper or other receptor sheet are well known. In spirit duplicating, the master copy is clamped to a cylinder and brought into contact with successive receptor sheets which are first lightly moistened with alcohol to dissolve and remove from the master copy a portion of the soluble ink forming the image areas. In stencil duplicating, the perforated stencil master copy is likewise clamped to a frame or cylinder, and ink is then forced through the perforations and onto the receptor sheet. Large numbers of reproductions may be made of the single master copy, but in each case changing to a new master copy involves stopping the machine and manually removing the old and affixing the new master copy.

The present invention provides for the rapid and automatic production of any desired number of thermographic reproductions of one or a series of graphic originals in independent disconnected sheet form. The apparatus automatically superposes the original and a copy-sheet, exposes the two-ply combination to effective irradiation, separates the two sheets, ejects the copy, and returns the original to the circuit, for the required number of cycles; and then automatically ejects the original and, if desired, inserts a new original and repeats the sequence. It is not necessary to interrupt the operation of the device in changing originals. The machine is capable of entirely automatic operation, producing any desired number of reproductions of each of any desired number of originals. With the most used graphic originals, such as typewritten letters, statements, reports,

2

etc., reproductions are prepared directly from the original; no intermediate dye image, stencil, or other master copy is required. The machine is equally capable of serving as a copy-machine for making single copies of such graphic originals.

The invention will now be further described in terms of the specific but non-limitative illustrative embodiment of the accompanying drawings, of which:

Figure 1 is a schematic representation, partly in section, of a typical multiple copier apparatus of this invention;

Figure 2 is a partial front elevation of the apparatus of Figure 1, including a partial section further identified in connection with Figure 3;

Figure 3 is a side elevation, partly in section, of the copy-paper feed station of Figure 1;

Figure 4 is a partial end elevation of the feed station of Figure 3;

Figure 5 is a representation, partly in section, of an alignment roll assembly as applied to the apparatus of Figure 1; and

Figure 6 is a representation, partly in section, of means for maintaining constant temperature at the print roll area.

In the apparatus illustrated, as in the description following, it will be recognized that copying is accomplished by the method of "back-printing," in which the radiation impinges directly on the printed surface of the graphic original, and the heat-pattern established thereby is transmitted through the thin paper backing of the original to the heat-sensitive copy-paper. The method has been found to be entirely satisfactory for copying typewritten correspondence, order forms, bills of lading, penciled sketches and reports, and other documents having a thin flexible base or backing of paper or the like. Papers printed on either one or both sides may be copied, since only the surface directly exposed to the radiation is effective in establishing a useful heat-pattern. Heavier papers, cardboard, etc. are comparatively stiff and inflexible and are not well suited to the type of copying procedures illustrated.

As indicated in Figure 1, a carrier belt 10 passes around a main roll 11, print roll 12, separator roll 13, drive roll 14, and guide roll 15. A guide belt 16 accompanies the carrier belt along the portion of its travel extending somewhat beyond rolls 14 and 15, being carried additionally by idler roll 17, drive roll 18, guide roll 19, and idler roll 20. The two belts advance at identical constant velocity in the direction indicated. The guide belt 16 may be of fabric or any other convenient strong flexible material; 5 mil tensilized transparent polyester film ("Mylar") has been used. The carrier belt 10 is transparent and heat-resistant; a 10-mil film of chlorotrifluoroethylene polymer, or other equivalent fluorocarbon polymer or copolymer, is preferred.

A source of intense radiation is provided by a tubular incandescent lamp 21 located along the enclosed focal line of an open-sided elliptical cross-section reflector 22 of which the exposed focal line is located at the surface of the print roll 12. Two or more such radiation sources may be employed if desired, being placed at different circumferential positions with respect to roll 12. Thus, two lamps 21 may be contained within a doubly elliptical reflector, the two parallel lines of concentrated radiation falling on the roll 12 on either side of the position of the single line provided in the structure illustrated.

A pair of arcuate shields 23, 24 are located in front of the main roll 11, and the probe or lever member 25 of a switch 26 crosses the space between the shields through a suitable opening in the outer shield 24. The outer shield is turned back at its lower extremity to form upper guide member 60, which, together with lower

guide member 61, define an entry chute for the introduction of single graphic originals in a manner later to be described. A doubly arcuate shield 27 is located in front of the line of contact of print roll 12 and separator roll 13.

A first feed device 28 is located above the assembly, and a second feed device 29 to the left of the print roll 12, as illustrated in Figure 1. A movable delivery panel 30 is located adjacent the vertically descending section of belt 10 just above the roll 17, and a receiving tray 31 is appropriately placed beneath the panel. Just above the panel 30 is located a deflector fan assembly 32. Suitable framework, bearings, power sources, circuit connections, switches and other control elements, and other necessary components are included as will be further indicated in the description of the operation of the device, but are omitted from the drawing for clarity of illustration.

The method of operation of the device will now be described.

With the belts 10 and 16 in motion as indicated, a sheet such as a letter, drawing, or other graphic original of which copies are desired is fed from the first feed device 28 onto the horizontal upper section of the carrier belt 10 and thus through the channel between shield members 23 and 24, thereby actuating switch 26 and initiating a sequence of operations. The sheet comes to rest beneath the belt and main roll 11 and against a stop 33, against which a sheet of sensitive copy-paper from second feed device 29 has previously been positioned. The two sheets are thereby brought into congruity.

Actuated by the sequence timer previously set in operation by the switch 26, pressure rollers 34, mechanically rotated at the same surface speed as the roll 11, next rise toward main roll 11 to lift the forward portions of the two sheets clear of the stop 33 and against the moving belt 10, whereupon the sheets, still in superposed position, are swept forward around the print roll 12 and between it and the transparent belt. Meanwhile the lamp 21 has been actuated and reaches full radiation intensity as the sheets come into position before the reflector. The radiation produces a visible change in the copy-paper in a pattern corresponding to the graphic pattern of the original.

The two sheets next are directed by deflector shield 27 past the deflector fan assembly 32 and, as will be apparent from the illustration and the foregoing description, with the copy-sheet toward the said assembly. Rapid rotation of the centrifugal fan elements 35, forcing air outwardly and across the face of the copy-sheet, sufficiently reduces the pressure in the space between the copy-sheet and the stationary guide flanges 36 so that the copy-sheet is lifted away from the belt 10 and from the printed original and deposited on the panel 30, from whence it slides into the receiving tray 31.

As the copy is being ejected, the original follows the belt 10 past the panel 30 and is carried between belts 10 and 16 to the upper horizontal section where it again enters the circuit between the two shields 23, 24. In the meantime the pressure rollers 34 are retracted, and another blank sheet of copy-paper is fed, by means of feed rolls 37, from a supply stack 38 and into position against the stop 33. The original, after again actuating the switch 26, falls into position atop the newly positioned sheet of copy-paper; and the cycle is repeated. In this way, any desired number of reproductions may be prepared from a single original by completely automatic operation.

After sufficient reproductions of the original have been produced, the operation is terminated by blocking the action of the feed roll 37, and preferably also the lamp 21. The original then makes a final circuit of the apparatus and is ejected at the fan assembly 32 and to the panel 30 and tray 31. The apparatus is then ready

for insertion of a further graphic original at the automatically actuated feed device 28.

Figure 3 illustrates in further detail the feed device 29. The stack 38 of sheets of copy-paper is supported on a spring-mounted base 39 which presses the paper lightly against the feed rolls 37. The forward edge of the stack contacts a stop member 40 forming a part of the frame 41. Conveniently, this stop member consists of a strip of fine sandpaper adhered to the frame surface. The sharp abrasive grains retain the edge of the paper in place until the sheet is forced past. The pressure rollers 34 are here illustrated in raised position as required to press a copy-paper and original into contact with the moving belt, and showing a slot in the frame within which the supporting axle slides.

Section 42-42 of Figure 3 is further illustrated in Figure 2, showing the retracted position of the rollers 34. Figure 2 also further illustrates the structure and position of rolls 11, 14, 17 and 18, shield 24 with guides 60 and 61, switch 26, panel 30, and belts 10 and 16, as viewed from the left of Figure 1.

Figure 4 represents an end view of a portion of the feed device 29. The feed rolls 37 are here indicated as having a knurled or roughened circumferential surface, and are preferably made of rubber, so as to impart to the top sheet of copy-paper from the stack 38 a sufficiently positive frictional drive to cause the sheet to snap free of the stop member 40 and advance into contact with the stop 33.

The first feed device 28 similarly comprises a frame 43 having a stop member 44, a spring-supported base 45, and feed rolls 46. The graphic originals from the supply stack 47 are individually fed into the cycle by controlled rotation of the feed rolls.

In order to obtain and maintain the desired lateral alignment of original and copy-paper, the two feed devices 28 and 29 are initially carefully aligned, and the two moving belts 10 and 16 are held in accurate alignment by suitable control means such as aligning rolls which may conveniently be in the positions indicated in Figure 1 as occupied by guide rolls 15 and 19. These rolls are also ordinarily so mounted as to maintain desired tautness in the respective belts.

Preferred and highly effective belt alignment control unit is indicated in Figure 5. The guide roll 15 is here indicated as comprising a tubular shell 49 pivotally supported on a fixed shaft 50 by a central self-aligning bearing assembly 51. The shell 49 rotates about the shaft on the bearing 51, the inner race of which is affixed to the shaft, and also on a terminally located control bearing assembly 52, the inner race 53 of which, in the form of a hollow stub shaft, is capable of limited movement with respect to the shaft. The position of this inner race 53, and therefore of the axis of the shell 49, is altered in accordance with changes in the edge position of the traveling carrier belt 10 by means of suitable mechanical linkage, here indicated as comprised of rod 54, fork 55, and offset 56, and in a direction to cause the belt to return to its previous path. A spring 62 provides tension to maintain the fork in constant light contact with the edge of the belt. In a typical installation a fork member contacting belt 10 between rolls 13 and 14 guides roll 15, and a fork member contacting belt 16 between rolls 18 and 19 guides the latter roll, which is of the same construction as roll 15. With such an arrangement it has been found that, as the two belts proceed in surface contact with each other, the lateral deviation of their edges is held to such a low value, i.e. less than $\pm \frac{1}{32}$ inch, that fully adequate alignment of original and copy-sheet is attained.

The operation of the multiple copier will now be described. It will be assumed that a supply of heat-sensitive copy-paper has been provided at the feed device 29, and a number of typewritten or other graphic orig-

5

inals at feed device 28; and that the machine is properly connected to a source of power.

A main switch is first closed, setting in operation the motor drive for the two belts and the deflector fan. The drive motor also operates a cam system for the copying sequence; alternatively, an electronic or other control system may be employed. A "copy" switch is next closed; this switch actuates feed roll 46 to feed into the circuit, and into operational contact with switch 26, a graphic original from stack 47.

A counting mechanism, not shown, is included in the circuit, and may be pre-set for any desired number of copies. As the printed sheet trips switch 26, the counting mechanism is advanced one unit. The sheet continues forward until its forward edge reaches the stop 33, where it is thus brought into congruency with an underlying sheet of copy-paper previously fed by rollers 37 from stack 38 into the same position against stop 33. Rollers 34 are then raised, to press the composite of copy-paper and original into contact with the belt 10 and thus to advance the same past lamp 21 which in the meantime has been brought to full copying intensity. Deflector shield 27 directs the composite downwardly along the belt 10 and past the deflector fan assembly 32, where the copy-sheet is separated from the original and deposited in the tray 31 by way of the panel 30, while the original continues along belt 10, between it and belt 16, and back into the cycle. During this period, the feed rolls 37 of feed device 29 are again actuated to place another sheet of copy-paper against stop 33 and in position for contact with the returning original.

When the desired number of reproductions has been produced, the counting mechanism automatically suspends the operation of the feed rolls 37 and permits the original to pass through the cycle without an accompanying copy-sheet and to be ejected into the tray 31. The counting mechanism then re-sets itself, a copy-sheet is fed into position, and a further graphic original is fed from feed device 28, starting the next sequence.

The counting mechanism may be adjusted to re-set itself and to provide the starting impulse which inserts the next original into the system, as just indicated. In such case each original will produce an identical number of copies. Alternatively, the mechanism may be set to require manual actuation for each original and thus more readily permit manual resetting of the counting mechanism.

The machine is also well adapted to the preparation of single copies of originals. For this purpose, the delivery panel 30 is swung inwardly against the downwardly moving segment of the belt 10; the stop member 33 is lowered, or the rollers 34 are raised into permanent contact with the belt; and the original and copy-sheet are pre-assembled into congruency and introduced into the circuit through the entry chute formed by guide members 60, 61. A suitable switch within the chute actuates the lamp 21 as the composite enters the circuit, and a further switch between deflector 27 and separator roll 13 de-actuates; or the lamp may be manually controlled if desired. The composite is ejected by the panel 30, and the copy-sheet and original are then separated by hand.

The lamp 21 may be partially or fully extinguished during all but the exposure portion of the cycle; or the carrier belt may be shortened and the lamp 21 maintained at full intensity during the entire cycle. In the latter instance particularly, the ambient temperature might otherwise increase substantially during the copying operation; an air blast is therefore desirably included for cooling the apparatus. Alternatively, or additionally, suitable automatic or manual controls may be provided for regulating the belt speed in order to compensate for differences in ambient temperature. These controls, as well as others for regulating the intensity of irradiation provided by the lamp 21, are also useful in compensating for differences in the temperature or other require-

6

ments of various copy-papers, or for differences in the thickness of paper employed in the graphic originals, or for other variations.

Rather than vary the speed of the machine to compensate for variations in temperature, it has been found desirable to maintain substantially a fixed temperature at the printing area. This result has been effectively accomplished by sensing the temperature near the operating face of the print roll 12 of Figure 1, e.g. with a thermistor in a control circuit, and therewith controlling a source of heat located within the print roll so as to maintain the desired conditions of uniform ambient temperature. One effective system is illustrated in Figure 6, showing a tubular incandescent filament lamp 57 mounted axially within the cylindrical shell of print roll 12 carrying belt 10, the heat output of the lamp being controlled by thermistor 58 operating through a suitable current-regulating device 59 which regulates the flow of current to the lamp filament, as indicated by the dotted line in Figure 6.

The apparatus hereinabove described is particularly applicable to the multiple reproduction of printed or other graphic originals having visibly distinct areas of different radiation-absorptivity, and therefore capable of providing differential-temperature patterns by selective absorption of intense radiant energy. As described, copies of such originals are rapidly and conveniently produced on heat-sensitive copy-paper, in any desired number and completely automatically once the copying process has been initiated. The apparatus is not restricted to this specific type of reproduction, since it is readily adaptable to other procedures requiring contact of a single isolated sheet of paper or the like, e.g. a dye-printed, perforated, magnetically charged, or other printed source of intelligence, with each of a series of copy-sheets capable of accepting a copy of the pattern thereon.

In these alternative procedures, the lamp 21 may be replaced by other suitable means for reproducing or transferring of intelligence. For example, magnetically recorded intelligence may be transferred from an original of high coercive force to a copy-sheet of lower coercive force by subjecting the composite to controlled idealizing action; dye images may be transferred by pre-moistening the copy-sheet with a solvent for the dye; photographic reproduction with actinic radiation is also contemplated. However, since other means for multiple reproduction of many other types of originals are already available, and since the procedures involved are particularly suited to copying on heat-sensitive copy-paper, the invention has here been described and illustrated primarily in terms of thermographic multiple reproduction of typewritten or analogous graphic originals.

What is claimed is as follows:

1. Apparatus for automatic multiple reproduction of printed intelligence including, in combination: first feed means for advancing an original into the copy-circuit; carrier means for conveying said original around said copy-circuit; second feed means for advancing a copy-sheet into the copy-circuit; alignment means for establishing congruency of said copy-sheet and said original; energizing means for copying said original on said copy-sheet; ejector means for ejecting a sheet from said copy-circuit; actuator means for initiating the copying sequence on insertion of said original into said copy-circuit; and control means for terminating said copying sequence and permitting ejection of said original from said copy-circuit.

2. Apparatus for automatic multiple thermographic reproduction of each of a plurality of independent graphic originals, including, in combination: first feed means for advancing an original into the copy-circuit; carrier means for conveying said original around said copy-circuit; second feed means for advancing a copy-sheet into the copy-circuit; alignment means for establishing congruency of said copy-sheet and said original; exposure means for strongly and briefly exposing said original to radiant

energy differentially absorbable in visibly different areas of said original; ejector means for ejecting a sheet from said copy-circuit; actuator means for initiating the copying sequence on insertion of said original into said copy-circuit; and control means for terminating said copying sequence and permitting ejection of said original from said copy-circuit.

3. Apparatus for automatic multiple thermographic reproduction of each of a plurality of independent graphic originals, including, in combination: first feed means for advancing an original into the copy-circuit; carrier means for conveying said original around said copy-circuit and including a flexible transparent continuous belt member; second feed means for advancing a copy-sheet into the copy-circuit; stop means for temporarily retaining each of said original and said copy-paper and for establishing alignment therebetween; start means for continuing the advance of said original and said copy-paper as a composite; exposure means for strongly and briefly exposing said original, through said transparent belt member and while in said composite, to radiant energy differentially absorbable in visibly distinct areas of said original; ejector means for ejecting a sheet from said copy-circuit; actuator means for initiating the copying sequence on insertion of said original into said copy-circuit; and control means for terminating said copying sequence and permitting ejection of said original from said copy-circuit.

4. The apparatus of claim 3 in which the ejector means includes means for reducing the air pressure at the free surface of a sheet following the copy-circuit.

5. The apparatus of claim 4 in which the ejector means comprises a high speed blower directing an air stream along said free surface, and guide means for preventing contact between said surface and said blower.

6. The apparatus of claim 5 including means for maintaining substantially constant ambient temperature at the exposure area.

7. The apparatus of claim 6 including a tubular print roll having an internal heating element, and means for regulating said element to provide substantially constant ambient temperature at the exposure area adjacent said roll.

8. The apparatus of claim 7 including counting means for regulating the number of copies produced from a single original.

9. Apparatus for repeatedly advancing a top sheet of a stack of paper into position for alignment with another sheet of paper adjacent a constantly advancing carrier member and for then advancing the composite in contact with said carrier, including a support for said stack of paper, a first stop means at a forward edge of said support and having a sharp roughened surface for contacting the forward edge of said stack, a second stop means for-

wardly of said first stop means for aligning said top sheet with said other sheet, drive roller means contacting the top of said stack for intermittently advancing said top sheet past said first stop and to said second stop, and roller means vertically movably located between said first and second stops for lifting said aligned sheets above said second stop and against said constantly advancing carrier member.

10. Apparatus for maintaining in a substantially unvarying path of movement an endless belt continuously advancing over a plurality of supporting rolls, including an adjustable supporting roll assembly, a contact member lightly pressing against an edge of said belt, and intervening linkage between said contact member and said assembly for altering the angle of the axis of rotation of said roll in a direction opposed to a lateral movement of said edge; said roll assembly comprising a cylindrical shell centrally rotatably and pivotally mounted on a fixed shaft and terminally rotatably supported on a hollow stub shaft encircling a segment of said fixed shaft at a distance therefrom sufficient to permit the required degree of pivotal movement of said shell; said intervening linkage connecting said contact member and said stub shaft.

11. Apparatus as herein described capable of repeatedly feeding a top sheet of a stack of paper into a processing cycle and comprising a support for said stack of paper, a stop means disposed generally vertically to and at a forward edge of said support and having a sharp roughened surface for contacting the forward edge of said stack, lift means for continuously raising said stack to a position with the upper sheet in line with an uppermost edge portion of said sharp roughened surface, and paper drive means located above said upper sheet for preventing upward lifting of said stack above said upper edge and for intermittently forcing by positive frictional drive, each said top sheet to snap free of said upper edge and advance past said stop means.

12. Apparatus as herein described capable of separating a copy-sheet from an original in congruent superposition therewith, said apparatus comprising carrier means for conveying the composite of said original and said copy-sheet to a sheet separation area, means for directing an air stream at high velocity along the free surface of said copy-sheet within said area to reduce the air pressure against said free surface and thus lift said copy-sheet, thereby to cause separation of said copy-sheet from said original, and means for advancing said original past said separation area.

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