(No Model.) 6 Sheets—Sheet 1.

E. ANTHONY.

PRINTING MACHINE.

No. 263,747. Patented Sept. 5, 1882

Fig. 2.

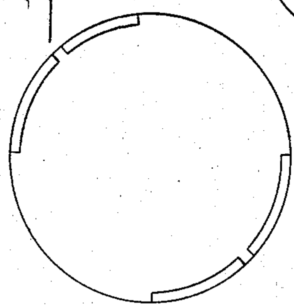


Fig. 4.

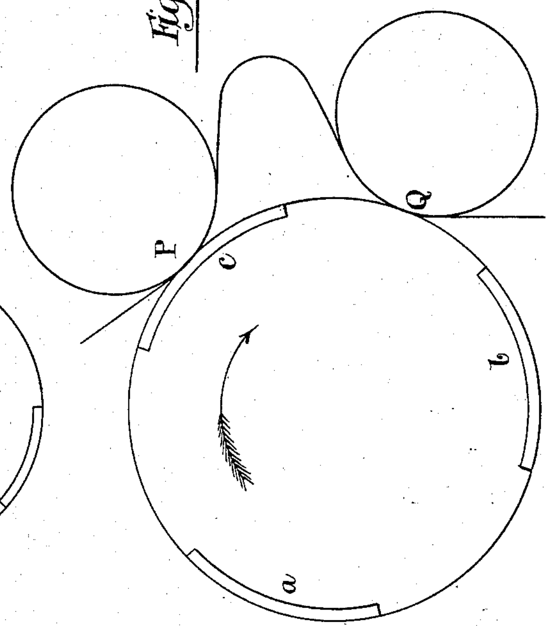


Fig. 1.

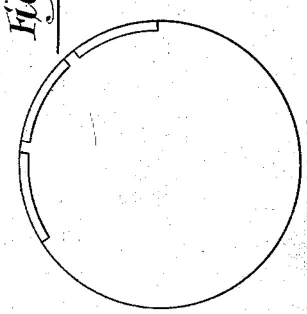
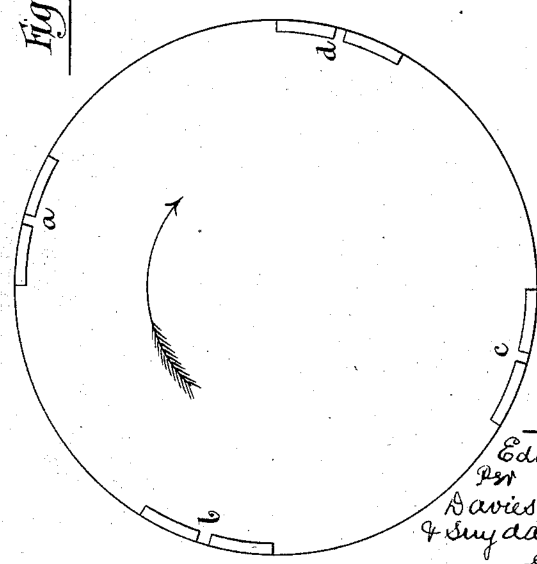


Fig. 3.



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(No Model.)

6 Sheets—Sheet 2.

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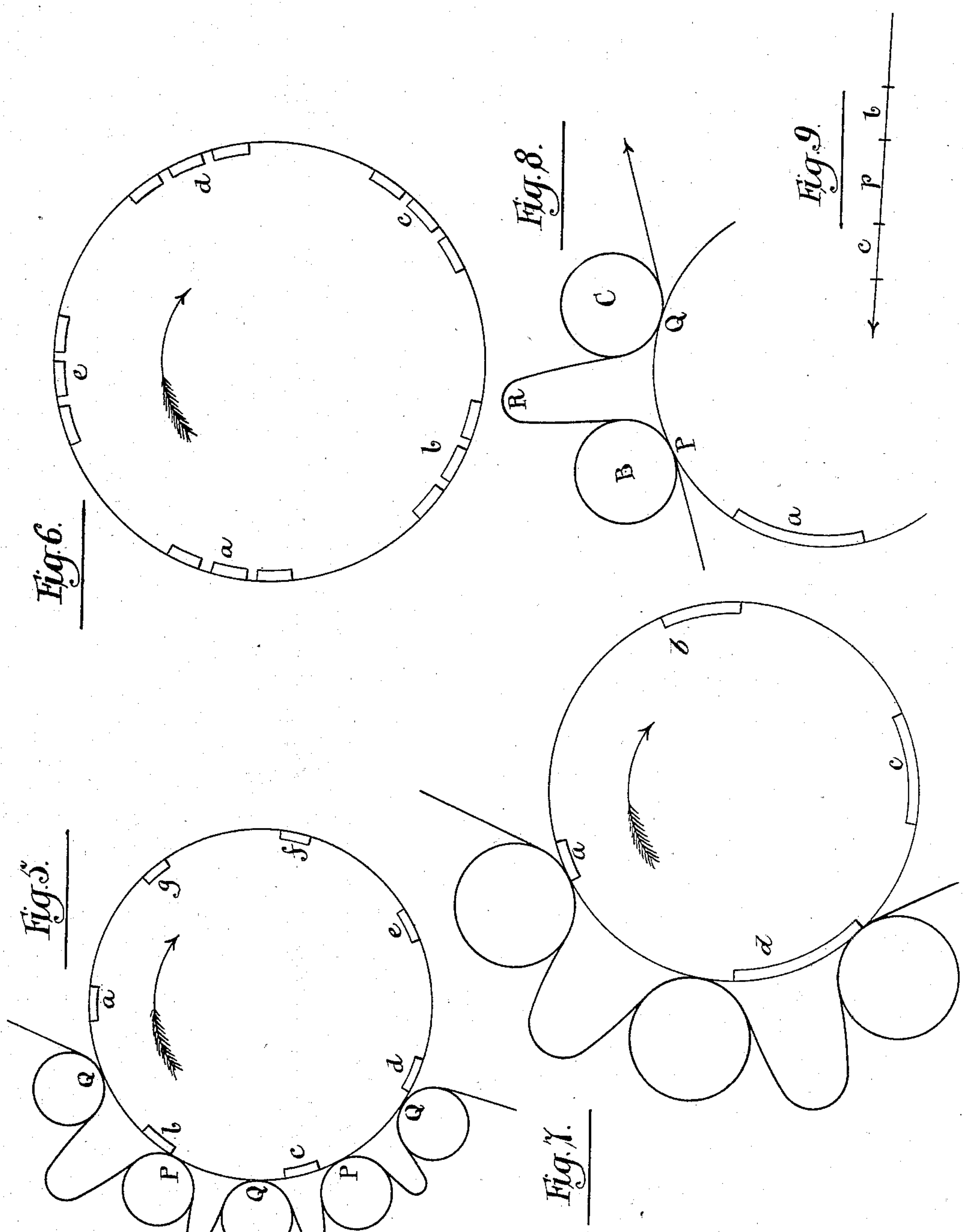

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6 Sheets—Sheet 3.

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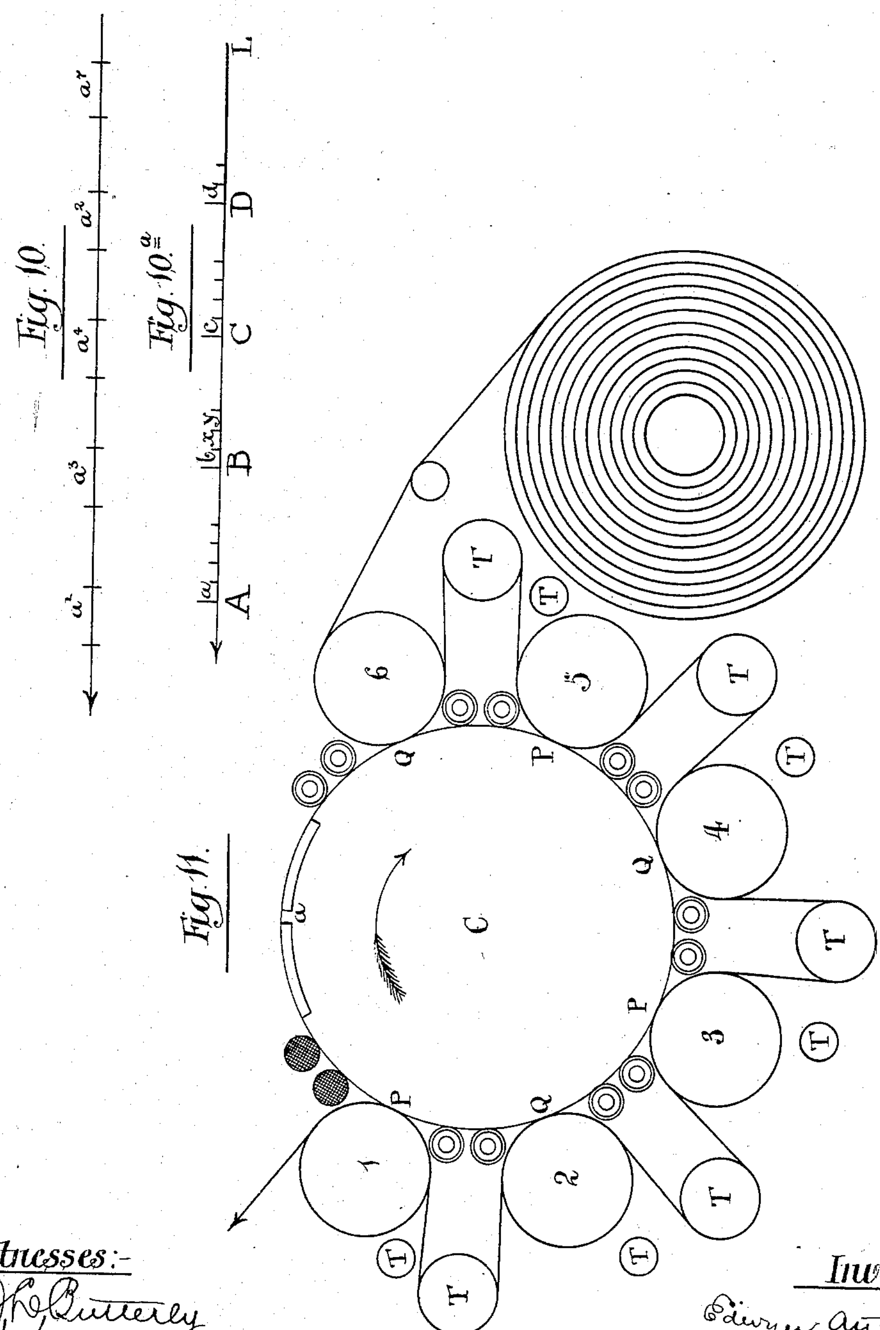

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6 Sheets—Sheet 4.

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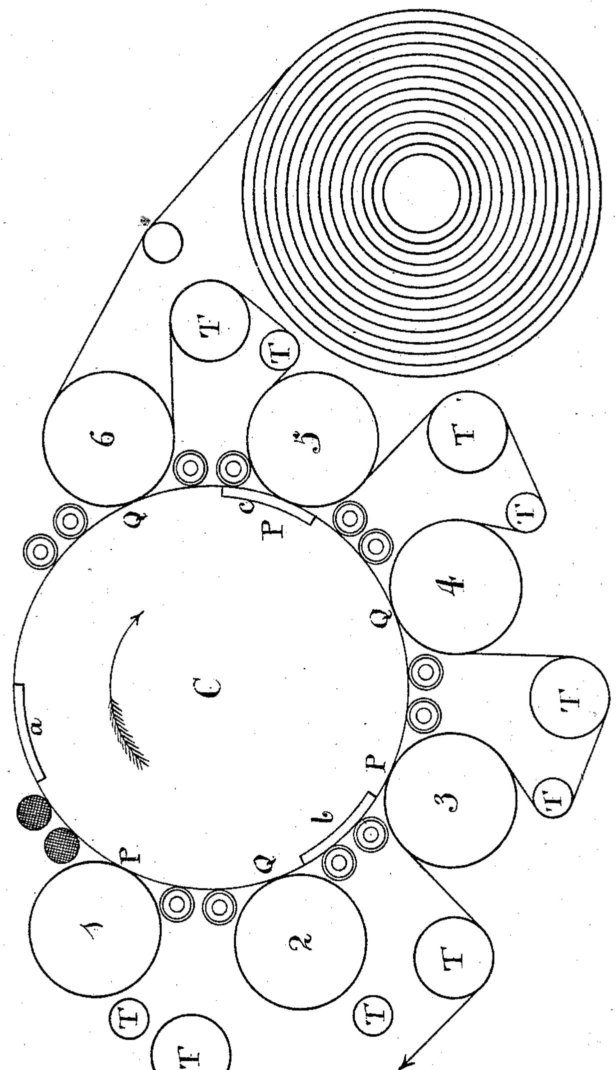
No. 263,747.

Patented Sept. 5, 1882.

Fig. 12.



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6 Sheets—Sheet 5.

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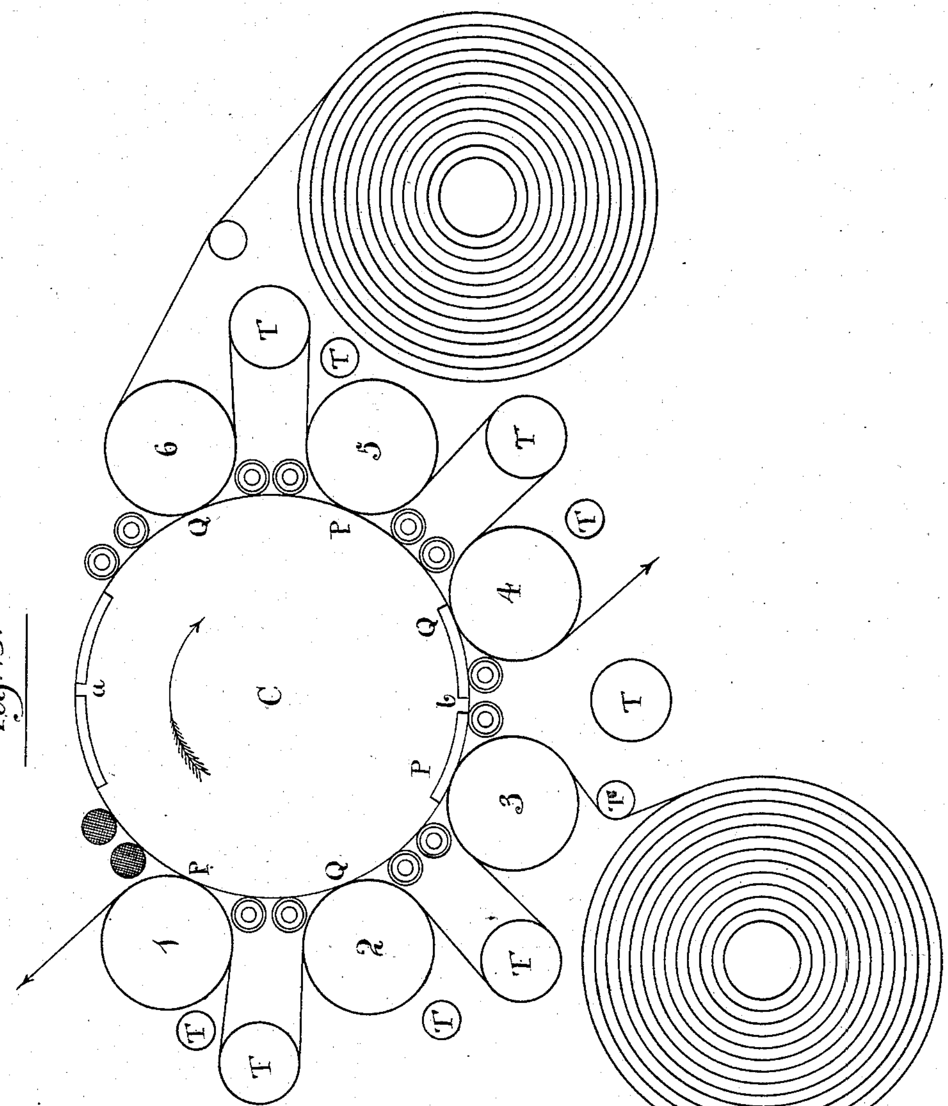
Fig. 13.



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(No Model.)

6 Sheets—Sheet 6.

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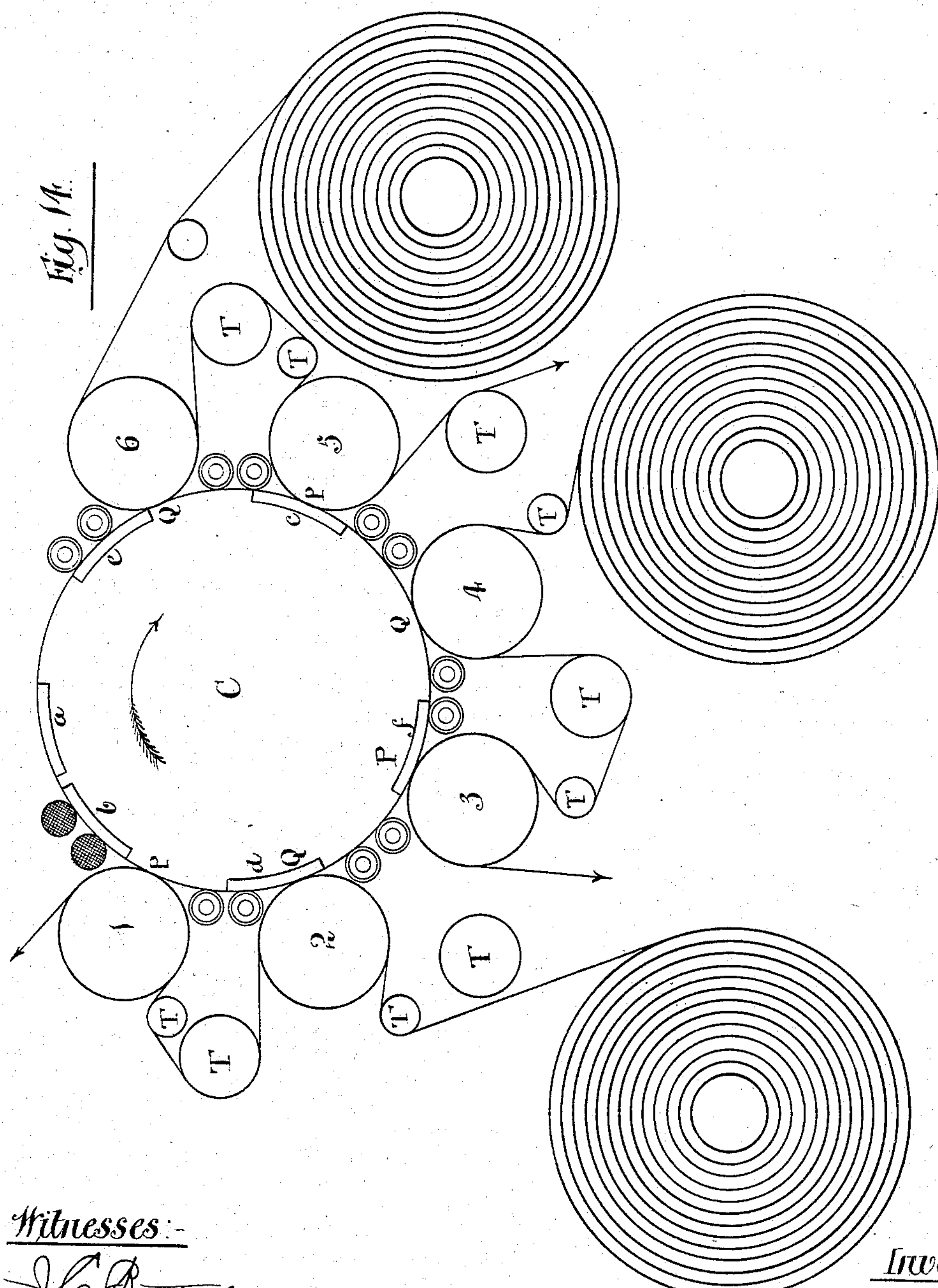
Fig. 14.



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UNITED STATES PATENT OFFICE.

EDWYN ANTHONY, OF NEW YORK, N. Y.

PRINTING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 263,747, dated September 5, 1882.

Application filed May 12, 1882. (No model.)

To all whom it may concern:

Be it known that I, EDWYN ANTHONY, a subject of the Queen of Great Britain, residing in the city of New York, in the State of New York, have invented a new and useful Improvement in Printing-Machines, of which the following is a specification.

My invention consists of a cylinder on which the forms are placed in several distinct portions, which may be equal or not to one another, in combination with impression-cylinders and carrier-rollers, arranged as hereinafter set forth.

In the description of my invention I do not include the case of a cylinder on which the forms are placed in two distinct portions which are equal to one another, because such a cylinder and its adjuncts are old and well known.

Figures 1 and 2 show known ways of placing the forms. Figs. 3, 4, 5, 6, and 7 illustrate forms placed on a type-cylinder in accordance with my invention. Figs. 8, 9, 10, and 10^a show (in connection with the specification) how to fix the length of web between the various impression-cylinders. Figs. 12 and 14 are examples of impression, carrier, and type cylinder, with forms arranged on the last-mentioned cylinder and distances of the web all suitably arranged. Figs. 11 and 13 respectively show the same machines that Figs. 12 and 14 respectively do, but arranged for printing a fewer number of forms than are used in the two last-mentioned figures.

Heretofore in web-printing machines, when the forms occupy only a part of the circumference of a cylinder, they have been placed either all together or divided into two equal portions, as shown in Figs. 1 and 2. By the methods herein described they can be divided into three or more portions, which may be equal or unequal. Into whatever number of portions the forms may be divided, the circumference of the cylinder must be taken some multiple of the sum of the arcs occupied by the forms. Call this multiple n, and let m denote the number of portions on the cylinder. Then, when the portions are equal, m and n may be any numbers whatever. When the portions are unequal, m and n may be any numbers prime to one another—*i. e.*, may be any two numbers which are not divisible without remainder by any the same number. Thus, in Fig. 3, $n=3$, $m=4$; in Fig. 4, $n=2$, $m=3$; in Fig. 5, $n=5$, $m=7$; in Fig. 6, $n=2$, $m=5$; and in Fig. 7, $n=3$, $m=4$, the several portions being equal or unequal at pleasure whenever n and m are prime to one another.

Impression-cylinders n in number for each roll must be placed round the form-bearing cylinder and the web passed under each of them, the distance of travel from one impression-cylinder to the next being fixed in the manner hereinafter shown. Thus, in Fig. 4 there must be two impression-cylinders; in Fig. 5, five, and in Fig. 7 three for each roll. We denote by a, b, c, d, &c., the m portions, also using those letters to express the breadth of each portion. It is clear that if the web issues from the last impression-cylinder continuously printed on every revolution of the type-cylinder will print on it each of the m portions repeated n times. When the portions are all equal in breadth the different ways in which the portions may be made to appear on the web are usually very numerous. In practice, however, one or other of two particular orders is the more useful. These two orders are: $a\,a$—(n times,) $b\,b$—(n times,) $c\ c$—(n times,) &c., and $a\,b\,c\,d$—$a\,b\,c\,d$, &c. The order $a\,a$—$b\,b$—$c\,c$ can always be produced, whatever m and n may be. The portions, however, must all be equal and placed round the cylinder at equal intervals from one another in the order $a\,b\,c\,d$— (contrary to the direction of motion.) The interval between any two consecutive portions will clearly be equal to $n-1$ times the breadth of any one of them. If the distance of travel of the webs from each impression-cylinder to the next is now taken equal to the arc of the circumference of the form-bearing cylinder between the points in which the said two impression-cylinders touch it plus the breadth of one portion—*i. e.*, plus $\frac{1}{nm}$ of the circumference of the form-bearing cylinder—the web will issue from the last impression-cylinder printed on in the order $a\,a$—(n times,) $b\,b$—(n times,) &c. For example, in Fig. 4, $a\,b\,c$ being all equal and placed at equal intervals in the order there shown, and the distance of travel being taken equal to the arc P Q$+\frac{1}{6}$ of the circumference, the web will come out $a\,a\,b\,b\,c\,c$, $a\,a\,b\,b\,c\,c$—. In Fig. 5, a, b, &c., being equal and placed as shown, and the travel being taken equal to the arc P Q$+\frac{1}{35}$

of the circumference, the web will come out — $a\ a\ a\ a\ a$, $b\ b\ b\ b\ b$, $c\ c\ c\ c\ c$, $d\ d\ d\ d\ d$, $e\ e\ e\ e\ e$, $f\ f\ f\ f\ f$ —.

The web can always be brought out in the order $a\ b\ c$, $a\ b\ c$, &c., whether the portions be equal or unequal, and whatever numbers n and m may be, provided they are prime to one another—*i. e.*, cannot be divided without remainder by any the same number. The order of the portions on the cylinder can be found as follows: Write them down in order, as above. Put a cross over the first, over the $n+1$, over the $2n+1$, over the $3n+1$, and so on, until m of them have been so marked. Then place them on the cylinder in the order thus shown, (contrary to the direction of motion,) the interval between each successive portion being taken equal to the sum of the breadths thus indicated. If the distance of travel from each impression-cylinder to the next be now taken equal to the arc of the circumference of the form-bearing cylinder contained between the points in which the said two impression-cylinders touch it plus $\frac{1}{n}$ of the circumference of the form-bearing cylinder, the web will come out printed in the order $a\ b\ c\ d$—$a\ b\ c\ d$, &c. For example, $n=7$ $m=5$. Here,

x x x
$a\ b\ c\ d\ e\ a\ b\ c\ d\ e\ a\ b\ c\ d\ e\ a\ b\ c\ d$
x x
$e\ a\ b\ c\ d\ e\ a\ b\ c\ d\ e$,

so that the order on the cylinder is $a\ c\ e\ b\ d$, (contrary to the direction of motion.) The interval between a and $c=a+2b+c+d+e$. The interval between c and $e=a+b+c+2d+e$. The interval between e and $b=2a+b+c+d+e$. The interval between b and $d=a+b+2c+d+e$. The interval between d and $a=a+b+c+d+2e$, and the distance of travel from one impression-cylinder to the next will equal the arc described above plus $\frac{1}{7}$ of the circumference. The web will come out — $a\ b\ c\ d\ e$, $a\ b\ c\ d\ e$. Again, in Fig. 7, $m=4$, $n=3$, and the breadths of the portions are supposed to have to one another the ratios 1:2:3:4. Then, writing down

x x
$a\ b\ c\ d\ a\ b$
x x
$c\ d\ a\ b\ c\ d\ a\ b\ c\ d$,

the order will be $a\ d\ c\ b$. The interval between a and $d=b+c=\frac{1}{6}$ of the circumference. The interval between d and $c=a+b=\frac{1}{10}$ of the circumference. The interval between c and $b=a+d=\frac{1}{6}$ of the circumference. The interval between b and $a=c+d=\frac{7}{30}$ of the circumference, and the distance of travel=arcPQ$+\frac{1}{3}$ of the circumference of form-bearing cylinder. To sum up, our results are: The order $a\ a$—$b\ b$, &c., is possible for all values of m and n; but the m portions must be all equal to one another. The order $a\ b\ c$—$a\ b\ c$, &c., is possible for all values whatever be the relative breadths of the portions; but m and n must be prime to one another. When m and n are prime to one another and the portions are also equal, we can bring out the web printed on in the order $a\ a$—$b\ b$, &c., or in the order $a\ b\ c$—$a\ b\ c$, &c. As before stated, when the portions are equal there are a variety of orders in which the portions may be impressed on the web. When the portions are unequal only one order is possible—namely, $a\ b\ c\ d$—$a\ b\ c\ d$, &c.

The distances of travel given above of the web from one impression-cylinder to the next are not the only possible ones. We shall now show how to find all the possible distances, and also how to obtain on the web all the possible orders of the m portions.

In Fig. 8, let B be any impression-cylinder, and C the one under which the web next passes. Then if the web comes out, as in Fig. 9, b denoting the imprint of the portion a by the impression-cylinder B, c the imprint of the same portion by the impression-cylinder c, and p the distance between the two imprints, then P R Q (the distance of travel of the web from P to Q) must equal arc P Q + breadth of $a+p$. If the positions of b and c are interchanged, then P Q R must equal arc P Q — circumference of type-cylinder minus the breadth of $a+p$. Thus, c before b: Distance=arc$+a$, (no interval between b and c;) distance=arc$+2\,a$, (interval of one breadth of a between b and c;) distance=arc$+3\ a$ (interval of two breadths of a between b and c;) distance=arc$+4\ a$ (interval of three breadths of a between b and c,) and so on. b before c: Distance=arc+circumference$-a$, (no interval between b and c;) distance=arc + circumference $-2\ a$, (interval of one breadth of a between b and c;) distance=arc + circumference $-3\ a$, (interval of two breadths of a between b and c;) distance= arc + circumference $-4\ a$, (interval of three breadths of a between b and c,) and so on.

It is clear that the distance P R Q given by the above formula may always be increased by a distance equal to the circumference of the type-cylinder or to any multiple thereof, and when the distance P R Q exceeds that of the circumference it may be similarly reduced until it becomes less than the circumference.

To fix the distances for any particular order, consider any one portion, a, Fig. 10, and suppose that the n cylinders print it on the web in the positions shown in the diagram by $a_1\,a_2\,a_3\,a_4$, &c. Numbering the cylinders from 1 to n in the reverse order to that in which the web passes under them, suppose the portion a_1 is printed by cylinder No. 1, then we can have the one next succeeding it—namely, a_3—printed by any one of the remaining $n-1$ cylinders; a_4, the next to a_3, by any one of the remaining $n-2$ cylinders, and so on, so that for the same order we have numerous ways of fixing the distances. Suppose in the diagram the suffixes represent the number of the cylinders—that is, that a_3 is printed by No. 3, and so on. Then (by the preceding) travel of web from No. 1 to No. 2=arc$+\mathrm{K}a$; travel of web from No. 2 to No. 3=arc+circumference$-la$; travel of web from No. 3 to No. 4=arc$+9a$, where k=one more than the number of breadths between a_1 and a_2, where l=one more than the number of breadths between a_2 and a_3, where 9=one more than the number of breadths between a_3 and a_4, &c. For example, let us consider the two orders before referred to: First, the order $a\ a\ a$—(n times) $b\ b\ b$. Here we can have $a_1a_2—a_nb_1b_2—b_n$; or $a_n+a_2a_1b_n—b_2b_1$, so that one arrangement (the one before given) is with the distance between successive impression-cylinders equal to the arc$+a$—*i.e.*, arc $+\frac{1}{nm}$ of the circumference; and another arrangement is arc$+\frac{nm-1}{nm}$ of the circumference, and these two are the only arrangements in which the quantity added to the arc is the same for all the impression-cylinders.

Next consider the order $a\ b\ c\ d—a\ b\ c\ d$, &c. Here we can have $a_1bcd—a_2bcd$, &c., or $a_nbcd—a_{n-1}bcd$, &c., so that one arrangement is with the distance between successive impression-cylinders equal to the arc$+\frac{1}{m}$ of the circumference (since $a+b+c+=\frac{1}{m}$ of the circumference;) and another is arc$=\frac{n-1}{n}$ of the circumference, and these two are the only arrangements in which the quantity added to the arc is the same for all the impression cylinders. All the arrangements remain the same, whether $a\ b\ c$, &c., are equal or unequal. By interchanging the suffixes of the letter a, and with the help of the formula given in connection with Figs. 8 and 9, we can write down all the possible arrangements of the distance of travel for any particular order. For instance, take the case of $n=3$, $m=4$, and the order $a\ a\ a$, $b\ b\ b$, $c\ c\ c$, $d\ d\ d$. Here there are six different arrangements, because there are six ways of arranging the suffixes 1 2 3. They are exhibited in the following table, each column representing one arrangement:

Travel from No. 1 to No. 2.	arc$+a$	arc$+2a$	arc$+3a$	arc$+2a$	arc$+a$	arc$+3a$
Travel from No. 2 to No. 3.	arc$+a$	arc$+3a$	arc$+2a$	arc$+a$	arc$+2a$	arc$+3a$

This table (and similar ones for other values of n) is true whatever number m may be, and it likewise holds for the order $a\ b\ c\ d$, $a\ b\ c\ d$—, provided the value of a is properly chosen. Thus, order $a\ a\ a—b\ b\ b$, &c., $a=\frac{1}{nm}$ of the circumference. For the order $a\ b\ c\ d$, &c., $a=\frac{1}{n}$ of the circumference, (whatever m may be, so long as it is prime to n, which it must be to make this order a possible one.)

As before remarked, the two orders $a\ a—b\ b—c\ c$, $a\ b\ c—a\ b\ c$, &c., are perhaps the only ones of use in practice. We may get any other possible order as follows: Let A D, Fig. 10[a], be a length of web equal to the circumference of the form-bearing cylinder, and on which, therefore, $m\ n$ portions can be printed, and let A L be divided into equal parts, A B, B C, C D, &c., so that each of them is just long enough to have n portions printed on it; and, again, let each of them, A B, B C, C D, &c., be divided into n equal parts. Each of these last parts will then be the right length for having any one portion printed on it. Suppose the portion a printed by No. 1 impression-cylinder in the place indicated by the figure. It is clear that the portion (call it b) which we place on the form-bearing cylinder next following a (contrary to the direction of motion) will be printed on the web in the place indicated by the figure. Similarly for the portion (call it c) next to b, and so on. Now, consider any of the spaces A B, B C, &c., (say B C,) we can, by suitably fixing the travel of the web, as hereinbefore explained, cause any one of the m equal portions $a\ b\ c$, &c., to be printed on the space n. Similarly any one of them may be caused to be printed on the space y, and so on. Thus we can fill up the n spaces which make up B C with all possible selections of the m portions $a\ b\ c$, &c. (Any one or more of them may be repeated any number of times, and of course one or more must be repeated if m is less than n.) Then with any filling up of B C we may place the portions in any order on the form-bearing cylinder. In this way we get all possible orders, for once the order of the portions on the cylinder is fixed, and also the order of the filling up of the web on any space equal to $\frac{1}{n}$ of the circumference, the positions of the portions on the remaining part of the web are also determined. If we fill up the space B C in all possible ways, we shall sometimes get the same order repeated one or more times, because different fillings up of B C sometimes produce the same order on the web. For example, if $n=4$, $m=3$, then the following fillings up of B C ($a\ a\ a\ a$, $b\ b\ b\ b$, $c\ c\ c\ c$, $a\ a\ a\ b$, $b\ b\ b\ c$, $c\ c\ c\ a$) produce the same order on the web. A similar remark applies to the arrangement of the portions on the cylinder. For example, any arrangement, and another the same, only in the opposite direction, will bring the web printed on in the same way except as regards its direction of motion.

In all the preceding a "portion" may consist of one, two, three, or any other number of forms, and the forms must be placed with a slight interval between successive ones, so that the web may be printed with suitable margins; and the "arc occupied by the forms" and similar expressions mean such spaces plus suitable margins.

All the foregoing also applies to the case of cutting before printing, the interval between successive sheets at the time of printing being added to the various distances hereinbefore given.

If n impression-cylinders are placed round a form-bearing cylinder, we can print either by using all of them, (the forms occupying $\frac{1}{n}$ part of the circumference,) or by using only some of them—say p of them—the forms occupying $\frac{1}{p}$ part of the circumference. If n is not a multiple of p, the distances of travel (or some of them) between successive impression-cylinders must be different when p cylinders are used to what they are when n cylinders are used; but when n is a multiple of p the distances may remain the same, and by properly fixing them we can leave out, when printing with p cylinders only, any $n-p$ of the cylinders we may select. When the order on the web is *a b c d—a b c d—*, m may be anything when printing from either p cylinders or n cylinders, provided it is prime to n when n are used and to p when p are used; but when the order is *a a a—b b b—*, then m must be the same for p as it is for n. In both cases we fix the distances of travel so that any the same portion is imprinted at equal intervals on the web by the impression-cylinders, which are to be omitted when printing from p cylinders only. For example, suppose $n=6$, $m=5$, and that the order is to be *a b c d e a b*, and suppose, when printing with three cylinders only, we omit to use cylinders 2, 4, and 5. Here when the six are used the web must come out *a b c d e* a_3 *b c d e a b c d e* a_4 *b c d e a b c d e* a_5 *b c d e a b c d e* a_3 *b c d e*. The other three cylinders may print the *a*'s without suffixes in any way. Let No. 1 print the first unsuffixed *a*, No. 3 the second, and No. 6 the third. Then, by the preceding rules, distance of travel from No. 1 to No. 2=arc+$\frac{1}{3}$ of circumference; distance of travel from No. 2 to No. 3=arc+$\frac{5}{6}$ of circumference; distance of travel from No. 3 to No. 4=arc+$\frac{1}{3}$ of circumference; distance of travel from No. 4 to No. 5=arc+$\frac{1}{3}$ of circumference; distance of travel from No. 5 to No. 6=arc+$\frac{5}{6}$ of circumference. With these arrangements, if the cylinders 2, 4, and 5 are caused not to make an imprint on the web, and twice as many forms are placed on the form-bearing cylinder as when the whole six are used, the web will be continuously printed on by the three cylinders, supposing it takes the same course that it did when the six were used.

The number of portions—*i. e.*, m—may be anything whatever, provided it is prime to n, and the portions may be equal or unequal in breadth, nor need m have the same value when three cylinders are used that it has when six are employed. Similarly the distances are fixed when the order is *a a—b b b—c c c;* but in this case m must be the same when p cylinders are used that it is when n are.

Figs. 11, 12, 13, 14 will help to illustrate these remarks. *c* is the form-bearing cylinder; 1 2 3 4 5 6, the impression-cylinders; and T T, &c., the carrier-rollers which convey the web from one impression-cylinder to the next.

In Fig. 11 six impression-cylinders are used, the forms occupying one-sixth of the circumference. In Fig. 12 four impression-cylinders are used, one-fourth of the circumference being taken up by the forms. As six is not a multiple of four, the distances of travel of the web from P to Q cannot be the same in both cases. In Fig. 13 three cylinders are used for each roll, and (six being a multiple of three) we can have the same arrangements from P to Q in both Figs. 11 and 13. One arrangement is: No. 1 to 2=arcPQ+$\frac{1}{3}$ of circumference; No. 2 to 3=arcPQ+$\frac{1}{3}$ of circumference; No. 3 to 4=arcPQ+$\frac{1}{2}$ of circumference; No. 4 to 5=arcPQ+$\frac{1}{3}$ of circumference; No. 5 to 6=arcPQ+$\frac{1}{3}$ of circumference. The web will then come out *a a a*, Fig. 11, and *a b, a b, a b*, Fig. 13.

In Fig. 14 three rolls are used, each employing two cylinders. The distances may be the same as in Fig. 12. One arrangement is: 1 to 2=arc+$\frac{1}{2}$ of circumference; 2 to 3=arc+$\frac{1}{2}$ of circumference; 3 to 4=arc+$\frac{1}{2}$ of circumference; 4 to 5=arc+$\frac{3}{4}$ of circumference; 5 to 6=arc+$\frac{1}{2}$ of circumference. Then the web will come out *a b c, a b c* in Fig. 12, and *a b c d e f* in Fig. 14. We have placed the forms in Fig. 14 in five portions, not all equal. They must be arranged on the cylinder in the manner hereinbefore explained. Since six is a multiple of two, the distances might have been fixed so that the distances of travel in Figs. 11 and 14 should be the same. One such arrangement is: 1 to 2=arc+$\frac{1}{2}$ of circumference; 2 to 3=arc+$\frac{2}{3}$ of circumference; 3 to 4=arc+$\frac{1}{2}$ of circumference; 4 to 5=arc+$\frac{2}{3}$ of circumference; 5 to 6=arc+$\frac{1}{2}$ of circumference.

All the foregoing methods apply whether the two sides of the web are printed by different cylinders or both sides by the same cylinder. In the former case the arrangements for the distances of travel are made separately for each cylinder, and then the travel of the web from the one form-bearing cylinder to the other is fixed so that the pages on each side shall properly back one another. In the latter case—*i. e.*, the forms for both sides on one cylinder—it is clear that the web may be reversed in any way and any number of times in its passage from impression-cylinder to impression-cylinder, all that is necessary being that each side of the web should pass under the same number of impression-cylinders. The forms must be arranged round the cylinder as hereinbefore explained, n denoting the number of cylinders used for printing one side of the roll, so that $2n$ will be the number for each roll. Then the travel for all the cylinders which print one side of the web can be fixed by the methods hereinbefore given, and then by the same methods the travel for the cylinders for the other side, subject to the web being properly backed and to the distances previously fixed for the other side.

I claim—

1. In a printing-press, a cylinder provided with forms placed on it and divided into three or more distinct portions, in combination with impression-cylinders and carrier-rollers arranged as set forth, whereby greater facilities are obtained for printing the forms on the web in various orders than when the forms are placed on it in one or two portions only, all substantially as described.

2. In a printing-press, a cylinder provided with forms placed on it and divided into distinct portions, not all equal to one another, in combination with impression-cylinders and carrier-rollers, arranged in the manner and for the purpose set forth.

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