Sept. 4, 1962 E. J. JUSTUS 3,052,296

UNIFLOW FOURDRINIER

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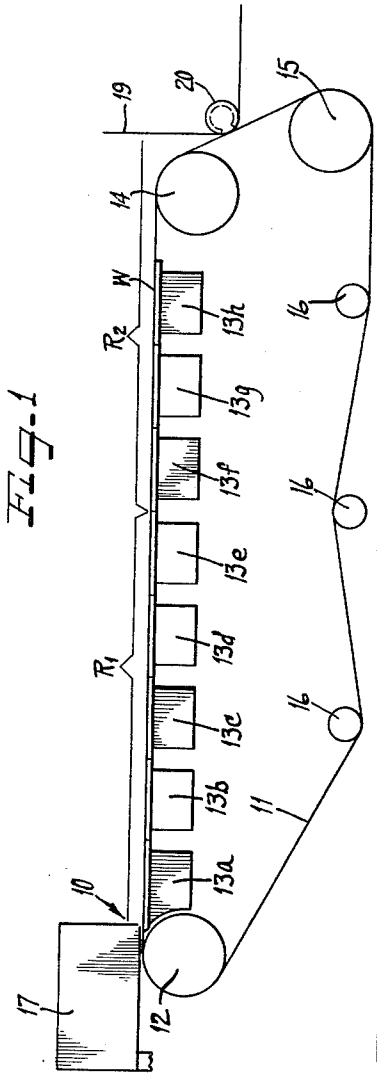


Fig-1

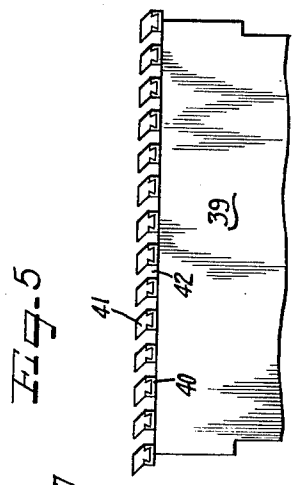


Fig-5

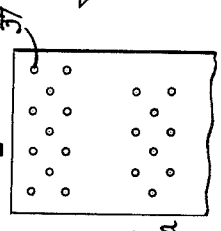


Fig-3

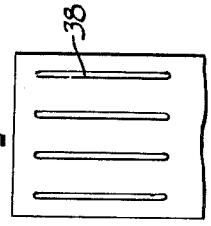


Fig-4

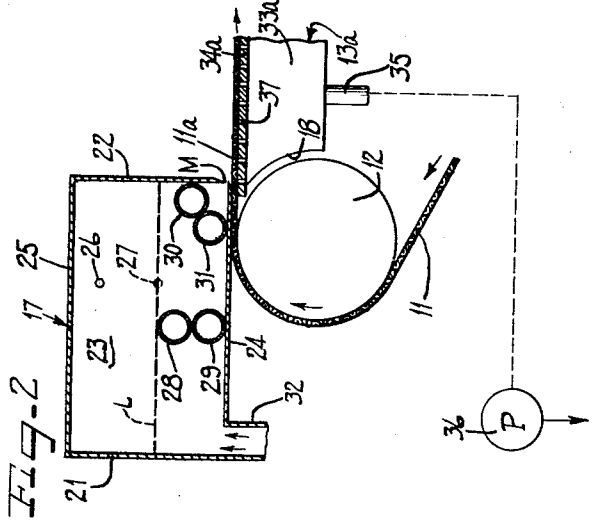


Fig-2

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Fig. 6

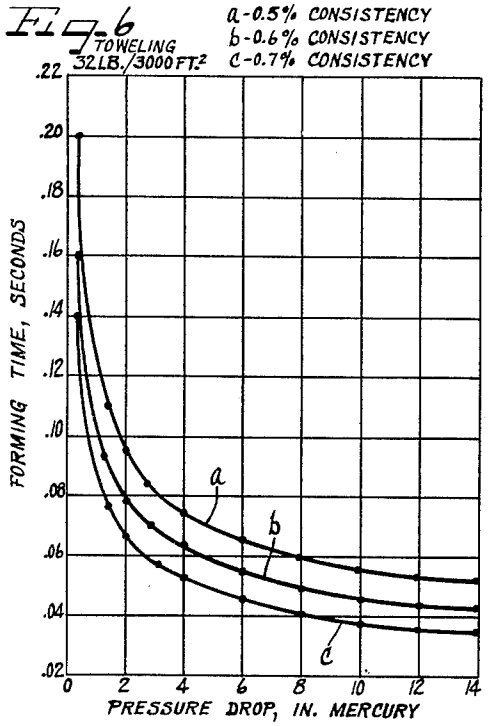


Fig. 7

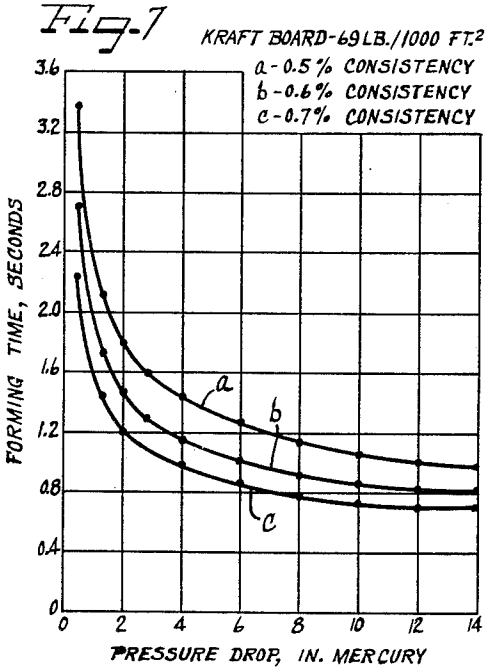
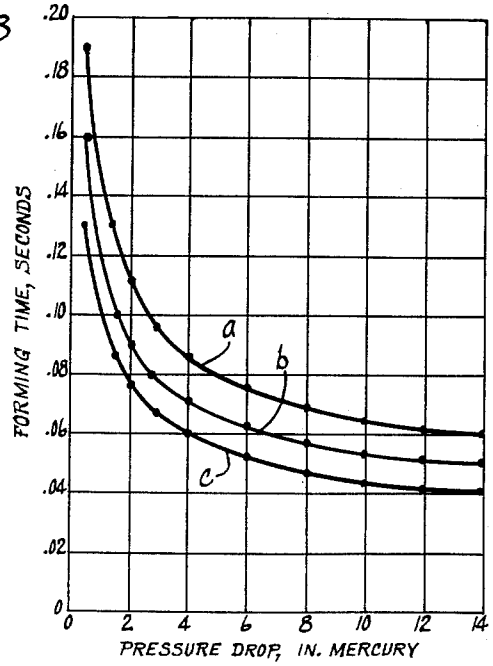


Fig. 8



KRAFT BAG - 40 LB./3000 FT.²
a - 0.5% CONSISTENCY
b - 0.6% CONSISTENCY
c - 0.7% CONSISTENCY

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UNIFLOW FOURDRINIER

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The present invention relates broadly to the manufacture of paper and like materials, and is more particularly concerned with a novel paper forming method and apparatus therefor featuring the provision of a foraminous stationary planar structure supporting a traveling foraminous member and extending continuously from the region at which the stock is applied to the foraminous member to the region whereat said stock becomes thickened to form a mat.

It is conventional to support the forming wire of the Fourdrinier type paper machine on table rolls in order to reduce sag and damage to the wire, as well as to promote drainage by the known action of the rolls in drawing water through the wire during roll rotation. Natural drainage, or drainage accelerated by the table rolls, normally leaves the newly formed sheet approximately 3% bone dry. Principally for this reason flat suction boxes were added to remove additional moisture from the web, however, it was soon found that the benefits of accelerated drainage provided by the suction boxes had associated disadvantages. The first attempts were to apply a maximum suction, but this was soon found to reduce substantially the wear life of the Fourdinier wire. In addition, this technique required enormous amounts of power to both drive the wire and pump the air removed. It is therefore accepted practice in the art to carry the forming wires upon table rolls, and it is well recognized that when suction boxes are utilized they represent at best a comprise between the water removal effect of the high vacuum and the difficulties accompanying said high vacuum.

Increased machine speeds have served to magnify these problems, and when attempts were made to increase drainage by a vacuum increase, the difficulties were accelerated and in some instances led to the seizure of the wire due to suction pressure and friction over the flat box surface. These difficulties with suction devices diverted workers in the art to experiments with drainage by means of table rolls which originally were simply smooth carrying rolls. As the pumping action became more clearly understood, rolls were often grooved, and in particular cases were constructed of open wire mesh surfaces similar to the known dandy roll. Further, the speed-size relation of the table rolls received considerable experimentation since it was known that smaller rolls could not only be placed closer to one another, but actually pumped more effectively. However, the high machine speeds compelled the use of larger rolls by reason of stiffness, balance and bearing speeds.

The length, weight and diameter of the table rolls utilized in modern paper machines requires that they be spaced from one another substantial distances, and this is wasteful of the drainage space available. Further, and possibly of greater importance, it has been shown that while the down-running side of the table roll draws water from the wire, the up-running side tends to throw water upward through the wire. As this water film is carried into the nip, considerable pressure is developed, forcing the water upwardly into and through the forming web to disrupt the formation thereof. Stated otherwise, it has been found that a relatively high pressure area exists at the up-running side of the roll, while a relatively low pressure area or vacuum curtain exists at the down-running side of the table roll. A portion of the water in this curtain is carried in the form of an air-water film around the roll, and upon entering the relatively high pressure area at the up-running side of the roll, the water is carried into the nip and an even greater pressure developed which in effect throws water through the forming web. There accordingly develops a large difference in the two sides of the paper, a defect which is referred to in the art as 2-sidedness.

In accordance with the novel concepts of the present invention, there is produced a paper characterized by the absence of wire marks thereon, a substantial improvement in the physical tests of the sheet, a marked reduction in 2-sidedness of the paper, and an improvement in the printing quality of the paper. These improvements are obtained at machine speeds approaching 2000 feet per minute, and it has been further found that there is apparently no speed limit on the structure of this invention, and in fact, there appears to be improvement with machine speed which results in higher flow rates through the entire stock system.

The structure effective to produce the improved results stated in the preceding paragraph comprises a looped traveling forming wire, rotary means guiding and driving said wire, stock flow means delivering stock to said forming wire at a region extending across the width of the wire, and suction flat box means supporting the wire from beneath and extending continuously from just beneath said region forwardly to a second region whereat the stock thickens to form a mat. The rotary means preferably comprise a breast roll and a couch roll within the loop of the wire, and it will be seen that table rolls characterizing the prior art structures have been entirely eliminated. This is apparently contrary to all prior teaching since the table roll disturbance has been considered necessary to break up small fiber conglomerations issuing from the headbox slice, and secondly, for the reason that the apparent wearing of the Fourdrinier wire against stationary surfaces was regarded as undesirable economically regardless of its possible benefits.

It is accordingly a primary aim of the present invention to provide a structure for making paper or the like featuring the inclusion therein of a wire forming surface permitting uniform, smooth and mono-directional drainage and avoiding reverse flow upward therethrough.

Another object of this invention is to provide a method of forming paper mat and like materials, which includes the steps of supplying an aqueous suspension of fiber to a moving foraminous surface, and applying a negative pressure beneath said surface from a region at which the aqueous suspension is supplied to said surface to a region at which the fibrous suspension becomes thickened to form a mat.

Still another object of the invention lies in the provision of a device for making paper and the like, which comprises means for controllably applying a flow of stock, a traveling foraminous member to which the flow of stock is supplied, a breast roll and a couch roll supporting said member, and a foraminous planar structure supporting said member between the breast and couch rolls extending from the place at which stock is applied to said member to a region whereat the stock becomes thickened to form a mat.

Other objects and advantages will become more apparent during the course of the following description, particularly when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

FIGURE 1 is an essentially diagrammatic elevational view of a paper machine embodying the novel structure of this invention and effective to practice the method herein disclosed;

FIGURE 2 is an elevational view, with parts in section, showing one form of stationary foraminous planar structure in close association with a breast roll and stock flow means;

FIGURE 3 is a fragmentary top plan view of the foraminous planar structure or suction box of FIGURE 2;

FIGURE 4 is a fragmentary top plan view of another form of suction box;

FIGURE 5 is a detail end view of a portion of another form of suction box; and

FIGURES 6, 7 and 8 are graphs plotting forming time as a function of pressure drop for three representative paper making stocks.

Referring now to the drawings, there is shown in FIGURE 1 a paper machine indicated generally by the reference numeral 10, and comprising a looped forming wire 11 trained over a breast roll 12, suction boxes 13*a–h*, a couch roll 14, a turning roll 15 and return rolls 16. In accordance with the principles of this invention, stock is deposited on the upper wire run 11*a* from a headbox 17 in a region defined generally by a line forwardly of the top center of the breast roll 12 and intersecting the leading edge of the first suction box 13*a*. The latter suction box accordingly has a generally arcuate front wall 18 to permit positioning said box as closely as possible to the breast roll 12. The slice jet from the headbox is accordingly laid upon the upper wire run 11*a* at essentially the region whereat said wire begins contact with the suction surface provided by the box 13*a*.

The stock is progressively dewatered during its travel on the upper wire run 11*a* to form a web W which is removed from the wire 11 by a pickup felt 19 urged against the web W by a suction pickup roll 20. Alternatively, the couch roll 14 may be of the suction type, and there may be employed in substitution for the felt 19 and roll 20 suitable press structure.

The headbox 17 may take various forms, and the particular structure illustrated in FIGURE 2 is to be considered exemplary only. The headbox 17 shown is provided with a rear wall 21, a front wall or slice 22 and side walls 23, 23, only one of which is shown. The headbox is also provided with a bottom floor or wall 24 and is closed with a top wall 25. If the headbox 17 is to be operated with air pressure above the stock level L, air is fed into said headbox from a suitable source of pressurized air through a conduit 26 so as to maintain a constant air pressure on the stock, and level control means 27 in the form of an outlet aperture maintains the stock at the desired constant L. If the stock level falls below the aperture 27, air pressure is bled out through the aperture and the pressure against the top of the stock is reduced so that the level rises again; whereas if the level of stock rises above the aperture 27, the air being fed in through the inlet conduit 26 builds up greater pressure above the stock and forces the stock level back down to the aperture 27.

Essentially in the middle portion of the headbox 17 there is mounted a pair of superimposed rectifier rolls 28 and 29 which extend the full width of the box 17 and are mounted for close running relation with each other. The bottom roll 29 also rotates in close running relation with the headbox floor 24, while the top roll 28 is just barely submerged by the stock level L. Across the mouth of the slice M there is mounted additional rectifier rolls 30 and 31, positioned for close running relation with each other as well as with the floor 24 and slice wall 22, so that all of the stock flowing through the headbox 17 must pass first through the stacked rectifier rolls 28 and 29 and then through the bridging rolls 30 and 31 before passing out of the mouth of the slice M. A stock supply conduit 32 communicates with the headbox interior and with a suitable supply of stock directed to the box by a source pump (not shown). The conduit 32 may carry therein suitable flow distribution means in accordance with accepted practices in the art.

As stated earlier, the breast roll 12, suction box 13*a* and headbox 17 are positioned relative to one another to assure that the jet slice issuing from the mouth M of the headbox is laid upon the upper wire run 11*a* closely adjacent the point at which said wire run makes contact with the suction surface of the box 13*a*. Practical considerations may require that the suction box 13*a* be spaced slightly downstream from the mouth of the slice M; however, the objective is to initiate dewatering of the stock essentially immediately after deposition upon the upper wire run 11*a*.

The suction boxes 13*a–h* constitute a foraminous stationary planar surface which avoids the earlier noted difficulties associated with table rolls and effects a progressive dewatering of the stock from a region closely adjacent its point of application to a region whereat the stock thickens to form a mat or web W. The number and size of suction boxes, and their cover configuration, may vary substantially according to the conditions encountered, and the arrangement of eight suction boxes 13*a–h* of FIGURE 1 is therefore merely by way of illustration. It is essential, however, that the suction boxes provide an essentially flat surface to the upper wire run 11*a*, that the stationary suction surface in the area of mat formation be substantially continuous or uninterrupted, and that in the web forming area up to the point whereat the fiber content is generally 3% of bone dry condition the negative pressure applied to the forming sheet be less than two inches of mercury. Subsequent to this region at which the slurry ceases to be liquid and has formed a mat, characterized as at approximately 3% of bone dry condition, additional dewatering may be accomplished to thicken the mat utilizing suction boxes drawing substantially higher vacuums, but preferably not in excess of four inches of mercury. It is thus to be seen that initially a very low vacuum pressure is utilized when the forming sheet is in slurry condition so that during dewatering up to the 3% fiber content condition there is no essential interference with normal fiber dispersion and the condition earlier referred to of 2-sidedness of the paper markedly reduced, if not eliminated.

Each suction box 13*a–h* comprises a chamber or housing 33*a–h* seating or supporting a cover member 34*a–h*, the covers of said boxes preferably abutting one another to provide an essentially continuous surface acting upon the forming wire passing thereover. Each suction box housing or chamber may communicate with a drop leg 35 connecting with a pump 36 (shown diagrammatically) to exhaust the interior of the respective housings. The pump means 36 to the suction boxes dewatering the slurry to an essentially 3% bone dry mat are of course controlled to limit the pressure to less than two inches of mercury, and by way of illustration, the number of said boxes may be five of the eight shown in FIGURE 1, and designated as suction boxes 13*a–e*. The region over which the suction boxes 13*a–e* effect a dewatering of the slurry to form a mat of about 3% of bone dry condition is identified in FIGURE 1 by the legend R_1, while the successive region over which the mat is further dewatered or thickened so that as transferred to the pickup felt 19 the sheet is in a condition of from 7 to 14% bone dry is designated by the legend R_2. As is of course appreciated, the region R_1 may require a greater number of suction boxes than shown in the illustration of FIGURE 1, and in fact, in one experimental installation sixteen suction boxes were employed and of this number thirteen drew vacuums of less than two inches of mercury.

The suction box covers or tops 34*a–h* are of course apertured, and the passages provided therein may be of various shapes and arrangements. As shown in FIGURES 2 and 3, the passages may be in the form of a

plurality of longitudinally spaced, transversely extending perforations 37, which may be drilled essentially vertically, or the passages may have substantial inclination from the top to the bottom of the cover. On the other hand, the suction passages may take the shape of longitudinally extending, transversely spaced slots 38 (FIGURE 4) extending in the direction of travel of the wire, or the suction passages may comprise combinations of perforations and slots. Further, certain of the suction boxes 13*a–h* may have perforated covers, while others may be provided with slotted tops.

Another form of suction box cover is shown in FIGURE 5, and this arrangement may be employed in association with the suction boxes of region R_1. A suction box cover 39 as shown may mount thereon a plurality of longitudinally spaced, transversely extending support members 40 suitably grooved to receive strip members 41 providing therebetween slots 42 in communication with the suction box interior. The strip members 41 are removably received in the support members 40, and accordingly the shape of the strip members when viewed in end may be varied to decrease or increase the slot opening. It is to be appreciated that other forms of suction box covers may be employed in the practice of this invention without departure from the novel concepts taught herein.

To produce a sheet devoid of wire marks at machine speeds closely approaching 2000 feet per minute, the vacuum pressures applied to the suction boxes of the region R_1 are preferably limited to two inches of mercury, as earlier noted. The pump means 36 may be controlled to exhaust the vacuum box interiors at various increments of pressure, and for example, the first suction box 13*a* may draw zero inches of mercury and the pressures in subsequent downstream boxes increased progressively to a maximum of two inches of mercury. The region R_2 may include one or more suction boxes of conventional configuration drawing substantially higher vacuums, but preferably not in excess of four inches of mercury. Further dewatering is effected on a couch roll of the suction type or by use of a suction pickup roll 20, so that the sheet as delivered to the pickup felt 19 or to a first press is in a condition of from 7 to 14% bone dry. This condition is of course necessary to permit the proper handling of the formed sheet through subsequent operations.

Substantial investigations have been undertaken relating pressure drops in inches of mercury to forming times in seconds for certain representative paper making stocks of various consistencies. FIGURE 6 is a graph plotting the results obtained from a toweling stock of 32 pounds/3000 sq. ft. weight of consistencies of 0.5, 0.6 and 0.7 percentages. FIGURE 7 plots results on a kraft board of the same consistencies, but having a weight of 69 pounds/1000 sq. ft., while FIGURE 8 portrays forming time as a function of pressure drop for a typical kraft bag stock of 40 pounds/3000 sq. ft. of the same consistency. Each graph clearly demonstrates a marked reduction in forming time as the vacuum pressure is increased from about 0.4 to two inches of mercury, and a noticeable but less decrease in forming time as the vacuum pressure is increased from two to four inches of mercury. It is to be further seen that no substantial reduction in forming time is obtained by an increase in pressure drop from four to fourteen inches of mercury. In addition to providing no substantial benefits in decreased forming time, an increase in pressure drop from four to fourteen inches of mercury gives rise to the serious disadvantage of increasing substantially the drag of the forming wire over the stationary suction boxes. Accordingly, the power requirements for operation of the Fourdrinier machine increase greatly, and machine speeds of about 2000 feet per minute cannot be obtained without prohibitive resulting costs.

Physical tests have been performed upon the sheet

produced by practice of the present method, and it has been found that substantial improvements were obtained in the characteristics of porosity, mullen, tensile, surface smoothness, and opacity. Print tests further indicate printing to be of exceptionally good quality. It has additionally been discovered that the percentage retention on the wire of fibers in the headbox is markedly increased. Specifically, it is usual when utilizing the table roll arrangement that not more than 50% of the fibers in the headbox are retained on the wire, whereas at least 70% of the fibers are retained by utilizing the foraminous planar structure of this invention. The result is a marked reduction in 2-sidedness of the paper. It is thus to be seen that the uniflow Fourdrinier herein disclosed essentially delivers to the couch roll the formation that is presented to the wire at the breast roll.

While not specifically shown in the drawings, the method of this invention also demonstrates particular promise on the coating of raw stock sheets. It has been found that the speeds of the machines are held down by the quality of the finished sheet, which in turn is a function of the poor quality and 2-sidedness of the coating raw stock. Accordingly, by obtaining through the present method markedly less 2-sidedness of the paper, substantial increases in machine speeds result in coating raw stock sheets.

It is to be seen from the foregoing that there is herein provided a wire forming surface which permit uniform smooth, and mono-directional drainage, that is, all drainage is downward through the wire without permitting reverse flow upward through the wire, such as is caused by the table roll arrangement of the prior art. The elimination of disturbances of flow permits improved quality of the sheet, and eliminates the costs involved in constructing and maintaining highly precise table rolls. By this invention the entire surface of the making wire is made effective for smooth unidirectional drainage, and there is accordingly obtained productive use of the space employed by table rolls, and avoidance of the impulsive drainage pattern of the series of conventional table rolls. In addition, by this invention the cost of providing high levels of suction pressure is reduced by utilization of vacuum pressures markedly lower than earlier employed, and by the reduction of the incidential large volumes of air which are normally handled. Since substantial space savings are effected, it is believed that the overall size of the wire part may be reduced for the same production rates, or greater capacity obtained in the same space requirements.

It is to be understood that various modifications may be effected in the method and apparatus of this invention without departing from the novel concepts thereof.

I claim as my invention:

1. A device for making paper or the like which comprises a looped traveling forming wire, means guiding and driving said wire, a breast roll and a couch roll positioned within the loop of the wire and defining therebetween a traveling upper reach of the wire, suction flat box means presenting a substantially continuous perforate surface supporting the entire upper reach of the wire from beneath and extending continuously from a first region after the off-running line of contact between the wire and the breast roll forwardly to a second region immediately ahead of the couch roll, and stock flow means delivering stock initially onto said forming wire at a third region directly opposite said first region whereat the flat box means act on the underside of the wire to create subatmospheric pressure conditions.

2. A device as claimed in claim 1 wherein the perforations in the flat box surface are formed by circular drilled passages.

3. A device as claimed in claim 1 wherein the perforations in the flat box surface are formed by slots.

4. A device as claimed in claim 1 wherein the suction flat box means at said first region has an arcuate front wall to conform with the top of the breast roll and extend the

first region to a line immediately forward of the off-running line of contact between the wire and the breast roll.

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