

Sept. 1, 1964

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3,146,801

FOURDRINIER WIRE AND METHOD OF MAKING THE SAME

Original Filed Dec. 3, 1956

4 Sheets-Sheet 1

Fig. 1.

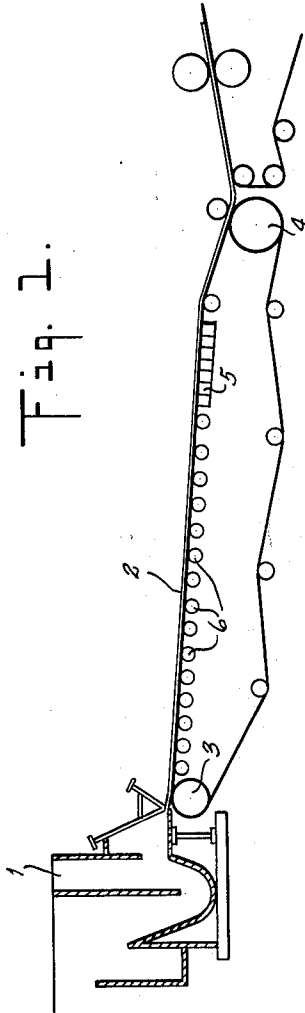
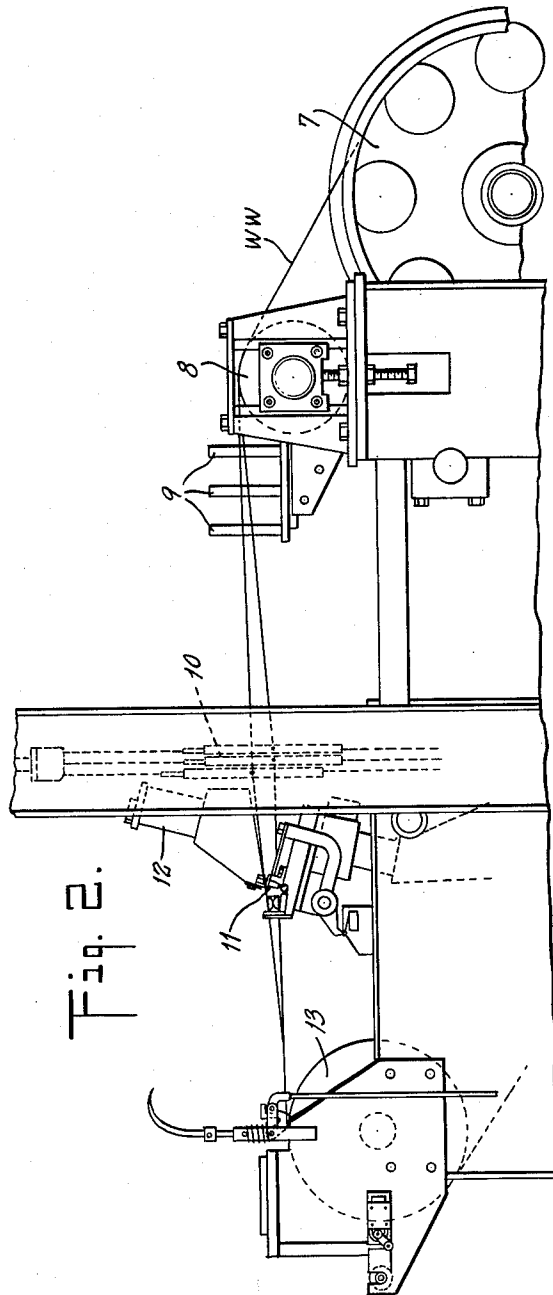


Fig. 2.



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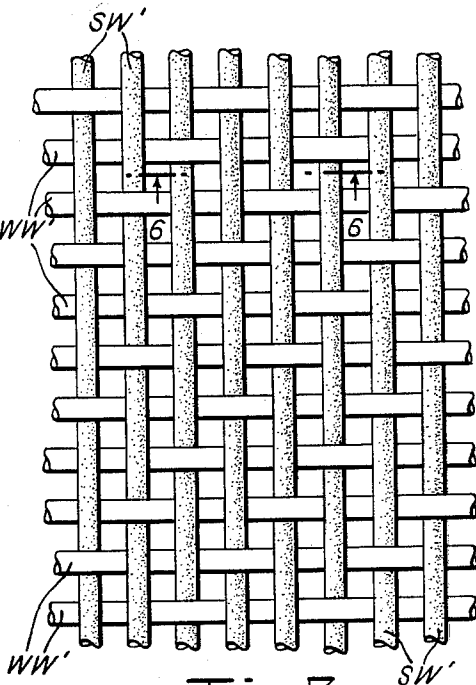


Fig. 3.

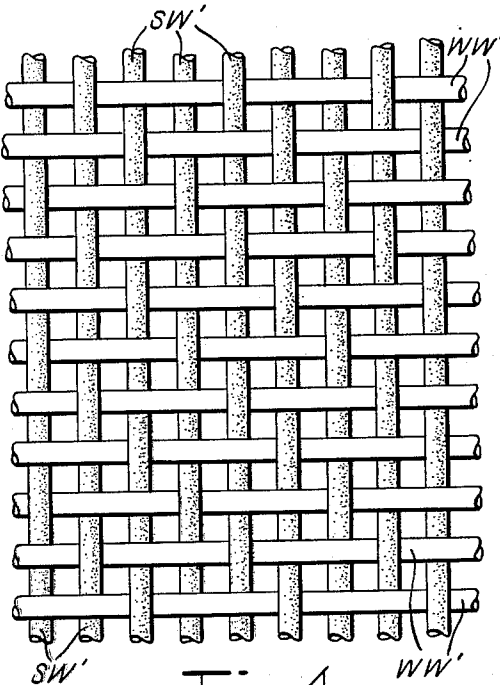


Fig. 4.

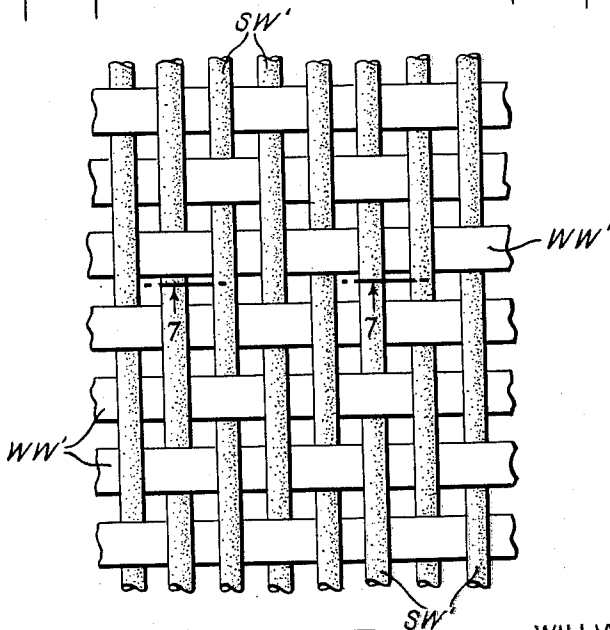


Fig 5

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Fig. 6.

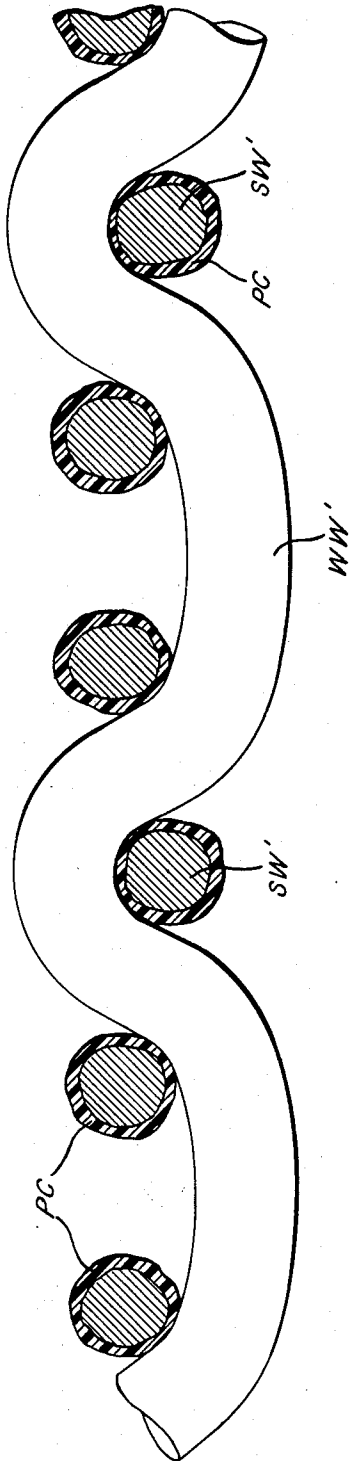
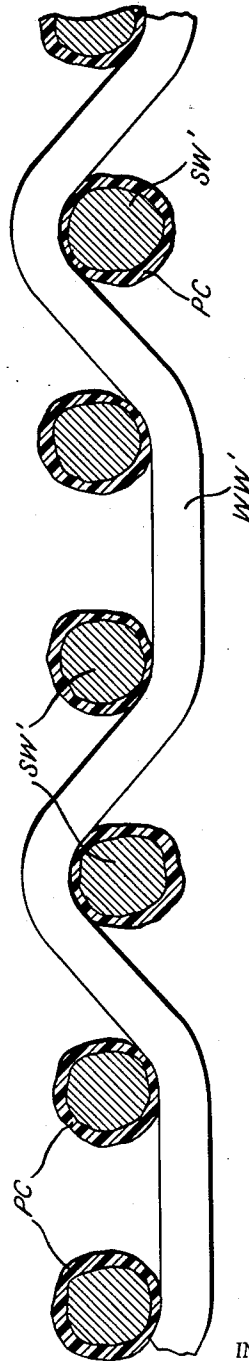


Fig. 7.



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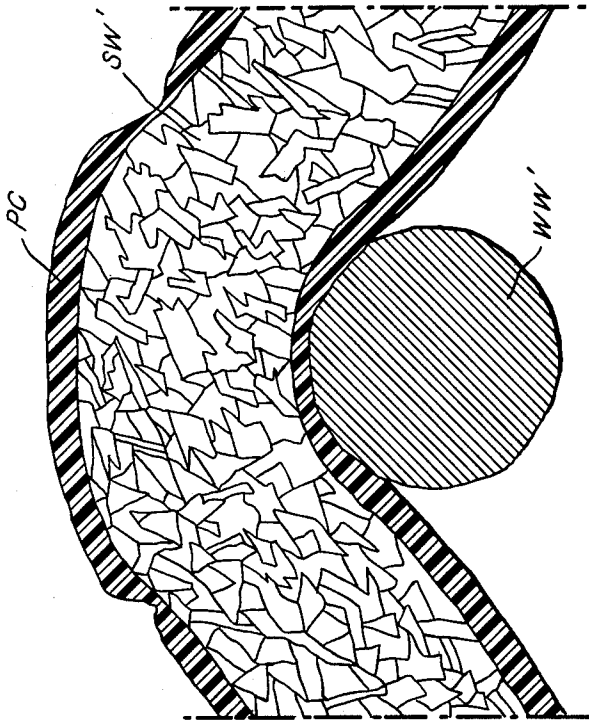


Fig. 9.

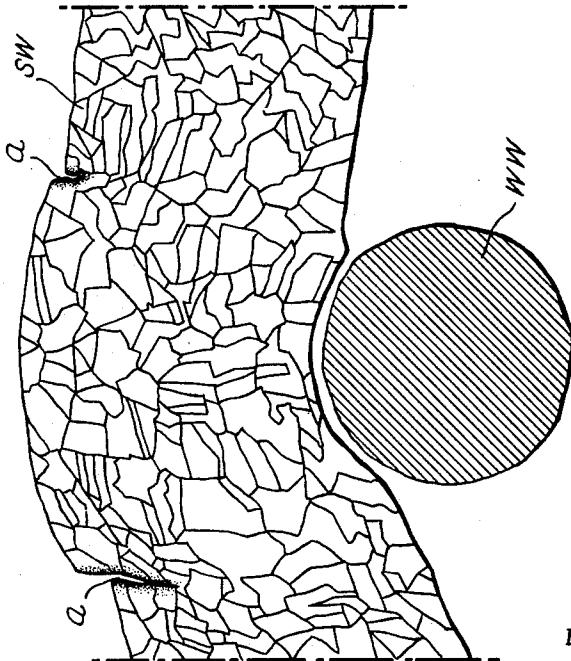


Fig. 8.

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3,146,801 FOURDRINIER WIRE AND METHOD OF MAKING THE SAME

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Continuation of application Ser. No. 625,692, Dec. 3, 1956. This application July 20, 1961, Ser. No. 125,573
3 Claims. (Cl. 139—425)

This invention relates to an improvement in Fourdrinier wire and its manufacture. When this improved wire is in use on a Fourdrinier paper machine the machine itself functions in an improved manner.

One of the objects is to make Fourdrinier wire last longer in service than any of the various prior art types. The present invention has been actually reduced to practice and has achieved this object successfully. In doing so it was found that the present invention provides many additional advantages which will become apparent from the following disclosure of specific examples of the invention.

Having reference to the accompanying drawings:

FIG. 1 is a schematic side elevation of the wet end of a Fourdrinier paper machine;

FIG. 2 is a schematic side elevation of a loom such as may be used to weave the improved wire;

FIG. 3 is a plan view showing on a greatly enlarged scale one example of the improved Fourdrinier wire, this view showing the top side which receives and processes the stock suspension;

FIG. 4 is a plan view like FIG. 3 excepting that this view shows the bottom side of the wire which runs in contact with the various rolls of the paper machine;

FIG. 5 is similar to FIG. 3 excepting that in this instance the wire is of the flat warp wire type as contrasted to the round warp wire type shown by FIG. 3;

FIG. 6 is a cross-section taken on the line 6—6 in FIG. 3 on a greatly magnified scale;

FIG. 7 is a cross-section taken on the line 7—7 in FIG. 5 on a scale similar to that of FIG. 6;

FIG. 8 is copied from a photomicrograph taken transversely with respect to a warp wire with the intersecting portion of the shute wire longitudinally bisected, the photomicrograph having been taken from a representative sample of prior art Fourdrinier wire; and

FIG. 9 is similar to FIG. 8 excepting that in this instance a representative example of the improved wire of the present invention is shown.

The Fourdrinier paper machine shown by FIG. 1 includes the head box 1 which feeds a dilute suspension of fibers evenly onto the surface of the moving endless Fourdrinier wire 2. This wire is looped around the breast roll 3 and the suction couch roll 4 under tension. The couch roll is powered rotatively so as to drive the wire 2 in the direction away from the head box 1 and the wire is, therefore, subjected to wear and bending as it travels over this roll and, of course, over the breast roll. Furthermore, the wire is dragged frictionally over the suction boxes 5 so as to receive abrasive wear from these elements and, of course, it must also travel over the various table rolls 6.

It can be seen that Fourdrinier wire is subjected to severe service conditions. In addition to the wear which it obviously receives, the wire is exposed to corrosive influences created by the water or so-called white water which drains from the suspension through the interstices or mesh openings of the wire. Thus the wire must resist abrasive wear, bending and chemical corrosion. When the wire fails the paper machine must be shut down to permit the removal of that wire and installation of a new

wire. The wire itself is an expensive product in any case.

In operation the stock fed to the wire by the head box 1 travels along on the wire to the couch roll 4 at which point the paper web is separated from the wire. The stock contains a very large amount of water and a part of this drains through the wire by gravity, a part is sucked through the wire by the suction boxes and couch roll, and a part may be removed by pressure rolls which must, however, force the water through the wire. In other words, all of the water must drain through the wire and it is important that any new kind of Fourdrinier wire must be capable of providing free water draining.

Since the paper is formed directly on the top surface of the Fourdrinier wire this surface must be smooth enough to provide paper of the desired smoothness. This requirement must be kept in mind when developing any new kind of wire.

Thus, as to the service conditions, any new Fourdrinier wire aimed at having a longer life must not only provide this longer life but must pass the water as freely as prior art types and must provide a smooth top surface. As will become apparent the present invention not only gives the longer life but provides for an improvement as to both drainage and surface. In addition to the above it must be possible to produce Fourdrinier wire without introducing unusual manufacturing problems. FIG. 2 shows a loom such as is used to make Fourdrinier wire. The warp wires WW, which extend longitudinally, are fed from the back beam 7 over the upper roll 8 and between the separators 9 to the heddles 10 which reciprocate vertically. The heddles separate the warp wires in opposite directions to permit passage of the shuttle (not shown) which travels transversely back and forth through the shuttle box 11 so as to weave the shute wires between the warp wires. After each shute wire is positioned the reed 12 beats the shute wire forwardly between the various diverging warp wires. The loomed wire then travels onto the breast roll 13.

It can be seen that the warp wires are tensioned by receiving a forward pull from the breast roll 13 while being held back by the back beam 7. As the reed 12 beats the warp wires must carry this beating force back to the back beam 7. The force with which the reed 12 must beat is determined by the difficulty encountered by driving each shute wire length forwardly to its proper position, this requiring sinuous deformation of the shute wire and deflection and to some extent deformation of the warp wires. The permanent deformation of the shute wire normally requires that this shute wire be a dead-soft annealed alloy, usually brass. The warp wires which are not so severely deformed are made of bronze to provide the finished Fourdrinier wire with greater tensile strength and wearing properties.

With the above described loom operation in mind it now becomes apparent why the obvious expedient of enlarging the normal diameter or gauge of the warp wires has not heretofore been a possibility. Although the warp wires determine the tensile strength and most of the wearing properties of Fourdrinier wire, the warp wire has heretofore of necessity been made with a smaller diameter or gauge than the shute wire. This has been required to provide the warp wires with sufficient flexibility to permit the reed 12 to beat the shute wire to its proper positions without running into the problems of excessive warp wire tension or excessive beating force.

It is, of course, impossible to attempt to accommodate warp wires of large diameters by beating the shute wire to an abnormally low count because this results in decidedly oblong mesh openings producing rough paper and allowing excessive escape of the fibers which should be retained on the Fourdrinier wire in the form of paper.

It is also impossible to excessively increase the warp wire tension and the beating force not only because this excessively loads the loom but very definitely because there is a limit to the ability of the shute wire to deform. Such efforts to, in effect, resort to brute strength results in complete rupture of the shute wire during the looming operation. Even with the practice of using warp wires which are smaller in diameter than the shute wire the latter is constantly subjected to minute intergranular surface ruptures or so-called fragmentation. FIG. 8 shows how in making standard Fourdrinier wire the shute wire SW has been subjected to a minute partial intergranular rupturing at the points *a* defining the limits of the abrupt shoulder forged when the reed drives the shute wire over the warp wires with the latter acting in the manner of a wedge. This condition with standard practices is always prevalent when making standard types of Fourdrinier wire, so it can be appreciated that aggravation of the cause by making the warp wires larger in diameter results only in complete rupturing of the shute wire. In many cases the loom itself is unable to withstand the severe working conditions that would be imposed upon it should the warp wires be enlarged from their usual proportions relative to the shute wire.

With all of the foregoing in mind, the present invention involves covering the shute wire with a plastic coating which is thin as compared to the cross-sectional area of the shute wire. This plastic coated shute wire is then interwoven through warp wires having a cross-sectional area at least substantially as great as the cross-sectional area of the shute wire. This is a twill weaving operation so as to produce Fourdrinier wire having a twill weave. During the twill weaving the shute is beaten into the warp wires with sufficient force to produce at least approximately square wire mesh openings in spite of the fact that the warp wires are larger in diameter by comparison with the usual ratio between the warp and shute wire diameters.

Apparently the plastic coating on the shute wire permits the latter to glide over the warp wires so freely as to permit a square mesh beat-up without stressing any of the wires to a degree causing the prior art troubles. It is known that the working forces required are substantially reduced even as compared to the stresses encountered by the prior art practice of weaving the shute wire through warp wires which are smaller in diameter than the shute wire. Using the same comparison, less beating force is required. Not only does the shute wire not rupture but it appears to be free from the incipient or partial intergranular rupturing so common in the prior art.

Note that in FIG. 8, showing the prior art, the warp wire WW is smaller in diameter than the shute wire SW, yet as shown at the points marked *a* its intergranular rupturing or fragmentation can be seen under the microscope. This type of trouble is not detectable yet it contributes greatly to shortening the service life of the Fourdrinier wire. This is in addition to the fact that the relatively small size of the warp wires inherently causes both weakness and wearing surfaces of reduced areas. Intergranular corrosion finds ready initiating points wherever these tiny ruptures occur.

Now look at FIG. 9 where the warp wire WW' has been increased in diameter so that it is equal to or substantially equal to the diameter of the shute wire SW' which in accordance with the present invention was covered with the thin plastic coating PC prior to the twill weaving operation. Note that the shute wire is free from abrupt surface protuberance and completely free from intergranular rupturing of any type. FIG. 9 is representative of the present invention with the shute wire beaten to provide either square mesh openings or openings which are very close to square. Obviously the shute wire metal has been strained more uniformly and

without localized strain concentrations because it glided into position between the heavy warp wires much more easily than heretofore, a fact borne out by the observable facts that the loom works with less warp tension and less beating force than is to be expected when weaving comparable prior art Fourdrinier wire while resorting to the common expedient of using warp wires of smaller cross-sectional area than the cross-sectional area of the shute wire.

The warp wire, when practicing the present invention may be either round or flat. The prior art has suggested the use of flat warp wire because it provides Fourdrinier wire having a flat working surface relatively free from wire knuckle protuberances of uneven heights. This flat warp wire advantage has been offset by the fact that the prior art weaving practices have resulted in transversely curving the flat warp wire due to the heavy beating force required to drive home the shute wire properly. This has been true even when the cross-sectional area of the flat warp wires was made less than the cross-sectional area of the shute wire, as has been customary heretofore. With the present invention the flat warp wires may be made with a cross-sectional area substantially equalling that of the shute wire, the plastic coating on the latter so easing the positioning of the shute wire as to permit the latter to be properly beaten up almost or to a square mesh opening without causing it to wedge the flat warp wires into transversely curved shapes. The flat warp wires remain flat, the loom stresses are reduced and no incipient fragmentation of the shute wire is apparent.

It is to be understood that the references above to our diameters are exclusive of the plastic coating. This coating deforms so as to be extremely thin where it is located between the intersecting wires. It is also to be understood that the present invention is not concerned with the substitution of plastic shute strands for the usual metal shute wire. The plastic coating used by the present invention is extremely thin as compared to the wire itself.

FIGS. 3 and 4, respectively, show the top and bottom faces of the new wire when the warp wire is round or circular, while FIG. 5 shows the new product when the warp wire is flat, FIG. 5 showing the top face. In these views no effort is made to show the plastic coating on the shute wire, the scale preventing this.

The cross-section shown by FIG. 6 serves to show the plastic coating PC as it appears when looking at photomicrographs of the FIG. 3 and FIG. 5 constructions, respectively. All of FIGS. 3 through 7 show the twill weave construction of the present invention.

The fragmentation problem results from the use of the cuprous alloys required to provide Fourdrinier wire with its necessary resistance to work hardening when it passes over the breast and couch rolls, and to provide the necessary corrosion resistance. Insofar as is known there is no satisfactory substitute for these cuprous alloys. Customarily the warp wires are bronze and the shute wire is brass annealed dead-soft to permit the prior art weaving practices.

The present invention so reduces the stresses and strains involved by the weaving, even when the warp wires are enlarged as described, as to permit the use of shute wire which is tempered to at least some degree. Obviously it is more desirable to use tempered wire because of its greater strength. The brass shute wire is cold drawn and, due to the cold deformation of its grain structure, it becomes tempered. When heated to a suitable temperature recrystallization occurs with consequent strain relief, and with adequate heat treatment a dead-soft condition is achieved. Such heat treatment or annealing is required during various wire drawing stages which are required to bring the wire to its ultimate size from a larger stock size. With the present invention it becomes possible to draw the wire once or twice through the wire drawing die following a dead-soft anneal. In other words, instead of finishing

the wire drawing operation with a dead-soft anneal as is usual, the present invention permits a finishing of the wire drawing operation with one or more draws following the dead-soft anneal. This, of course, has reference to the shute wire, the latter then being coated with the plastic and woven as described. This has heretofore been an impossibility.

The present invention is, of course, not concerned with heavy wire fabric such as is used for insect screening, sieves and the like. The brass shute wire will range in diameter from about .005" to .018", a shute wire count ranges from about 30 to 90 wires per inch, and the minimum warp count is about 40 wires per inch. This minimum is given because it shows that at the least the beat-up is square excepting for the ten wire difference. Usually wire made in accord with the present invention has the same shute and warp wire counts. It is to be understood that whether the warp wires are round or flat their cross-sectional area substantially equals the cross-sectional area of the shute wire. In the case of round warp wire all of the wire will have substantially the same diameter and will be within the range specified for the shute wire. All of this is made possible by the thin plastic coating on the shute wire which permits the weaving without overloading the loom and without fragmentation of the shute wire.

The use of tempered shute wire has been mentioned and it is to be understood that the degree of temper permissible must be determined experimentally for different wire dimensions. The use of tempered wire is, of course, not required and in many cases the use of dead-soft annealed wire may be found to be preferable.

Having successfully achieved the object of the invention by actual reduction to practice, experimental runs with the wire have shown many other advantages. It has already been mentioned that flat warp wire remains flat after the weaving. Also as previously indicated, the many minute incipient or partial ruptures commonly found in prior art Fourdrinier wire, are completely eliminated insofar as it has been possible to detect by extensive sampling and microscopic examinations.

In addition to the above, it has been found that weaving blemishes which could not be corrected in the loom when practicing the prior art, can be corrected in the case of the present invention. This is believed to be due to the fact that the very easy looming made possible by the thin plastic covering, reduces the normal work hardening induced in the wire by the action of the reed and the warp wire tension. This advantage might be one reason for not using initially tempered shute wire. In shipping Fourdrinier wire it sometimes happens that the bundle slips in transit so as to make lengthwise ridges in the wire. When this occurs with prior art wire the ridges mark the paper and within a very few hours split out while running on the paper machine. In the case of the present invention an experimental bundle slipped and made such ridges, but running for twenty hours on a Fourdrinier paper machine the ridges had disappeared or, in other words, the new Fourdrinier wire had ironed itself out.

The present invention using the larger warp wires and with the shute wire beaten substantially square, not only drains as well as prior art Fourdrinier wire but very appreciably and noticeably better. In experimental runs with the new wire operators have been able to reduce the vacuum on the suction boxes to almost half the usual value and, in fact, in some instances it has been found necessary to remove suction boxes altogether. The paper machines may be brought up to full speed much more quickly than when using the prior art wire. The new Fourdrinier wire is unusually quiet when running on the paper machine. The wear or service life is increased radically not only because the warp wires can now be made larger but also because the freer drainage permits a reduction in the suction required which, in turn, reduces the frictional wear.

The surface of the new wire is even smoother than in the case of the old. Paper with a smoother finish becomes possible.

All of the foregoing advantages are obtained regardless of whether the warp wires are round or flat. The weave should be twill, at least the shute wire should be given a thin coating of plastic, and with these precautions the diameter of the warp wires may be made to equal those of the shute wire. This has reference to actual wire diameters exclusive of the plastic coating. If the additional advantages are disregarded, the plastic coating may be removed from the shute wire after weaving without detracting from the fact that the result is a new Fourdrinier wire having a warp wire cross-sectional area equalling that of the shute wire, with the latter made of a cuprous alloy, and with this shute wire free from intergranular ruptures. In this state alone the wire inherently has a much better service life than the prior art wire.

The plastic coating may be any polyamide or fluorocarbon plastic providing a non-conductive coating. The well known "Nylon" may be used. Insofar as it has been determined so far, any plastic having the toughness to retain its integrity adequately as the reed beats the shute wire to position, can be used. In practicing the present invention the coating should be uniform, the present practice being to build the coating up in increments of .0004" thickness by successive dipping practice. In other words, equipment such as is used for enameling wire may be used, each incremental layer being allowed to solidify before a new run is made through the liquid plastic. The present invention requires the use of a coating thickness of from .0015" to a maximum of .003", this range is suitable for all of the shute wire sizes previously given. It can be seen that this coating is extremely thin when compared to the diameter of the shute wire. The warp wires may also be coated with the plastic as described, this having the advantage of promoting even better drainage and giving the finished wire a more attractive appearance.

The necessary seaming required to produce the endless Fourdrinier wire may be effected in the usual way used for the prior art wire. The brazing heat may destroy some of the plastic coating which would give the seam the drainage characteristics of prior art wire although this will not introduce the prior art fragmenting problem or change the fact that the warp wires are large. The seam may be sprayed with plastic to give it the same drainage characteristics as the balance of the wire so that all of the advantages of the present invention may be retained at the seam.

This application is a continuation of my application Serial No. 625,692, filed December 3, 1956.

I claim:

1. A Fourdrinier wire comprising a twill weave of metal warp and shute wires, the warp wires having a minimum count of about 40 wires per inch and a cross-sectional area at least substantially as great as the cross-sectional area of the shute wires and the latter having a cross sectional area equal to that of round wire having a diameter ranging from about .005" to .018", said shute wires having a count of about from 30 to 90 wires per inch and being interspaced at least approximately as closely as are the warp wires, at least the shute wires being covered by a plastic coating having a thickness of from .0015" to .003" and which is thin as compared to the cross-sectional area of the shute wires and which is interposed between the warp and shute wires where they intercross, said coating being tough enough to retain its continuity between the warp and shute wires and providing a surface permitting the shute wires to glide relative to the warp wires.
2. A Fourdrinier wire comprising a twill weave of metal warp and shute wires, the warp wires having a minimum count of about 40 wires per inch and a cross-sectional area at least substantially as great as the cross-sectional area of the shute wires and the latter having a cross sec-

tional area equal to that of round wire having a diameter ranging from about .005" to .018", said shute wires having a count of about from 30 to 90 wires per inch and being interspaced at least approximately as closely as are the warp wires, at least the shute wires being covered by a plastic coating having a thickness of from .0015" to .003" and which is thin as compared to the cross-sectional area of the shute wires and which is interposed between the warp and shute wires where they intercross, said coating being tough enough to retain its continuity between the warp and shute wires and providing a surface permitting the shute wires to glide relative to the warp wires, at least the shute wires being made of a cuprous alloy having a tendency to fragment when strained excessively and the shute wires being substantially free from such fragmentation.

3. A Fourdrinier wire comprising a twill weave of metal warp and shute wires, the warp wires having a minimum count of about 40 wires per inch and a cross-sectional area at least substantially as great as the cross-sectional area of the shute wires and the latter having a cross sectional area equal to that of round wire having a diameter ranging from about .005" to .018", said shute wires having a count of about from 30 to 90 wires per inch and being

interspaced at least approximately as closely as are the warp wires, at least the shute wires being covered by a plastic coating having a thickness of from .0015" to .003" and which is thin as compared to the cross-sectional area of the shute wires and which is interposed between the warp and shute wires where they intercross, said coating being tough enough to retain its continuity between the warp and shute wires and providing a surface permitting the shute wires to glide relative to the warp wires, at least the shute wires being made of a cuprous alloy having a tendency to fragment when strained excessively and the shute wires being substantially free from such fragmentation, the shute wires being tempered to a substantial degree greater than an annealed dead-soft condition.

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