Oct. 26, 1965 C. A. LEE 3,214,326

PAPER PRESSING METHOD, FELT AND APPARATUS

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Fig. 1

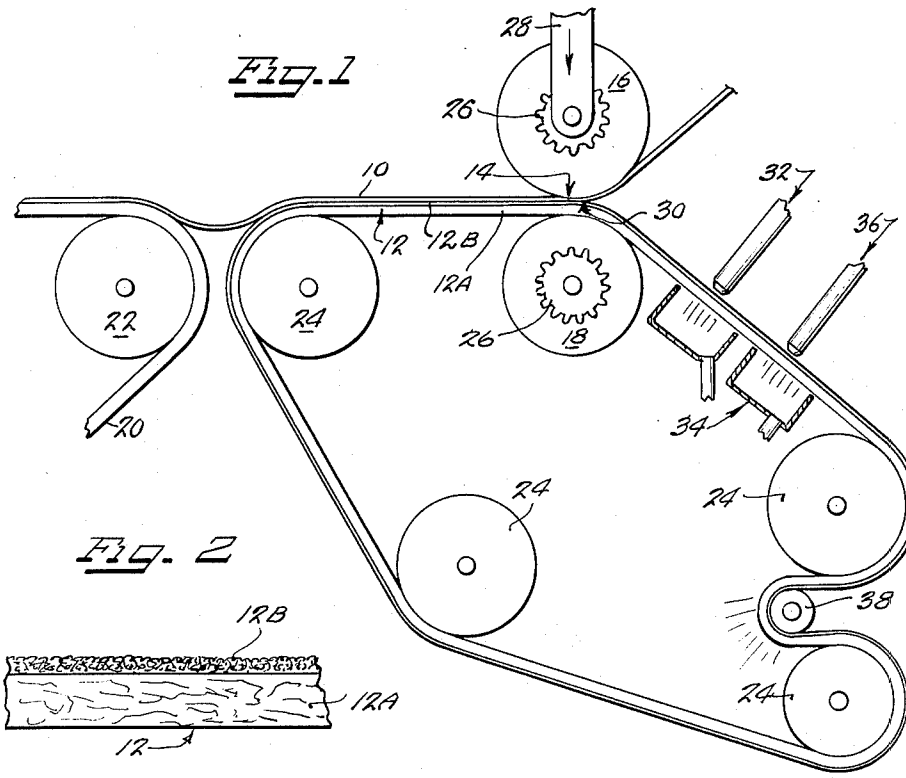


Fig. 2

Fig 3

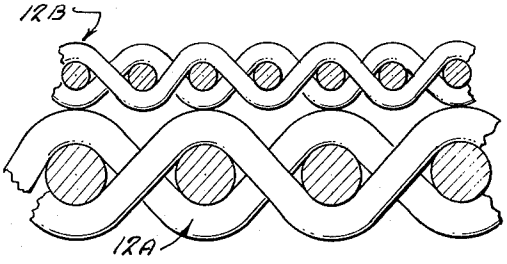


Fig. 4

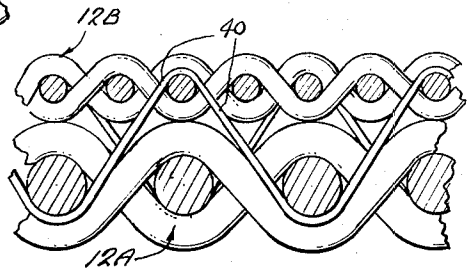
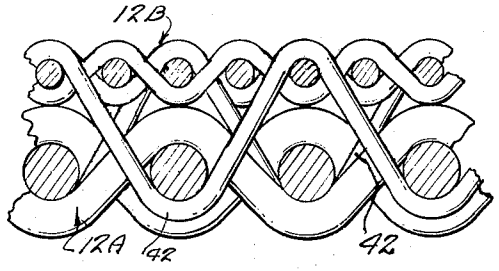


Fig. 5



Inventor
CHARLES A LEE

By Anderson, Luedeka, Fitch Even & Tabin
Attys

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PAPER PRESSING METHOD, FELT AND APPARATUS

Charles A. Lee, Knoxville, Tenn., assignor to Huyck Corporation, New York, N.Y., a corporation of New York

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7 Claims. (Cl. 162—205)

The present invention relates generally to paper making and, more particularly, it relates to improved methods and means for dewatering a sheet on a papermaking machine. Still more particularly, it relates to an improved composite or duplex fabric used in the press section of a papermaking machine, in lieu of conventional felts.

In the manufacture of paper and paperboard, a continuous sheet of cellulosic fiber is formed upon a supporting medium. This sheet initially comprises large quantities of water and has very little strength. Accordingly, it is necessary to provide a carrier for the sheet until sufficient moisture is removed therefrom to provide a self-supporting sheet.

In the case of a Fourdrinier papermaking machine, initial removal of water, or "dewatering," is accomplished in the wire section of the machine by the use of gravity drainage from the wire which carries the formed paper web aided by table rolls and suction boxes. The sheet is thereafter removed from the wire at a couch roll, where it is conventionally transferred to an absorbent felt usually of wool or the like. Additional dewatering is then effected by passing the web and its supporting felt through a series of press rolls called the press section, whereby water is expressed from the sheet, the water being absorbed by the felt or, if there is an excess of water, running from the rolls in the manner of water from a clothes wringer.

Following the press section, the sheet is conducted over and between dryer rolls, which are heated and which effect removal of most of the remaining water by evaporation, to provide a paper product of the desired moisture content. It is desirable to remove as much water as possible from the web on the Fourdrinier wire and in the press section of the machine in order to reduce the amount of heating which is required in the drying rolls to complete the moisture removal process.

In the press section several difficulties appear unless care is taken. First, there is the problem of the interstices of the absorbent felt filling up with "fines" from the papermaking fibers. This is remedied by cleaning the felt after each pass through the press section; however, even with the usual cleaning procedures the felt, when used with certain kinds of papers, becomes clogged with "fines" and must be often changed. This results in expense as a result of the expenditure of felt and the loss of production incident to the shut-down period required to change the felt. Second, there is the problem of crush which occurs when too much pressure is applied to the wet paper web at any given stage in the dewatering process. ("Crush" refers to a defect in paper, the formation of which has been broken by running it too wet through the press section and which manifests itself by mottling on the paper surface.) Because of the crushing problem, pressures must be carefully controlled on the various pairs of rolls in the press section and because of this problem, a substantial number of pairs of rolls are required, and the paper coming from the press section contains in the neighborhood of 65–70 percent moisture for most types of paper. Finally, there is the problem that the paper web has a greater affinity for water than the conventional felt, and most of any water that is expressed into a conventional felt is immediately reabsorbed by the paper web as soon as the paper web and the felt leave the pressure nip.

It is an object of the present invention to provide an improved method and means for dewatering a cellulosic sheet. A more particular object of the present invention is to provide a method and means whereby increased amounts of moisture are removed from the sheet in the press section of a papermaking machine. Other objects and advantages of the present invention will become apparent from the following description and claims, taken in conjunction with the accompanying drawings in which:

FIGURE 1 shows a form of apparatus for removing water from a paper web in accordance with the invention;

FIGURE 2 illustrates one form of duplex fabric of this invention;

FIGURE 3 illustrates another form of duplex fabric of this invention;

FIGURE 4 illustrates another form of duplex fabric of this invention; and

FIGURE 5 illustrates still another form of duplex fabric of this invention.

I have discovered that the problem of crush may be minimized if not eliminated and that the efficiency of the press section may be greatly enhanced by modifying the press section in accordance with the present invention. In accordance with the present invention, the pressing is accomplished while the wet web **10** is supported upon an endless porous and permeable carrier medium **12** of particular design in such a way that preferably substantially all of the water expressed from the web in the nip **14** of press rolls **16**, **18** is permanently removed from the web by passing through the web and the carrier in a direction generally perpendicular to the plane of the web and carrier. The press rolls are shown to be solid rolls, although open rolls may be used. It is, however, one of the advantages of the present invention that open rolls are not necessary to achieve the desired dewatering. Open rolls and attendant suction boxes involve a number of mechanical difficulties and considerable expense. Solid rolls are much simpler and cheaper. At the same time the water is removed more efficiently than by methods heretofore known. Means is provided to deposit the wet web **10** on the carrier **12**. As shown in FIGURE 1 the web is transferred from a Fourdrinier wire **20** aat a couch roll **22** and deposited on the carrier **12**. The carrier is supported for endless movement on a number of rolls, such as rolls **24**. The carrier **12**, with the web **10**, is caused to move between the press rolls **16**, **18** by driving the press rolls, as by gears **26**. Force applied to bracket **28** applies the necessary force to press roll **16** to create the desired pressure.

As has been pointed out above, the permeable carrier medium is of a particular construction. In the case of an ordinary papermaker's felt, porosity and permeability vary inversely with the amount of pressure that is exerted upon it. Thus, as a wet web on a felt enters the pressure nip of a pair of pressure rolls, the permeability of the felt becomes minimized at the point of maximum pressure and any water expressed from the wet web cannot readily flow through or into the felt. This causes the free water to flow back laterally in the web toward the inlet side of the nip and thus causes derangement of the fibers and crushing. In the instant invention, water flows in the web substantially only perpendicularly of its surface into the carrier.

In accordance with the present invention, the wet web is supported upon an endless, carrier fabric that is substantially incompressible so that the permeability of the carrier does not vary substantially with pressure. Unlike conventional felts, the carrier is dimensionally stable

under pressure, and its permeability therefore will not change as the carrier and web pass through the pressure nip. Further, the fabric desirably has particular dimension characteristics. The permeability of the fabric should desirably be such that the amount of water in the wet web may pass into the fabric under the pressure in the nip of a given pair of rolls in the time that it takes the traveling web and fabric combination to pass through the rolls. This avoids any excess of water which might then be forced backwardly through the web and cause crushing.

Since the fabric is usually supported by a solid roll, the water flowing into the carrier fabric cannot pass out the other side. For this reason it is necessary that the carrier be porous, with the water running into the pores of the fabric.

Were this a conventional woven fabric, the water could be thus removed from the wet paper web; however, as the carrier fabric and web assemblage passed from the nip, the paper web would reabsorb substantially all of the water from the fabric, leaving the web uncrushed but also full of water. In this invention a composite, or duplex, carrier fabric is used that will prevent the return of the water from the fabric to the web. As shown in FIGURES 2, 3, 4, and 5 the fabric **12** is made in two layers, a base layer **12A** and a barrier layer **12B**. The base layer **12A** is open and very porous. It has sufficient void volume to hold all of the water to be pressed from the wet web at the nip. (The void volume of a fabric is that part not filled with fiber; that is, it is the pore volume of the fabric that is available to be filled with water as the fabric and web are pressed together.) Overlying this base layer, and between the base layer **12A** and the web **10**, is the barrier layer **12B** which serves to impede the flow of water between the base layer **12A** and the web **10**.

This barrier layer **12B** must be permeable in order that the water may be pressed from the wet web through the barrier layer into the base layer in the time that it takes the web and fabric to pass between the press rolls. On the other hand, it must not be so permeable as to permit any substantial amount of water to flow back from the base layer when the pressure is relieved. The water is more easily moved into the base layer than back into the web because great pressures are applied to drive the water from the web through the barrier layer into the base layer, whereas only capillary action acts to move the liquid back through the barrier layer. As shown at **30**, the web is preferably separated from the carrier fabric as soon as it leaves the pressure nip in order that there be insufficient time for any substantial amount of water to move by capillary action back through the barrier layer.

In accordance with the present invention the wet web, during the passing, is supported upon an endless, substantially incompressible fabric which is preferably made from synthetic fibers which do not absorb water. The carrier fabric may be made from nylon, Dacron, or other suitable synthetic fibers, or it may be made of natural fibers which have been treated, as with resin, so as to make them non-absorbent of water. Dacron is a tradename for a synthetic fiber made by the condensation of dimethyl teraphthalate and ethylene glycol and sold by E. I. du Pont de Nemours & Co. The fabric may be generally of the type disclosed in U.S. Letters Patent No. 2,903,021 to Holden et al.; however, it is made in a manner providing two separate layers.

To prepare a fabric having a base layer and an overlying barrier layer, a fabric may be first woven in accordance with teachings of Holden et al., preferably using textured or staple yarn. It is possible to use a yarn made from multiple plys of monofilament which has been textured by making loops in the various plies at different points; although none of the filaments are broken, the yarn is shorter than the original monofilaments and is fuzzy from the loops. The important criterion of the yarn for this purpose is that it be possible to raise the nap on the fabric produced. The fabric must be woven to provide substantial void volume. The thread count and diameter of the yarn used should provide open construction and, obviously, must be strong enough to support the web and pass through the machinery. Its principal requirement is, however, that it have sufficient void volume to absorb all of the water expressed from the web. On the other hand, the weaving must be close enough to support the barrier layer and the web without marking the paper. The barrier layer may then be produced from the woven fabric by buffing the surface thereof. The buffing will raise the nap and produce a very fine surface next to the web. The buffing of the basic fabric is continued until the buffed surface layer has the desired permeability. It is preferably at this stage that the fabric is stabilized by chemical or heat treatment or both, in accordance with the teachings of Holden et al., to render both layers of the fabric relatively incompressible. A fabric made in this fashion is illustrated in FIGURE 2.

As an alternative, the base layer can be prepared substantially as disclosed by Holden et al. using the same criteria as just described, except that the fabric need not be woven of textured or staple yarns. Then a separate fabric can be woven that is relatively fine. It is closely woven to provide the requisite low permeability as described above and preferably has a negligible void volume. A fabric made in this fashion is illustrated in FIGURE 3. In this species the carrier fabric may be in two separate layers. This has the advantage that the two layers may be separated following the nip and the water readily removed from the base layer. On the other hand, this creates certain handling difficulties and the fabric is preferably made by permanently fastening the two fabrics together over substantially their entire length, which may be done in any conventional manner, as by heating, gluing or sewing. As shown in FIGURE 4, the two layers **12A** and **12B** can be sewed or laced together by laces **40**. Alternatively, the two layers can be woven at the same time and joined during the weaving as shown in FIGURE 5, where the yarn of layer **12B** is woven into layer **12A**, as at **42**.

In addition to providing the barrier layer with the appropriate permeability by the manner in which it is woven or mechanically treated its effectiveness may be increased by giving its surface a high wetting angle for water, which thus impedes the flow of water by capillary action. The wetting angle should be high relative to the wetting angle of the web.

The material of which the barrier layer is made may be selected to provide this high wetting angle, or the surfaces thereof may be treated chemically as with certain fluorocarbons, silicones, long chain nitrogen compounds, zirconium waxes, thermo-setting resins or some other hydrophobic chemical to provide the desired wetting angle.

Generally more than one pressure nip is required because initially the water content of the web is so great that, if enough pressure is exerted to express substantially all of the water at one nip, it cannot flow away fast enough at high speeds to avoid crushing.

After passing through one or more pressure nips and after the desired solids level is reached in the paper web, the sheet is transferred to a subsequent press fabric or to the dryer rolls. After the sheet is transferred from the carrier, the carrier may be cleaned, as with a water shower **32**, and dried, as with a suction box **34** or an air shower **36**, or both. Additionally, water may be removed by pasing the fabric over a roll **38** having a relatively short radius so as to cause the fabric to make a sudden turn, thereby spinning out water by centrifugal force. Thereafter, the fabric is returned to receive another portion of the wet web for dewatering.

The mechanism of dewatering the web in accordance with the present invention takes the wet web, the fiber mat of which mechanically holds water between its fibers, and presses it in contact with the permeable carrier which is substantially incompressible, and whose permeability and void volume are therefore practically constant. During the pressing, the paper fibers are compacted thereby causing any water contained between the fibers to be expressed from the passageways between the fibers. This water flows into the permeable carrier which, as has been pointed out, is sufficiently permeable that the water contained in the wet paper web and expressed by the pressure between the rolls can flow through the barrier layer into the base layer of the carrier in the time that the carrier and web pass through the nip under the effect of the pressure of the nip. The base layer has sufficient void volume to contain all of the water that is forced through the barrier layer. When the pressure is released, the permeability of the barrier layer is so small as to prevent any appreciable flow of water back through the barrier layer before the web is removed from the carrier fabric.

The particular fabrics used depend upon the operating conditions. They depend upon the particular type of paper to be made and upon the particular machines used, as well as their speed of operations. Following the above teachings, one skilled in the art can use the fabric best suited for the particular operating conditions. However, the following specific examples are illustrative.

Example I

To make a basis weight of 100 lbs. per 1000 square feet on a papermaking machine operating at a speed of approximately 700 ft. per minute, and with a paper web having a solid content of about twenty percent when entering the nip, the base layer of the fabric should have a void volume per 100 square feet of at least 500 cubic inches, and the barrier layer should have a drainage rate of about 3 gallons of water per square inch per minute per pound of pressure per square inch.

Where the barrier layer is produced by buffing a base fabric, the base fabric may be woven from 420 strands of 6 denier per strand nylon in the machine direction and 102 strands of 19.3 denier per strand nylon in the cross direction. The thread count may then be 11 per inch in the machine direction and 25 per inch in the cross direction. Then the barrier layer may be produced by buffing the surface of the fabric until the desired permeability is achieved.

Where the layers are prepared separately, the base layer may be woven from 420 strands of 6 denier per strand nylon in the machine direction and 102 strands of 15.3 denier per strand nylon in the cross direction. The thread count of the fabric may be 11 per inch in the machine direction and 25 per inch in the cross direction. The barrier layer may then be woven from 68 strands of 2.06 denier per strand nylon in the machine direction and 8 strands of 20 denier per strand nylon in the cross direction. The thread count of the barrier layer may be 75 per inch in the machine direction and 60 per inch in the cross direction.

Example II

To make a basis weight of about 50 lbs. per 1000 square feet on a papermaking machine operating at a speed of 800 ft. per minute, and with a paper web having a solid content of about twenty percent when entering the nip, the base layer of the fabric should have a void volume of at least 400 cubic inches per 100 square feet and the barrier layer should have a drainage rate of about 2.5 gallons of water per minute per square inch per pound of pressure per square inch.

Where the barrier layer is produced by buffing a base fabric, the fabric may be woven from 420 strands of 6 denier per strand nylon in the machine direction and 102 strands of 15.2 denier per strand nylon in the cross direction. The thread count may then be 13 per inch in the machine direction and 25 per inch in the cross direction. Then the barrier layer may be produced by buffing the surface of the fabric until the desired permeability is achieved.

Where the layers are prepared separately, the base layer may be woven from 420 strands of 6 denier per strand nylon in the machine direction and 102 strands of 15.3 denier per strand nylon in the cross direction. The thread count of the fabric may be 13 per inch in the machine direction and 25 per inch in the cross direction. The barrier layer may then be woven from 68 strands of 2.06 denier per strand nylon in the machine direction and 8 strands of 20 denier per strand nylon in a cross direction. The thread count of the barrier layer may be 85 per inch in the machine direction and 60 per inch in the cross direction.

As is shown from the foregoing examples, there has been provided improved means for dewatering the web on a papermaking machine which results in economies of operation and/or higher machine speeds.

Various of the features of the present invention are set forth in the following claims:

What is claimed is:

1. A method of removing water from a wet web in the press section of a papermaking machine comprising the steps of continuously disposing the wet web on a substantially incompressible endless carrier having a base layer and a barrier layer, the base layer being permeable and porous and having a void volume greater than the amount of water to be removed from the web, and the barrier layer being permeable and disposed between the base layer and the web; continuously passing the carrier and the web thereon between a pair of press rolls; continuously pressing the pair of press rolls together with the carrier and the web therebetween with pressure sufficient to move water through the web substantially perpendicularly of its surface and through the barrier layer of the carrier into the base layer of the carrier but with a pressure insufficient to substantially decrease the permeability and void volume of said barrier layer or the void volume of said base layer; carrying the expressed water from the nip between the pair of press rolls in the base layer; thereupon removing the web from the carrier, the barrier layer of the carrier being of such low permeability that substantially all of the expressed water remains in the base layer after the pressure is relieved and substantially none thereafter returns to the web from the base layer before the web is removed from the carrier; and thereafter removing the water from the base layer before the carrier again receives the web.

2. Apparatus for removing water from a wet web in the press section of a papermaking machine comprising a pair of press rolls; a substantially incompressible endless carrier having a base layer and a barrier layer, said base layer being permeable and porous and having a predetermined void volume, and said barrier layer being permeable and having a void volume substantially less than that of said base layer; means for supporting said carrier for endless movement; means for disposing the wet web on said barrier layer; means for passing said carrier and the web thereon between said pair of press rolls; means for pressing pair of press rolls together with the carrier and the web therebetween with pressure sufficient to move water through the web substantially perpendicularly of its surface and through said barrier layer into said base layer but with a pressure insufficient to substantially decrease the permeability and void volume of said barrier layer or the void volume of said base layer, said barrier layer being of such low permeability that substantially all of the expressed water remains in said base layer after the pressure is relieved; and means beyond said nip for removing water from said base layer.

3. A carrier for supporting a wet web in a papermak-

ing machine during the removal of water from the web comprising a permeable endless belt substantially incompressible under the pressure exerted in the nip of a pair of press rolls forming a part of a papermaking machine and made of fibers that do not absorb water and consisting of a base layer and a barrier layer, said base layer being permeable and porous and having a predetermined void volume, and said barrier layer having substantially less void volume than said base layer and being sufficiently permeable to permit water to be forced therethrough at the pressures exerted by said press rolls and at the same time of such low permeability that substantially all of the expressed water remains in said base layer after the pressure is relieved for a substantial period of time.

4. A carrier for supporting a wet web in a papermaking machine during the removal of water from the web comprising a permeable endless belt substantially incompressible under the pressure exerted in the nip of a pair of press rolls forming a part of a papermaking machine and made of fibers that do not absorb water and consisting of a base layer and a barrier layer, said base layer being permeable and porous and having a predetermined void volume, and said barrier layer having substantially less void volume than said base layer and being sufficiently permeable to permit water to be forced therethrough at the pressures exerted by said press rolls and at the same time of such low permeability that substantially all of the expressed water remains in said base layer after the pressure is relieved for a substantial period of time, the surfaces of said barrier layer being water repellant, thus having a wetting angle for water substantially greater than the wetting angle of the web.

5. A carrier for supporting a wet web in a papermaking machine during the removal of water from the web comprising a permeable endless belt substantially incompressible under the pressure exerted in the nip of a pair of press rolls forming a part of a papermaking machine and made of fibers that do not absorb water and consisting of a base layer and a barrier layer, said base layer being permeable and porous and having a predetermined void volume, and said barrier layer having substantially less void volume than said base layer and being sufficiently permeable to permit water to be forced there through at the pressures exerted by said press rolls and at the same time of such low permeability that substantially all of the expressed water remains in said base layer after the pressure is relieved for a substantial period of time, said base layer being formed of woven yarn and said barrier layer being formed on said base layer from nap raised from one surface of said base layer.

6. A carrier for supporting a wet web in a papermaking machine during the removal of water from the web comprising a permeable endless belt substantially incompressible under the pressure exerted in the nip of a pair of press rolls forming a part of a papermaking machine and made of fibers that do not absorb water and consisting of a base layer and a barrier layer joined by yarns woven into both layers to form a unitary duplex fabric, said base layer comprising a fabric woven so as to be permeable and porous and have a predetermined void volume, and said barrier layer comprising a fabric of a weave substantially less open than that of said base layer and interwoven with said base layer, having substantially less void volume than said base layer and being sufficiently permeable to permit water to be forced therethrough at the pressures exerted by said press rolls and at the same time of such low permeability that substantially all of the expressed water remains in said base layer after the pressure is relieved for a substantial period of time.

7. A carrier for supporting a wet web in a papermaking machine during the removal of water from the web comprising a permeable endless belt substantially incompressible under the pressure exerted in the nip of a pair of press rolls forming a part of a papermaking machine and made of fibers that do not absorb water and consisting of a base layer and a barrier layer joined by yarns woven into both layers to form a unitary duplex fabric, said base layer comprising a fabric woven so as to be permeable and porous and have a predetermined void volume, and said barrier layer comprising a fabric woven with a weave substantially less open than that of said base layer, having substantially less void volume than said base layer, and being sufficiently permeable to permit water to be forced therethrough at the pressures exerted by said press rolls and at the same time of such low permeability that substantially all of the expressed water remains in said base layer after the pressure is relieved for a substantial period of time, said barrier layer being fastened to said base layer over substantially its entire area.

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DONALL H. SYLVESTER, *Primary Examiner.*

MORRIS O. WOLK, *Examiner.*