Recent Developments in Paper Making Relevant to Indian Industry

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It is a recognised necessity that the pulp and paper industry renovates the existing plant and machinery and modernises inducting energy efficient equipment and new process technology to be able to cope up with the increasing market needs on quality, diversifying into utilizing different grades of pulpable raw materials like bamboo, hard woods, pine, bagasse and other agricultural residues as well as annual plants, and still be viable.

The market expects the industry to produce the quality grades in both writing printing and industrial kraft. The changing pattern of the packaging industry to different corrugated boxes of varying properties and packaging end uses, call for increased strength of base paper from which the containers are made. Similarly, the writing and printing paper industry has developed into such a new era, inducting new machinery and high speed printing technology calling for paper of such quality like uniform caliper, high smoothness and finish, high strength properties with loading materials needing dimentional stability, good ink penetration and high opacity apart from very high brightness and wet strength in the paper.

There could be certain supplementation in furnish to the paper machine by incorporating long fibre pulp, taking advatange of the concession given by the government to import soft wood fibres from abroad.

Let us restrict ourselves to review the development of plant and machinery available in the country, apart from those available in the market, with the view to improve upon the quality and grades of paper that the industry can produce considering that fact that there is always a limitation on the fibre-source. The government would appreciate these constraints and would like to work together with the industry with the liberal import of technological backup alongwith the needed fiscal benefits in the form of concessions to the industry to make this industry viable.

The shortage of raw material should motivate the industry to obtain higher yield from the same quantum of raw material. The reduction in energy consumption and other inputs would lead to cost effectiveness. Modernisation with efficient equipment and process technology will difinitely lead to production

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of high value added items and superior quality of the products. An analysis of the forces stimulating the technical progress must consider these relevent decisive factors.

1. Increasing demand on the quality of the paper products. Consumer's growing awareness of the quality and technical demands of the convertors involve ever-increasing product quality demands, in competition, these demands must be satisfied by the machines and production facilities of higher efficiency.

2. Economic output on paper machine installation. The production should not be exclusively confined to attaining peak output, but also attempt to achieve optimum efficiency. Its criterian is economy, the optimum relationship between expenditure and profit.

3. Demand for higher degree of automation of machinery and paper making plants. The high degree of automation and changeover to fully automatic processes and machines are required to increase the output and economy, for example, at higher operating speeds and to manufacture products of greater uniformity and better quality.

   Placing the economy of the whole manufacturing process on a sound basis is the specific problem of the development of the machinery and the equipments used by the industry.

How to assess & measure this progress? In analogy with the yard-sticks usually applied to mechanical engineering and process engineering, the following assessment criteria are put forward for the appraisal of the technical level of development of existing or new production facilities and the evaluation of the quality of process technology:

i) Quality of performance of the functional task.
ii) Quality of mastering the manufacturing tolerances.
iii) Reliable attainment of output.
iv) Favourable usage properties.
v) Ease of handling.
vi) Operating attendance and maintenance characteristics.
vii) Human and Environmental relations etc.

The phenomenal growth in the paper industry since 1970 with the establishment of large number of small mills based on second-hand imported machinery using agricultural residues and waste paper and as to how the capacity utilization has been going down from 90% in 1970's to 60% at present, are some of the immediate problems plaguing the industry. The need is for harnessing the alternative raw material, modernising the existing units, reducing the investment cost on one hand , and providing necessary financial and fiscal supports on the other hand, attract fresh investments, are some of the important areas needing immediate attention.

This paper aims at bringing out the experiences of paper making in the industry over the period of time and highlights incorporation of some of the recent developments in paper making and machinery design on the existing plant and machinery in order that productivity increases apart from continued availability of the machines aimed at higher production, grade and quality.

The paper making commences at the stock preparation section where the bleached or unbleached pulp after having been screened and cleaned, as well as bleached in the pulp mill is received in the stock chests. The strength in the pulp has to be liberated by subjecting the stock to refining applications, wherein the surface area per unit volume of the fibre is enhanced by proper fibrillation. This unit operation is done through refiners. The age old technology has been the use of horizontal valley beaters most widely known as Hollander Beaters, which are still used today for beating rags, gunny and other special grades of stock needed for specific end use. The more recent developments in the field of cylindrical machines are strekerfiners and Vargo Beaters. The basic characteristic of the cylindrical machine is the zero plug angle which ensures a constant peripheral speed in the refining zone. These machines are known for low throughputs, high energy consumption, large floor area batch operation, poor utilization of rotor tackles, poor mixing and indifferent grades of stock refined. Over the years, many mills have changed over from these energy inefficient beaters to more efficient refining machines.

Over a century the conical refiners have been used in the industry. Both plug and shell are fitted with bars or knives in the axial direction. Further advances in the designs of tackles have been the development of cast plug and shell liners with the plug angles in the range of 16 to 20° in the case of conical refiners and 50 to 60° in the case of wide angle refiners. The bar heights in a normal conical refiner vary from 10 to 12 mm and in case of wide angle refiner up to 30 mm. The bar width again is dependant upon the foundry technology limiting to lower level of 6 mm.

The stock to be refined is fed under pressure at a controlled consistency between 3 to 4%. It is the experience that these machines are again suitable for low throughout and are more prone to cut the fibre rather than fibrillating them, apart from high energy requirements for idle running. The advances in metallurgy also played a very prominent role in the development of these refiners and recently cast stainless steel rotor and shell liners have been introduced.

The disc refiners have found place in the Indian Industry since last twenty years or more. The refining elements are coaxial and parallel to each other, with 2 or 4 discs as in a double-flow disc refiner. The refining mechanism consists of a free-floating disc rotor between the two non-rotating discs. The advantage of the disc refiner is that it has low moment of inertia requiring less no load and higher margin of power for refining. These machines are known for relatively high throughput as much as 120-150 tonnes per day, capable of achieving 15 to 20° SR increase through one pass.

Their hydraulic capacities are relatively high and hence the energy consumption per tonne of paper processed is less than 50% of the energy consumed for the same duty by the conical refiners. The refiner plates are available in cast and welded designs. The average life of the discs in stainless steel welded designs is as high as 8 to 12 months between replacements.

The stock after refining is taken through either in a batch or in a continuous manner for further processing, wherein the required additives are mixed, before it is taken to the machine through the approach-flow system. In many of the Kraft machines some wet end additives are also used. Adequate care has been taken in batch system to ensure that the pumps and the requisite chests are provided with enough capacity in order that in most cases the stock has the minimum time of 30 minutes to provide for latency, the fixation of dyes and other additives on to the stock.

Many recent machines have adopted continuous stock proportionating and additives system. It requires a reasonable degree of instrumentation and controls for proportionating the different additives to the stock. This is achieved through metering pumps, tandem driven through a D.C. motor, controlled electronically. The proportioning is regulated through sensing the stock flow and consistency monitored through a magnetic flow meter and a consistency controller. The stock from the machine chest is picked up by the fan pump to process it through the constant part of the paper machine. Here again are many variations that depend upon the machine capacity, grades and quality of the paper made. Many of the recent machines have incorporated in them two stage fan pump system in which the stock at controlled consistency is processed through the centrifugal cleaner with or without provision for deaeration followed by vertical pressure screens. The critical fact of the systems which influence the operations are the constant flow, and consistency of stock to the head-box,system's stability without any variation in pressure and flow rate, good stock cleaning, low air content to prevent flocculationand to aid drainage.

Centrifugal cleaning operations aim at cleaning the stock to free it from spinning contraries and the residual specks from the stock. The principle adopted in the centrifugal cleaning is taking advantage of the difference in density between the acceptable pulp and rejectable spinning constraries by creating a density gradient in conical container where a pressure drop is created by pumping in stock at high velocities. In the process of separation, the rejectable contraries alongwith certain portion of the stock get thickened and stock gets cleaned.

There are many different variations in the design of centrifugal cleaners available on the above principles. In view of the increased demand of paper quality, the attention of the paper machinery manufacturers has been forced continuously in the development of centrifugal cleaners over many years to attain a high degree of cleaning efficiency at minimum energy cost. Twenty to thirty years ago the first centrifugal cleaners were called Hydroclone's which operated at pressure drops ranging from 22 to 35 meter water column. The older designs were slowly replaced and subsequently called Vortex Cleaners. The later development by many of the designers aimed at optimising the internal hydro-dynamic flow patterns reducing the thickening ratio and withstanding higher temperature operations. In the latest design the inlet to the cleaners has been so much modified, helping to reduce the entry loss to the cleaners, however, with a higher feed velocity. This in turn generates a higher Centrifugal force with the result it is possible to obtain a high cleaning efficiency at low pressure drops. The metallury used in these centri-cleaners was originally mild-steel followed by cast iron, cast-iron rubberlined, stainless steel and injection moulded thermo-plastics like polyamide known for high abrasion resistance.

Oxide ceramic cones are used to withstand the high erosion experienced at such high centrifugal fields. Many variations in the designs are available, however, keeping in view the desired gravitational force which varies between 10 - 100 g. The centrifugal cleaners are arranged in a number of stages usually 3 to 4 with the final stage of cleaners provided with the fibre saving equipment using the principles of elutriation, with a view to minimise fibre loss from the system and preferentially removing the specks and other spinning contraries from the pulp.

The centrifugal cleaner bodies are available with individual capacities ranging from 80 to 3000 litres per minute depending on the type of pulp to be cleaned and the degree of cleanlines desired.

There are also designs available which are usually aimed at deaerating the stocks when it is processed in the approach flow system for high speed machines. The Indian industry has access to all these designs available today and many of the mills have these unit equipments with them. The consistency of processing pulp through these centri-cleaners is in the range of 0.6 to 1.2% depending on the type of centrifugal cleaners used, aiming at high degree of speck removal.

The accepted stock from the primary stage of the centrifugal cleaning is further treated in vertical pressure screen to remove the fibre bundles, shives, if any, and any other light contraries that may have escaped the centrifugal cleaning system. The centrifugal screening is accomplished with passing the stock under pressure at regulated flow through the unit equipment provided with either a slotted or perforated basket.

The screen by virtue of having a hydro-foil provided in the rotor creates a positive and negative pressure in the process of its rotation across the screen basket which maintains the screen from plugging. In this process the accepted stock emerges out of the screen at an appropriate level under pressure and the stock is further lead to the secondary fan pump through dilution or directly to the headbox mainfold. Many mills have adopted different configurations of the equipment application, their location and the mode of use. Invariably the critical factors in the selection of the equipments and their lay-out in the plant entirely depends on the specific grades of pulp and production programme.

From the point of view of energy considerations optimum velocities have to be selected in the approach flow piping. Many years ago these stock pipes in the approach flow system were made out of copper and over a period of time there is a slow changeover to stainless steel. A very high degree of surface smoothness is needed for speciality machines to minimise slime build up in the system.

The extent of instrumentation depends entirely upon the grade of paper, production, the extent of automation desired by the individual mill. The three variables to be controlled are, mainly flow, consistency and pressure.

Some of the recent machines of capacity range 100 to 275 tonnes per day, have gone in for deculator cleaning system where the stock is degassed under vacuum to ensure that it is devoid of air. This system has been incorporated by the news-print mills in the country. However, the centrifugal cleaners do have certain provisions to remove the entrapped air from the stocks and some Mills have used these equipments for their stock cleaning and deaeration applications.

Let us now review the developments in paper machines. The machine comprises headbox, wire part containing a variety of dewatering elements of a suitable length depending on the stock used and paper made, followed by press section, Dryer section with or without size press, calender and Reel. From thereon it is processed further for converting, sorting and packing.

Most machines installed in the late fifties or earlier were of width from 2.2 to 3.2 meters and wire length 22 - 24 meters. All these machines were installed for a capacity of 30 - 50 TPD and speed up to 200 meters per minute. These machines generally were installed on first floor, with the approach flow system including pressure screens, located on first floor. These machines invariably had in them only open head boxes with the wire table comprising table rolls followed by plain or suction couch and in some places with lump breaker roll. The solid content of the web leaving couch was in the range of 16 - 20%.

All these machines had in them the following basic disadvantages:

i) Two sidedness

ii) Low retention

iii) Basis weight variation across the deckle

iv) M.D./C.D. properties variation

v) Limitation on speeds due to open head box and open draw in press sections.

vi) Too many breaks in press section

vii) Time consuming wire and felt changes

viii) Heavy energy consumption in the form of steam and power.

In the intervening period since late 60's there has been slow change-over in parts in following sections:

i) Converting open head box to closed head box for pressure/vacuum applications.

ii) Incorporating forming board, foils, wet suction boxes etc. to have controlled dewatering, higher retention and reduced two-sidedness.

iii) Increased wire-length to accommodate increased machine speeds and installation of synthetic wires.

iv) Plain couch replaced by suction couch roll with single or two vacuum zones.

v) Better broughton vacuum system with automatic controls.

vi) Increased wire tension, to increase M.D./C.D. properties.

vii) Installation of forward turning roll followed by suction pickup and compact press systems.

In the following paragraphs we would discuss in detail the possible variations and the designs available based on current developments in the industry.

Head Box and Wire part.

The stability and uniformity of the jet geometry as well as its high adaptability to different operating conditions are of utmost importance to paper quality. All the machinery designers had recognized this necessity and developed their designs, resulting in improved versions of head-box over the past few decades.

The development of head boxes since the time of open headboxes are illustrated in Figure 1. The trend over wider paper machines and higher operating speeds has resulted in the development of closed type high turbulence head box utilizing tube tanks to sub-divide total stock flow into a large number of individual flows. The desired micro-turbulence is generated inside the tube banks due to the specially designed profile at the outlet of the tube banks. The intensity of micro-turbulence is almost 3/4 times in the case of latest head boxes when compared to the conventional closed type head boxes. The residence time in the later version of head boxes is low as such the micro-turbulence generated is passed over to the jet falling on wire. This combined with the increased speeds of the machines eliminated the need for installation of shake mechanism.

Consequent increase in machine speeds, posed associated drainage problems, particularly important is to increase the production of imporved sheet quality with existing machines without extending the fourdrinier section. The pressure and suction pulses caused by a table roll have a detrimental influence on the formation of light sheet at high machine speeds. This undesirable effect gets aggravated with the increased table roll diameter. The table roll diameter has to be increased with the width and speed increase of the machines. After a certain point, the drainage effect of the table roll can not increase further with increase in machine speeds. Dewatering by means of table roll also gives a washing effect, which tends to remove fines from the wire side of the machine and increase the two sidedness.

The above problems can be best solved by installing stationary dewatering elements like single foils, foil boxes and wet suction boxes.

The single and multifoil boxes with foil angles in the range of 0 - 4°, either fixed or variable become handy replacement for the obsolete table rolls, for such modifications.

The experience has shown that the most effective and least disruptive turbulence generation is possible by a closed head box or a high turbulence head box followed by closely spaced hydrofoils. The explanation is that the suction developed by any given foil arrangement increase with velocity of the wire in a manner very similar to that of the table roll, but at a lower level, without a stock jump. At low speeds it is common for the jet to land on the wire directly over the breast roll. In these cases, the breast roll behaves like a large table roll and removes a very high percent of the slice flow. As speed is increased the breast-roll drainage becomes too great and produces very violent disturbances on top of the wire. It is, therefore, imperative in such conditions to shift the slice jet beyond the breast-roll by a distance of 15-25 cms from the top dead centre of the roll and allow the jet to fall on the forming board. This is possible by shifting the front lip behind the dead centre of the roll and allowing the jet to impinge on the wire supported by the forming board at a very shallow angle.

The wire table can be suitably reorganised by changing the table rolls by installing foils, foil boxes, wet suction boxes etc., depending on the grade and quality of paper and machine speeds. The dandy roll on the machine is installed at a convenient position supported over table rolls preceded and followed by flat suction boxes, to lead the web to the couch roll from where it emerges out at a solid content of 20% and above. It is by virtue of incorporating these stationary dewatering elements, and by installing a foward turning roll to minimise the slip, closed draw with suction pickup has been possible. A typical arrangement of conventional wire table with open head box and that of possible variations with closed press is illustrated in Figure 2. Typical arrangement of dewatering elements is illustrated in Figure 3.

In recent times, efforts have been made to improve the dewatering in the wire section by means of heating the stock, by providing steam boxes as in the Devronizer system. The Devronizer system cause the web to release more water, as such the press section should have adequate capacity in felts and uhle boxes to remove this additional expelled water.

Press Part

The objective of the press section is to remove maximum amount of water from the web before it goes to the dryer section apart from achieving bulk reduction and improved sheet smoothness. Since moisture removal at press section is relatively inexpensive compared to dryers, lot of developments have taken place in press design. The average sheet dryness entering the drying section has gone up from 35 - 36% level to 45% or even higher. It may be of interest to note this increase in dryness by 9%, reduces the load of water removal from dryer section by almost 33%. The machines installed prior to 1960 were all with open draw. Since the sheet consistency as also the wet strength are low at this point, it becomes a weak link in operation of the paper machine and particularly does not suit for high machine speeds. Open draw machines are generally limited to 250 meters per minute speed. Sometimes poor man's pickup is used to stabilise the sheet taken off the wire. The basic press arrangement had been the "Straight through press" as illustrated in Figure 4. The inlet dryness to the first nip ranges between 20 - 22%. It is suitable for basis weights 50 gsm and above. This arrangement can be used for lighter grades of paper also by shifting the felt run of second press close to the first press for supporting the web. Its main advantage is that it requires minimum of frame-work, easy to operate, maintain and for clothing.

The development of suction pickup arrangement has enabled various press configuration with close web transfer. This arrangement eliminates press breaks and ensures machine productivity apart from high quality web. Some of these designs are as under:

TRI NIP Press

This press arrangement is illustrated in Figure 5. Here the first open draw is at 43 - 45% solids after the press section. The nip pressure can be in the range of 90, 100 and 110 kg/cm in the three nips. It is suitable for printing paper upto 150 gsm. With the application of double felting in the first press, both sides of the web are treated equally to ensure even ink absorption. It can be used for slow pulps to protect the web from being crushed in the first nip.

FOUR NIP Press

The trinip arrangement can be extended to four nip press. It can be used with twin wire machines. It is suitable for high speed printing paper machines with speeds up to 1400 meter/minute. The four nips provide maximum drainage, leading to high sheet dryness which ensures excellent runnability at all speeds. It is illustrated in Figure. 6.

Double compact press

It is illustrated in Figure 7. Here the main features are, extremely short draw and high drainage capacity. The dryness at the end of the press is 42 - 45% depending upon the type of stock.

It can be used for basis weight up to 200 gsm. Its main advantage is that it is well suited for press rebuilds on existing machines due to its compactness. The use of fabric in the first press nip prevents shadow marking. The second press nip can have fabric, grooved rolls or blind hole rolls. This arrangement with the third wet press is suitable for printing papers free of shadow marking and having low two-sidedness.

Yankee Press

Figure 8 illustrates the Yankee Press arrangements. This arrangement is suitable for M.G. grades of paper with basis weight in the range of 16 to 40 gsm. The maximum speed can be 700 - 800 meters per minute.

Transfer of paper from the press to dryers

Let us review the transfer of paper from the press part to the dryers. Now-a-days the dryer section runnability controls how fast the machines run. The stresses imposed in the sheet by air movements and by centrifugal and adhesion forces increase logarithmically with speed. They cause disturbances such as machine direction wrinkles as well as waves in the sheet, edge flutter and breaks. The traditional method of increasing the draw between sections to stabilise the sheet is no longer valid as it increases the tension unacceptably. Many new ideas have been put into application on the machines. Let us review the details.

In the usual press section to dryers configuration used until the early 1980's the open draw is often long, depending on the machine design. (Figure 9A). Flutter, which can lead to sheet breaks, can give serious problems at this point because:

i) The paper is at its heaviest and weakest when the draw is applied.

ii) Bonding is not complete and tension causes irreversible stretch, i.e. plastic deformation.

iii) The paper has to be run quite tight to avoid billowing caused by air coming upwards from the basement.

iv) The paper carries boundary air into the nip creating over pressure and sideways air flows as the sheet joins the cylinder.

v) Air flows caused by the last press felt and the Ist no draw dryer fabric may also interfere.

Shortened run:

"No draw" single felting is now used on nearly all fast machines in the first and often later sections. A number of machines have improved conditions at the press to dryer transfer simply by moving the felt roll above cylinder 1 close to the press roll. (figure 9B). The paper travels in contact with the no draw dryer fabric. The length of unsupported paper in the draw, and the stresses on it, are greatly reduced.

Blow Boxes:

To stabilise the paper and hold it under the "no draw" fabric as it feeds to the first cylinder, press run blow boxes, are now widely used (figure 9C). Air blows upwards from full width slots in the blow boxes and creates an under pressure which pulls the paper into good contact with the no draw fabric. It is still important to reduce boundary air movements in this area since a draw of about 2% is still needed. This can be done by the close approach of the press felt to break up the boundary air flow of the no draw fabrics (shown dotted in figure 9C). On some machines deflectors are used inside the fabric as it returns to the turning roll R to prevent air being pumped through the fabric at the nip with this roll.

Foils:

An alternative method, used less often, is the foil which creates under pressure as it diverges from the no draw fabric (Figure 9D). Seals at the positions shown and along both edges are important to maintain the under pressure. The amount of under pressure can only be adjusted at a shut.

Vacuum Transfer Roll:

A transfer roll with low vacuum is positioned close to the press roll holding the paper as it transfers to the surface of the no draw fabric. This system has been installed by Voith, and Beloit use the vacuum transfer roll followed by a foil which has vacuum zones at the edges where it is most critical, Figure. 9E.

On a fast machine the vacuum roll was not successful, probably because the draw was being applied over such a short length (from the press roll to the first contact with the fabric round the vacuum roll).

Vacuum roll replacing lst top cylinder :

This unusual arrangement runs well on LWC papers with a vacuum roll of 1.25 m diameter replacing the first top cylinder. (figure 9F). The low vacuum zone holds the sheet until it is under the no draw fabric.

Dryer Part

The objective of the dryer part is to evaporate moisture from the paper sheet and to remove it from the paper making area. The effectiveness of the drying process is controlled by the earlier operations. If the sheet comes to dryer exceptionally wet or very weak, with wet streaks, or with variation in basis weight, the drying process can not make any corrections. The evaporatig system runs on the interaction of the sheet, the drying cylinder, machine clothing and the air movement around the dryers.

Firstly, the conditions inside the drying cylinder must be right so as to get the maximum possible temperature at the cylinder surface. A scoop or syphon is used for removing the condensate from the cylinder continuously so that the condensate does not form an insulating barrier preventing heat exchange. Rotary syphons are normally used for speeds above 400 meters per minute and stationary syphons at lower speeds. If the paper machine is designed for multi-products, wherein it has to operate at a lower and higher seeds, generally, a stationary syphon system is used. The presence of air within the dryer reduces the effective steam temperature. The secondary function of the syphon is to remove this air. The removal of condensate and air is enhanced by the effects of blow through steam. However, the presence of blow through steam needs its reutilisation in other dryers.

A properly designed steam and condensate system provides a satisfactory condensate removal. This permits flexible temperature control and high specific drying rates with full utilisation of latent heat.

In special reference to Indian context, many machines are 2.2 to 3.76 meter wide deckle cover a range of speeds between 250 and 600 meters per minuts. For these speeds and machines running on lower speeds in majority of the cases the condensate removal from the drying cylinder has been possible with the use of scoops. On faster machines either stationary or rotary syphons are used. The requisite clearance between the drying cylinder and scoop or the syphons plays a vital role in making the drying operations efficient. Older machines had clearance between the scoop and the drying cylinders in excess of 5 mm and as high as 15 mm. The recommended clearance ideally suited will be 1.5 to 3 mm in case of syphons and 3 mm and above in case of scoops.

Let us now review in brief the optimal type of steam and condensate removal system taking reference to the steam distribution pattern in some of the older machines and revised over the period of time.

There are three basic designs of steam and condensate systems:

Individual Controls:

In this case individual drying cylinders are provided with steam inlet, steam trap, sight glasses and valves and the condensate is removed from them collected in a centralised condensate tank from where it is sent back to the boiler house. Most of the old machines are having this arrangement.

Cascade Heating System:

Here the condensate is removed by the differential pressure across the cylinder. Blow through steam is provided for the removal of the condensate and the non-condensable gases. In this case the dryer section is divided into three or more heating groups to achieve the cascading effect.

Thermo compressure system:

In this case the flash steam of one group is used for other group and the desired pressure inside the cylinder is achieved by means of an ejector thermo-compressor arrangement where motivating high pressure steam is used for the pressure control. This system is suitable for the high-speed machines manufacturing single grade of paper like newsprint.

Hood and pocket ventilation system:

The installation of hoods and pocket ventilation system helps in boosting up the dryer's performance and moisture profile control across the width of the machine.

During the process of drying paper large quantity of water is evaporated in the form of water vapour. The efficiency of the drying depends upon how fast the water vapour is removed from the place from where it is generated. It is achieved by circulating the air through the hood system in order that the humidity in the vicinity of the drying cylinder is kept low and the moist air is removed alongwith the water vapour & exhausted to the atmosphere.

The quantity of air and its temperature circulated through the hoods depends upon the climatic conditions & also the period of winter at the location where the mill is installed. In tropical countries like ours, most of the conventional medium size and speed machines have in them open hood system. The technology of machine hood and ventilation is developed so much that it is difficult to describe the details in this paper. However, in the context of our experience, it would be appropriate to mention that apart from the hoods installed with requisitie air heating as well as removal system, the productivity of the machines can be increased by incorporating pocket ventilation system in the dryers by a margin of 10 to 15%. This has been introduced in many of the existing mills by blowing hot air through the dryer section at vulnerable places to promote the specific evaporation rate.

Some of the recent large and high speed machines have incorporated in them close-hood system alongwith pocket ventilation using synthetic dryer screens and doing away with the conventional felt dryer system. These systems have in them optimal heat transfer, apart from recovery of heat from the vapours to achieve minimum steam consumption per tonne of paper.

CALENDERS

The major part of all grades of paper and boards is used for printing. Good printability depends on the surface, quality of finish in the sheets. It is the prime task of calenders to create uniform sheet caliper and to improve the surface finish. To cater to the most varied demands of various grades of papers & boards, calenders with different number. type of rolls and nip loading facilities are utilized.

During the process of calendering due to high nip pressure the roll tends to deflect. For good calendering with uniform caliper the nip should be uniform without any deflection. In the early stages, this was achieved by providing camber to the bottom calender roll. However, this was not the ultimate solution, since the crown can be provided only suitable for a particular nip pressure.

Hence for any other operating condition, it will not give the same kind of performance. Further developments in the form of swimming rolls came up at a later stage. Internal oil pressure is applied inside the swimming roll and this pressure can be varied such that it will counteract the nip pressure applied, to give a uniform linear nip. In the swimming rolls technology, there are further developments in the form of Nipco Rolls, Vario Rolls and Profile Rolls.

The vario rolls have specific advantage of overcoming the deficiencies that are experienced in the swimming roll by individual segmental deflection controls, consequently leading to uniform line contact at the nip.

The conventional paper machines had earlier 2-3 stacks each comprising 6 rolls. These were slowly replaced by the introduction of swimming rolls with interposed plain rolls.

The earlier concept of calender rolls being cooled by a jet of chilled air has been wholly withdrawn. The current application of calender, aims at heating the rolls internally, consequently leading to nip pressures being lowered. By this process the web of paper gets plasticised and compressed by an "ironing effect", while the middle layer of the web of the paper remains cool, resilient and bulky. The paper is smoother, much glossier and requires less ink while having higher strength. This goes with the present market trend which is slowly changing to using lighter paper than what has ever been used so far in the past years for the same end use. The modern paper reels should have good surface quality requiring:

i) uniform thickness of paper and good roll profile.
ii) higher dimensional stability and strength to print at high speeds.
iii) good smoothness
iv) uniform porosity.
v) lower ink consumption
vi) good ink peneteration
vii) uniform density of paper.

These can be achieved by a calender with only four rolls, of which the top and bottom will be swimming rolls and the intermediate rolls will be heated rolls whose surface temperature can be controlled within close range. The different configurations of the calender application available for the industry are illustrated in Figures 10.

Machine Drives

It is essential that the drive system of the paper machine operates with utmost reliability. Since the paper making process is extremely sensitive and can be affected by various factors, its drive system should be very reliable and should not cause costly machine down time.

The main types of paper machine drives are as under:-

Line Shaft Drive

These are normally used for machine speed upto 350 m/min. and wire width approx. 4 meters. The main advantage of line shaft drive is low capital and maintenance cost, highly dependable in operation and the fault detection can be done by the operating staff itself.

Combination of line shaft and sectional electric drive:

On machines where several drive groups are situated in the wet section, it is often extremely difficult to adopt a purely mechanical line shaft type drive. In such cases the combined drive is used.

The wire turning roll, suction couch roll, wire roll, dandy roll, pick up suction roll, first press and wringer press canbe provided with electric helper drive. The point of separation between sectional electric drive and line shaft drive depends upon the basic design of the press section.

Sectional Electric Drive.

The Sectional electric drive is usually employed for high speed paper machines operating at speeds above 400 m/min., when the high power transmission and specified accuracy in regulation does not permit the use of line shaft drive. The Sectional electric drive comprises individual DC motors, gear unit, cardon shaft or intermediate shaft as per the requirements.

The sectional electric drive can be used in conjunction with bevel gear units with splash or forcedfeed oil lubrication, since these type of gear units have proved to be dependable for continuous operation.

The D.C. motor drives can be controlled by means of thyrister controls. With the thyrister control the sheet draw can be precisely regulated. This facilitates better speed control when different furnishes are used for various grades of paper and when the shrinkage of the sheet varies.

The most modern machines have analog or digital controls for the speed torque and web tension depending upon the process requirements.

Fibre Recovery

The recovery of fibres and fillers from the lean white water can amount to substantial savings. The excess white water from the paper machine is sent to pulp mill and stock preparation for dilution at various places. However, this recycling of back water really does not help in recovering of fiber, since the white water recycled to the pulp mill gets further impaired by washing and refining second time. This neccessitates installation of in-plant fibre recovery system for the paper machine.

There are three basic principles of fiber recovery namely, Sedimentation, Filtration, Floatation.

The selection of plant and machinery for fibre recovery system depends upon the capacity of the machine, cost and also the production programme which the machine has over a period of time. Each system has its own advantages and disadvantages and is a matter of choice.

General

The discussions in this paper so far have been restricted to fourdrinier machines only. There are further developments in the paper machine involving twin wire machines etc., which is a subject by itself and would require a great deal of time to discuss and would be beyond the purview of this particular paper. However, for a moment let us review the manufacturing of boards. The maximum basis weight the fourdriniers can accommodate with satisfactory quality but at limited drainage rate, is about 300 gsm depending upon the adequate drainage capacity of the stock. Inspite of the applciation of a dandy roll, the top side of the web is taken no longer satisfactory as the stock must have relatively high head-box consistency and as in the course of drainage heavy flocculation occurs on the top side. With free pulps, namely kraft liner, the secondary slice can apply a light weight top layer with a higher freeness to a bottom layer of lower freeness, the top layer has to be drained through the bottom layer and they may have only low thickness.

To take advantage of high dilution and fast drainage to obtain good formation, sheet forming is subdivided into two more plies which are later on couched together. The advantage of multiplied sheets over, single ply sheets are:

i) Low head box consistency, improved formation.

ii) Higher production rate due to shortened drainage time.

iii) Combination of individual plies from different plies and from different colours.

iv) Manufacturing of heavy weight boards.

The cylinder moulds have the following main designs, restricted flow vat and cylinder mould former, including suction former and ultra-former etc. In case of restricted flow vat, the action of centrifugal force and the suction impact of the couch roll limits its speeds to maximum 100 meters per minute at a maximum vacuum of 80 to 100 mm wg., while the suction formers can be operated for boards, manufacturing at operating speeds of 250 to 450 meters per minute. It has the added advantage of picking heavier web leading to higher production.

The press and dryer configuration remain unaltered as in fourdrinier machines. However, the machine speeds are relatively low when compared to the conventional low grammage paper machines.

Due to limitation of time and space, the developments, in respect of machine clothings, wires, finishing equipement and other related topics could not be accommodated in this paper.

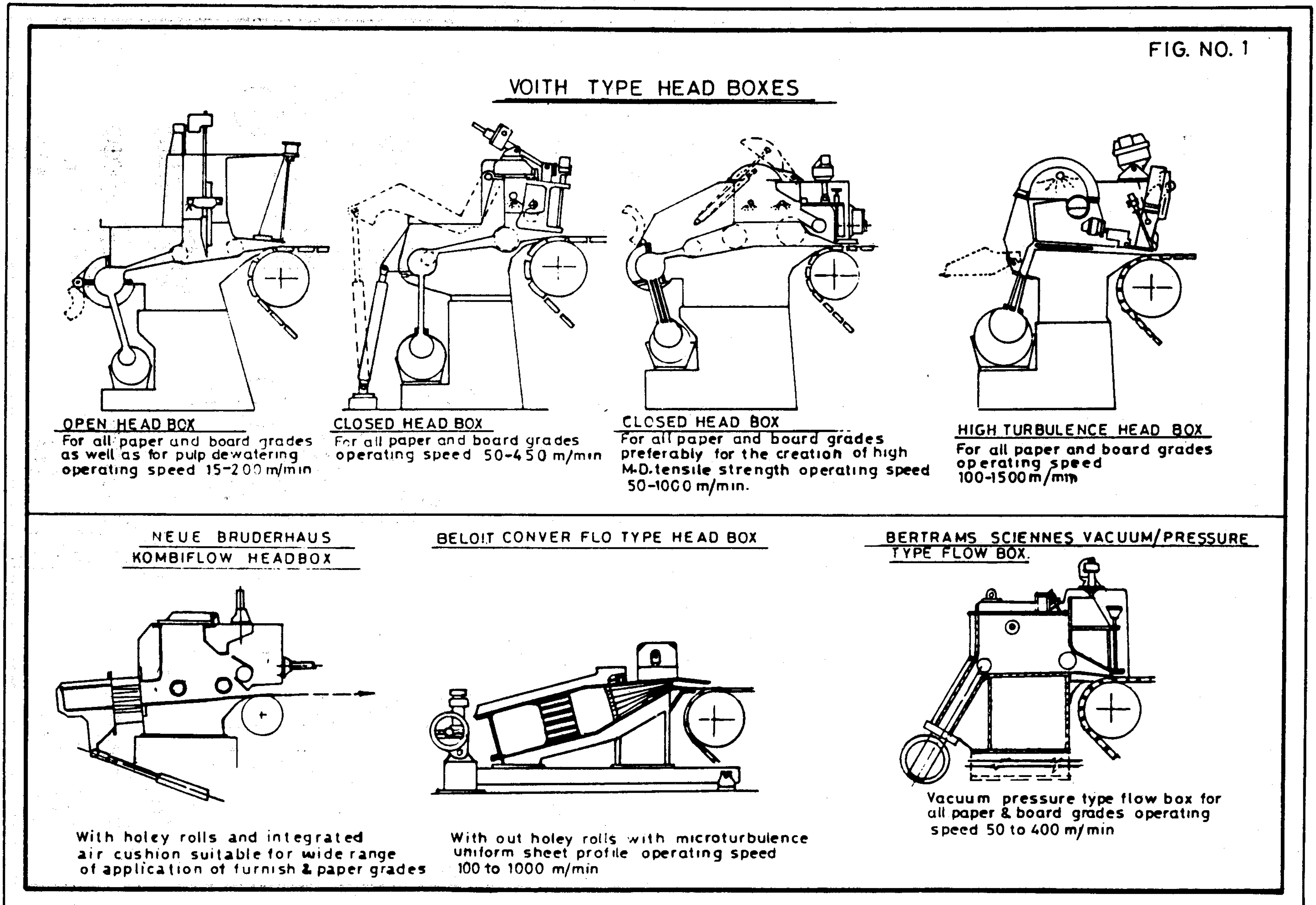
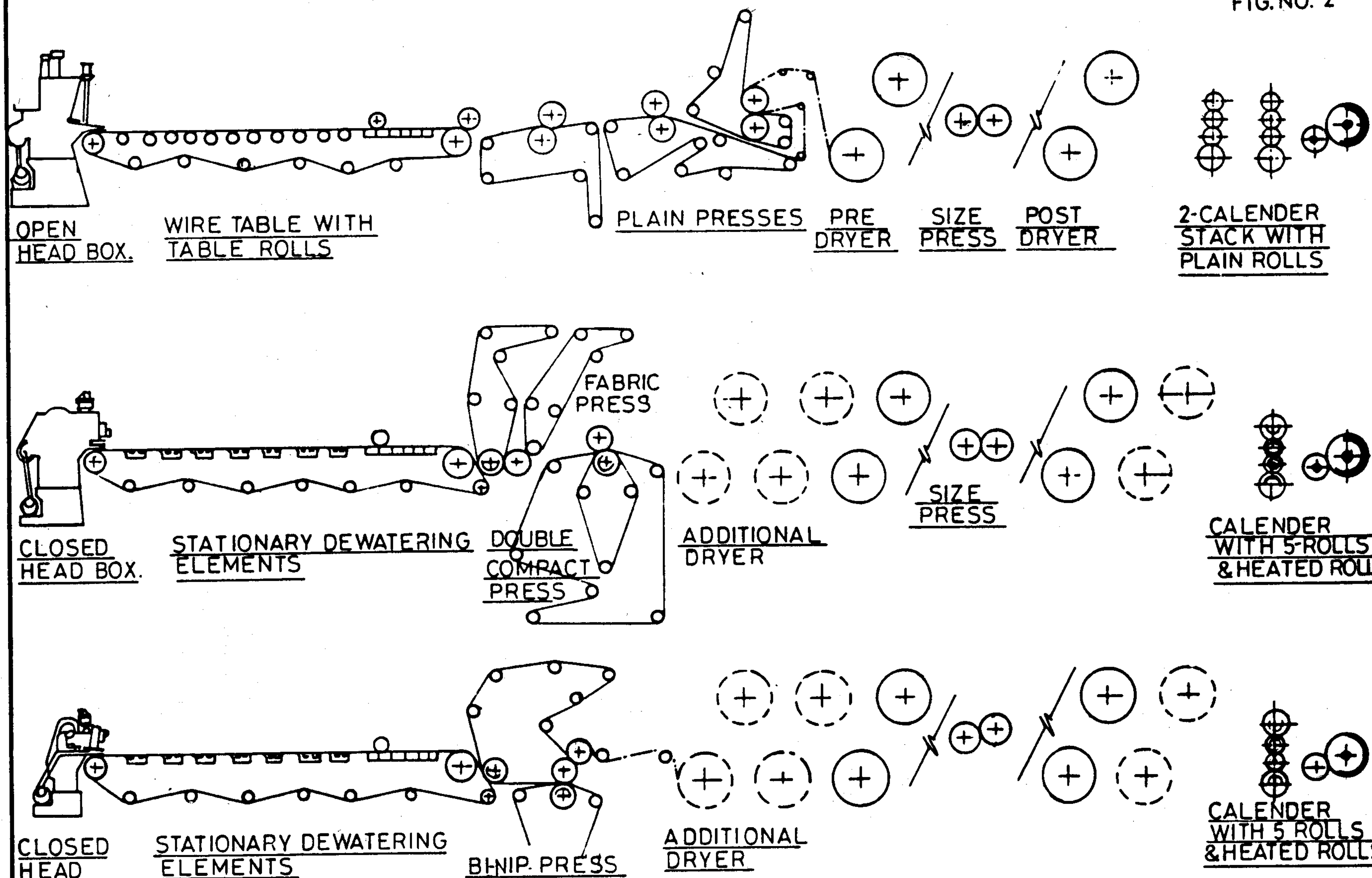


FIG. NO. 1
VOITH TYPE HEAD BOXES
OPEN HEAD BOX
For all paper and board grades as well as for pulp dewatering operating speed 15-200 m/min
CLOSED HEAD BOX
For all paper and board grades operating speed 50-450 m/min
CLOSED HEAD BOX
For all paper and board grades preferably for the creation of high M.D.tensile strength operating speed 50-1000 m/min.
HIGH TURBULENCE HEAD BOX
For all paper and board grades operating speed 100-1500 m/min
NEUE BRUDERHAUS
KOMBIFLOW HEADBOX
With holey rolls and integrated air cushion suitable for wide range of application of furnish & paper grades
BELOIT CONVER FLO TYPE HEAD BOX
With out holey rolls with microturbulence uniform sheet profile operating speed 100 to 1000 m/min
BERTRAMS SCIENNES VACUUM/PRESSURE
TYPE FLOW BOX.
Vacuum pressure type flow box for all paper & board grades operating speed 50 to 400 m/min

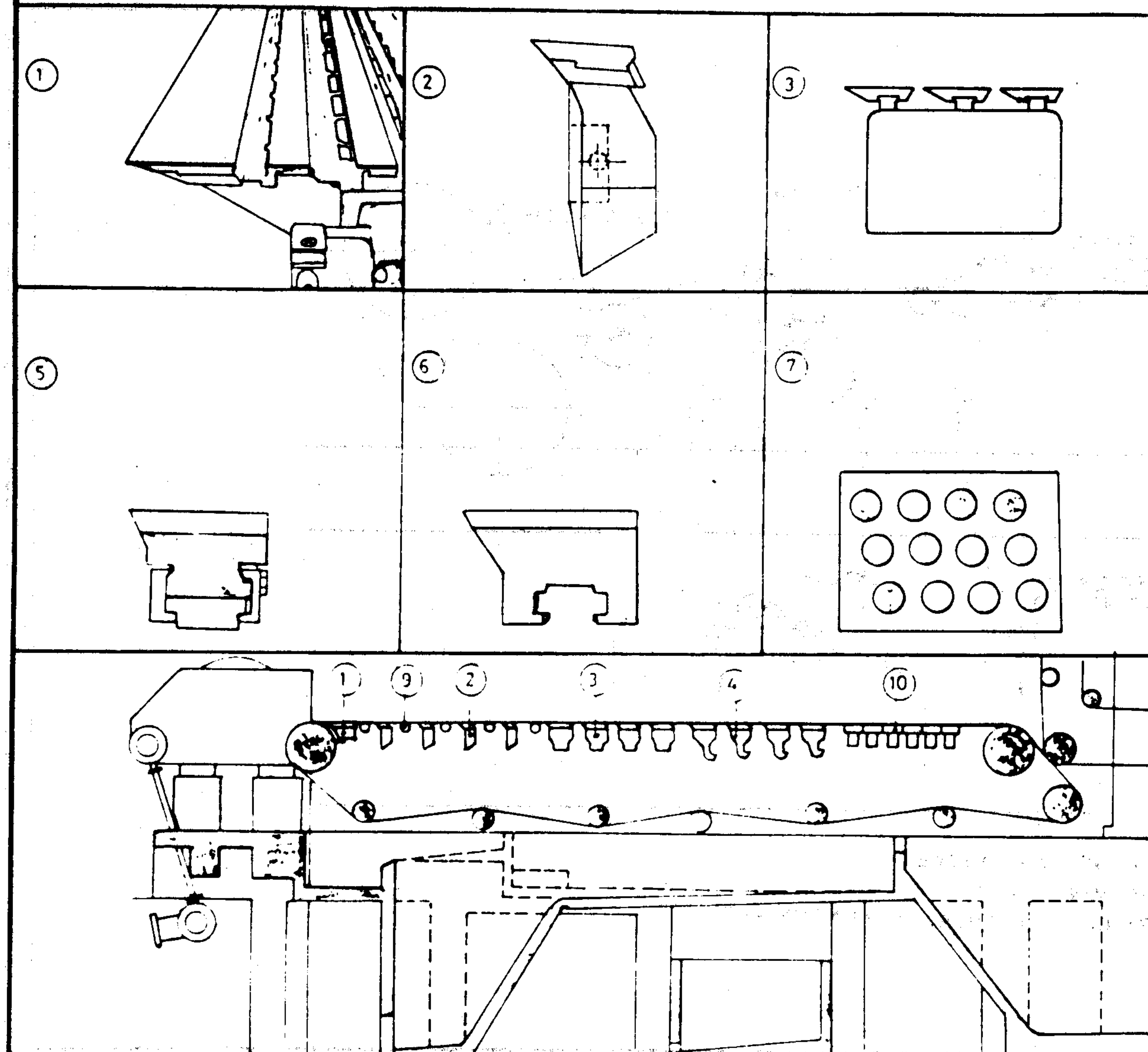
FIG. NO. 2



PAPER MACHINE CONFIGURATIONS

DEWATERING ELEMENTS

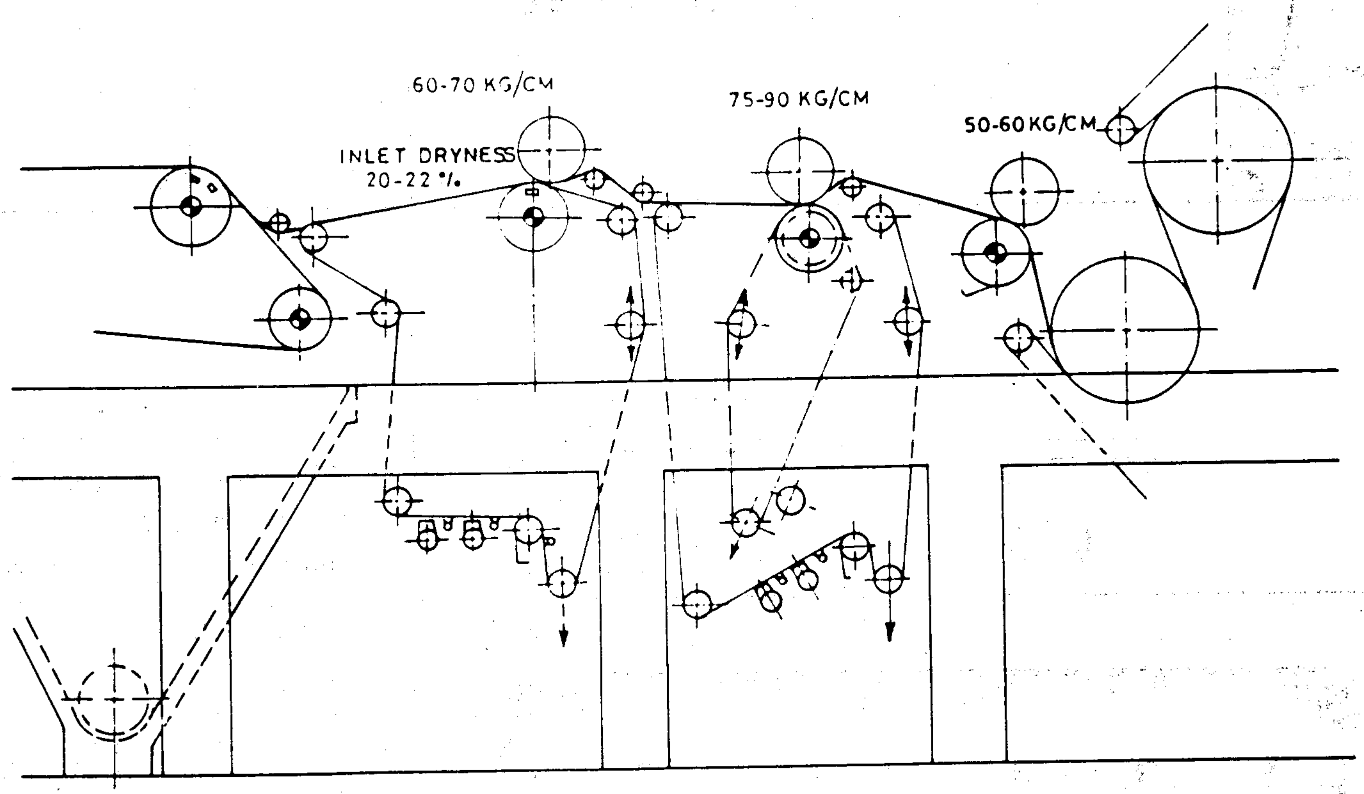
FIG. NO. 3



1 FORMING BOARD.
2 SINGLE FOIL.
3 FOIL BOX.
4 WET SUCTION BOX.
5 SINGLE FOIL WITH CLAMPING DESIGN.
6 " " " SLIDING DESIGN.
7 FLAT SUCTION BOX TOP-HOLE PATTERN
8 FLAT SUCTION BOX TOP-SLOT PATTERN.
9 TABLE ROLL.
10 FLAT SUCTION BOX.

FIG. NO. 4

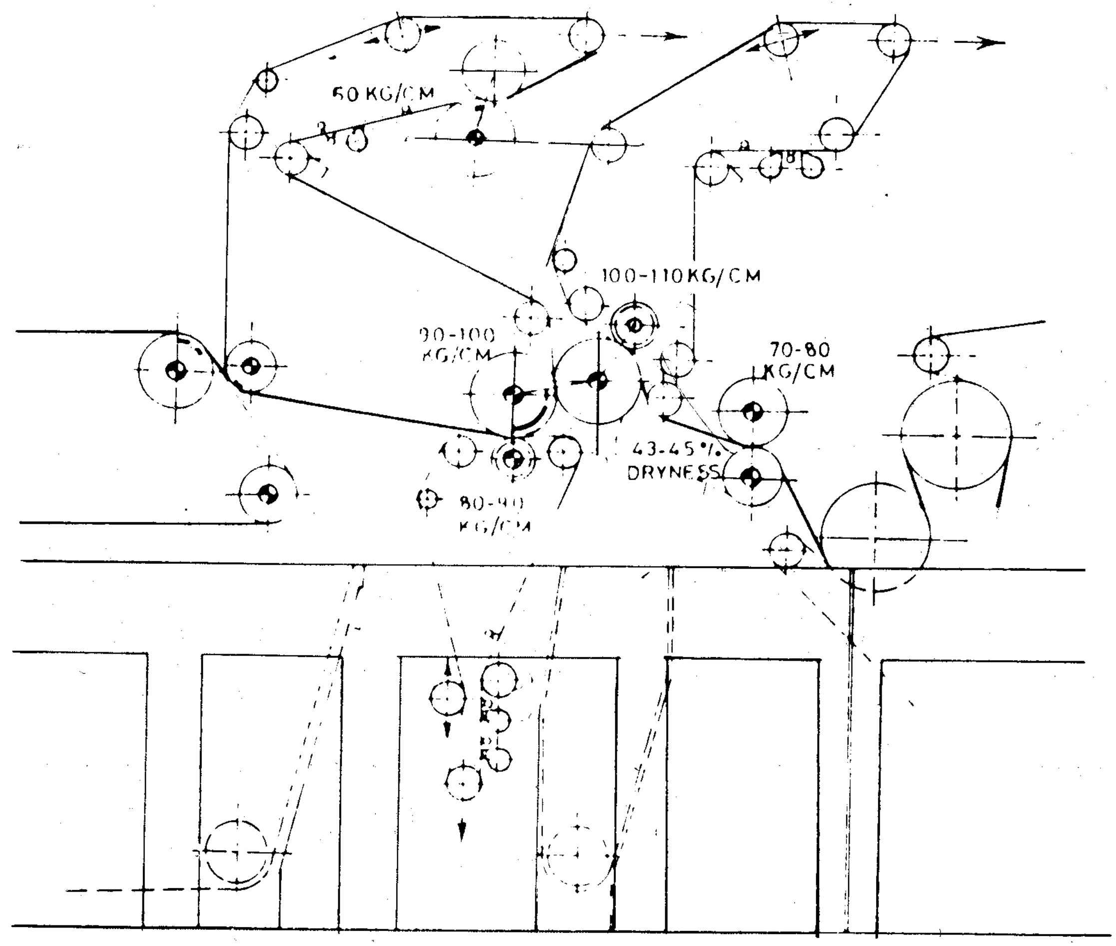
STRAIGHT THROUGH PRESS



BASIS WEIGHT RANGE 50 GSM AND ABOVE
MACHINE SPEED 300 M/MIN (MAX)
MINIMUM FRAME WORK, EASY TO OPERATE, MAINTAIN AND CLOTHE.

FIG. NO. 5

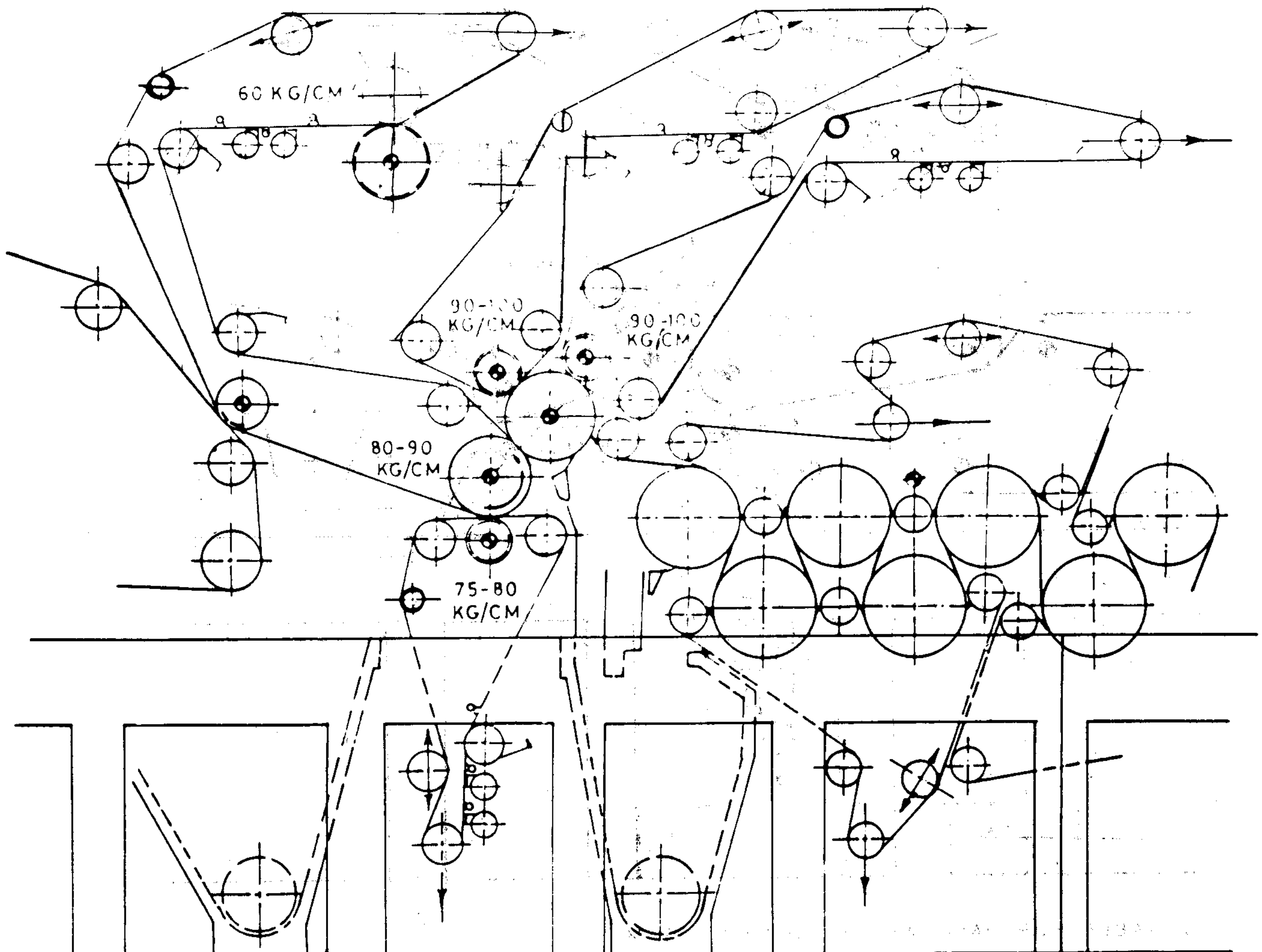
TRI NIP PRESS



SUITABLE EOR BASIS WEIGHT UPTO 150 GSM
DOUBLE FELTING FOR EVEN INK ABSORPTION
SUITABLE FOR SLOW PULPS

FIG. NO. 6

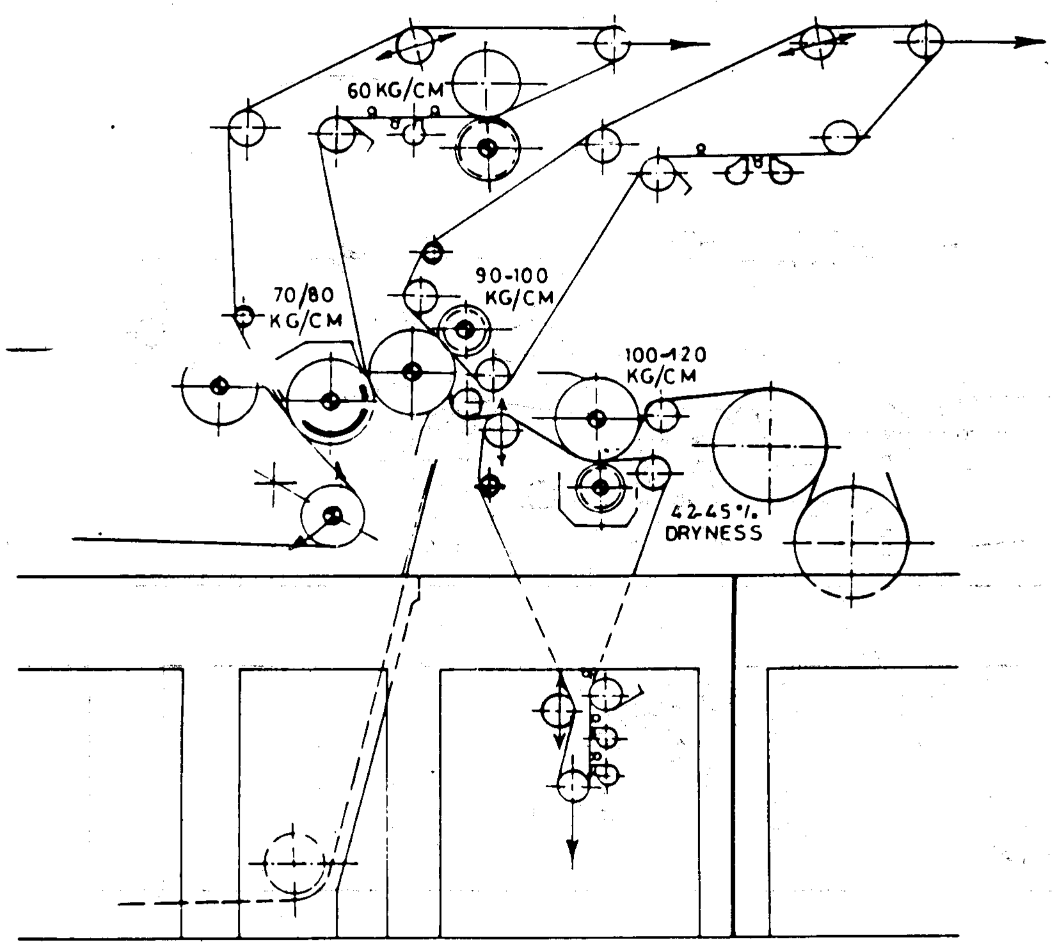
FOUR NIP PRESS



SUITABLE: HIGH SPEED M/CS.
FOR PRINTING GRADE EXCELLENT RUNNABILITY GIVING TROUBLE FREE OPERATIONS

FIG. NO. 7

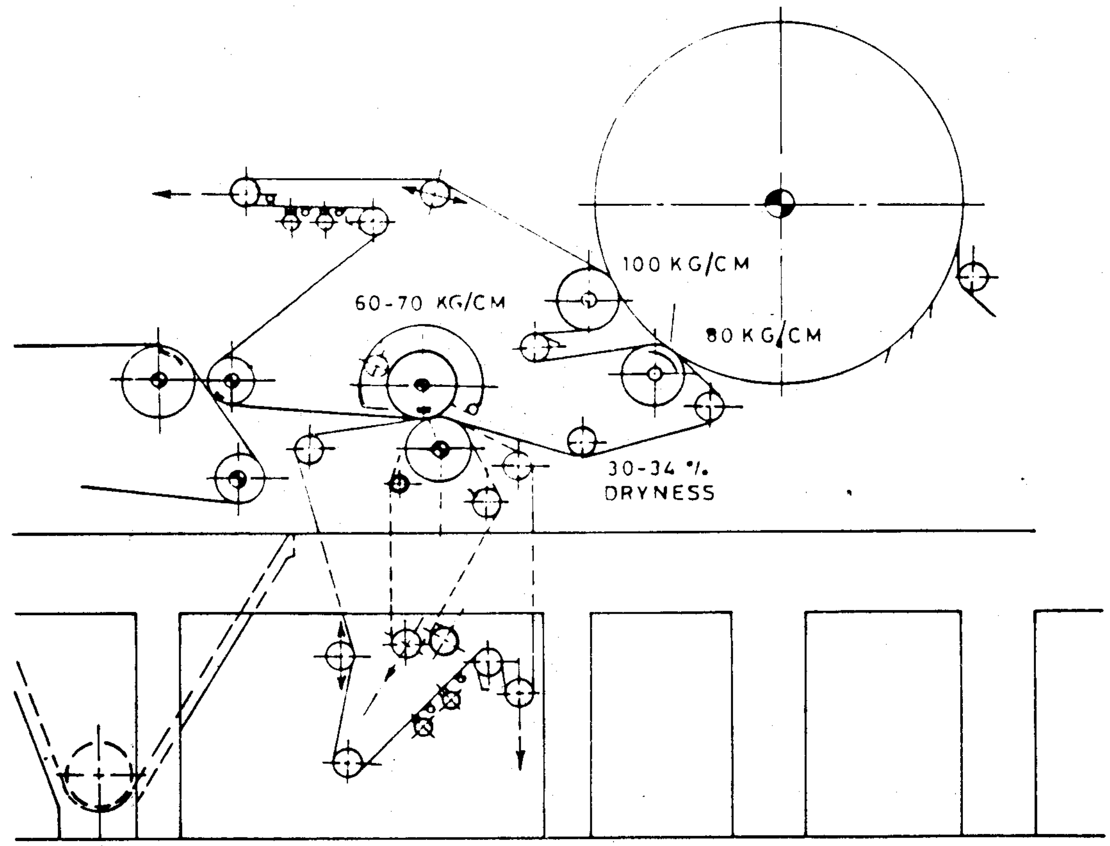
DOUBLE COMPACT PRESS



SUITABLE FOR MACHINE REBUILDS DUE TO COMPACTNESS
BASIC WEIGHT 200 GSM, OR EVEN HIGHER FOR BOARD
2nd PRESS WITH GROOVED/BLIND HOLE ROLL, LOW TWO SIDEDNESS, NO SHADOW MARKING.

FIG. NO. 8

YANKEE PRESS

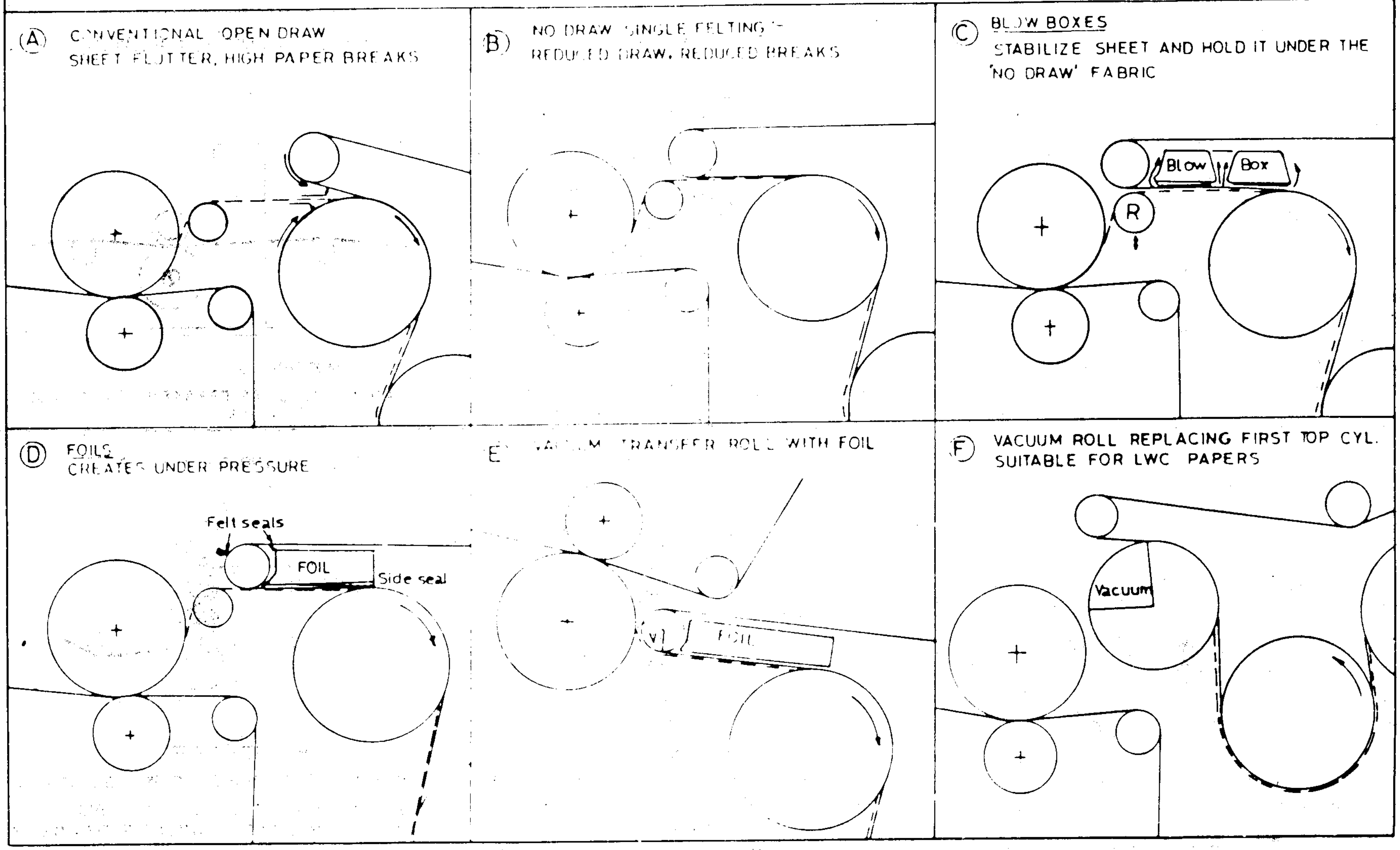


SUITABLE FOR 16-40 GSM MG-GRADES OF PAPER

SPEED LIMIT 700-800 M/MIN

PRESS TO DRYERS PAPER TRANSFER

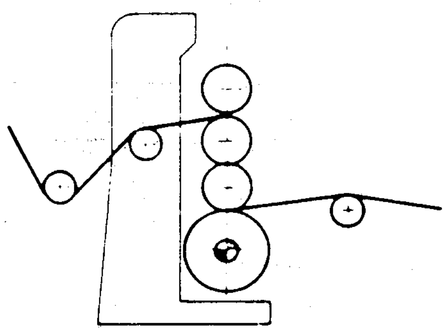
FIG. NO. 9



CALENDER CONFIGURATIONS

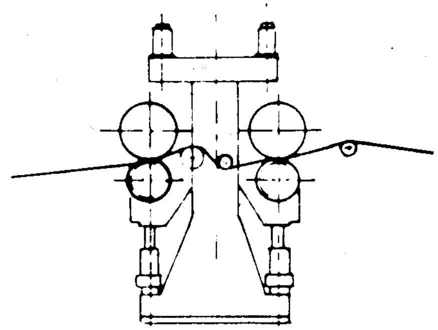
FIG. NO. 10

4-ROLL CALENDERS WITH PLAIN ROLLS



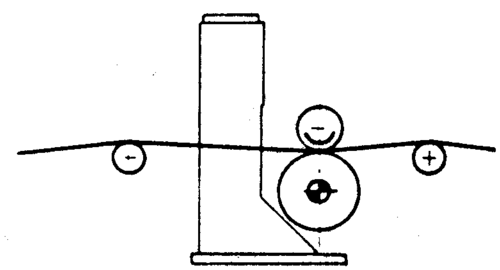
LIMITATION ON MAX. APPLICABLE
NIP PR. = 50-60 KG./CM.

KUSTERS MAT-ON-LINE



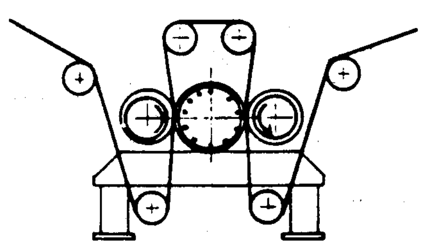
MATTE VELVETY EFFECTS PRODUCED 'ON M/C'
WITHOUT SECONDARY OPERATIONS, ON COATED
PAPERS MAX NIP PR 100 KG./CM

2-ROLL CALENDERS, TOP S. ROLL



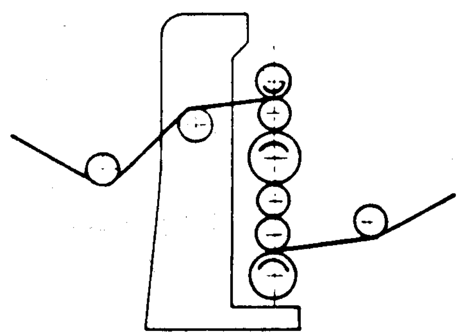
LOW SMOOTHNESS
CAN BE USED AS BREAKER STACK ALSO.
NIP PR. = 100 KG./CM.

GLOSS CALENDERS FOR PAPER & BOARD



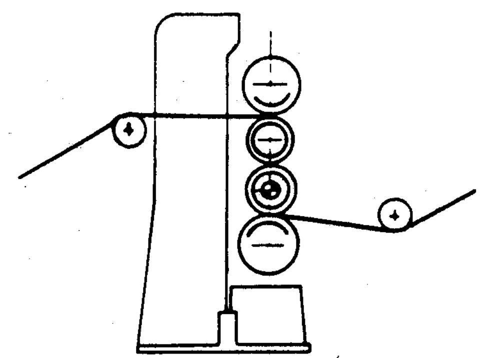
HIGHER BULK, UNIFORM SURFACE GLOSS &
IMPROVED PRINTABILITY, NIP PR 150 KG/CM

6-ROLL CALENDERS WITH S-ROLLS



TOP S-ROLLS CAN BE IN DIFFERENT POSITIONS
WITH NIP PR180KG/CM FOR PAPER GRADES,
WHICH ARE SENSITIVE & DIFFICULT TO SMOOTH

4-ROLL CALENDERS WITH S. ROLLS



WITH HEATED INTERMEDIATE ROLLS, WITH 120
KG/CM NIP PRESSURE FOR HIGHER BULK,
BETTER SMOOTHNESS, GREATER FLEXIBILITY