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(72) Feltaláló(k):

ALBRECHT, Melvin J., Homeworth, OH 44634 (US)

(73) Jogosult(ak):

**The Babcock & Wilcox Company, Barberton,
OH 44203-0351 (US)**

(74) Képviselő:

**Danubia Szabadalmi és Jogi Iroda Kft.,
Budapest**

(54)

Kúpos gőz/víz ciklon szeparátor

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(22) Date of filing: **23.05.2008**

(54) **Steam/water conical cyclone separator**

Konischer Dampf-/Wasserzyklon-Abscheider

Séparateur de vapeur/eau conique à cyclone

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
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(73) Proprietor: **The Babcock & Wilcox Company**

Barberton, OH 44203-0351 (US)

(72) Inventor: **Albrecht, Melvin J.**

Homeworth, OH 44634 (US)

(74) Representative: **D Young & Co LLP**

120 Holborn

London EC1N 2DY (GB)

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Description

Field and Background of the Invention

[0001] The present invention relates in general to cyclone separators for separating steam from water, in the steam drum of a boiler.

[0002] U.S. Pat. No. 2,271,634 to Fletcher discloses a cylindrical cyclone separator having a circular whirl chamber, a tangential inlet, a central steam outlet located at the top of the circular whirl chamber, and a water outlet located at the bottom of the whirl chamber. To prevent water from being discharged through the steam outlet, means are provided for increasing the downward component of the incoming stream of steam and water mixture. This means is a segmented plate having downwardly and rearwardly inclined edges that causes the incoming steam and water mixture to be deflected downwardly towards the water outlet of the separator.

[0003] U.S. Pat. No. 2,293,740 to Kooistra discloses a similarly designed cyclone separator that does not utilize the segmented plate but rather employs a bottom cup at the bottom of the whirl chamber which confines the steam to the upper portion of the whirl chamber and prevents it from passing down into the separated water as it discharges from the whirl chamber, into the drum.

[0004] U.S. Pat. No. 2,298,285 to Fletcher discloses another variation of the cylindrical cyclone separator this time employing a rim or cap on top of the cyclone separator steam outlet together with the segmented plate. The rim acts to enhance separation of water and reduction of pressure drop in the separator.

[0005] U.S. Pat. No. 2,321,628 to Rowand et al. discloses a cyclone separator which is closer in configuration to the present standard shown in FIG. 1 of the present application. The circulator whirl chamber in this reference is the frustum of a cone at the upper portion and substantially cylindrical at the lower portion where the water is discharged. Again, a tangential inlet is employed to deliver the steam water mixture into the cyclone separator, and is of a vertical extent substantially equal to that of the tapered portion of the whirl chamber. The tapered configuration acts to direct the entering steam water mixture into a slightly downward direction to prevent upward spread of the deflected water and enhance separation of the steam therefrom.

[0006] U.S. Pat. No. 2,346,672 to Fletcher discloses a substantially cylindrical cyclone separator this time having instead of a tangential inlet a large steam/water inlet which extends over a large fraction of the perimeter of the cyclone separator. As indicated in the reference, the inlet can extend to approximately 1/3 of the perimeter of the cyclone separator to provide adequate flow capacities. One object is to produce a separator or densifier which operates effectively with low pressure drop so that it can be advantageously used where only a small pressure head is available.

[0007] U.S. Pat. No. 2,395,855 to Fletcher discloses a

substantially cylindrical cyclone separator having a tangential inlet and where the steam outlet center is located eccentric of the whirl chamber center to effect enhanced separation of steam from the water. This design also employs the segmented plate seen in the previously described patents.

[0008] U.S. Pat. No. 2,402,154 to Fletcher and the aforementioned U.S. Pat. No. 2,395,855 are both divisionals of the same application. The 2,395,855 patent is drawn to the particular type of fluid separator itself; while the 2,402,154 patent is drawn to the combination of this device in a steam generator.

[0009] U.S. Pat. No. 2,434,637 to Brister, U.S. Pat. No. 2,434,663 to Letvin and U.S. Pat. No. 2,434,677 to Stillman are all drawn to various aspects of the perforated cone used at the top of the cyclone separator to enhance separation of the steam from the water.

[0010] U.S. Pat. No. 2,532,332 to Rowand is drawn to the particular construction of the separators which today are generally considered as secondary scrubbers.

[0011] U.S. Pat. No. 2,732,028 to Coulter is also drawn to a cyclone separator device very similar to that employed at this time. The cyclone separator has the aforementioned frustoconical upper section and generally cylindrical lower section with a tangential steam water inlet located on the side of the frustoconical section. The overall emphasis of this reference is drawn to means of simplifying the construction for accessibility and repair of the elements located in the steam drum. This is accomplished by dividing the steam space in the drum into separate compartments, one or more of which are open to the water space of the drum into the necessary drum safety valves while one or more of the other compartments are open to the steam and water separators of the drum the saturated steam outlets. Partitions are used to accomplish this division and they are effective in maintaining the separation of the drum components during normal operation but are easily broken when the safety valves are opened.

[0012] U.S. Pat. No. 2,891,632 to Coulter is drawn to a cyclone steam separator quite similar to that disclosed in the earlier mentioned Fletcher patent (U.S. Pat. No. 2,346,672) with the exception that instead of the steam water inlet being located only approximately along 1/3 of the circumference of the separator, this cyclone separator has the entire circumference provided with an array of vanes that "slice" the incoming steam water mixture into thin sheets to enhance separation of the steam from the water.

[0013] U.S. Pat. No. 5,033,915 to Albrecht is also drawn to a cyclone steam separator. The cyclone separator is a modified version of the standard conical cyclone separator that provides a lower pressure drop than the standard conical cyclone for an equivalent number of or an equivalent steam capacity of the separators. The major modification of this separator is that the cyclone separator's tangential inlet has been lengthened by 3 inches. This increase in length increases the cyclone inlet flow

area by 28%.

[0014] FIG. 1 is a side sectional view of a conventional cyclone separator which is in current use by the assignee of the present application.

[0015] The conventional cyclone separator is generally designated 4 and comprises a conical portion 8 to which a vertically elongated tangentially connected steam/water inlet 6 is connected. The inlet 6 corresponds in axial length to the axial length of the conical portion 8.

[0016] Cyclone separator 4 includes an upper cylindrical steam outlet 10 which, in use, is surrounded by a cap with a perforated cover (not shown).

[0017] A lower cylindrical water outlet 12, having a water outlet ring 14, is connected to the bottom of conical portion 8 for discharging water which has been separated from the steam/water mixture.

[0018] The conventional cyclone separator of FIG. 1 could be improved by decreasing its pressure drop without adversely affecting the capacity of the separator.

[0019] FIG. 2 is a side sectional view of a cyclone separator 20 described in U.S. Pat. No. 5,033,915. The cyclone separator 20 includes a tangential inlet 26 which extends into the lower cylindrical portion 22 of the cyclone separator 20. Steam that passes through the cyclone separator 20 is discharged through the upper cylindrical steam outlet 30. A lower cylindrical portion 22 having a ring shaped water outlet 24, is connected to the bottom of conical portion 21 for discharging water which has been separated from the steam/water mixture. The width of the inlet 26 of the cyclone separator 20 is defined by tangential outer wall 28 and the inner edge 32 of an inner wall 34.

Summary of the Invention

[0020] Particular aspects and embodiments are set out in the appended independent and dependent claims

[0021] The present invention seeks to improve the cyclone separator of FIG. 1 by decreasing its pressure drop without adversely affecting its capacity. The present invention also seeks to provide an evaluate performance of the cyclone separator of FIG. 2 and 3 while allowing the device to be installed in smaller diameter steam drums.

[0022] The present invention provides a modified conical cyclone separator for applications that require a lower pressure drop than the standard conical cyclone would give, for an equivalent number of or an equivalent steam capacity of the separators. The new conical cyclone gives increased capacity for both steam and water, lower pressure drop and is unaffected by water level fluctuations. This new type of low pressure drop conical cyclone separator is a modified version of the standard conical cyclone separator and a shorter length design of the low pressure conical cyclone separator given in FIGS. 2 and 3. A major difference between this separator and the standard conical cyclone separator is that the new cyclone separator's tangential inlet has been widened by

11 mm (7/16 inches). This increase in length increases the cyclone inlet flow area by 28%.

[0023] The widening of the tangential inlet extends the horizontal inlet configuration into the conical portion of the cyclone separator while maintaining the same length as the standard conical cyclone. This differs from the low pressure drop cyclone separator given in FIGS. 2 and 3. The low pressure drop cyclone had a lengthened tangential inlet and a resulting longer overall length. The present invention will provide a conical cyclone separator that will have the same overall length as the standard conical cyclone separator and an equivalent flow area of the low pressure drop conical cyclone separator. Thus, the overall space envelope the cyclone separator of the present invention occupied in the steam drum is kept substantially the same as a standard conical cyclone.

[0024] In the conventional cyclone separator of FIG. 1, the axial length of the conical portion of the separator, and also the coextensive axial length of the inlet, amounts to approximately $\frac{1}{2}$ to total height of the separator. In accordance with the present invention, the axial length of the inlet will remain the same but the horizontal length of the inlet will increase by approximately 11 mm (7/16 inch) which amounts to approximately 28% increase in the flow area of the inlet opening and an increase of the total width of the separator inlet of approximately 16%.

[0025] This modification has been found to substantially decrease the pressure drop of the separator when compared to the standard separator without adversely affecting the capacity of the separator. The modification has also been shown to be approximately as effective as the low pressure drop cyclone separator in FIGS. 2 and 3 in achieving decreased pressure drop without adversely affecting the capacity of the separator. A major benefit of this invention is the ability to incorporate a lower pressure drop cyclone separator into steam drum which cannot accept the longer length of the low pressure drop cyclone separator given in FIGS. 2 and 3.

[0026] The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific benefits attained by its uses, reference is made to the accompanying drawings and descriptive matter in which a preferred embodiment of the invention is illustrated.

Brief Description of the Drawings

[0027] In the drawings:

FIG. 1 is a vertical sectional view of a conventional conical cyclone separator;

FIG. 2 is a low pressure drop cyclone separator described in U.S. Pat. No. 5,033,915;

FIG. 3 is a horizontal sectional view of the separator

shown in FIG. 2;

FIG. 4 is a vertical sectional view of a cyclone separator of the present invention;

FIG. 5 is a horizontal sectional view of the separator shown in Fig. 4;

FIG. 6A is a graph showing moisture carryover versus steam flow for the conventional cyclone separator and the low pressure drop separator described in U.S. Pat. No. 5,033,915;

FIGS. 6B is a graph showing moisture carryover versus steam flow for the conventional cyclone separator and the regular length low pressure drop cyclone separator of the present invention;

FIG. 7A is a graph showing conical cyclone pressure drop versus steam flow for the conventional cyclone separator and the low pressure drop conical cyclone separator described in U.S. Pat. No. 5,033,915;

FIG. 7B is a graph showing conical cyclone pressure drop versus steam flow for the conventional cyclone separator and the regular length low pressure drop cyclone separator of the present invention;

FIG. 8 is a graph showing moisture carryover versus steam flow for the conventional cyclone separator and the regular length low pressure drop cyclone separator;

FIG. 9A is a tangential inlet of a cyclone separator of the present invention; and

FIG. 9B is a connector box for connecting the tangential inlet shown in FIG. 9A to, e.g., a saturated steam line.

Description of the Preferred Embodiment

[0028] Referring to the drawings in particular, wherein like reference numerals designate the same or functionally similar elements throughout the several drawings, and to FIGS. 4 and 5 in particular, the invention embodied in FIGS. 4 and 5 comprises a conical cyclone separator generally designated 40 which is mounted within a steam drum (not shown). Preferably, the cyclone separator 40 is adapted for mounting inside a steam drum that has an inside diameter of less than 60 inches.

[0029] The purpose of a cyclone separator is to improve the efficiency of separation between steam and water in a steam/water mixture, by swirling the mixture at high velocity around the interior of the separator. The greater mass of the water causes it to move to the outside of the swirling stream leaving a concentration of steam which is discharged through the upper cylindrical outlet

50. From outlet 50, the steam is further separated and treated by conventional scrubbers and other equipment (not shown).

[0030] The water which has been removed from the mixture is discharged through a lower cylindrical portion 42 and a ring shaped water outlet 44 at the bottom of the separator 40. The separator 40 includes a main conical portion 41.

[0031] An axially elongated tangentially connected steam/water inlet 46 is connected to the separator. As best shown in FIG. 5, the tangential opening between the inlet 46 and the interior of separator 40, amounts to approximately 1/3 of the circumference of the separator 40. As with the separators illustrated in FIGS. 1, 2 and 3, the separator 40 of FIGS. 4 and 5 has a maximum inside diameter of approximately 292mm (11.5 inches), with the inlet 46 having a width, in the upper horizontal section, of 68mm (2 11/16 inches) between a tangential outer wall 48 and the inner edge 52 of an inner wall 54. Also see Fig. 9A. According to the present invention, the width to height ratio for the inlet 46 is thus approximately 1:4. In the conventional separator of FIG. 1, this ratio is approximately 1:5 and for the low pressure drop separator of FIGS. 2 and 3, this ratio is approximately 1:6.5

[0032] In an embodiment, an axial length of the inlet 46 is about 1/2 of the axial length of the housing or cyclone separator 40.

[0033] Extensive tests have been conducted to compare the performance of the new conical cyclone separator 40 of FIGS. 4 and 5, from the performance of the conventional separator of FIG. 1 and the low pressure drop separator of FIGS. 2 and 3.

[0034] In FIGS. 6 - 8, the performance of the low pressure drop cyclone separator 40 of the present invention is compared to the standard cyclone separator and the taller low pressure drop separator shown in FIGS. 2 and 3. As shown in FIG. 6, the steam flow capacity for the separators is the same. In FIG. 6, depending upon flow and pressure conditions, the reduction in pressure drop can range between 25% to 40%.

[0035] Based upon the data shown in FIGS. 6 - 8, performance of the new low pressure conical cyclone separator 40 has been formulated as follows: (1) steam capacity is the same as the standard 292mm (11.5 inch) ID conical cyclone separator, and (2) the pressure drop is 30% less than the standard 292mm (11.5 inch) ID conical cyclone separator.

[0036] According to the present invention, thus a relatively simple modification yields substantially improved results in an unexpected manner.

Claims

1. A cyclone separator (40) for separating steam from water in a steam/water mixture, comprising:

a separator housing having a conical portion

- (41) with an axial length, an upper edge and a lower edge, an upper cylindrical steam outlet portion (50) connected to the upper edge of the conical portion (41) and having a central opening for discharging steam from the housing; 5
a lower cylindrical water outlet portion (42) having a bottom water outlet ring (44) for discharging water from the housing; and
an axially elongated steam/water mixture inlet (46) connected tangentially to the housing, the inlet (46) having a width to height ratio of approximately 1:4, an axial 10
length amounting to approximately 50% of the axial length of the housing, the inlet (46) includes an outer tangential wall (48) and an inner wall (54) having an inner edge (52), the inlet (46) having an upper width between the outer wall (48) and the inner edge (52) of approximately 68mm (2 11/16 inches), and wherein the inlet (46) extends the full axial length of the conical portion (41). 15
2. The cyclone separator (40) of claim 1, wherein the housing has a maximum inside diameter of 292mm (11.5 inches). 20 25
3. The cyclone separator (40) of claim 1, wherein the inlet (46) has a lower width greater than the upper width and where the inlet (46) ends at the lower cylindrical portion (42). 30

Patentansprüche

1. Zyklonabscheider (40) zum Trennen von Dampf von Wasser in einem Dampf-/Wasser-Gemisch, umfassend: 35
- ein Abscheidergehäuse, aufweisend einen konischen Teil (41), mit einer axialen Länge, einem oberen Rand und einem unteren Rand, einen oberen zylindrischen Dampfauslassteil (50), der mit dem oberen Rand des konischen Teils (41) verbunden ist und eine mittlere Öffnung zum Abführen von Dampf aus dem Gehäuse aufweist; 40
einen unteren zylindrischen Wasserauslassteil (42), der einen unteren Wasserauslassring (44) zum Abführen von Wasser aus dem Gehäuse aufweist; und 45
einen axial langgestreckten Dampf-/Wasser-Gemischeinlass (46), der tangential mit dem Gehäuse verbunden ist, wobei der Einlass (46) ein Breiten-zu-Höhen-Verhältnis von ca. 1:4, eine sich auf ca. 50% der axialen Länge des Gehäuses belaufende Länge aufweist, wobei der Einlass (46) eine tangentielle Außenwand (48) und eine Innenwand (54) mit einem Innenrand (52) enthält, wobei der Einlass (46) eine obere 50

Breite zwischen der Außenwand (48) und dem Innenrand (52) von ca. 68 mm (2 11/16 Zoll) aufweist, und wobei sich der Einlass (46) über die volle axiale Länge des konischen Teils (41) erstreckt.

2. Zyklonabscheider (40) nach Anspruch 1, wobei das Gehäuse einen maximalen Innendurchmesser von 292 mm (11,5 Zoll) hat.
3. Zyklonabscheider (40) nach Anspruch 1, wobei der Einlass (46) eine untere Breite aufweist, die größer ist als die obere Breite, und wobei der Einlass (46) an dem unteren zylindrischen Teil (42) endet.

Revendications

1. Séparateur à cyclone (40) servant à effectuer une séparation entre de la vapeur et de l'eau dans un mélange vapeur/eau, comprenant :

un logement de séparateur comportant une partie conique (41) présentant une longueur axiale, un bord supérieur et un bord inférieur, une partie de sortie de vapeur supérieure cylindrique (50), raccordée au bord supérieur de la partie conique (41) et comportant une ouverture centrale servant au rejet de la vapeur à partir du logement ; une partie de sortie d'eau inférieure cylindrique (42) comportant un anneau de sortie d'eau inférieur (44) servant au rejet de l'eau à partir du logement ; et
une entrée de mélange vapeur/eau (46) axialement allongée, raccordée de manière tangente au logement, l'entrée (46) présentant un rapport de la largeur à la hauteur d'approximativement 1:4, une longueur axiale correspondant à approximativement 50 % de la longueur axiale du logement, l'entrée (46) comprenant une paroi extérieure tangente (48) et une paroi intérieure (54) comportant un bord intérieur (52), l'entrée (46) présentant une largeur supérieure entre la paroi extérieure (48) et le bord intérieur (52) d'approximativement 68 mm (2 11/16 pouces) et l'entrée (46) s'étendant sur la totalité de la longueur axiale de la partie conique (41).

2. Séparateur à cyclone (40) selon la revendication 1, dans lequel le logement présente un diamètre intérieur maximal de 292 mm (11,5 pouces).
3. Séparateur à cyclone (40) selon la revendication 1, dans lequel l'entrée (46) présente une largeur inférieure plus grande que la largeur supérieure et dans lequel l'entrée (46) se termine au niveau de la partie inférieure cylindrique (42).

FIG. 1

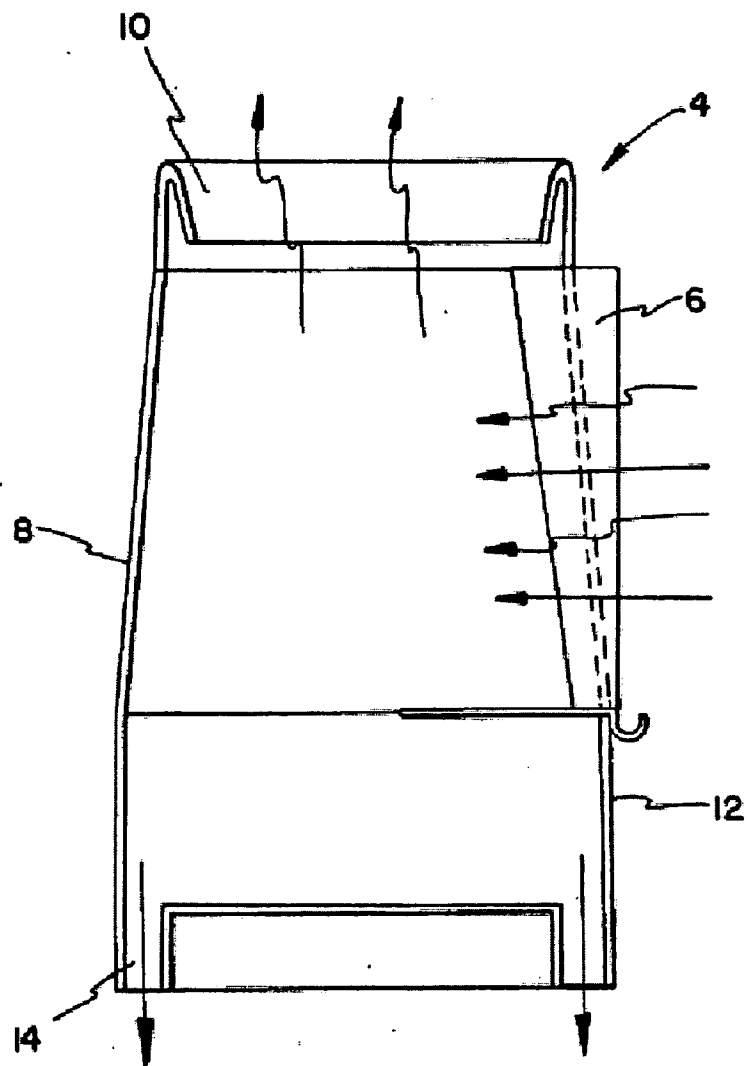


FIG. 2

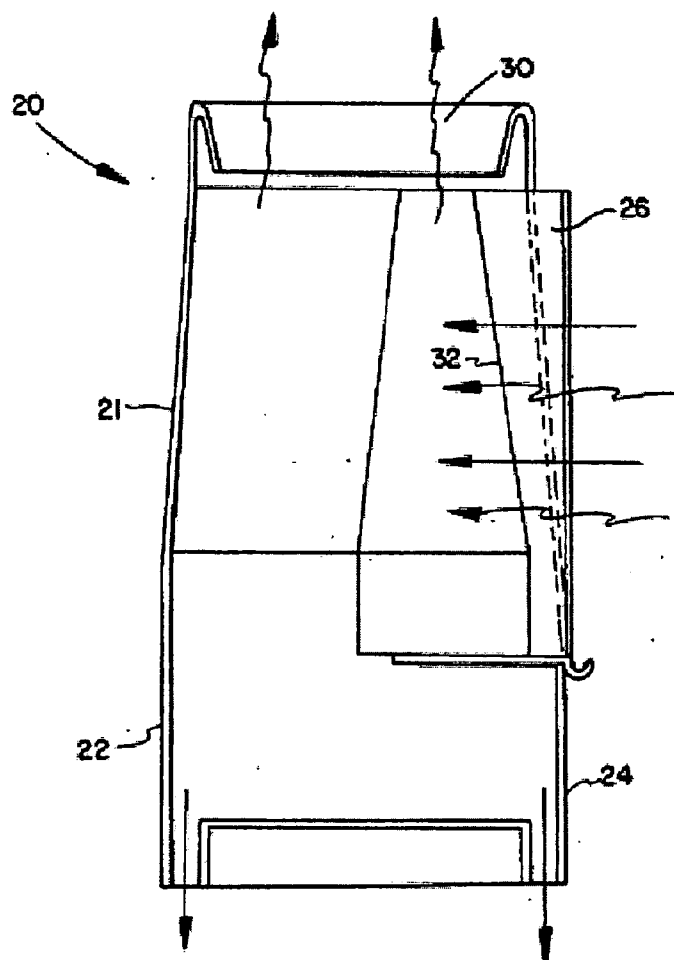


FIG. 3

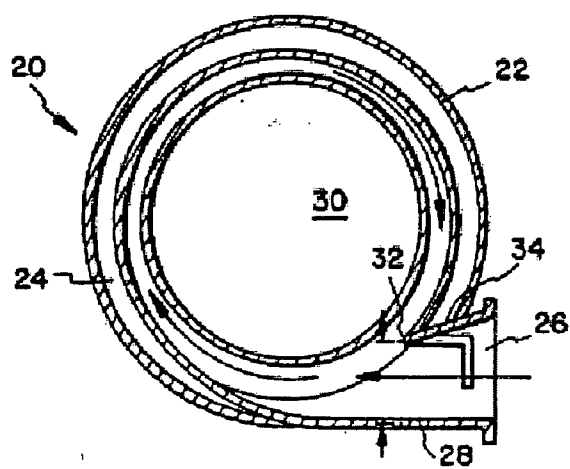


FIG. 4

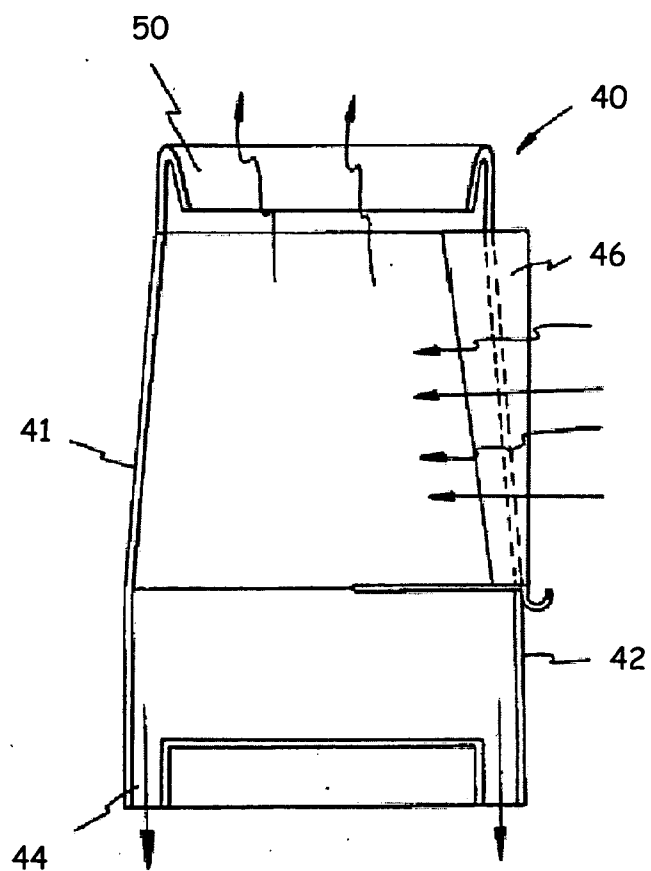


FIG. 5

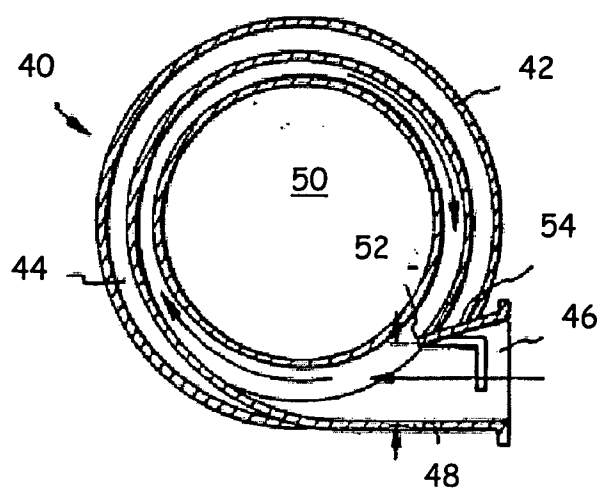


FIG. 6A

POWER SERIES TEST

20kg/s (160,000 LB/HR) WATER FLOW
0mm (INCH) WATER LEVEL

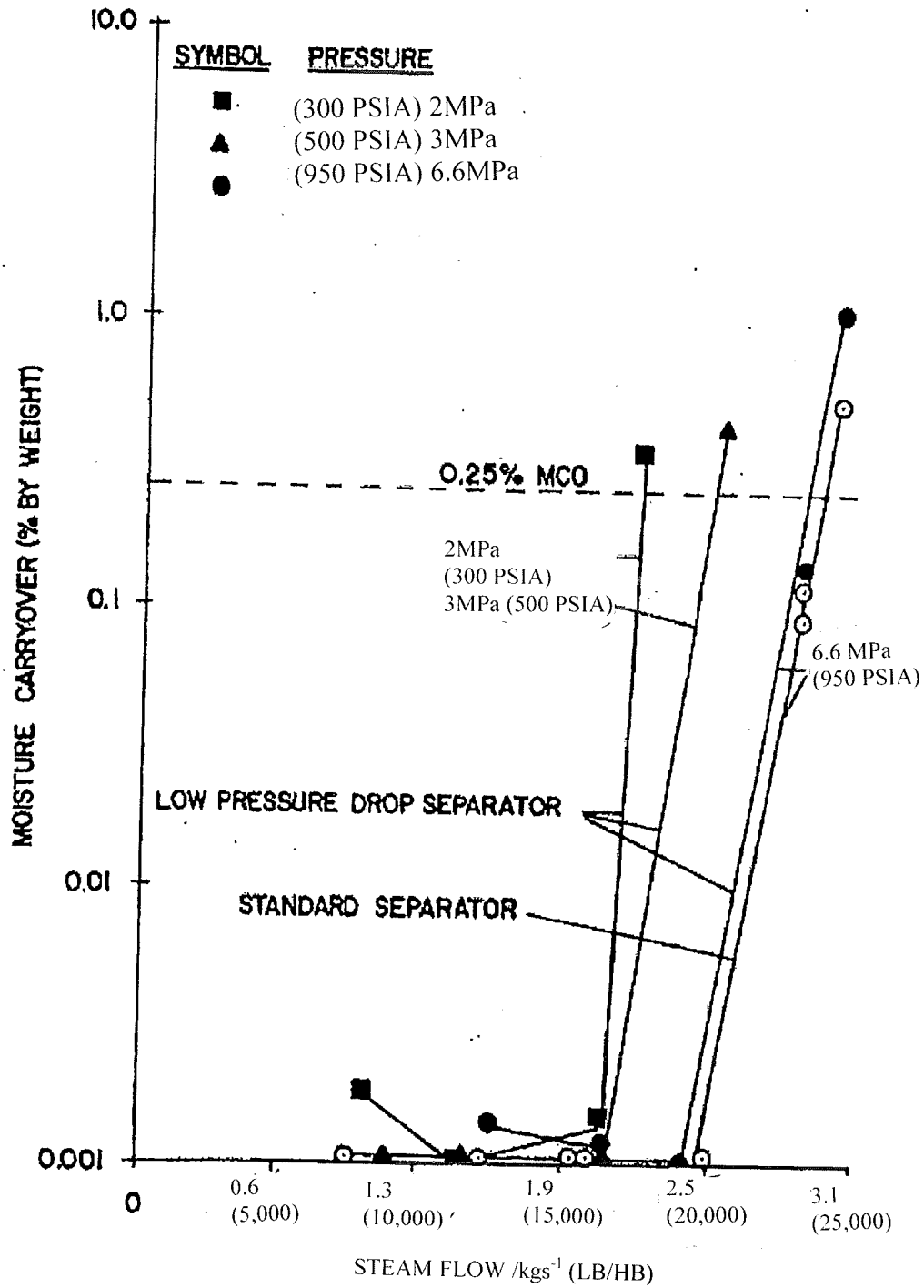


FIG. 6B

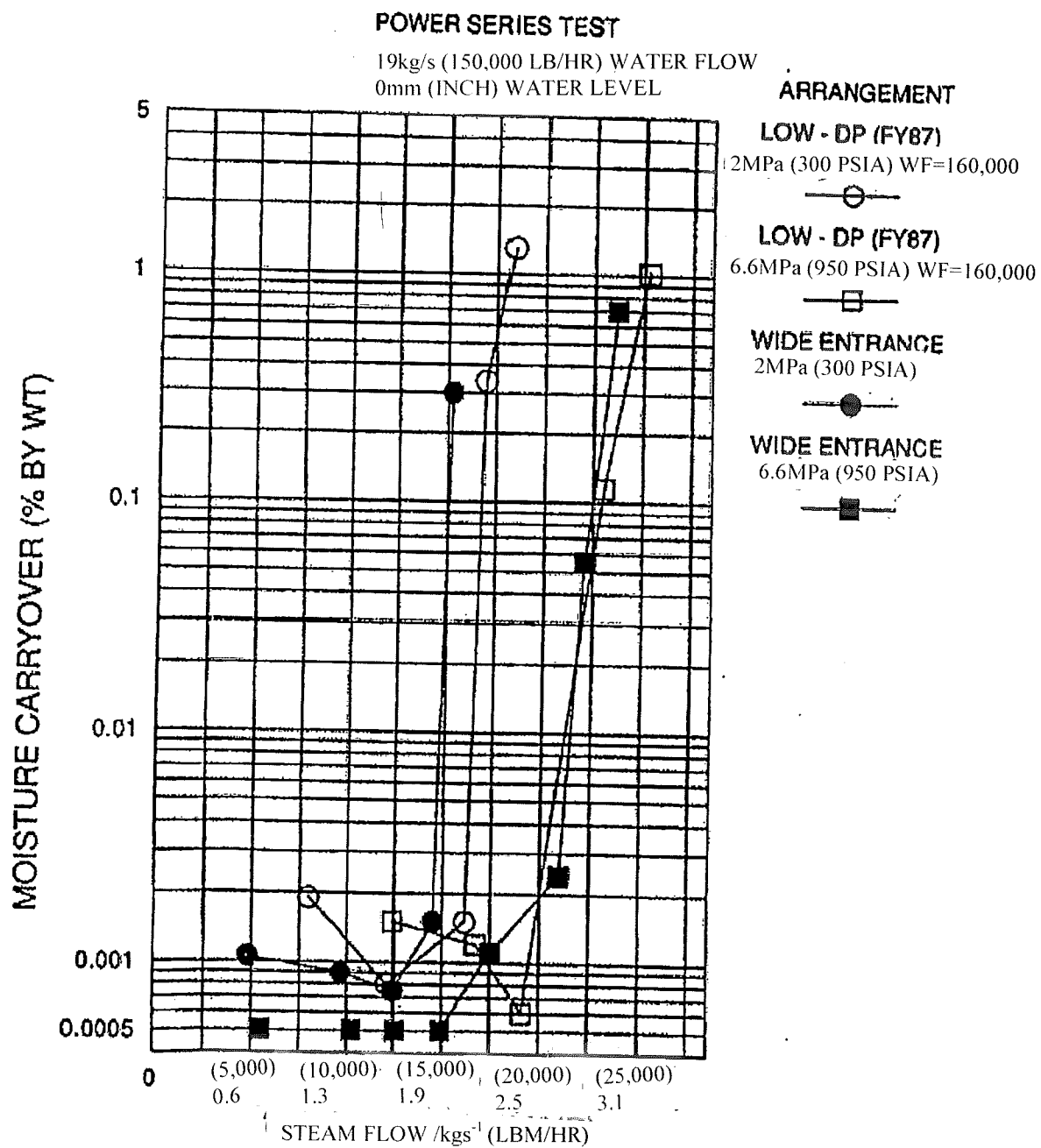


FIG. 7A

POWER SERIES TEST

20kg/s (160,000 LB/HR) WATER FLOW

0mm (INCH) WATER LEVEL

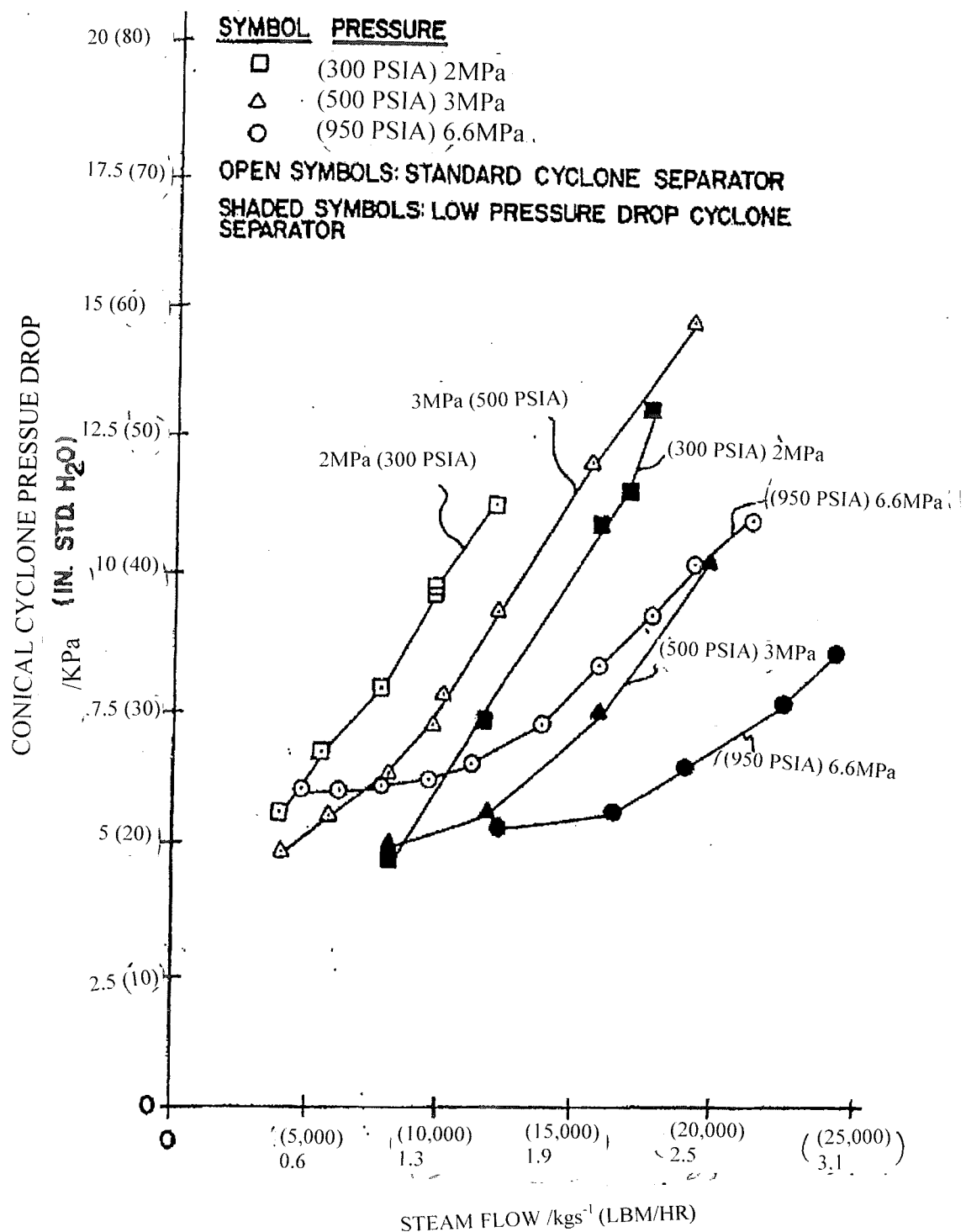


FIG. 7B

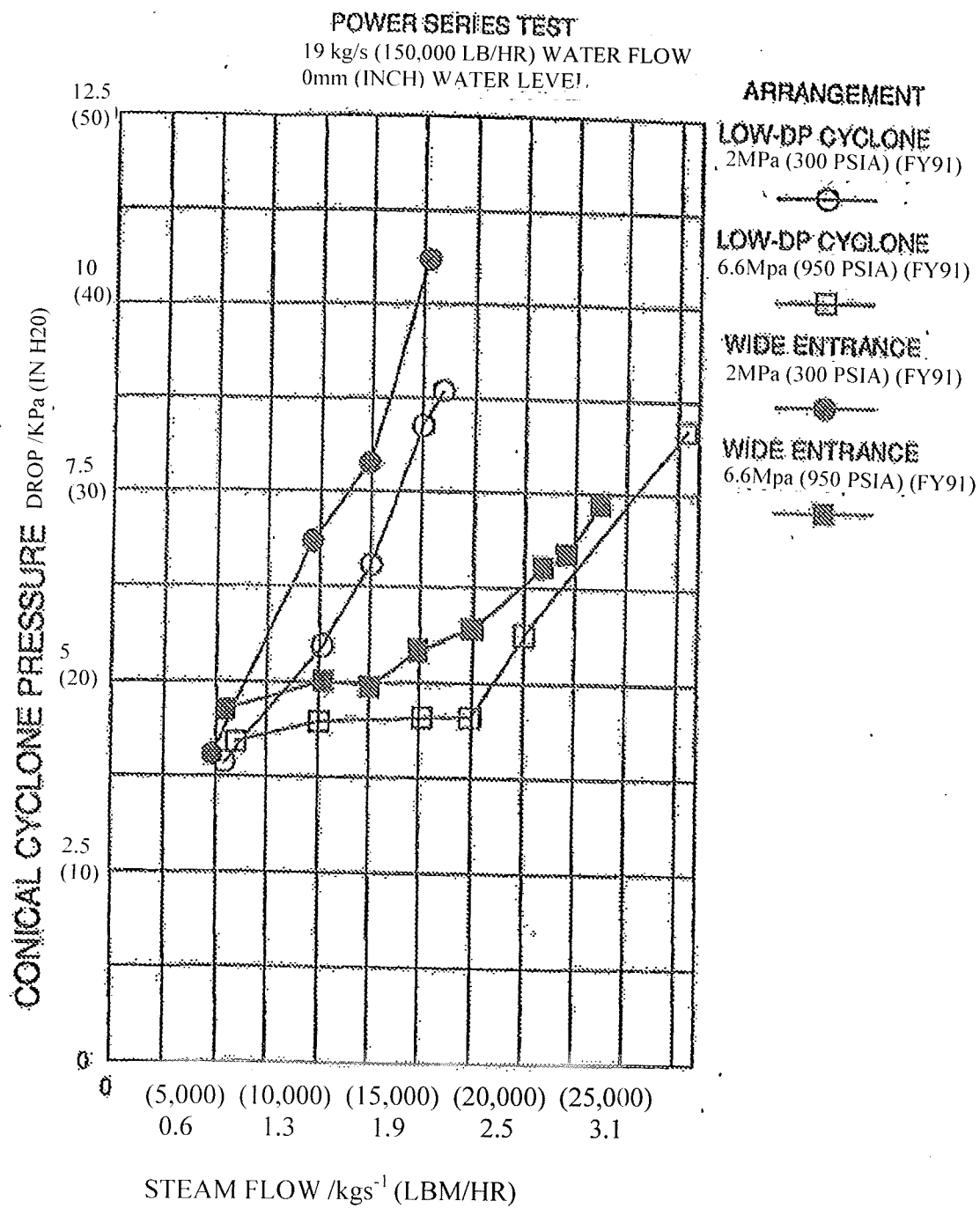


FIG. 8

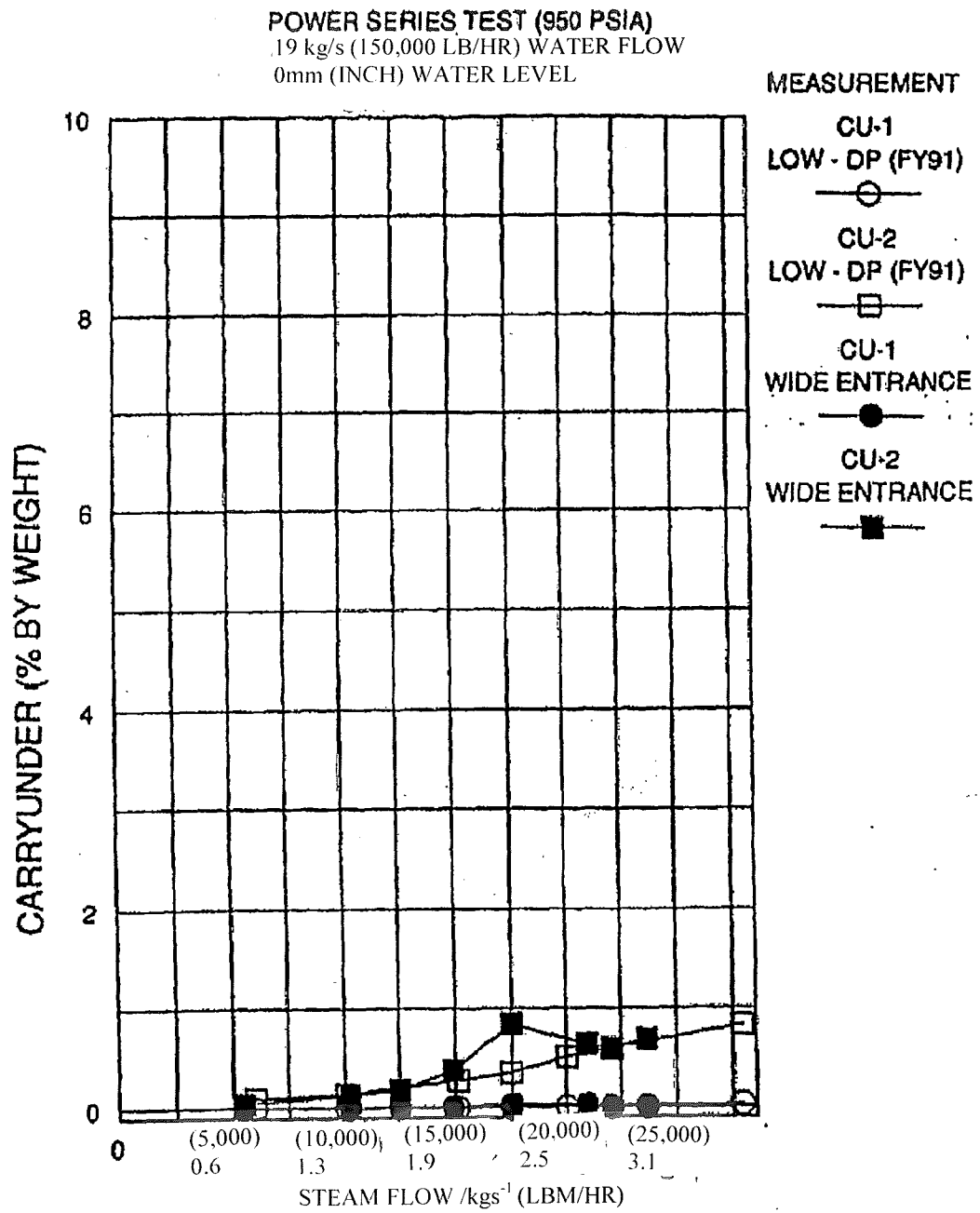
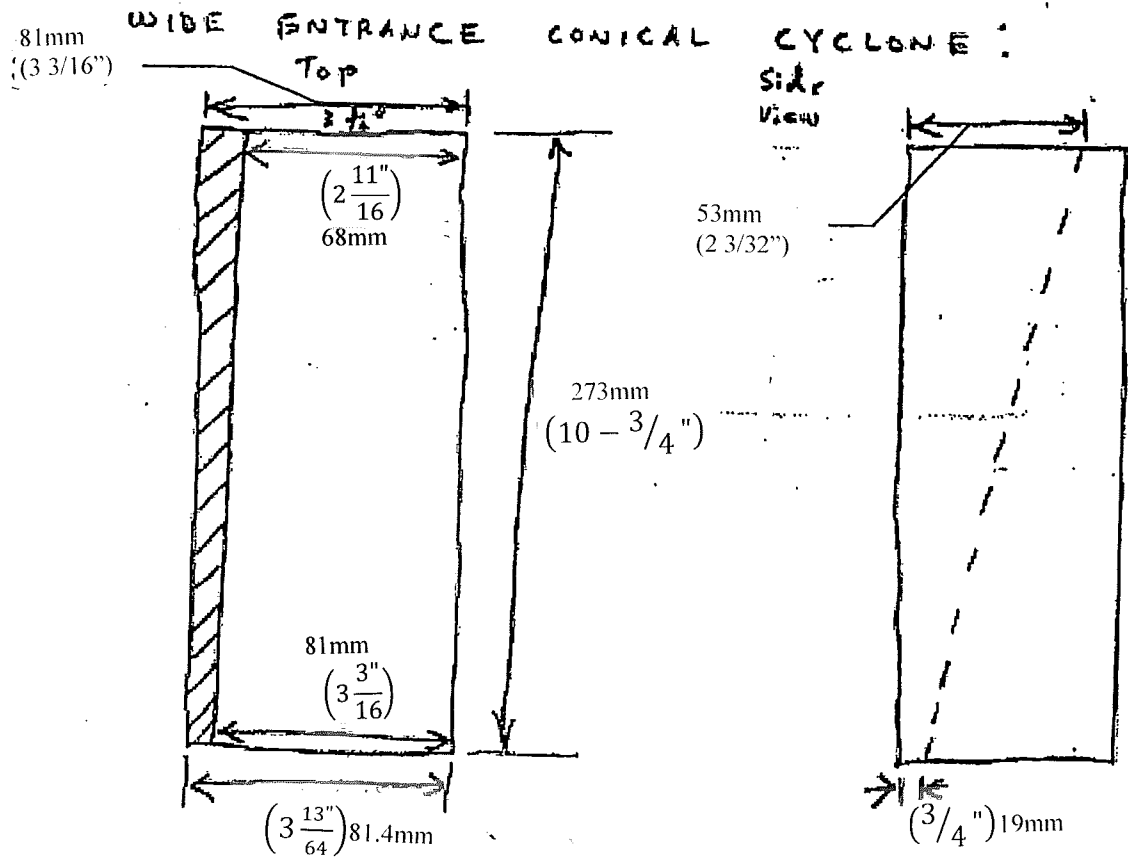


FIG. 9A

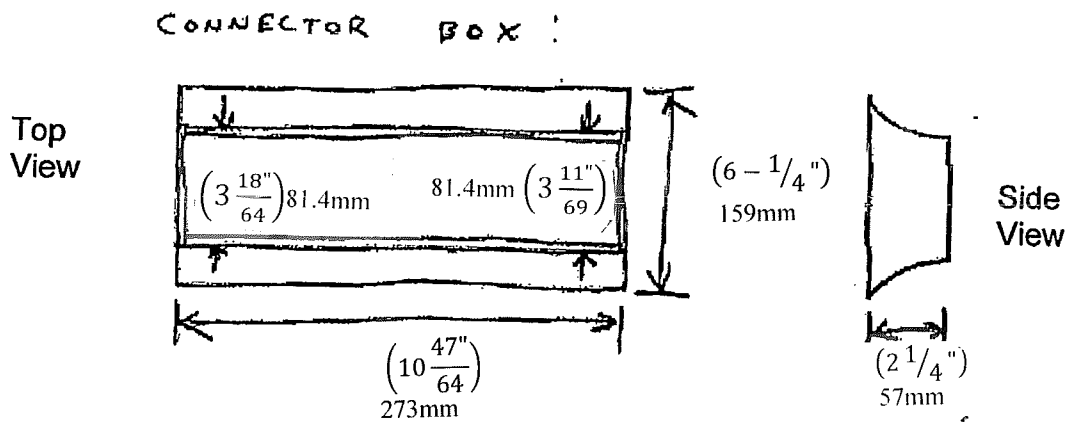


A
$$\left(= \frac{1}{2} \left(2 \frac{11}{16} + 3 \frac{3}{16} \right) \left(10 \frac{3}{8} \right) \right) = 0.02 \text{m}^2$$

$$= 31.6 \text{ in}^2$$

$$= 0.2193 \text{ ft}^2$$

FIG. 9B



REFERENCES CITED IN THE DESCRIPTION

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KÚPOS GŐZ/VÍZ CIKLON SZEPARÁTOR

Szabadalmi igénypontok

5 1. Ciklon szeparátor (40) gőz/víz keverékben gőz víztől való elválasztására, amely tartalmaz szeparátorházat, melynek axiális hosszal rendelkező kúpos része (41), felső széle és alsó széle, egy a kúpos rész (41) felső széléhez csatlakoztatott és gőz házból történő ürítésére központi nyílással rendelkező felső hengeres gőzkivezető része (50) van;

víz házból történő ürítésére alsó vízkivezető gyűrűvel (44) rendelkező alsó hengeres vízkivezető részt (42); továbbá

10 egy a házhoz érintőlegesen csatlakoztatott, axiálisan elnyúlt gőz/víz keverék beömlést (46), a beömlés (46) szélesség:magasság aránya mintegy 1:4, a beömlés (46) a ház axiális hosszának mintegy 50%-ával megegyező axiális hosszal rendelkezik, a beömlés (46) külső érintőleges falat (48) és belső széllal (52) rendelkező belső falat (54) foglal magában, a beömlésnek (46) a külső fal (48) és a belső szél (52) közötti felső szélessége mintegy 68 mm (2 11/16 hüvelyk), továbbá ahol a beömlés (46) a kúpos rész (41) teljes axiális hosszában terjed.

15 2. Az 1. igénypont szerinti ciklon szeparátor (40), ahol a ház maximális belső átmérője 292 mm (11,5 hüvelyk).

3. Az 1. igényponti szerinti ciklon szeparátor, ahol beömlés (46) a felső szélességnél nagyobb alsó szélességgel rendelkezik, továbbá ahol a beömlés (46) az alsó hengeres résznél (42) végződik.

