CLAIMS

1. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one array of annular passages having a radial width different than a radial width of a second array of annular passages.

2. The flow conditioner of claim 1 wherein the plate has at least one subdividing ligament having a width different than a width of a second subdividing ligament.

3. The conditioner of claim 1 whereby the central circular channel is subdivided into 2 or more separate passages.

4. The conditioner of claim 1 whereby the subdivision into segmented annular passages is achieved by means of ligaments aligned along a radius of the circular geometry of the conditioner.

5. The conditioner of claim 1 whereby the subdivision into segmented annular passages is achieved with ligaments that are aligned at an angle relative to a radius of the circular geometry of the conditioner.

6. The conditioner of claim 1 whereby the sides of each subdividing ligament are straight and parallel.

7. The conditioner of claim 1 whereby the sides of each subdividing ligament are curved.

8. The conditioner of claim 1 whereby the sides of each subdividing ligament are non-parallel.

9. The conditioner of claim 1 whereby the internal corners of the segmented annular passages are rounded.

10. The conditioner of claim 1 whereby the upstream edges of the passages are chamfered or rounded.

11. The conditioner of claim 1 whereby the downstream edges of the passages are chamfered or rounded.

12. The conditioner of claim 1 whereby all passages have a substantially equal hydraulic diameter.

13. The conditioner of claim 1 whereby the ratio of the length of the passages to their hydraulic diameter is greater than 1.

14. The conditioner of claim 1 whereby the ligaments that subdivide the annular passages get progressively thicker at distances that are further from the center of the pipe, in order to obtain an approximation of a fully-developed flow profile.

15. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one subdividing ligament having a width different than a width of a second subdividing ligament.

16. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one array of annular passages having a radial width different than a radial width of a second array of annular passages and at least one subdividing ligament having a width different than a width of a second subdividing ligament.

17. A method of producing an optimized geometry of flow conditioner for a circular pipe having an axis comprising the steps of:

a. storing a desired value for a pressure loss coefficient of the conditioner in non-transitory memory;

b. storing a shape of velocity profile desired in the memory;

c. Setting manufacturing goals;

d. storing a number of annular rings to be used in the conditioner to subdivide the pipe cross-section in the memory ;

e. storing a number of subdivisions for each annular ring and for a central circular passage area of the conditioner in the memory;

f. setting a width of each annular ring to an initial value in the memory;

g. setting a width of circular ligaments of the conditioner to an initial value in the memory;

h. setting a width of subdividing ligaments of the conditioner to an initial value in the memory;

i. calculating a hydraulic diameter of each of the passages of the conditioner with a computer from information stored in the memory in steps a-g, the computer in communication with the memory;

j. setting a thickness of the conditioner plate to a value based on a desired ratio of passage length to hydraulic diameter in the memory;

k. determining resistance and flow characteristics of the conditioner geometry with the computer based on steps a-g and i; and

l. adjusting the geometry iteratively with the computer until the goals are achieved.

18. The method of claim 17 including the step of setting a pressure loss coefficient of less than 2 in the memory.

19. The method of claim 17 including the step of entering into the memory a target flow profile based on fully developed flow conditions.

20. The method of claim 17 including the step of entering into the memory a flat velocity profile.

CLAIMS

1. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one array of annular passages having a same radial width different than a same radial width of a second array of annular passages, the subdividing ligaments get progressively thicker at distances further from the pipe's axis.

2. The flow conditioner of claim 1 wherein the plate has at least one subdividing ligament having a width different than a width of a second subdividing ligament.

3. The conditioner of claim 1 whereby the central circular channel is subdivided into 2 or more separate passages.

4. The conditioner of claim 1 whereby the subdivision into segmented annular passages is achieved by means of ligaments aligned along a radius of the circular geometry of the conditioner.

5. The conditioner of claim 1 whereby the subdivision into segmented annular passages is achieved with ligaments that are aligned at an angle relative to a radius of the circular geometry of the conditioner.

6. The conditioner of claim 1 whereby the sides of each subdividing ligament are straight and parallel.

7. The conditioner of claim 1 whereby the sides of each subdividing ligament are curved.

8. The conditioner of claim 1 whereby the sides of each subdividing ligament are non-parallel.

9. The conditioner of claim 1 whereby the segmented annular passages have internal corners and the internal corners of the segmented annular passages are rounded.

10. The conditioner of claim 1 whereby the upstream edges of the passages are chamfered or rounded.

11. The conditioner of claim 1 whereby the downstream edges of the passages are chamfered or rounded.

12. The conditioner of claim 1 whereby all passages have a substantially equal hydraulic diameter.

13. The conditioner of claim 1 whereby the ratio of the length of the passages to their hydraulic diameter is greater than 1.

14. The conditioner of claim 1 whereby the ligaments that subdivide the annular passages get progressively thicker at distances that are further from the center of the pipe, in order to obtain an approximation of a fully-developed flow profile.

15. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one subdividing ligament having a width different than a width of a second subdividing ligament, the sides of each subdividing ligament are straight and parallel.

16. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one array of annular passages

having a radial width different than a radial width of a second array of annular passages and at least one subdividing ligament having a width different than a width of a second subdividing ligament, the sides of each subdividing ligament are straight and parallel.

17. A method of producing an optimized geometry of flow conditioner for a circular pipe having an axis comprising the steps of:

a. storing a desired value for a pressure loss coefficient of the conditioner in non-transitory memory;

b. storing a shape of velocity profile desired in the memory;

c. Setting manufacturing goals;

d. storing a number of annular rings to be used in the conditioner to subdivide the pipe cross-section in the memory;

e. storing a number of subdivisions for each annular ring and for a central circular passage area of the conditioner in the memory;

f. setting a width of each annular ring to an initial value in the memory;

g. setting a width of circular ligaments of the conditioner to an initial value in the memory;

h. setting a width of subdividing ligaments of the conditioner to an initial value in the memory;

i. calculating a hydraulic diameter of each of the passages of the conditioner with a computer from information stored in the memory in steps a-g, the computer in communication with the memory;

j. setting a thickness of the conditioner plate to a value based on a desired ratio of passage length to hydraulic diameter in the memory;

k. determining resistance and flow characteristics of the conditioner geometry with the computer based on steps a-g and i; and

l. adjusting the geometry iteratively with the computer until the goals are achieved.

18. The method of claim 17 including the step of setting a pressure loss coefficient of less than 2 in the memory.

19. The method of claim 17 including the step of entering into the memory a target flow profile based on fully developed flow conditions.

20. The method of claim 17 including the step of entering into the memory a flat velocity profile.

21. A flow conditioner for a circular pipe having an axis comprising: a plate having a face to be disposed in the circular pipe with the face of the plate perpendicular to the axis of the pipe, said plate having a central circular passage area through which fluid flows surrounded by two or more concentric arrays of segmented annular passages for fluid flow defined by separating and subdividing ligaments, with at least one array of annular passages having a radial width different than a radial width of a second array of annular passages, the sides of each subdividing ligament are straight and parallel.