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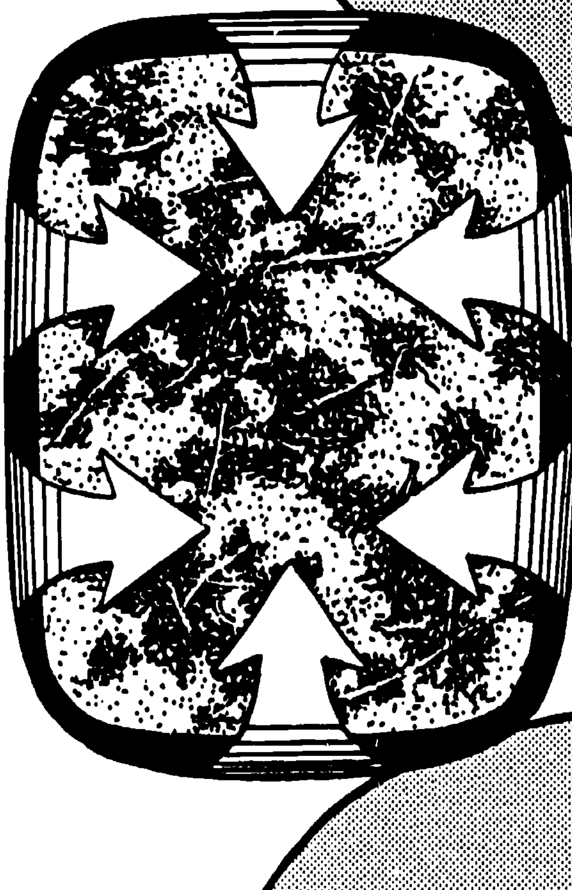
ABSTRACT

This two-lesson unit on rotating biological contactors (RBC's) is designed to be used with students who have had some experience in wastewater treatment and a basic understanding of biological treatment. The first lesson provides information on the concepts and components of RBC treatment systems. The second lesson focuses on design operation and maintenance. The teaching guide includes: (1) an overview of the unit; (2) lesson plans; (3) lecture outlines; (4) overhead transparency masters for use with the second lessor· (5) student worksheets (with answers); and (6) two copies of a fi quiz (with and without answers). The lecture outline for the first lesson includes reference to a set of slides developed for use with the lesson. Instructors are encouraged to add their own slides or to change the order of slides to fit their own teaching styles. (JN)

Biological Treatment Process Control

Rotating Biological Contactors (RBC's)



Instructor's Guide

Linn-Benton Community College
Albany, Oregon 1984

BIOLOGICAL TREATMENT PROCESS CONTROL

ROTATING BIOLOGICAL CONTACTORS (RBCs)

INSTRUCTOR'S GUIDE

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1984

ROTATING BIOLOGICAL CONTACTORS
(RBC's)

Instructor's Guide

ROTATING BIOLOGICAL CONTACTORS

Overview of Lessons

This group of training material on RBC's is designed to be used with the intermediate student. It is assumed that this student has some experience in wastewater treatment and a basic understanding of biological treatment. The objective of this section is to supply the basics and the operational parameters of the RBC treatment system. At the conclusion of this section each student should have a good understanding of how an RBC treatment system fits into waste treatment and the every day characteristics of operation.

Lesson Plans

The material provided is divided up into two lectures. All the materials are to be used as instructor lecture support. This is not designed to be used as self-study or stand alone material. Each instructor should review the written material and possibly use the references given before giving a presentation.

equipment needed:

1. training room large enough to hold the expected number of participants comfortably.
2. 35mm slide projector and screen.
3. overhead projector.
4. chalkboard and/or acetate and overhead pens.

Lesson I: Concepts and Components

There are 36 slides in this section which covers the basic components of an RBC system and how this system might fit into a wastewater treatment flow scheme. Also covered in this section are the basics of process control via visual observation. These slides are arranged in a suggested presentation order. Each instructor should consider adding slides to the presentation or changing the order of these slides to fit his or her style. Slide number 36 is a lead-in slide for lecture II. Estimated time of presentation: 30 min.

note: you may want to give the group a short break at this point.

Lesson II: Design Operation and Maintenance

This second lecture covers the design parameters of the RBC system. Overhead transparencies are supplied to help show the examples of calculating both the organic and hydraulic loadings. There are two examples given for each loading parameter. It is suggested that more examples be given especially if the target group is weak in math skills. This second lecture reviews the method of process control via visual observation. It is important to stress the value of observation of the biomass characteristics under normal operating conditions and abnormal conditions. This section finishes up with normal equipment maintenance procedures. Estimated time of presentation: 30 min.

Self-Test

At the conclusion of the instructional material, a short self test is provided to evaluate the student's progress. This test can be used immediately following the lectures or possibly as a take-home exercise to be handed in or mailed in later. If the test is given following the lectures give the students 15 min. to work on it. Go over the questions and answers after all have finished.

Additional Comments

If possible you should bring in operators that have direct experience with the process control of a RBC treatment system. The material in this section should only supply the basis for operational control and where possible real applications should be used. At the conclusion of the training session try and schedule a field trip to a treatment plant with RBC's in use.

ROTATING BIOLOGICAL CONTACTORS
(RBC's)

LECTURE OUTLINE

LESSON I - CONCEPTS AND COMPONENTS

I. Introduction

A. RBC uses in treatment flow schemes
1. Secondary treatment — slide 4
2. Tertiary treatment — slide 5
3. Expanded secondary treatment — slide 6
4. RBC multi-uses — slide 7

B. Review of secondary treatment
1. General comparison to A/S and TF — slide 8
2. Biological treatment: fixed or dispersed — slide 9
3. RBC fixed growth: Biomass — slide 10
4. Aerobic conversion of organics to energy, CO_2, water, and new cell material — slide 11
5. Excess biomass sloughs and settles in clarifier — slide 12

II. RBC Components and Equipment

A. RBC shaft or drum components
1. Plastic preformed discs stacked up to form a shaft. 12 ft in diameter & 25 ft long — slide 13
2. RBC shaft covers for protection — slide 14

B. RBC process flows
1. No sludge recycle to RBC's — slide 15
Note: at this time no original design calls for any recycle. Sometimes sludge is recycled back to the primary clarifier for thickening.
2. Series and parallel flow patterns — slide 16
3. RBC stage is distinct process unit, a series of stages is called a train of stages. — slide 17

C. Shaft drive mechanisms - introduction — slide 18
1. Mechanical drive — slide 19
a. Motor
b. Gear reducer or chain
c. Shaft bearing
2. Mechanical drive advantages/disadvantages — slide 20
3. Air drive — slide 21
a. Air control valve
b. Air header and diffuser
c. Air cups
4. Air drive advantages/disadvantages — slide 22

III. RBC Process Monitoring

A. General monitoring - visual observation — slide 23
   1. First stage - uniform color and thickness — slide 24
   2. Middle stages - lighter color, patchiness — slide 25
   3. Later stages - sparse growth, possible reddish growth if nitrification is occurring — slide 26
   4. Multi-stage comparison — slide 27
      Note: the photos used in this comparison are not from the same unit. These extremes were used to make the point.

B. Abnormal conditions - visual observation
   1. Filamentous bacteria or anaerobic conditions — slide 28
   2. System startup or toxic loadings — slide 29

C. Monitoring for process control
   1. General monitoring - influent and effluent — slide 30
      a. BOD
      b. Suspended solids
      c. Temp
      d. pH
   2. Monitoring for nitrification — slide 31
      a. Ammonia-nitrogen
      b. Nitrate-nitrogen

IV. Review

A. Uses of RBC in waste treatment — slide 32
B. Biomass sloughing/settles in clarifier — slide 33
C. Flow patterns — slide 34
D. Visual observation for process control — slide 35
E. Lead in to Lesson II — slide 36

ROTATING BIOLOGICAL CONTACTORS
(RBC's)

LECTURE OUTLINE

LESSON II - DESIGN OPERATION AND MAINTENANCE

I. RBC Design Parameters

A. Design characteristics for RBC application
1. Flow rates
2. Organic and solids loading
3. Industrial waste influence
4. Weather (temperature)

B. Example performance ranges
1. Plans have been designed to treat flows ranging between 18,000 gpd to 50 MGD
2. Hydraulic loading
a. BOD removal 1.5 to 6 gpd/sq ft
b. Nitrogen removal 1.5 to 1.8 gpd/sq ft
3. Organic loading (soluble BOD) 3 to 5 lbs BOD/day/1,000 sq ft
a. BOD removal 80 to 95 percent
b. Effluent total BOD 15 to 30 mg/l
c. Effluent soluble BOD 7 to 15 mg/l
d. Effluent ammonia-N 1 to 10 mg/l
e. Effluent nitrate-N 2 to 7 mg/l

C. Computing hydraulic loading
1. Gallons per day per square foot of media surface
2. Required information:
a. Flow
b. Surface area of media in square feet
3. Equation:

$$= \frac{\text{Flow, gal/day}}{\text{Surface area, sq ft}}$$

4. Example 1:
Flow, MGD = 3.5 MGD
Surface area, sq ft = 1,000,000 sq ft

$$= \frac{3{,}500{,}000 \text{ gpd}}{1{,}000{,}000 \text{ sq ft}}$$

$$= 3.5 \text{ gpd/sq ft}$$

5. Example 2:
Flow, gpd = 66,000 gpd
Surface area, sq ft = 40,000 sq ft

$$= \frac{66{,}000 \text{ gpd}}{40{,}000 \text{ sq ft}}$$

$$= 1.65 \text{ gpd/sq ft}$$

D. Computing organic (BOD) loading
   1. Pounds of BOD per day per 1,000 square feet of surface area
   2. Required information
      a. Primary effluent BOD or soluble BOD
      b. Surface area of media in 1,000 sq ft
   3. Equation:

$$= \frac{\text{BOD applied, lbs BOD/day}}{\text{Surface area in 1,000 sq ft}}$$

   4. Example 1:
      Soluble BOD = 2,000 lbs BOD/day
      Surface area = 1,000,000 sq ft
      (1,000,000 sq ft is the same as 1,000 1,000 ssq ft units)

$$= \frac{\text{2,000 lbs BOD/day}}{\text{1,000 X 1,000 sq ft}}$$

$$= \text{2.0 lbs BOD/day/1,000 sq ft}$$

   5. Example 2:
      Soluble BOD = 7,500 lbs BOD/day
      Surface area = 1,400,000 sq ft

$$= \frac{\text{7,500 lbs BOD/day}}{\text{1,400 X 1,000 sq ft}}$$

$$= \text{5.4 lbs BOD/day/1,000 sq ft}$$

   Note: you may want to run through these calculations as metric examples.

II. Characteristics of the Biomass-Process Control

A. Daily inspection of the biomass growth on the shafts by a trained operator is the single most important element of process control monitoring.

B. RBC first stage observations
   1. Most critical, reflects condition of waste stream
   2. Normal:
      a. Uniform brown-to-gray color
      b. Uniform biomass thickness, thin layer, no patches
   3. Abnormal:
      a. Heavy, shaggy biomass represents organically overloaded first stage. May be indication of high organic load to plant or in-plant side stream problem.
      b. Heavy, shiny growth with white slime appearance is an indication of a filamentous bacteria, Beggiatoa, growing on the media. Cause may be the presence of sulfides and a low DO environment.
      c. Black in color with odors, anaerobic conditions have developed. Possible organic overload or "dead" spots in RBC tanks.

C. RBC middle stage observations
   1. Same general observations as the first stage with:
      a. Gradually lighter shades of brown
      b. Progressively more patchy as you move away from the first stage.
   2. Abnormal - same as first stage observations

D. RBC final stage observations
   1. Very light in color and sparse growth as BOD is used up.
   2. Light tan and golden shades are predominately nitrifying bacterial populations.
   3. Reddish colored biomass sometimes occurs, indication of advanced nitrifying stage. Reddish tint caused by the growth of higher worm forms.

E. Severe sloughing
   1. Toxic or inhibitory materials
   2. Extremes in hydraulic or organic loadings
   3. Air flushing from air header (too much air)

III. Process Control Testing

A. Influent/effluent BOD
   1. Comparison for process efficiency

B. Influent/effluent SS
   1. Comparison for process efficiency

C. Dissolved oxygen
   1. Measure DO at each stage
   2. Look for anaerobic dead spots

D. Temperature
   1. Look for extreme changes

E. Nitrification process testing
   1. Ammonia-N
   2. Nitrate-N
   3. Alkalinity

IV. Making Process Control Changes

A. Flexibility available
   1. Multiple stages that can be taken on and off line
   2. Multiple RBC trains
   3. Series or parallel flow change
   4. Movable baffles to divide shafts

B. Set up for maximum BOD removal and/or high organic loadings
   1. Maximum number of shafts operable in first stage
   2. Monitor appearance and DO

C. Set up to encourage nitrification
   1. Maximize the number of stages in series in a train
   2. Monitor pH and alkalinity

V. RBC Maintenance

A. Mechanical drive systems
   1. Observe for odd noises and heat from motor and bearings
   2. Look for oil leaks or spills, check oil levels
   3. Inspect chains or belts for alignment and tightness
   4. Be sure all guards over moving parts and equipment are in place and secure.

B. Air drive system
   1. Inspect blower condition:
      a. Pressure
      b. Temp
      c. Vibration
      d. Lubrication
   2. Check shaft bearing for wear and vibration
      a. Lubrication schedule
   3. Purge air lines and header, exercise control valve
   4. Check for damaged or lost air cups
   5. Time shafts for revolution speed (shaft speeds)

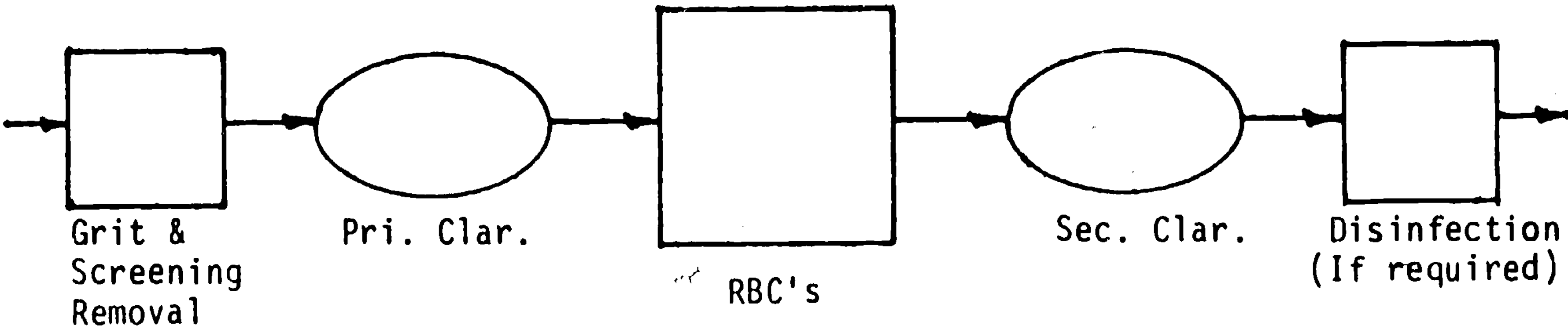

Grit &
Screening
Removal
Pri. Clar.
RBC's
Sec. Clar.
Disinfection
(If required)

FIGURE 1

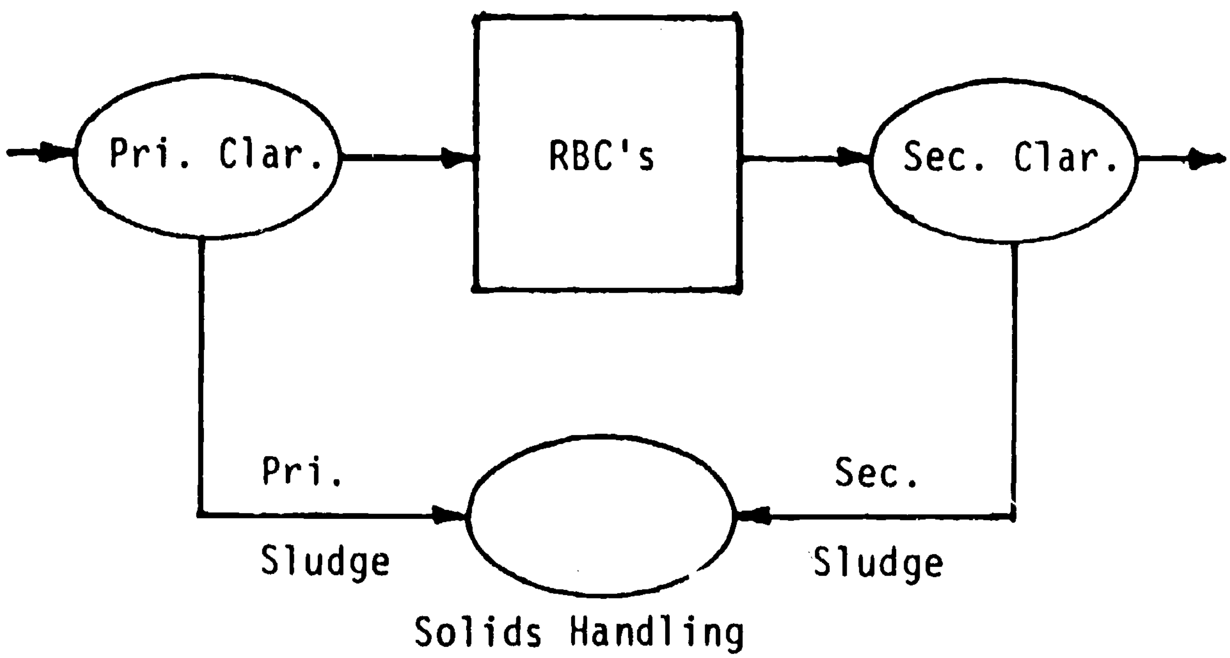
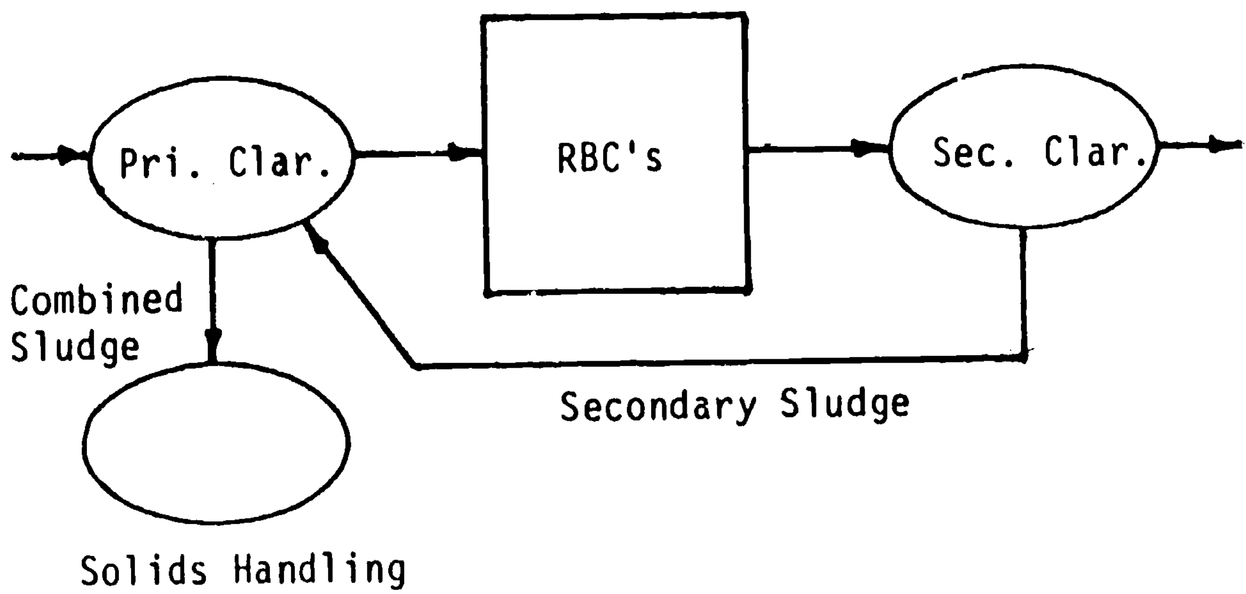
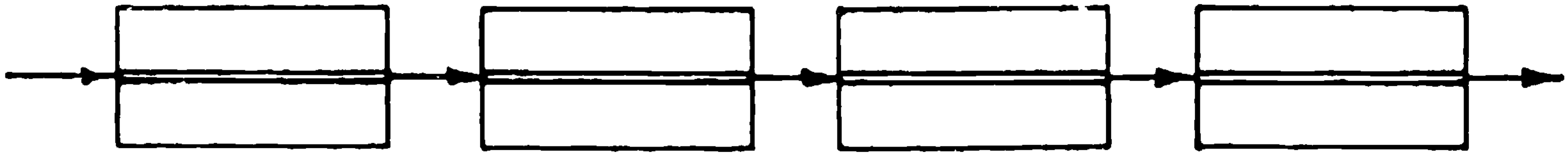
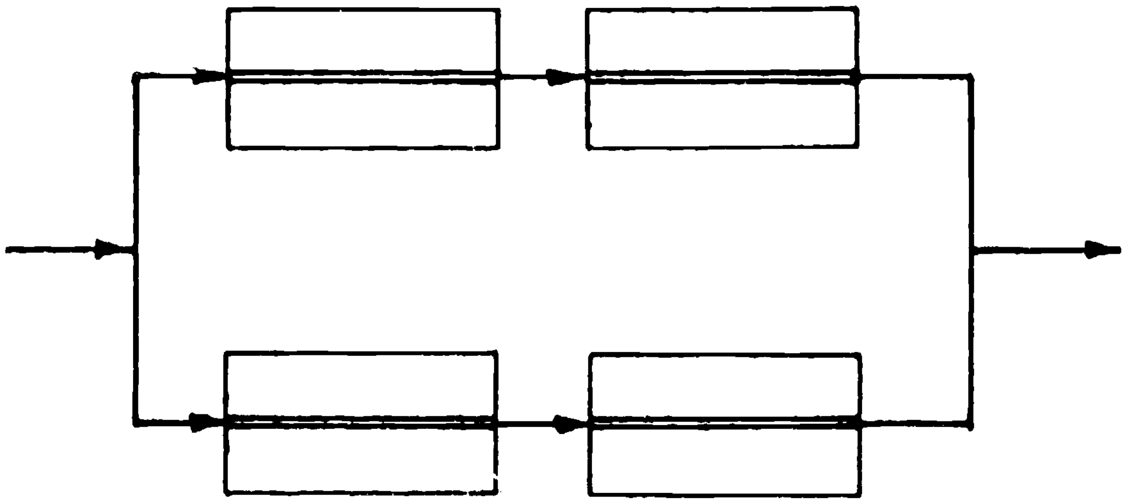

Pri. Clar.
RBC's
Sec. Clar.
Pri.
Sludge
Sec.
Sludge
Solids Handling

FIGURE 2


Pri. Clar.
RBC's
Sec. Clar.
Combined
Sludge
Secondary Sludge
Solids Handling



SERIES FLOW



PARALLEL FLOW

FIGURE 3

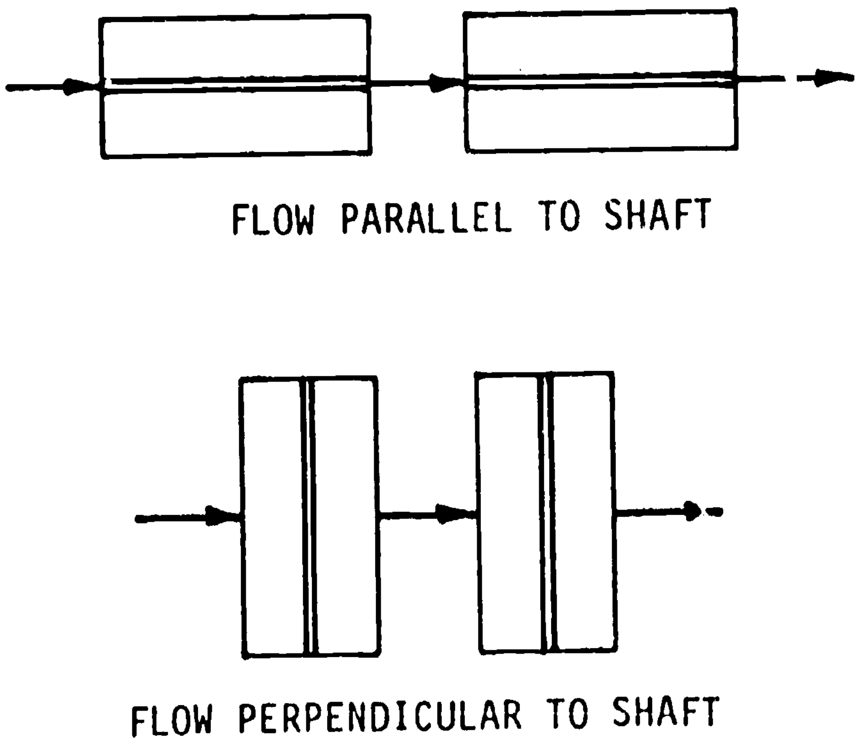
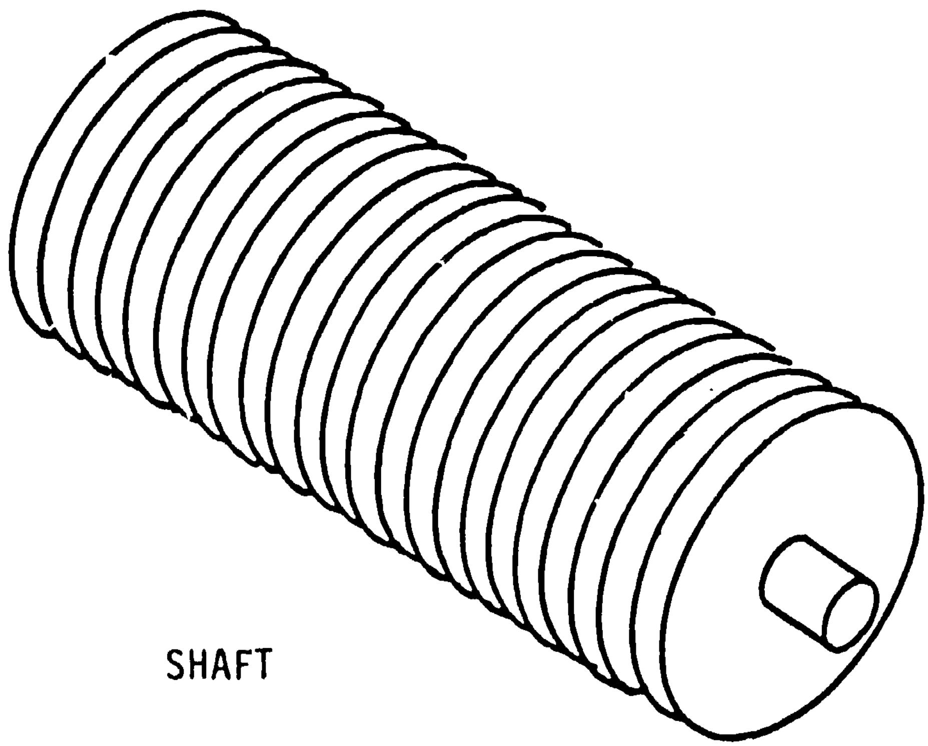


FIGURE 4

I-RBC-14



SHAFT

FIGURE 5

I-RBC-15

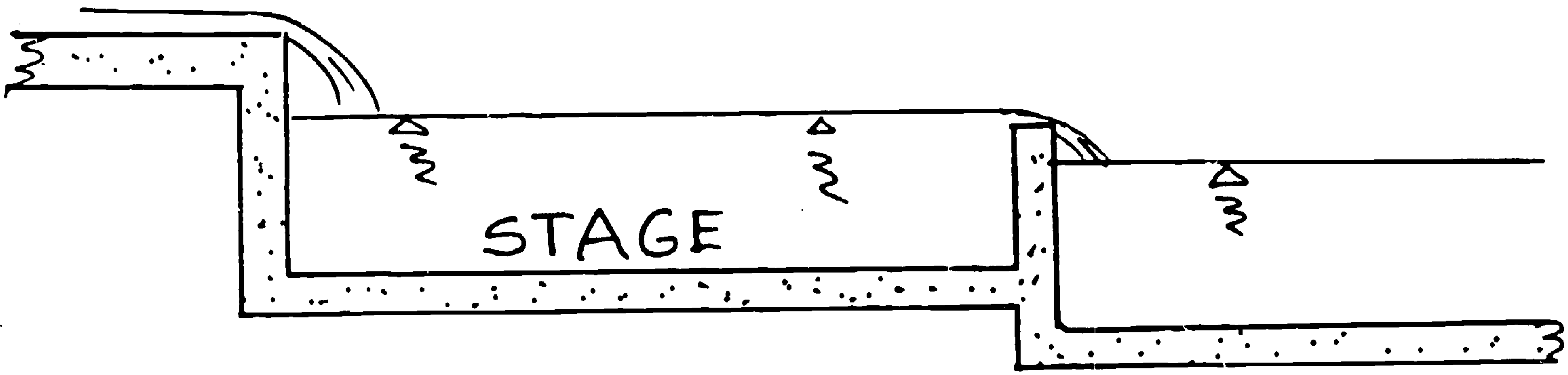
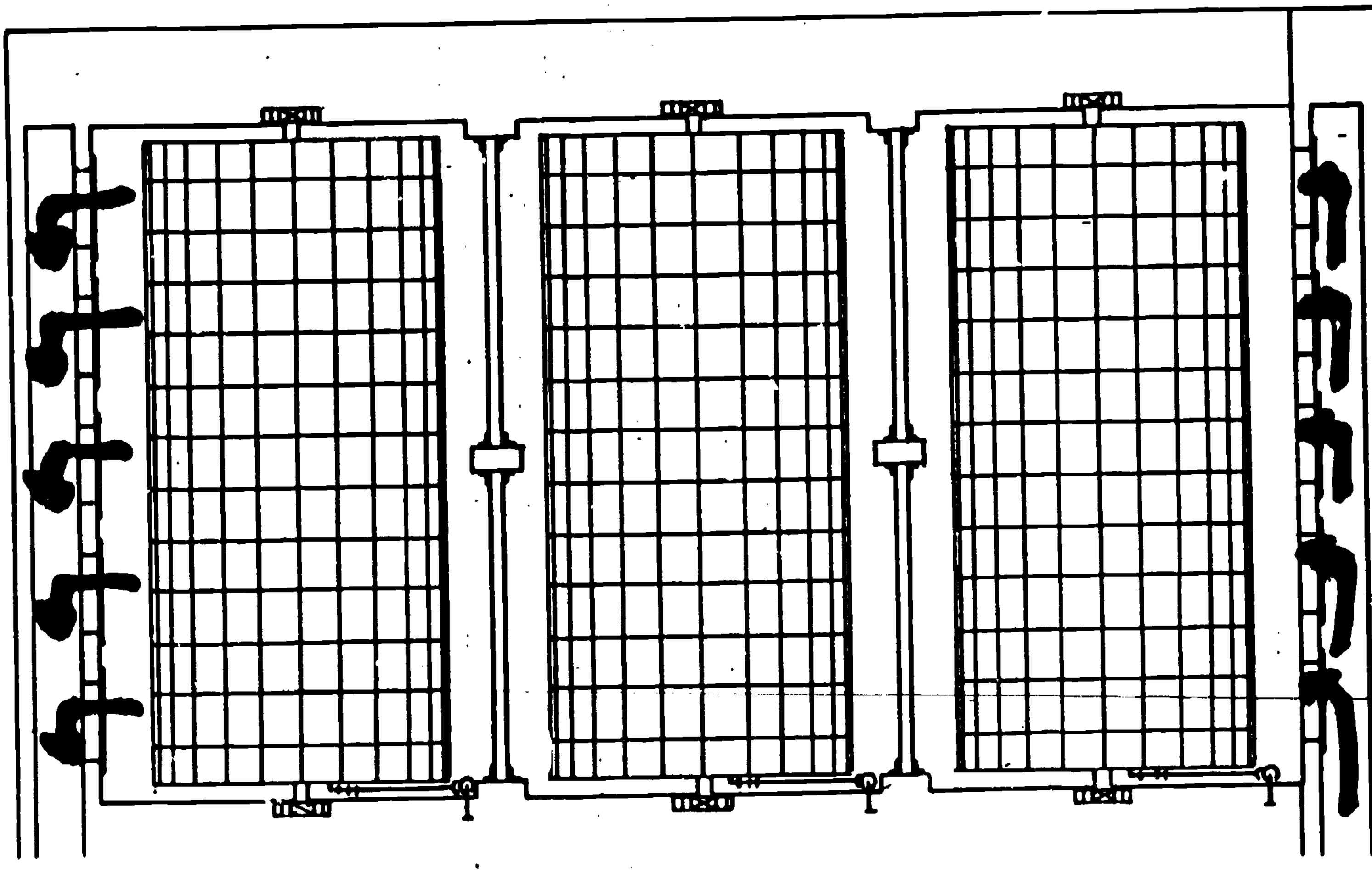
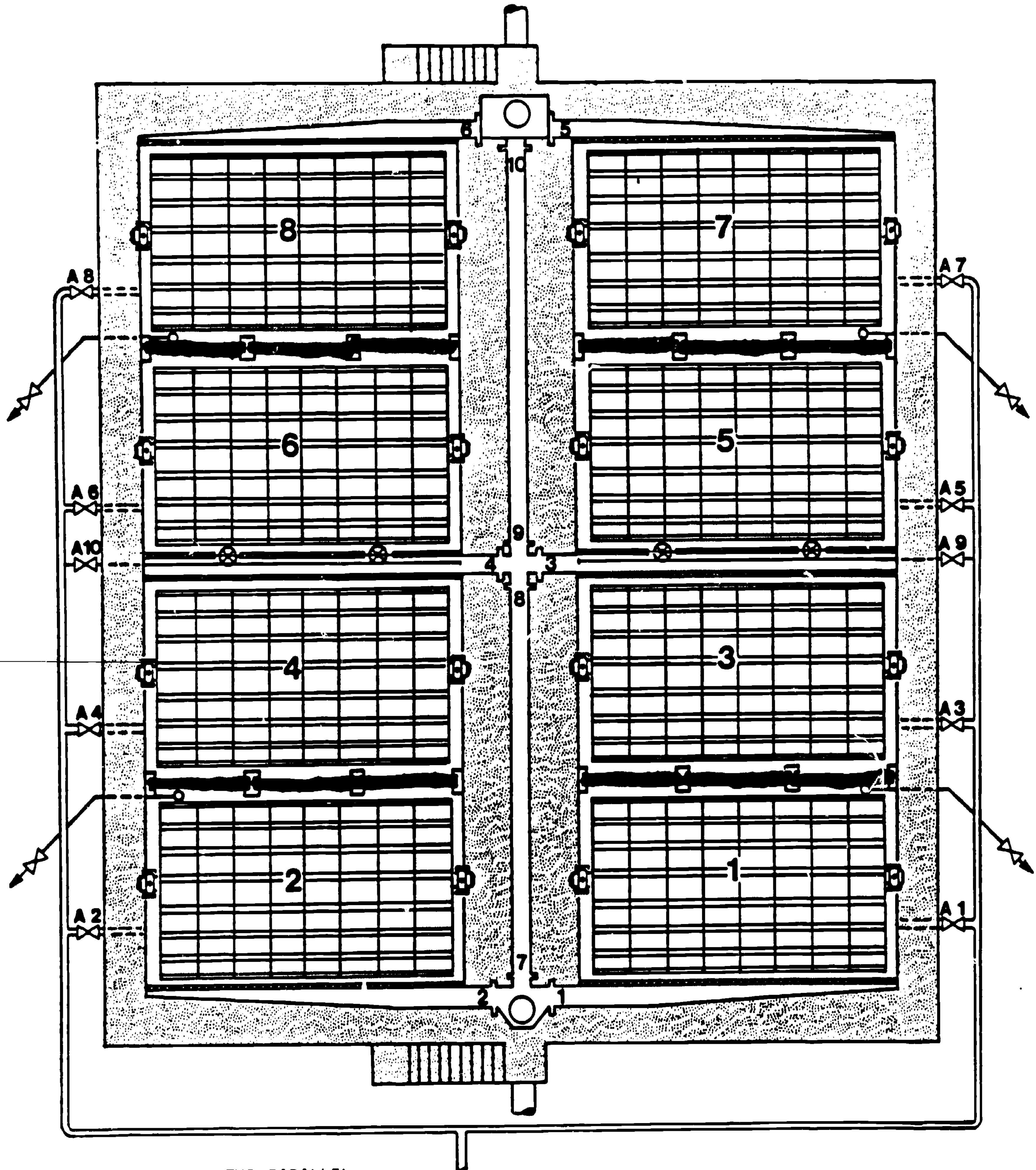


FIGURE 6

FIGURE 7

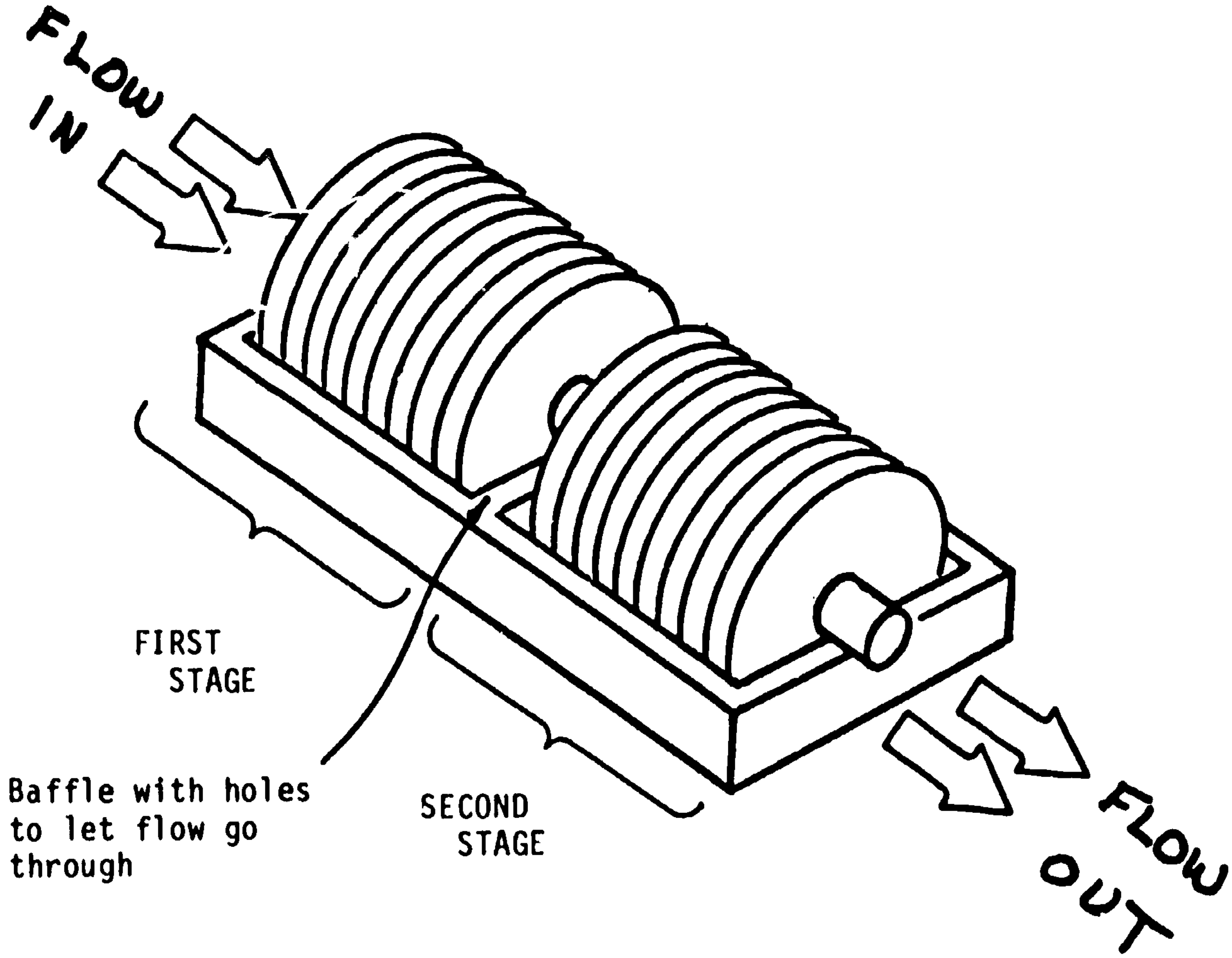


ONE TRAIN OF THREE STAGES



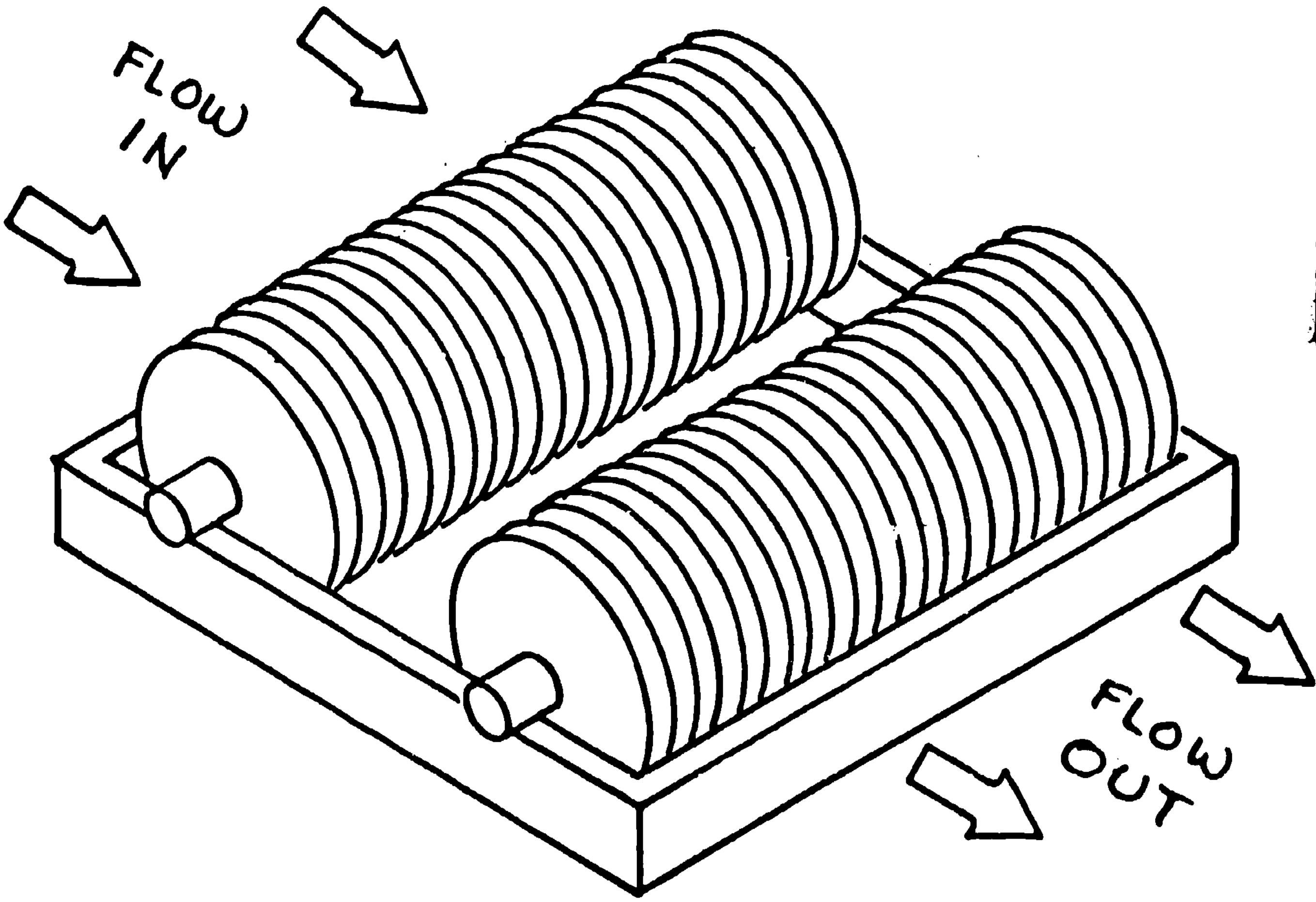
TWO PARALLEL
FOUR-STAGE TRAINS

FIGURE 8



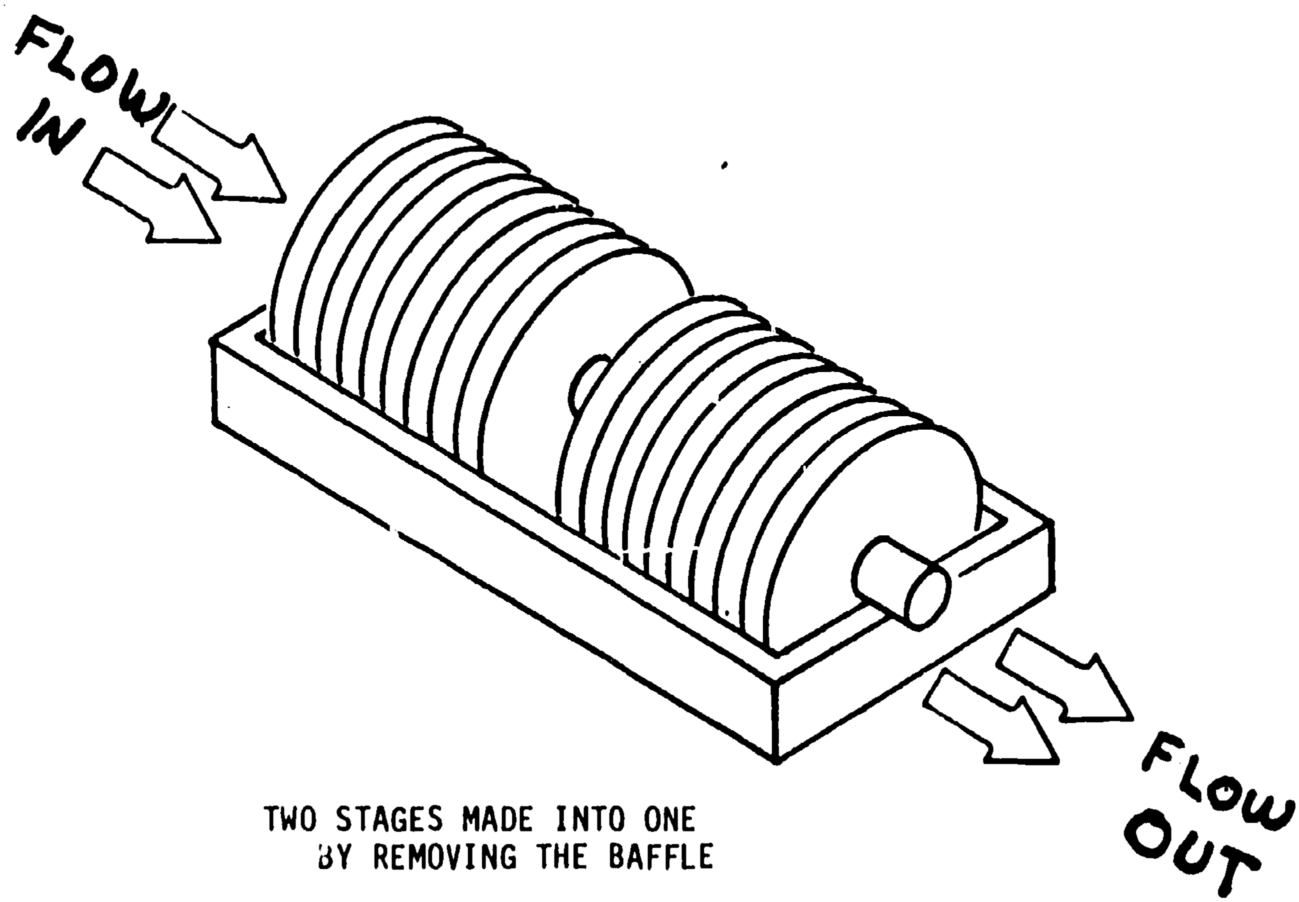
TWO STAGES ON ONE SHAFT

FIGURE 9



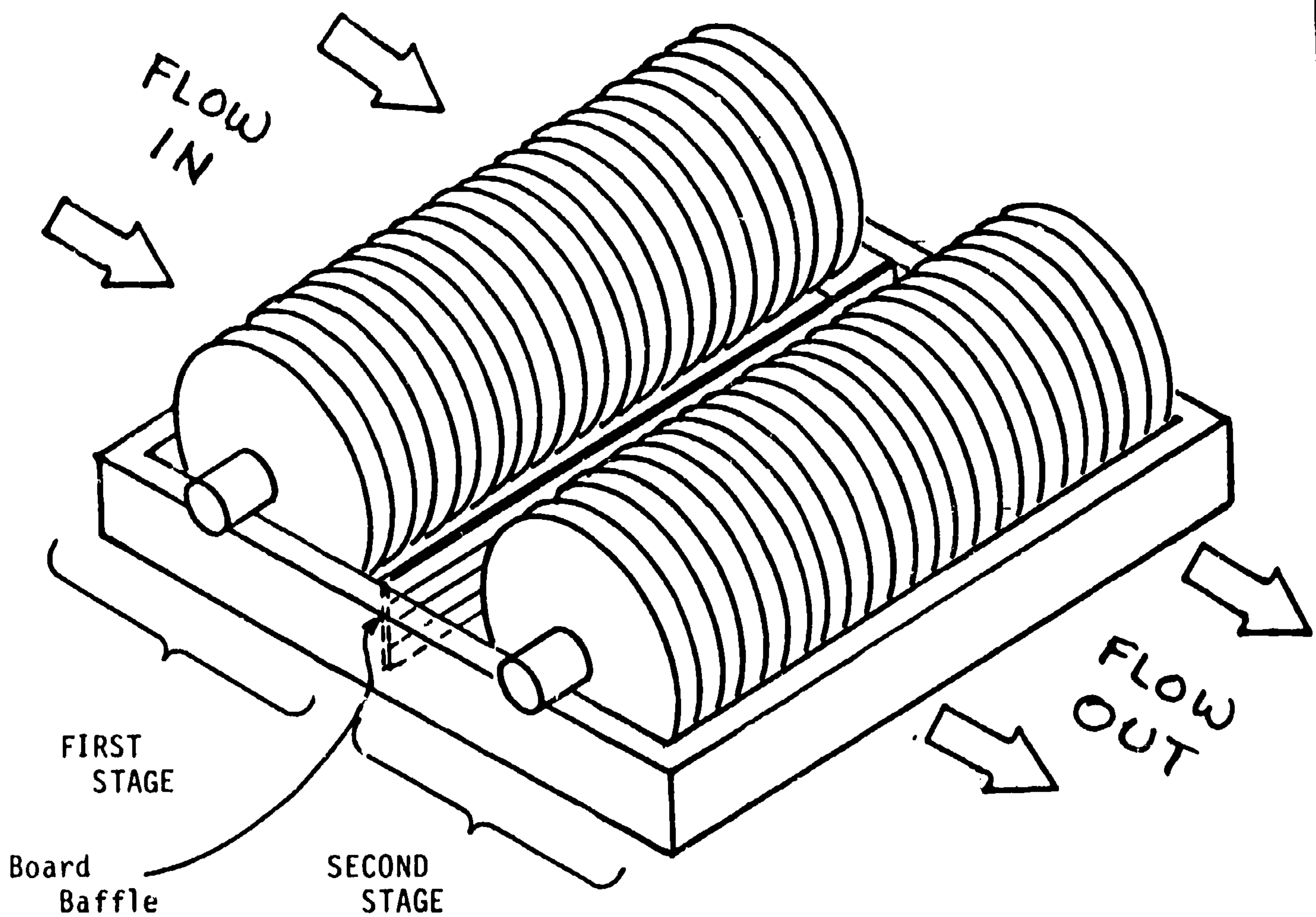
TWO SHAFTS IN ONE STAGE

FIGURE 10



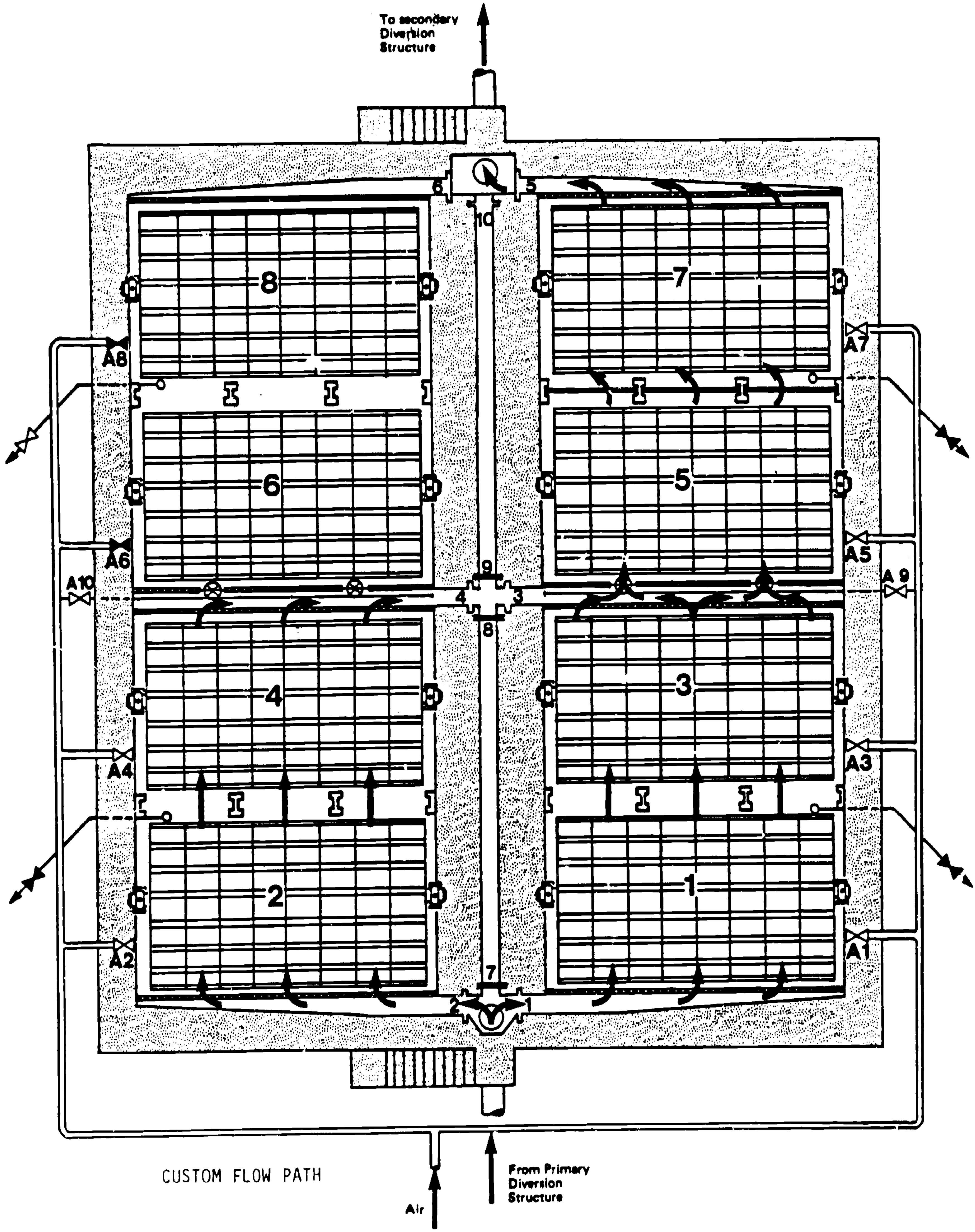
TWO STAGES MADE INTO ONE
BY REMOVING THE BAFFLE

FIGURE 11



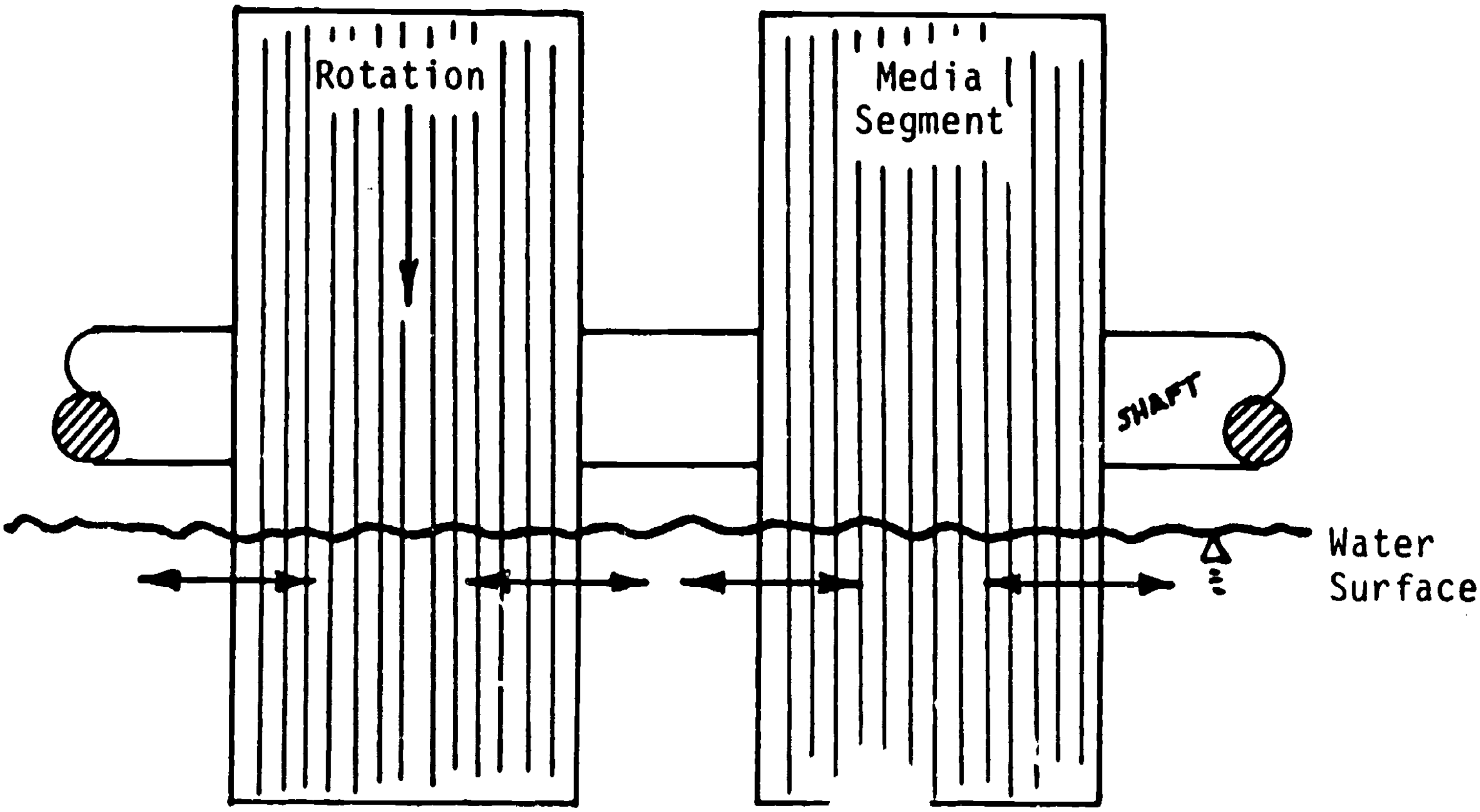
ONE STAGE MADE INTO TWO BY
PUTTING IN A BAFFLE

FIGURE 12



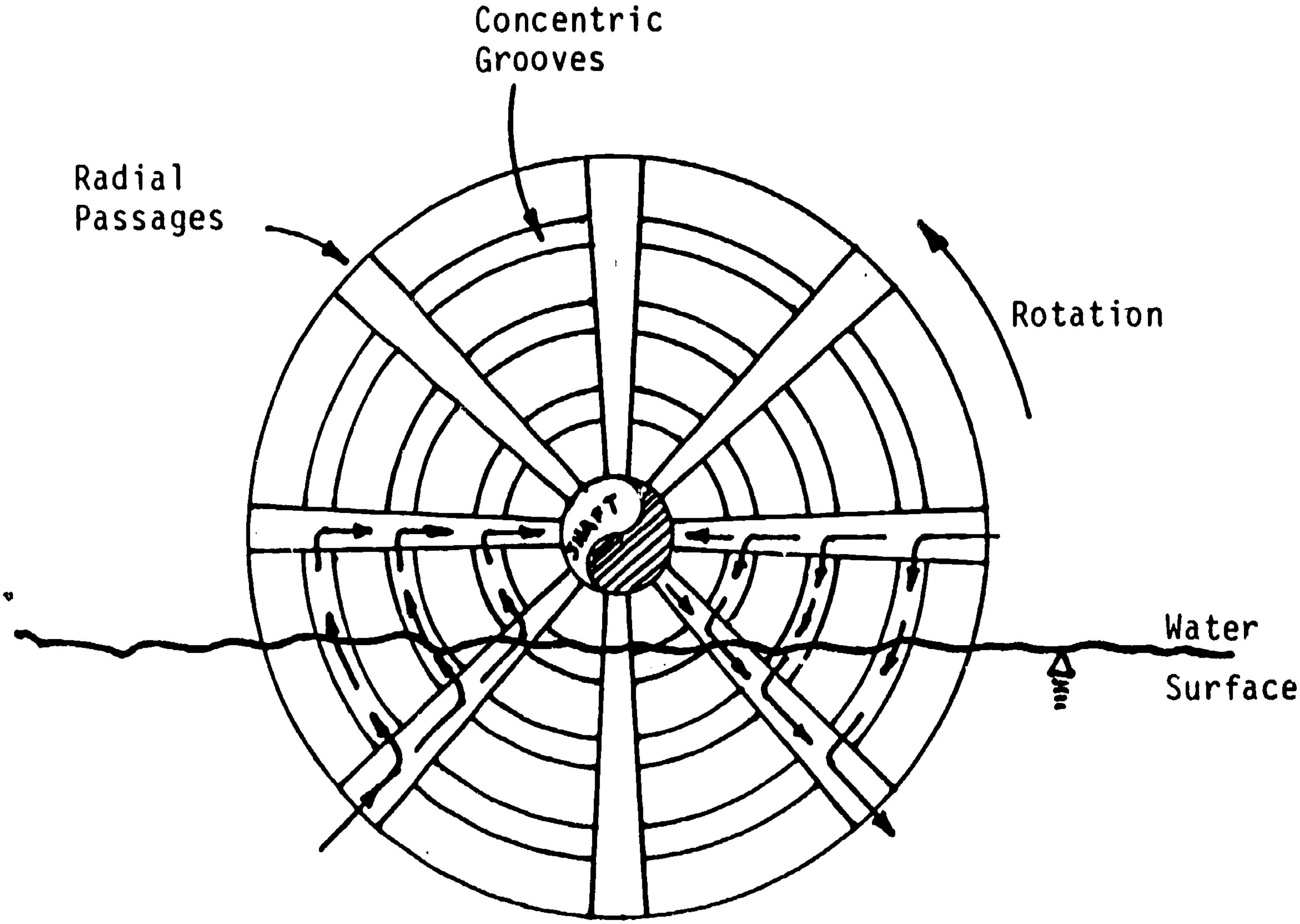
CUSTOM FLOW PATH

FIGURE 13



AXIAL FLOW

FIGURE 14



RADIAL FLOW
FIGURE 15

$$\text{HYDRAULIC LOADING, } GPD/FT^2 = \frac{\text{FLOW}_{GPD}}{\text{SURFACE AREA}_{FT^2}}$$

$$BOD\ LOADING_{LBS/DAY} = INF\ BOD_{MG/L} \times FLOW_{MG} \times 8.34$$

$$\text{ORGANIC LOADING}_{\text{LBS/1000 FT}^2} = \frac{\text{INF BOD}_{\text{LBS/DAY}}}{\text{SURFACE AREA}_{\text{1000's FT}^2}}$$

Answers to Worksheet 1 - Concepts and Components

1. The wastewater treatment process in which a shaft containing synthetic media is rotated in a tank filled with process water is called __rotating__ __biological__ __contactor__.

2. The rotating drum of the RBC unit that is made up of the media from end bearing to end bearing is called the __shaft__.

3. A series of drums lined up in a row is called a __train__.

4. The two basic arrangements for liquid to flow through an RBC plant is __series__ and __parallel__.

5. The tank or basin which is said to be the hydraulic point of no return is called the __stage__.

6. Healthy biomass is __brown__ colored on the first stage and tends toward __lighter brown, gold or reddish__ in later stages.

7. The two types of drum drive systems are:

   __mechanical drive__

   __air drive__

8. When excess growth on an RBC drum falls off the media the process is called __sloughing__.

9. If the surface of the RBC media has a black color and there are strong odors then __anaerobic__ conditions have developed.

Answers to Worksheet 2 - Process Control

1. Design flow rates for an RBC should fall in the 2.25 to 2.50 gpd/square foot range.

2. The normal range of BOD removal for a well operated RBC system is 80 to 95 percent.

3. Heavy, shiny, white patches of growth on the first stage biomass is a growth of Beggiatoa bacteria developing when sulfides are present.

4. The recommended set up for maximizing BOD removal and/or dealing with high organic loads would be to maximize the number of shafts in the first stage.

5. To set up to encourage nitrification maximize the number of stages in a train.

6. Give two advantages of the mechanical shaft drive system:

   low capital cost

   positive speed control

   low power usage

7. Give two disadvantages of the air drive system:

   high capital costs

   high power costs

   requires speed adjustment

8. Calculate the hydraulic loading on an RBC system that has a total surface area of 600,000 sq ft and has a flow of 2 MGD.

$$\text{Hydraulic loading, gpd/ft}^2 = \frac{2{,}000{,}000 \text{ gpd}}{600{,}000 \text{ ft}^2}$$

$$= 3.33 \text{ gpd/ft}^2$$

9. Calculate the organic loading for an RBC system that is 750,000 sq ft and the BOD applied per day is 1800 lbs BOD/day.

$$\text{Organic Loading, } \frac{\text{lbs BOD}}{\text{1000 sq ft}} = \frac{\text{1800 lbs}}{\text{750 thousand ft}^2}$$

$$= 2.4 \frac{\text{lbs}}{\text{1000 sq ft}}$$

10. Calculate the organic loading for an RBC system that has an influent BOD of 100 mg/l, a flow of 1.75 MGD, and a surface area of 400,000 sq ft.

BOD, lbs/day = BOD, mg/l X Flow, MGD X 8.34

= 100 mg/l X 1.75 MGD X 8.34

= 1460 lbs/day

$$\text{Organic Loading, } \frac{\text{lbs BOD}}{\text{1000 sq ft}} = \frac{\text{1460 lbs}}{\text{400 thousand ft}^2}$$

$$= 3.65 \frac{\text{lbs}}{\text{1000 sq ft}}$$

Final Quiz

Directions: for each question select the best answer and mark that answer with either an X or a check. There is only one correct answer per question.

1. The RBC treatment process is a:

_____ a. chemical treatment process
_____ b. biological treatment process
_____ c. tertiary treatment process
_____ d. treatment addition
_____ e. none of the above

2. The microbial growth in an RBC secondary treatment process more closely resembles the:

_____ a. MLSS in an activated sludge process
_____ b. feathery floc from an alum reaction
_____ c. heavy solids from a primary clarifier
_____ d. bacterial growth in the anaerobic digester
_____ e. zoogleal slime from a trickling filter

3. The rotating "drum" of the RBC unit that is defined as being the media from end bearing to end bearing is called:

_____ a. a train
_____ b. the shaft
_____ c. a bio-unit
_____ d. a secondary unit
_____ e. a stage

4. A series of RBC treatment units or "drums", lined up in a row, which take the flow from the influent to the effluent is called:

_____ a. parallel flow
_____ b. stage groups
_____ c. a series shaft
_____ d. a train
_____ e. a secondary series

5. The excess growth on an RBC disc eventually falls off the media into the flow stream and settles in the secondary clarifier. This process is referred to as:

_____ a. sloughing
_____ b. purging
_____ c. toxic shock
_____ d. bio-growth removal
_____ e. none of the above

6. Biomass is the general term describing growth on the RBC media. The characteristics of a normal biomass used for the removal of carbonaceous waste would be:

_____ a. uniformly thin
_____ b. uniform brown color
_____ c. no bare spots or patches
_____ d. only a few hundredths of an inch in thickness
_____ e. all of the above are correct

7. Visual observation of the middle stages of an RBC treatment system would normally show:

_____ a. thick, heavy growth
_____ b. very sparse growth, red in color
_____ c. lighter shades of brown, some clear patches
_____ d. shiny, greasy appearance
_____ e. looks the same as the first stages

8. Observation of the last stages of an RBC treatment system that is set up for nitrification would have the characteristics of:

_____ a. heavy, dark brown growth
_____ b. sparse growth with possible reddish color
_____ c. uniform covering, golden color
_____ d. shiny, greasy appearance
_____ e. all of the above will occur

9. If the surface of the RBC media has a black color and there are strong odors, then:

_____ a. filamentous bacteria are growing
_____ b. there is a grease buildup
_____ c. the plant has received a toxic load
_____ d. nitrification is occurring
_____ e. anaerobic conditions have developed

10. A heavy, shiny growth with a white slime appearance that may occur on the RBC disc is an indication of:

_____ a. the growth of Beggiatoa, a filamentous bacterium
_____ b. a severe buildup of grease
_____ c. the failure of the pretreatment system
_____ d. denitrification is occurring
_____ e. a white colored growth never shows up

11. Usually, a great deal of flexibility is built into an RBC system so that adjustments can be made in accordance to the changes in the characteristics of the influent waste stream. The set up for maximum BOD removal and/or high organic loads would be:

_____ a. maximize the number of shafts in the first stage
_____ b. increase the flow rate to all trains
_____ c. recycle 50% of effluent to head of plant
_____ d. maximize the number of stages in a train
_____ e. bypass excess flow and go for coffee

12. To set up an RBC system to encourage nitrification to take place you would:

_____ a. slow down the flow coming to the plant
_____ b. add ammonia nitrogen at head of plant
_____ c. decrease the RAS rate
_____ d. maximize the number of stages in a train
_____ e. none of the above

13. The normal range of BOD removal for a well operated RBC system is usually given as:

_____ a. between 75% and 80%
_____ b. between 80% and 95%
_____ c. between 85% and 99%
_____ d. around 50%
_____ e. with recycle about 85%

14. Total effluent BOD of a well operated RBC system should fall in the range of:

_____ a. 1 to 5 mg/l
_____ b. 5 to 10 mg/l
_____ c. 15 to 30 mg/l
_____ d. greater than 50 mg/l
_____ e. none of the above

15. The hydraulic loading of RBC's is given in terms of gallons per day per square foot of media surface. Calculate the hydraulic loading of an RBC system that has a total surface area of 500,000 sq ft and sees a flow of 1.75 MGD.

_____ a. 0.286
_____ b. 3.0
_____ c. 3.5
_____ d. 40,875
_____ e. 558

16. To calculate the organic loading for an RBC system, you would need to:

_____ a. multiply the BOD by the flow
_____ b. divide BOD mg/l by surface area
_____ c. multiply surface area by lbs BOD
_____ d. divide by 1000 sq ft units
_____ e. divide lbs BOD/day by surface area

17. Calculate the organic loading of an RBC system that has a soluble BOD of 95 mg/l, a flow of 1.8 MGD, and a surface area of 700,000 sq ft.

_____ a. 1,426
_____ b. 0.002
_____ c. 0.244
_____ d. 2.0
_____ e. 3.5

18. There are two types of drive systems that are used to rotate the RBC shafts the waste stream. Which of the answers given below is <u>not</u> an advantage of a mechanical shaft drive system?

_____ a. high torque on shaft
_____ b. low capital cost
_____ c. positive speed control
_____ d. low power usage
_____ e. all are advantages

19. When considering the advantages and disadvantages of an air drive system, which of the answers given below is <u>not</u> a disadvantage of an air drive system?

_____ a. thinner biomass
_____ b. high capital costs
_____ c. high power costs
_____ d. rotational speed adjustments required
_____ e. all are disadvantages

20. If you were to make the required adjustments to the RBC system that force nitrification to occur, what additional laboratory test would you perform to monitor this process?

____ a. influent and effluent BOD
____ b. ammonia-N, nitrate-N, and alkalinity
____ c. influent and effluent ammonia-N
____ d. BOD, DO, and alkalinity
____ e. DO, ammonia-N, and nitrogen gas

Answers to Final Quiz

Directions: for each question select the best answer and mark that answer with either an X or a check. There is only one correct answer per question.

1. The RBC treatment process is a:

____ a. chemical treatment process
_X_ b. biological treatment process
____ c. tertiary treatment process
____ d. treatment addition
____ e. none of the above

2. The microbial growth in an RBC secondary treatment process more closely resembles the:

____ a. MLSS in an activated sludge process
____ b. feathery floc from an alum reaction
____ c. heavy solids from a primary clarifier
____ d. bacterial growth in the anaerobic digester
_X_ e. zoogleal slime from a trickling filter

3. The rotating "drum" of the RBC unit that is defined as being the media from end bearing to end bearing is called:

____ a. a train
_X_ b. the shaft
____ c. a bio-unit
____ d. a secondary unit
____ e. a stage

4. A series of RBC treatment units or "drums", lined up in a row, which take the flow from the influent to the effluent is called:

____ a. parallel flow
____ b. stage groups
____ c. a series shaft
_X_ d. a train
____ e. a secondary series

5. The excess growth on an RBC disc eventually falls off the media into the flow stream and settles in the secondary clarifier. This process is referred to as:

X a. sloughing
__ b. purging
__ c. toxic shock
__ d. bio-growth removal
__ e. none of the above

6. Biomass is the general term describing growth on the RBC media. The characteristics of a normal biomass used for the removal of carbonaceous waste would be:

__ a. uniformly thin
__ b. uniform brown color
__ c. no bare spots or patches
__ d. only a few hundredths of an inch in thickness
X e. all of the above are correct

7. Visual observation of the middle stages of an RBC treatment system would normally show:

__ a. thick, heavy growth
__ b. very sparse growth, red in color
X c. lighter shades of brown, some clear patches
__ d. shiny, greasy appearance
__ e. looks the same as the first stages

8. Observation of the last stages of an RBC treatment system that is set up for nitrification would have the characteristics of:

__ a. heavy, dark brown growth
X b. sparse growth with possible reddish color
__ c. uniform covering, golden color
__ d. shiny, greasy appearance
__ e. all of the above will occur

9. If the surface of the RBC media has a black color and there are strong odors, then:

__ a. filamentous bacteria are growing
__ b. there is a grease buildup
__ c. the plant has received a toxic load
__ d. nitrification is occurring
X e. anaerobic conditions have developed

10. A heavy, shiny growth with a white slime appearance that may occur on the RBC disc is an indication of:

X a. the growth of Beggiatoa, a filamentous bacterium
___ b. a severe buildup of grease
___ c. the failure of the pretreatment system
___ d. denitrification is occurring
___ e. a white colored growth never shows up

11. Usually, a great deal of flexibility is built into an RBC system so that adjustments can be made in accordance to the changes in the characteristics of the influent waste stream. The set up for maximum BOD removal and/or high organic loads would be:

X a. maximize the number of shafts in the first stage
___ b. increase the flow rate to all trains
___ c. recycle 50% of effluent to head of plant
___ d. maximize the number of stages in a train
___ e. bypass excess flow and go for coffee

12. To set up an RBC system to encourage nitrification to take place you would:

___ a. slow down the flow coming to the plant
___ b. add ammonia nitrogen at head of plant
___ c. decrease the RAS rate
X d. maximize the number of stages in a train
___ e. none of the above

13. The normal range of BOD removal for a well operated RBC system is usually given as:

___ a. between 75% and 80%
X b. between 80% and 95%
___ c. between 85% and 99%
___ d. around 50%
___ e. with recycle about 85%

14. Total effluent BOD of a well operated RBC system should fall in the range of:

___ a. 1 to 5 mg/l
___ b. 5 to 10 mg/l
X c. 15 to 30 mg/l
___ d. greater than 50 mg/l
___ e. none of the above

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