

AMERICAN FOUNDRYMEN'S SOCIETY TRAINING AND RESEARCH INSTITUTE

CAST METALS TECHNOLOGY SERIES



BASIC PRINCIPLES OF GATING



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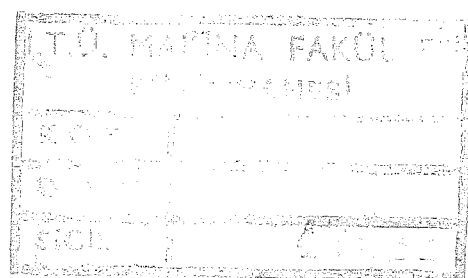
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PREFACE

This programmed learning course is one of a series of courses prepared by the Training and Research Institute of the American Foundrymen's Society, and is primarily designed to enrich the technical knowledge of a person who is beginning a career in the metal casting industry. These courses, however, may also be used by more experienced foundrymen to learn scientific principles in specific areas of cast metals technology. They may be used individually or as instructional and testing material to supplement group instruction.

This course is on the basic principles of gating. In it you will study the ways and means by which foundrymen direct and control the flow of molten metal from the crucible or ladle into the mold cavity. The gating system has been described by one writer as, "the plumbing through which molten metal flows." The fundamentals presented in this program are based on the laws of hydraulics, and their application to horizontal and vertical gating systems was the subject of extensive research. Therefore it is hoped and expected that after you have completed this course you will think of the gating system as something more than a "plumbing system."

The course has been divided into three main sections: The first section briefly reviews the terms used in discussing the gating system, then goes on to discuss the basic principles of fluid flow. In the second section, the parts of the horizontal gating system are individually studied to see how they may be designed to aid in producing controlled flow of molten metal to the mold cavity. The third section presents a similarly detailed study of the vertical gating system.

Generally speaking, much of the material presented in this programmed course can be applied to the many varieties of alloys and casting shapes poured in the cast metals industry. It is recognized that some of the principles discussed will be more generally applicable to some alloys and casting shapes than to others. It must be realized further that the course teaches scientific principles which, in some isolated cases, may not be practical because of other factors involved. In such cases, sound judgment and experience must be applied. However, the broad background of basic gating principles taught by this course should be beneficial to all foundrymen.

The critical review, comments, and helpful suggestions of Messrs. Jack B. Caine, Donald L. LaVelle, William D. McMillan, and Ronald W. Ruddle aided in the preparation of this course, and are greatly appreciated.

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GENERAL SUGGESTIONS

1. The person taking this programed course should study only a relatively small part of it at one time. The amount will vary with the individual and should probably not exceed 50 frames at a time. There is no reward for speed when studying this course, but there is a reward for careful, thorough study of the material. That reward is to understand the subject. Each individual is a specific case, and should proceed at a rate comfortable and effective for him.
2. In order to gain the full benefit of this course it is important that the student write the answer in the spaces provided before looking at the correct answer. Obviously, anyone who wants to cheat can do so very easily; however, he will not understand or remember the material nearly as well as he would otherwise. In other words, he is cheating himself.
3. The post test is an important part of the learning process. It gives the student a chance to see what he has learned. In the case of the formal classroom training situation, it allows the instructor to see whether the trainee did his assigned work. Here, as in the course, the answers are readily accessible, but once again, the person who looks at them before completing the test will cheat only himself.
4. The person studying this programed course may be worried about the language used. Every attempt has been made to keep the English basic. In many cases, terms are defined as they occur in the course, so that the person taking the course need not proceed without first knowing the meaning of the term.

INTRODUCTION

- A. This is a programmed text, and you do not study it the same way that you would a regular textbook. To begin, remove the response mask from the rear cover and place it so that it completely covers the answer column at the right-hand side of this page.

Each small part of the text (each frame, as they are called) will give you a bit of information and at the same time require that you supply a bit of information in a space allowed for it. For example, you are interested in learning about the casting of metals, and the purpose of this course is to teach you something about how metals are _____.

Write the proper word in the blank, then slide your response mask down until it is even with the bottom of this frame, and stop! The correct answer will be shown in the answer column. Do not move the mask again until you have read all of the next frame.

cast

- B. Sometimes you may be given a choice of words, as in, "This frame is printed in _____ (green/black/red) ink. Did you fill in the answer, as you should? But more often you will be asked to provide one particular _____ for the blank. Now slide your mask down to here. _____→

black
word

- C. If you said "answer" for the second part of the frame above, that will do. Most of the time you will provide just the exact word or words, and no others. Sometimes, however, it will be just as correct to use words that mean _____ (the same/a different) thing.

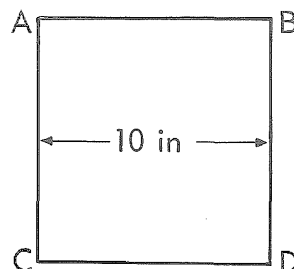
the same

- D. Besides what it said in words, the frame above told you that the number of blanks allowed for one answer _____ (is equal to/does not equal) the number of words in the answer.

is equal to

- E. Here and there you will find a long blank with a broken line, like this: _____. This means that the answer has one or more words; it's up to you to provide it, or them.

- F. Sometimes you may just indicate a part:
The top side of this square is indicated by line _____. Or you may work out something: The area of the square is _____.



AB
100 sq in.

G. A word or two of caution:

(1) If you give a wrong answer, go back and study that frame (and as many others before it as you need to) until you find out what went wrong. It is important that you understand each frame before going on to the next.

(2) Remember, this is a text, not a test. Looking ahead will give you the answers, but it won't teach you how to get them; that comes only from doing the work yourself.

(3) In programed texts, even if you're studying with a group, the rate of study and how well you learn are both determined by you. So you have both the opportunity and the responsibility to study carefully and thoroughly.

H. You will notice that from page 3 on, the left-hand pages are printed upside down. This is not an error. Work all the right-hand pages until you have gone through to frame 136, then turn the book over and continue on with frame 137. Go to it, and good luck.

I THE FLOW OF MOLTEN METAL

[1]

The system through which molten metal flows to reach and fill the mold cavity is called the gating system. The fundamental requirements of a gating system are as follows:

1. The metal should flow through the gating system with as little turbulence as possible, so that mold gases and air will not be trapped in the stream and the molding sand will not be washed away.
2. The metal should enter the mold cavity in a manner that will produce temperature differences between points in the casting which promote proper freezing of the molten metal.
3. The gating system must deliver clean metal (free of slag and dross) at a rate and velocity sufficient to completely fill the mold cavity before freezing.
4. The gating system must be economically practical; that is, it must not be too expensive to mold and the quantity of metal used in the system should be kept to the minimum amount that will produce the desired result.

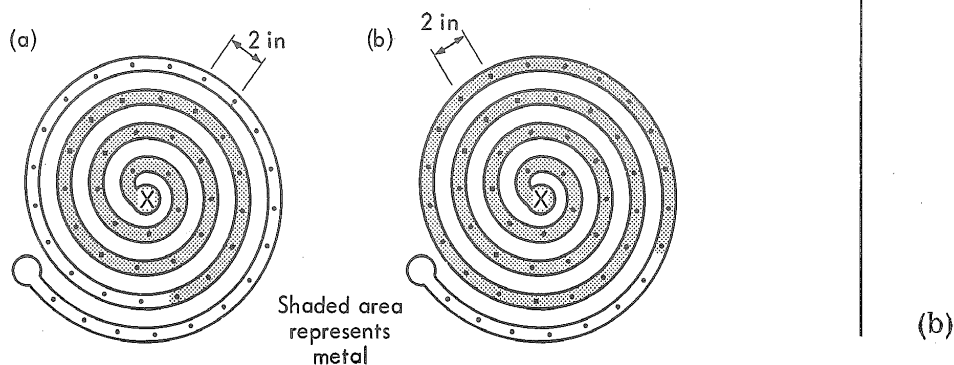
[2]

The flow of molten metal compares favorably with the flow of most liquids, including water. In some cases, the flow of water will be compared to the flow of molten metal so that you may see how similar fluid actions occur in everyday life.

First of all, let's look at some of the terms that are used in referring to the flow of molten metal, and also study some of the basic hydraulic principles that affect fluid flow.

[3]

As used in the foundry, the term "fluidity" means the capability of a molten metal to fill a mold. The standard fluidity spiral (illustrated below) is used to test the fluidity of a given molten metal. Molten metal is poured through a channel (X) of standard height, and the measure of fluidity is the distance the metal will flow before the leading edge freezes. Which of the examples below shows the greatest fluidity? _____



[4]

Fluidity is affected by several factors. Two of the important ones are superheat and the composition of the metal. Of these two, the most important is superheat, which occurs when the temperature of a metal is increased above its melting point.

Which of the metals listed below were superheated when poured? _____

	Metal		
	A	B	C
Melting Temp.	1500°F	1805°F	1750°F
Pouring Temp.	1600°F	1805°F	1760°F

A, C

[5]

The terms, "temperature" and "heat" are often used to describe the same thing, when actually there is a distinct difference between them.

Temperature is the degree of hotness or coldness of a material, and it is measured in degrees (°) Fahrenheit or centigrade.

The reading on a thermometer placed in a glass of water indicates the _____ of the water.

temperature

[6]

Heat is that energy which causes a material to rise in temperature. It is measured in British thermal units (BTU's) or calories.

The temperature of water in a pot is 40°. Over a period of time the temperature of the water increases to 100°. To bring about this rise in temperature, _____ was added to the water.

heat

[7]

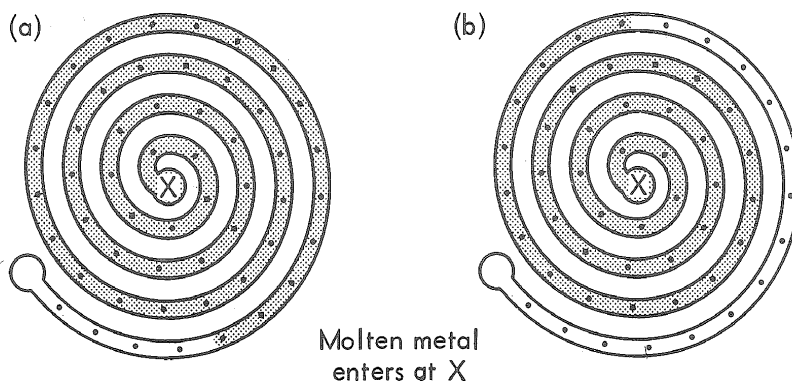
In order to cause a rise in _____, we must add _____ faster than it is lost.

temperature
heat

[8]

Superheating a metal will increase the length of time it will remain molten and flow; it will take a longer period of time for it to reach the temperature at which it will begin to solidify (freeze).

In the standard fluidity spirals below, the composition of the metals is the same. Other conditions equal, in which example was the metal poured with a higher superheat? _____



(a)

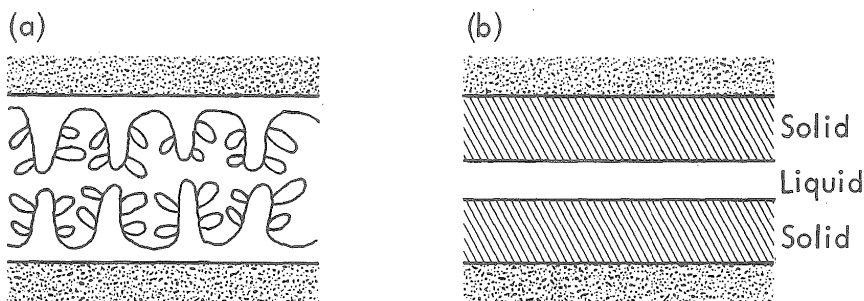
[9]

The most effective way to increase fluidity is to add superheat to the molten metal. Care must be taken when increasing superheat, however, because too much superheat can damage both the mold material and internal structure of the metal.

[10]

The composition of an alloy places it into one of two classifications of solidification which affect fluidity. An alloy that solidifies in a mushy manner, with tree-like growths (dendrites), over a wide range of temperature, is said to have a wide solidification range.

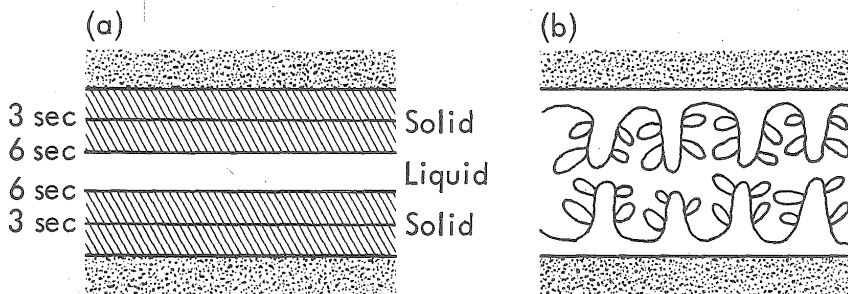
Which illustration represents an alloy that has a wide solidification range? _____



(a)

[11]

In which of the illustrations below will the molten metal have a clear channel to flow through as the metal begins to freeze? _____

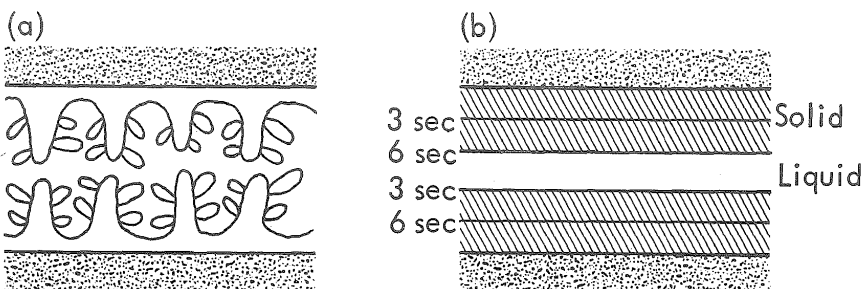


(a)

[12]

An alloy that solidifies over a short temperature range, by a gradual inward growth of a wall of solid metal, is said to have a narrow solidification range.

Which illustration represents an alloy that has a narrow solidification range? _____



(b)

[13]

Of the two ranges of solidification, fluidity will be most hindered by the _____ (narrow/wide) solidification range.

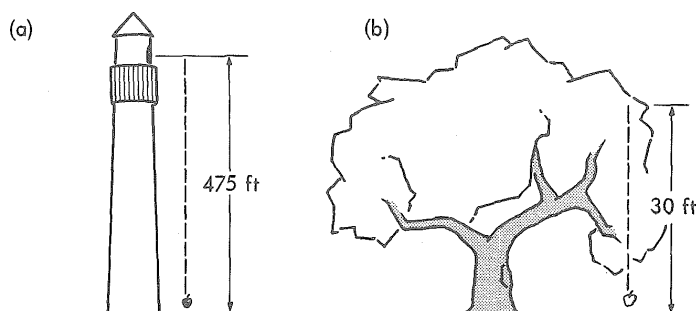
For example: Low carbon steel can be said to have a narrow solidification range, whereas red brass and many light alloys can be said to have a wide solidification range.

wide

[14]

The speed of a falling object is affected by the force of gravity. The greater the distance an object has to fall, the greater will be its velocity (feet per second).

In the illustrations below, which apple will be falling at the greater velocity at the point of impact with the ground? _____

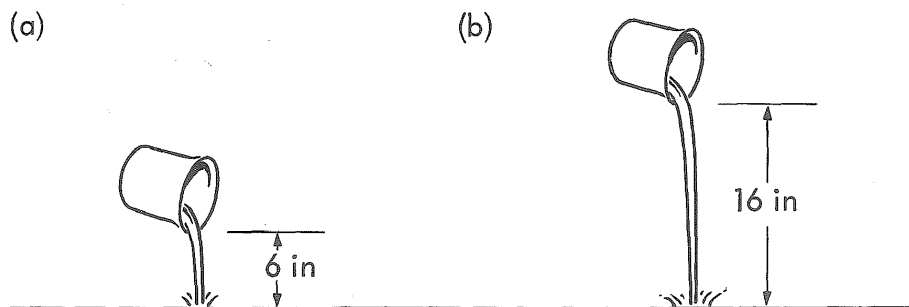


(a)

[15]

Gravity also affects a stream of liquid as it is poured from a container. As the stream of liquid falls, its speed or velocity is increased.

These two glasses contain the same amount of water, but the water is poured from different heights. Which stream will have the greater velocity at point of impact? _____

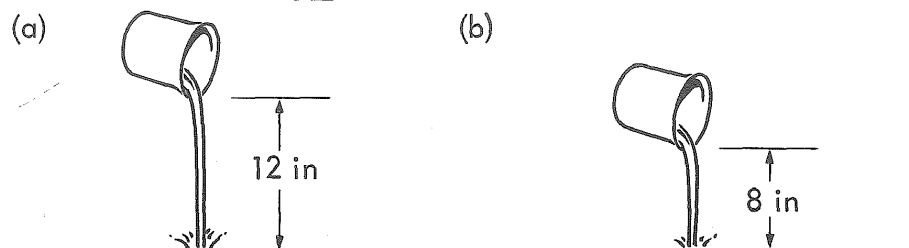


(b)

[16]

The greater the velocity of the falling stream, the more splashing or turbulence there will be when the stream strikes a surface.

Which stream of water will make the greater splash when it strikes the surface? _____



(a)

[17]

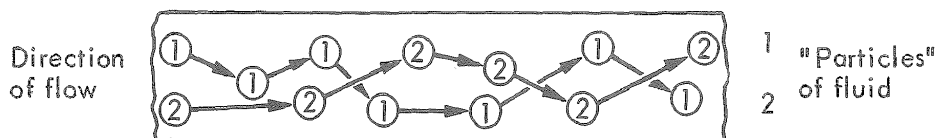
The farther a stream of molten metal falls the greater its _____ will be. This in turn causes _____ when the molten metal strikes a surface.

velocity (or speed)
splashing (or turbulence)

[18]

The flow of a liquid can be either turbulent or laminar (smooth). Turbulent flow is characterized by irregular movement of the "particles" of fluid, both across the stream and in the direction of flow.

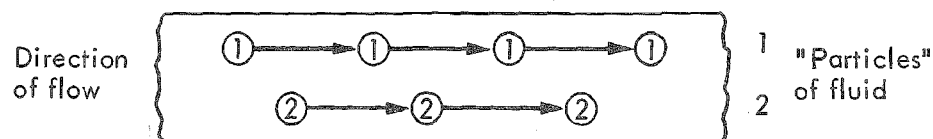
The "particles" of fluid in the channel below are flowing in a _____ manner.



turbulent

[19]

In laminar (smooth) flow, the "particles" of fluid all proceed smoothly, parallel to the direction of flow. The manner in which these "particles" of fluid are flowing is called _____ flow.



laminar (or smooth)

[20]

The following list groups some alloys by their sensitivity to turbulence.

High	Medium	Low
Light alloys, such as magnesium bronze, aluminum bronze, and silicon bronze	Low-carbon steels, ductile iron	Irons other than ductile, red brass

[21]

Flow rate is the measure of the amount of liquid flowing past a given point in a given period of time; e.g., 500,000 tons of water pass over Niagara Falls every minute.

500,000 tons/min, of water, is the _____ of Niagara Falls.

flow rate

[22]

In the foundry, the flow rate of molten metal is measured in pounds per second (lb/sec).

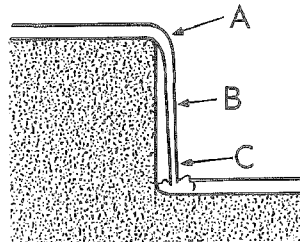
The amount of molten metal flowing past a given point in the gating system is measured in _____.

lb/sec (or pounds per second)

[23]

The manner in which the liquid flows and enters the mold cavity is determined partly by its velocity; the greater the velocity, the more turbulent the flow of liquid will be.

At which point in this illustration will there be the greatest velocity and thus the most turbulence? _____



C

[24]

Velocity and speed are terms which mean the same in the study of fluid flow.

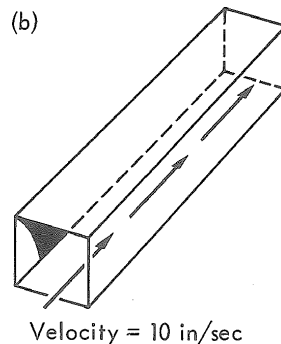
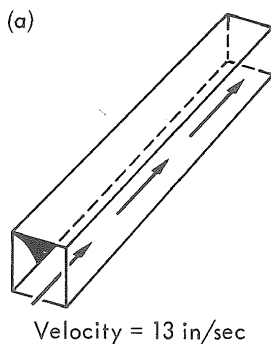
The current in a river is measured at 20 mph. The velocity of the water in the river is _____.

20 mph

[25]

In a foundry, the velocity of a stream of molten metal is measured in inches per second (in/sec) or feet per second (ft/sec).

In which channel does the molten metal have the highest velocity? _____

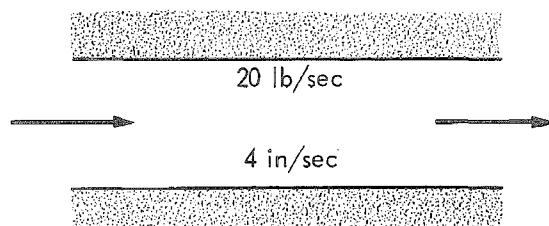


(a)

[26]

The flow rate of molten metal in this channel is _____.

The velocity of the molten metal stream in this channel is _____.

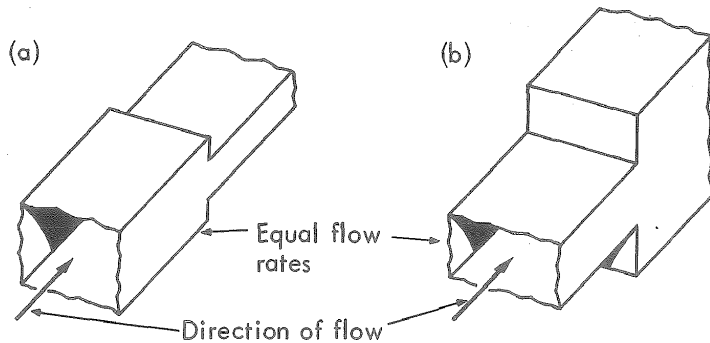


20 lb/sec
4 in/sec

[27]

The law of continuity states that the velocity of a stream is increased as it enters a smaller channel.

In which illustration will the velocity of the stream be increased? _____

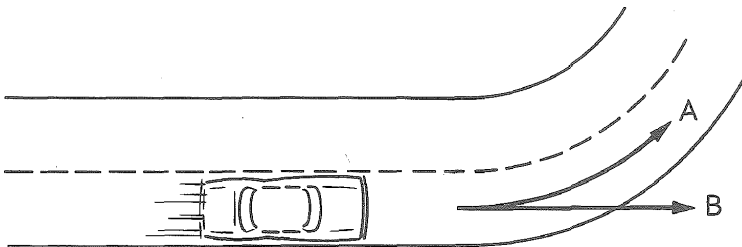


(a)

[28]

Newton's first law of motion states another characteristic of fluid flow, that an object (or fluid) in motion remains in motion in a straight line and at the same speed until some other force is exerted on it to change its speed or direction.

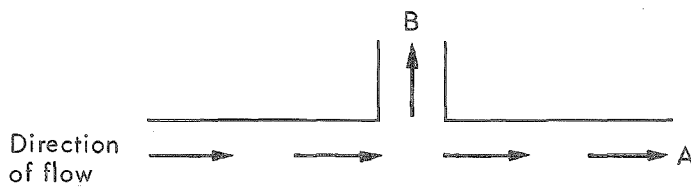
We encounter this law every time we drive a car. In which direction will the car have a tendency to go? _____



B

[29]

The same law applies to a flowing liquid. In which direction does the stream of liquid have a tendency to flow? _____

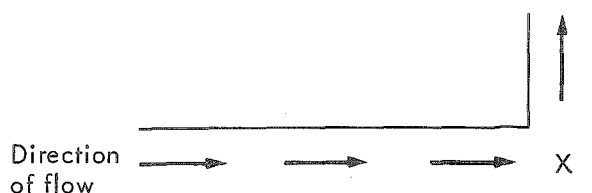


A

[30]

Any sudden or sharp change in the direction or speed of flow will create turbulence.

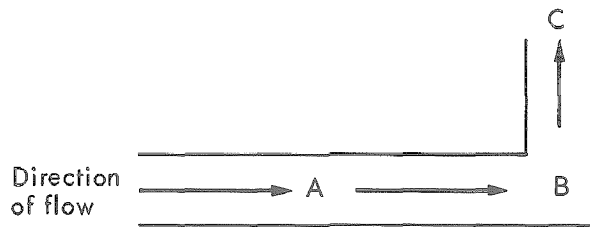
In area X the _____ and _____ of flow have been changed.



direction
speed (or speed and
direction)

[31]

In which area indicated below will the greatest amount of turbulence be located? _____

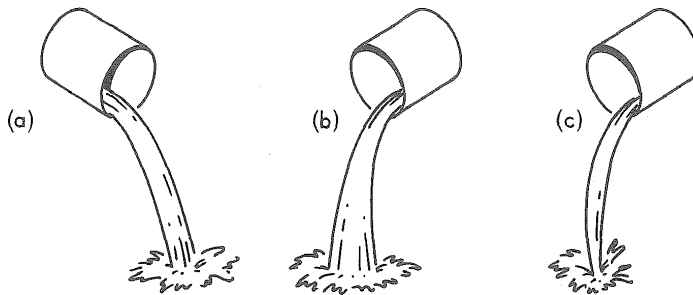


B

[32]

Velocity affects a falling stream of liquid in another way. As the velocity increases, the cross-sectional area of the stream decreases.

Which of these three falling streams of liquid is correctly drawn? _____

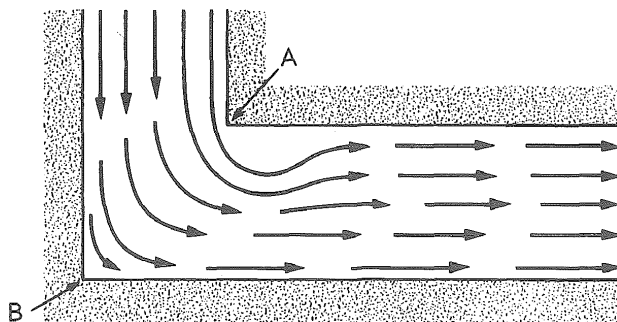


(c)

[33]

A stream of liquid flowing around a sharp corner will contract as it makes the turn. This causes the fluid to separate from the inside corner and create a low-pressure air space.

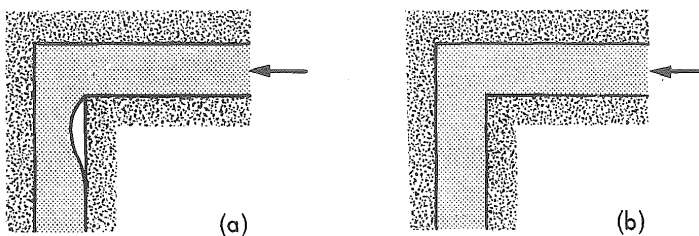
At which corner will an air space develop? _____



A

[34]

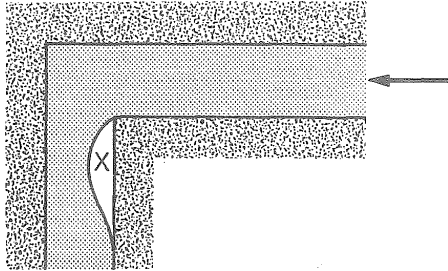
Let's consider a stream of liquid changing from horizontal to vertical flow. These illustrations show sections of a runner. Which one is correctly drawn? _____



(a)

[35]

As the stream drops over a sharp edge it separates from the wall. This separation causes a _____-pressure area to be formed at X.

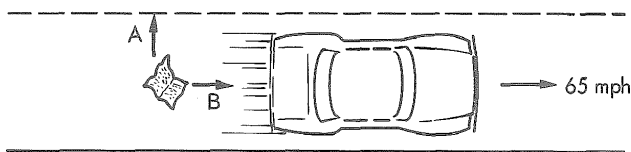


low

[36]

As the stream of metal flows past low-pressure areas, it will have a sucking action. A low pressure area can be observed behind a car moving at a reasonable speed.

In which direction will the paper move immediately after the car has passed over it? _____

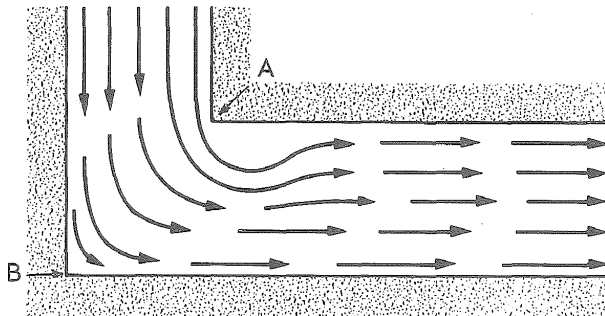


B

[37]

Molding sand is permeable; that is, it permits the passage of air or gas through it.

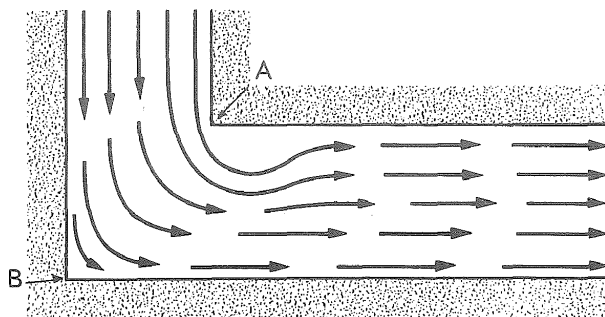
In which area will air and mold gases be drawn into the stream of molten metal? _____



A

[38]

In which corner would you expect a high-pressure area to develop? _____ (This will help force the stream to turn the corner.)

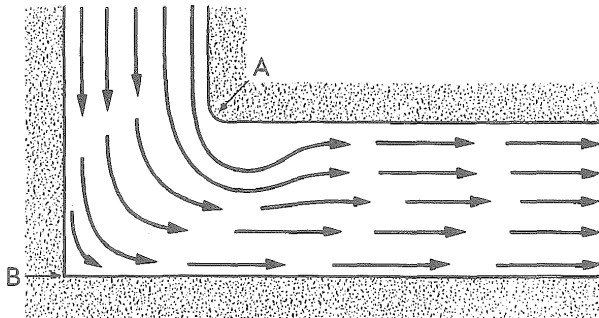


B

[39]

When molten metal turns a sharp corner, sand erosion can occur at the high-pressure point.

At what point in this illustration is sand erosion most likely to take place? _____



B

[40]

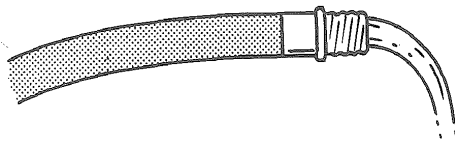
No matter whether you have a horizontal flow changing direction on the same plane, horizontal flow changing to vertical, or vertical flow changing to horizontal, the corner effects are the same. At the _____ (inside/outside) corner there will be a _____-pressure area, and air or mold gases can develop and be entrapped in the stream; at the _____ (inside/outside) corner there will be a _____-pressure area and possible sand erosion.

inside
low
outside
high

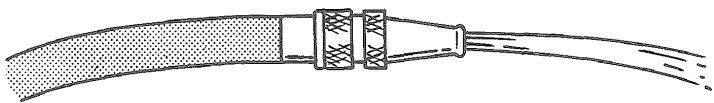
[41]

The garden hose and nozzle form a prime example of a stream of liquid flowing from a large channel to a small channel.

Without a nozzle, a stream of water traveling at a low velocity goes only a short distance before it is affected by the force of gravity.



At the same flow rate, a nozzle on the hose will cause an increase in the _____ of the stream, which, you will recall, causes severe _____.



velocity
turbulence

[42]

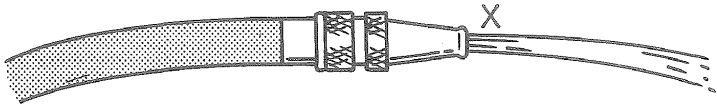
If the hose with the nozzle is placed on the ground, the high-velocity stream can cause severe erosion.

Similarly, if high-velocity inlets are attached to the mold cavity, they can cause severe _____ of the mold or core surfaces.

erosion

[43]

The area around the end of the nozzle becomes a low pressure area. If a small piece of paper were held at X it would be drawn _____ (into/away from) the stream.

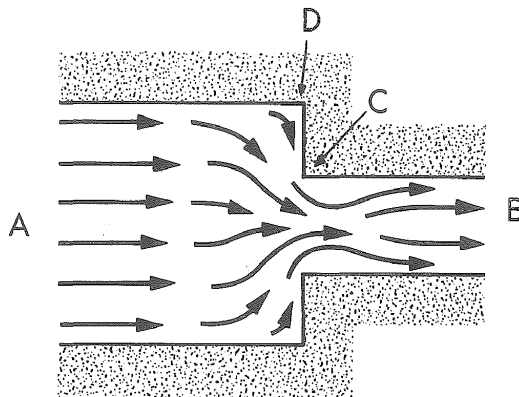


into

[44]

This same principle applies in a gating system, anywhere there is a sharp connection between a large channel and a small channel. The stream of molten metal must contract to fit the smaller channel. As it flows around the corner of the connection, it tends to pull away from the wall of the smaller channel (remember?) and form a low-pressure area.

In which channel (A or B) will the velocity of the stream of molten metal be greater? _____ In which area (C or D) will air and mold gases be most likely to be drawn into the stream of molten metal? _____

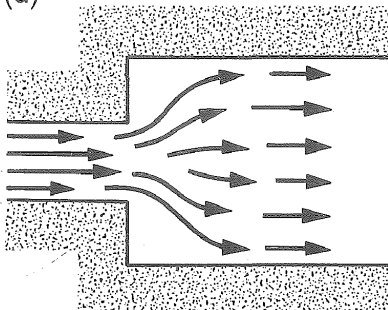
B
C

[45]

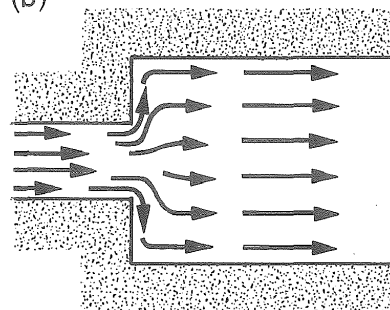
How about flow from a small channel to a larger channel? We found earlier that a fluid in motion (in this case, molten metal) tends to continue moving in a straight line until other forces change it. This causes it to pull away from the inside corner (and inside wall) of a turn.

Which flow pattern below is correct?

(a)



(b)

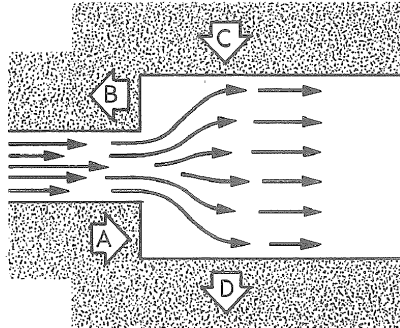


(a)

[46]

Since a fluid tends to pull away from an inside corner, it is safe to say that a sharp increase in the size of a channel causes a _____ area to form.

In this illustration, in which directions will the mold gases in the sand next to the channel tend to move? _____ and _____



low-pressure
A, C

[47]

We know that, at a constant flow rate, a decrease in channel size means an increase in the velocity of the fluid. But when the flow is into a larger channel, the fluid doesn't need to move fast to get out of the way of the fluid behind it. Therefore it seems reasonable to say that an increase in channel size means a _____ in fluid velocity.

decrease

[48]

So now what do we know about changes in channel size? We know that at a constant flow rate:

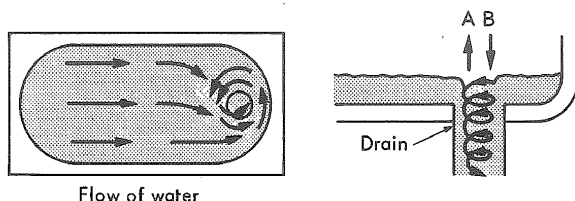
- (1) An increase in channel size means a _____ in velocity.
- (2) A decrease in channel size means an _____ in velocity.
- (3) If the change in channel size is a sharp change, no matter whether it's to a larger size or a smaller size, just inside the new channel there will be a _____ - _____ area.

- (1) decrease
- (2) increase
- (3) low-pressure

[49]

You will recall that a change in the direction of flow will cause or increase turbulence. Well, a vortex is the whirlpool action of a fluid which occurs as the liquid level over a drain is decreased, drawing air down into the drain or openings. Since it constantly changes the direction of the fluid flow, a vortex causes _____.

The side view of the bathtub shows a typical development of a vortex. In which direction is air drawn, A or B? _____

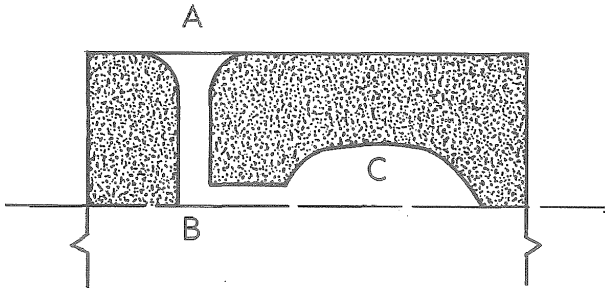


turbulence
B

[50]

In the foundry industry, the term "bathtub effect" is sometimes used to describe the vortex action in pouring basins and cups used to deliver molten metal in sprues.

In this illustration, where will a vortex be formed if precautions are not taken to prevent it? _____



A

[51]

Turbulence in the flow of molten metal causes such problems as the entrapment of dross or slag and air in the stream, erosion of mold walls, and rough casting surfaces.

True laminar flow is difficult to achieve and is seldom if ever found during the pouring of a casting. However, steps can be taken to control the amount of turbulence, thereby reducing the problems it can cause.

II THE HORIZONTAL GATING SYSTEM

[52]

Now let's find out how the basic design of the gating system can control the flow of molten metal and fill the mold cavity efficiently and with minimum turbulence.

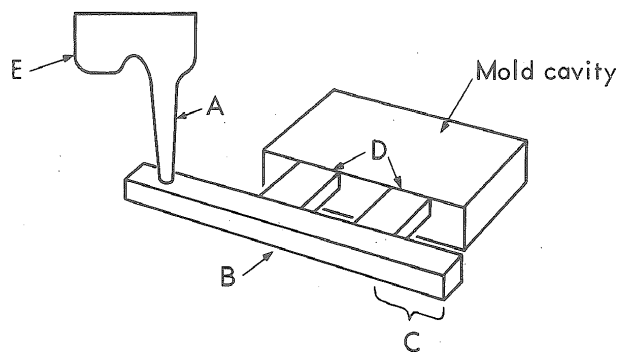
First we will identify the parts of a basic gating system, then we will study them separately to see how they help the gating system perform its function.

Although the gating system consists of several different parts, each is affected by the preceding and following parts.

[53]

This illustration shows the parts of a basic gating system. Fill in the letter that best identifies the following parts.

- (1) Sprue — A vertical passageway through which molten metal enters the runner. _____
- (2) Pouring basin — The enlarged offset portion of the mouth of the sprue into which molten metal is first poured. _____



Note: All drawings of gating system parts and casting shapes are for identification and illustrative purposes only! They are not intended to show a recommended system for a specific casting.

- (1) A
- (2) E

[54]

Referring to the illustration in the preceding frame, fill in the letters that best identify the parts of the system listed below.

- (1) Runner — The horizontal passageway through which the molten metal flows to the gates. _____
- (2) Gate — The short passageway that connects the runner to the mold cavity. _____
- (3) Runner extension — That part of the runner which extends beyond the last gate as a blind end. _____

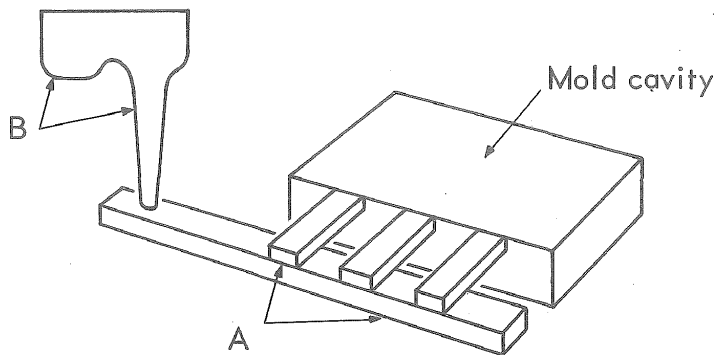
- (1) B
- (2) D
- (3) C

[55]

The gating system can be divided into vertical and horizontal components. The vertical component is made up of the pouring basin and the sprue; the horizontal component consists of the runner and the gates.

Identify the two components in this illustration.

- (1) Vertical component _____
 (2) Horizontal component _____

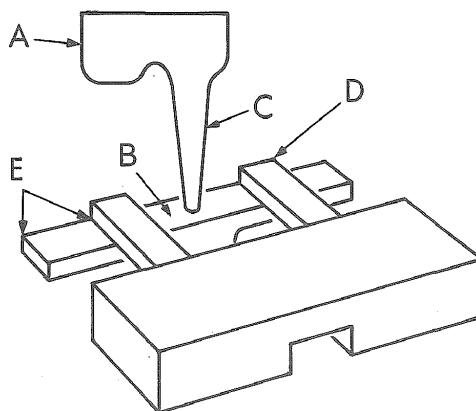


- (1) B
 (2) A

[56]

Identify the parts of this gating system.

- (1) Runner _____
 (2) Pouring basin _____
 (3) Gate _____
 (4) Sprue _____
 (5) Runner extension _____



- (1) B
 (2) A
 (3) D
 (4) C
 (5) E

[57]

When the molten metal enters the sprue, conditions should be as close as possible to those that are present when full flow has been established. It is important to establish such conditions and a full gating system as soon as possible in the pour.

We will now see how this can be done.

[58]

Proper flow conditions can be started in that part of the gating system which directs the stream of molten metal into the sprue.

The part of the gating system with which the molten metal first comes into contact is the _____.

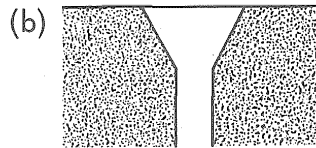
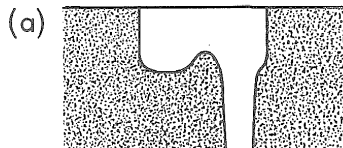
- (1) Runner
- (2) Gate
- (3) Pouring basin

(3) Pouring basin

[59]

The figures below represent a pouring basin (a) and a pouring cup (b). The pouring cup is most commonly used because it is economical and easy to mold. However, the pouring cup has several disadvantages.

In which example is the pourer most likely to pour directly down the sprue? _____

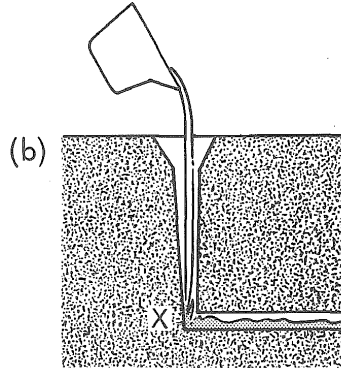
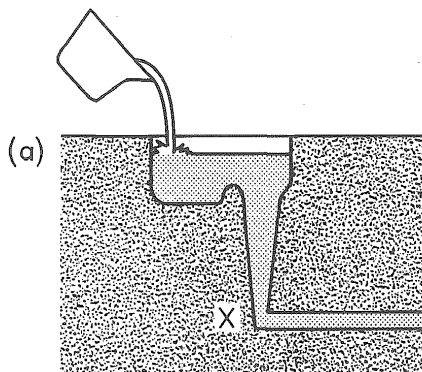


(b)

[60]

You recall the effect of gravity on a poured fluid, such as molten metal; the further the stream falls, the greater its velocity.

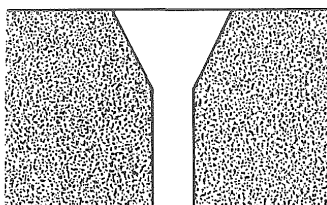
In which case will the stream have the greatest velocity at point X? _____



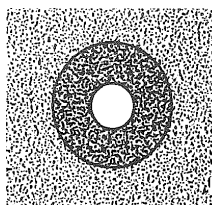
(b)

[61]

The velocity would be decreased if the pourer were to direct the stream of molten metal onto the surface of the pouring cup, but the shape of the cup encourages the formation of a vortex. And we know that, in the pouring of a casting, a deep vortex is just what we _____ (want/don't want).



Side view



Top view

don't want

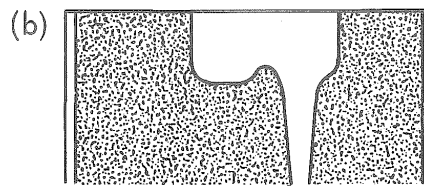
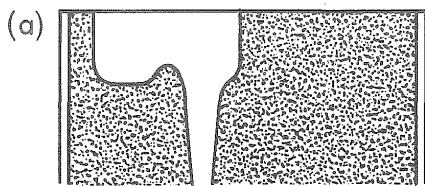
[62]

Let's see how the proper design, location, and use of the pouring basin can aid in establishing the proper flow of molten metal early in the pour.

[63]

The closer the lip of the ladle or crucible is kept to the pouring basin, the less chance there is for severe turbulence in the pouring basin.

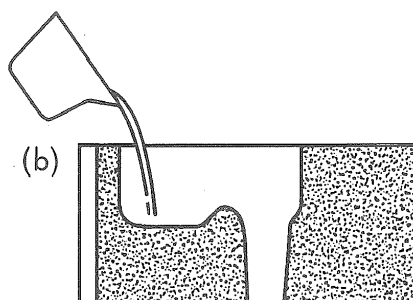
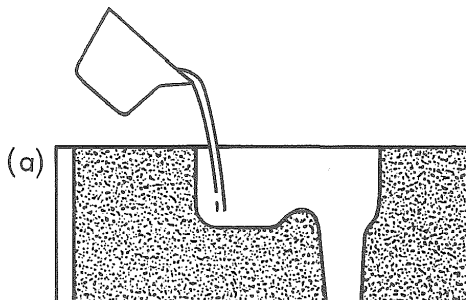
Assume that you are about to pour from a full ladle. In which example below would you have the least space between the lip of the ladle and the pouring basin? _____



(a)

[64]

Other conditions being equal, in which pouring basin will the falling stream of molten metal create the least turbulence? _____

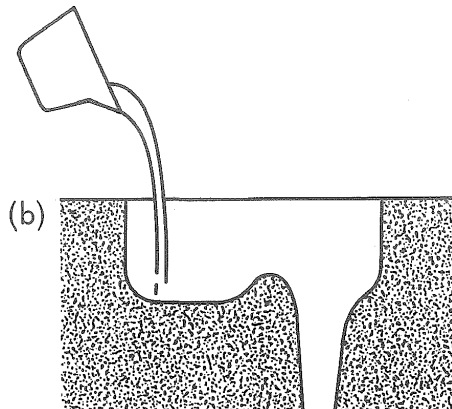
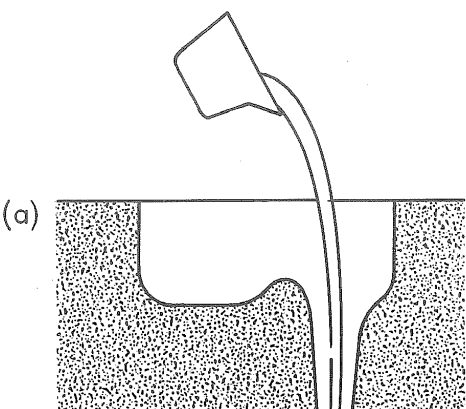


(b)

[65]

Molten metal should be poured into the section of the pouring basin away from the sprue. This buildup of molten metal will aid in rapid filling of the sprue and reduce the chances of a vortex forming over the sprue.

In which example will the pouring basin aid in settling up the proper flow conditions? _____

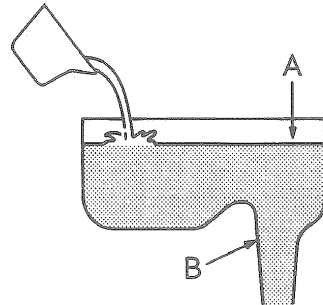


(b)

[66]

Slag and dross are lighter than molten metal and so will float on the surface. Therefore, if the pouring basin is properly filled, slag and dross can be kept out of the sprue.

In which area will slag and dross be found in this basin? _____

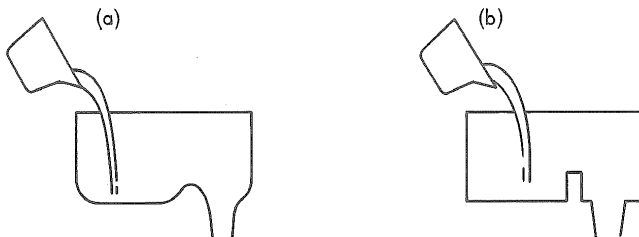


A

[67]

We have already found that a flow of molten metal will become turbulent any time it has to make a violent change in direction.

Which pouring basin will be most likely to produce a smooth flow of molten metal (and also be less prone to erosion)? _____

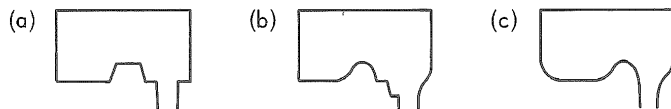


(a)

[68]

The edge of the orifice in the pouring basin should be rounded and should blend with the sprue. The rounded edge will increase the rate of flow (lb/sec), reduce or eliminate air pockets and, in sand molds, prevent the washing away of the edge.

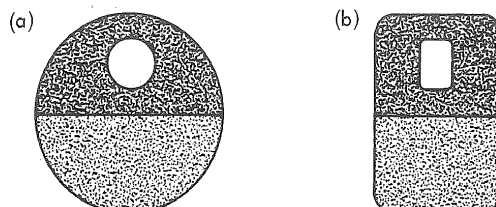
Which of these pouring basins has an orifice that is correctly designed for efficient flow? _____



(c)

[69]

The shape of the pouring basin can aid in the prevention of vortex formation. Imagine that you are looking down into these two pouring basins from above. Which one is best designed to prevent vortex formation? _____



(b)

[70]

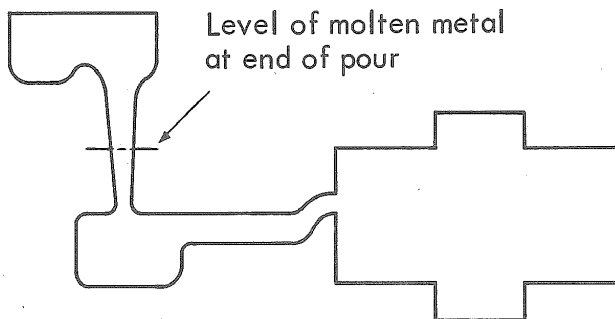
There are six points to be remembered when designing or making a pouring basin:

- (1) The basin should be large enough to permit easy control of the pouring stream.
- (2) The length and width of the basin should be the minimum dimensions consistent with (1).
- (3) The depth of the basin should be sufficient to maintain a level of molten metal at a height which will prevent vortex formation.
- (4) The edge of the orifice should blend into the sprue.
- (5) The lip of the ladle or crucible should be kept as close as possible to the pouring basin.
- (6) The molten metal should be poured into the pouring basin as uniformly and as rapidly as possible, and without being spilled.

[71]

The term "pouring short" means that, at the end of the pour, the mold and the gating system are not completely full of molten metal. That is, pouring was stopped too soon.

Check the figure carefully. As a result of this pouring, the mold cavity will be _____ (completely/partially) filled.

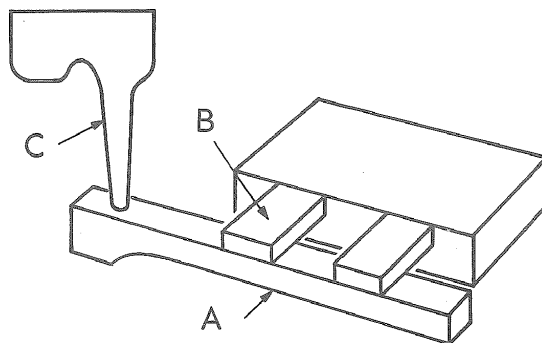


partially

[72]

As the molten metal leaves the pouring basin it enters the sprue.

Which part of this gating system is the sprue? _____

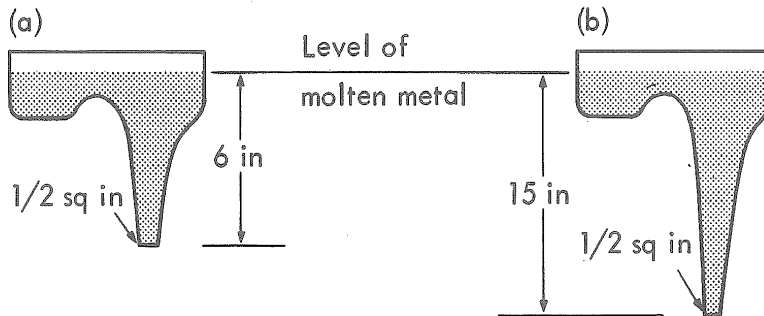


C

[73]

The flow of molten metal and the effects of the flow can be controlled through proper sprue design.

In which one of the sprues shown will the stream of molten metal have the lower velocity (and therefore the least turbulence) at the outlet? _____

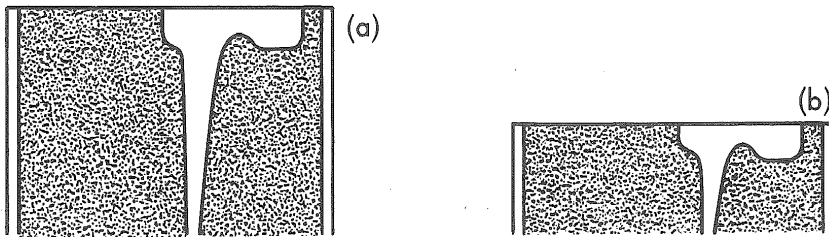


(a)

[74]

The height of the sprue is mainly determined by the height of the part that contains it (and which will be identified later).

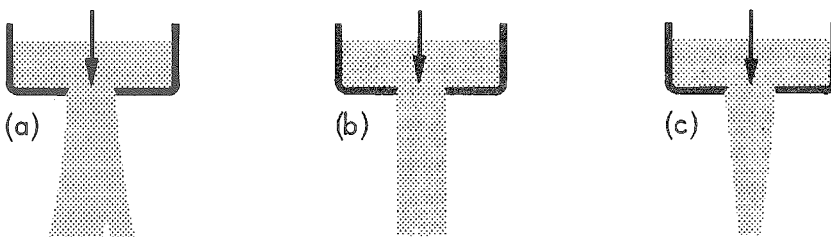
Assuming that both parts can be used on the same mold, which would give the lowest velocity at the outlet of the sprue? _____



(b)

[75]

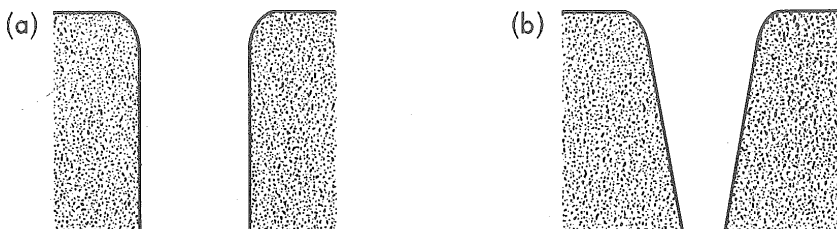
In free fall, before the system is filled, which shape does the stream of molten metal form? _____



(c)

[76]

So in which case shown below will the falling stream of molten metal remain in contact with the walls of the sprue? _____

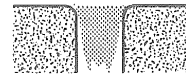
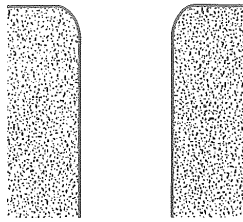


(b)

Note: For frames 76 through 81, assume that sprues are attached to full pouring basins.

[77]

Sketch the shape of fluid flow in this sprue.



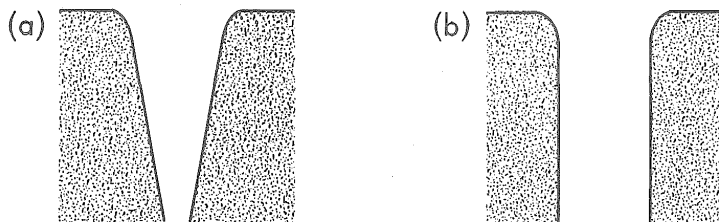
[78]

If the falling stream of fluid remains in close contact with the sprue walls, instead of pulling away from them, a low-pressure area _____ (will/will not) be formed.

will not

[79]

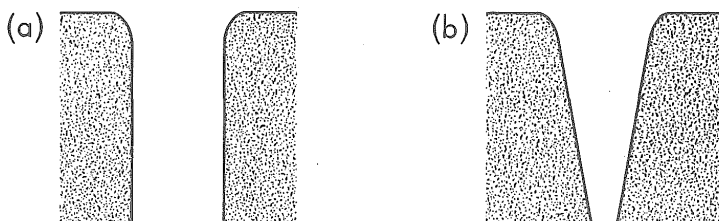
Which shape of sprue practically eliminates the chance that air and mold gases will be drawn into the stream through the sprue walls? _____



(a)

[80]

The sprue should be completely filled with molten metal as quickly as possible. Compare the sizes of the two sprues shown. Assuming equal pouring rates, which sprue will be filled in the least time? _____

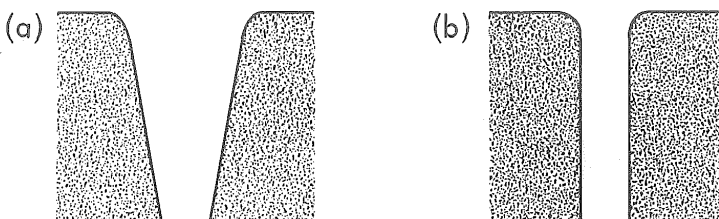


(b)

[81]

Another advantage to the tapered sprue is that, assuming a tapered sprue and a straight sprue with exits the same size, the flow rate through the tapered sprue is 15% greater than the flow rate through the straight sprue.

With equal exit areas in both sprues, which sprue will have the greater flow rate? _____



(a)

[82]

Since the flow rate through a tapered sprue is 15% greater than the flow rate through a straight sprue of equal exit area, we can reduce the height of the tapered sprue by 15% and still have the same flow rate as the straight sprue.

[83]

If we reduce the height of the sprue, we can pour the molten metal from a point lower than before. This means that the fluid will fall at a slower _____ than it would from a greater height, and will create less _____ as it passes through the sprue outlet.

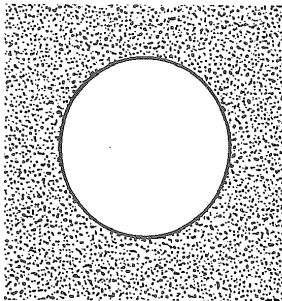
velocity
turbulence

[84]

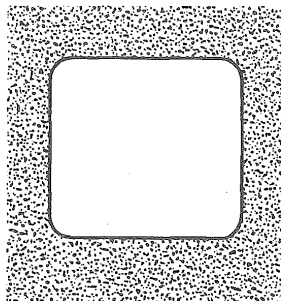
We mentioned earlier that the shape of a pouring basin could help prevent the formation of a vortex. Likewise, the cross-sectional shape of the sprue can help prevent vortex formation.

Imagine three sprues whose respective cross sections are shown below. In which one would a vortex be least likely to form? _____

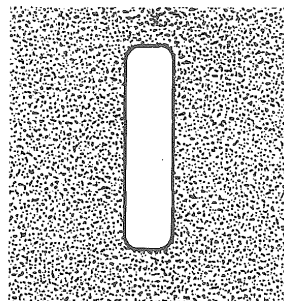
(a)



(b)



(c)



(c)

[85]

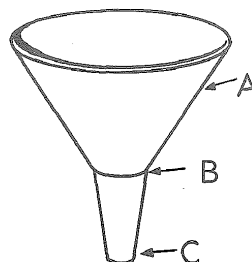
No matter what the cross section of a sprue may be, the corners of the sprue outlet should be rounded, primarily to keep the sand of the mold from breaking away. However, it also reduces the _____ that occurs when a fluid changes direction or velocity quickly.

turbulence

[86]

We all have used a funnel at one time or another. If we pour more liquid into the funnel than the end of the spout is able to discharge, the funnel will fill and then overflow. Thus the area of the spout opening controls both the flow rate and the pouring rate.

Which part of this funnel has final control over the flow rate and the pouring rate? _____

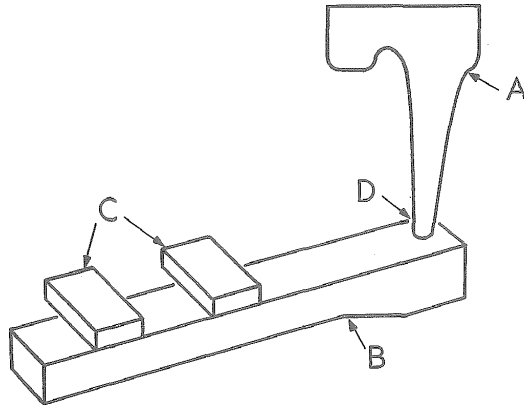


C

[87]

When the height of molten metal is held constant, the opening at the bottom of a tapered sprue determines the flow rate. This opening is referred to as a "choke," and it has the smallest cross-sectional area in the gating system.

Where in this gating system is the "choke" located? _____



D

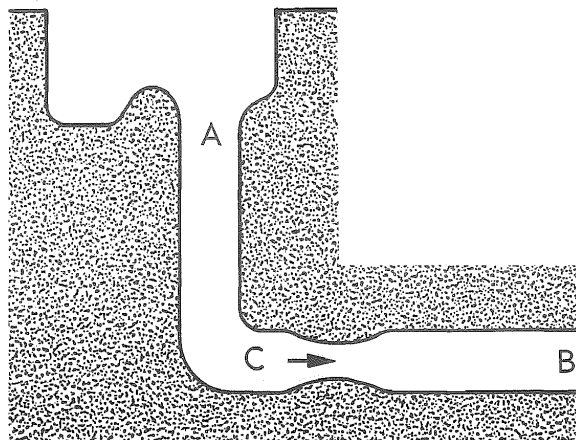
[88]

To make pattern making and production molding easier and more economical, a straight sprue is very often used. In this case, the choke should be placed as close to the base of the sprue as possible, so that:

- (1) The sprue may be filled as quickly as possible and kept filled during pouring.
- (2) The turbulence created by the choke may have a chance to subside, and the molten metal may approach laminar flow in the runner before it enters the gates and the mold cavity.
- (3) The lower velocities in the runner may have a chance to float dross and slag to the top surface of the runner.
- (4) Sand erosion in the runner may be minimized.

[89]

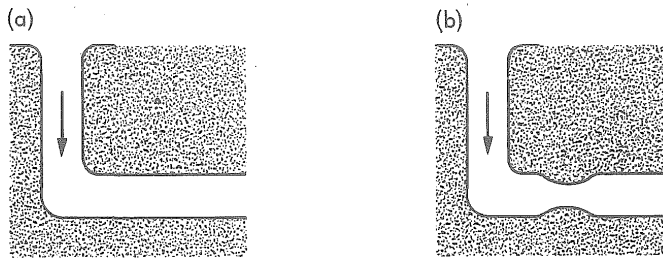
Which letter indicates the section of the gating system that will establish the flow rate? _____



C

[90]

Which sprue will be the easier to keep filled during pouring? _____



[91]

You will recall that the part of a gating system that has the smallest area and determines the flow rate in the system is called a _____.

(b)

choke

[92]

A decrease in the size of a channel means an _____ in the velocity of flow. Therefore, just as a fluid is passing through the choke, its velocity will _____.

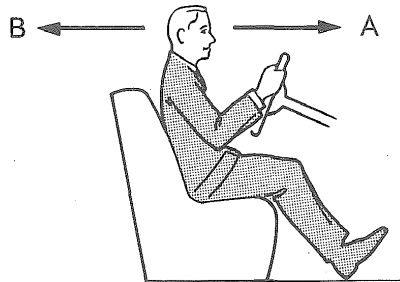
increase
increase

[93]

As it leaves the sprue, the molten metal travels at its greatest velocity and develops its maximum kinetic energy.

We know that an object in motion tends to remain in motion in the same direction and at the same velocity. Well, kinetic energy is the energy associated with that motion.

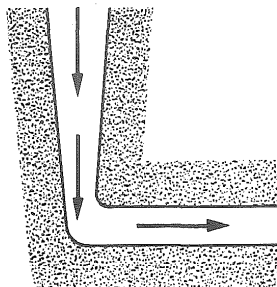
Imagine that the man in the illustration is riding in a car that is moving swiftly forward and comes to a sudden stop. His kinetic energy, the energy associated with his motion, will cause him to move in direction _____.



A

[94]

Kinetic energy in the stream of molten metal tends to keep it flowing in one direction and at the same velocity. In the sprue base this direction of flow is abruptly changed. Any abrupt change in direction of flow causes severe _____ in the stream.

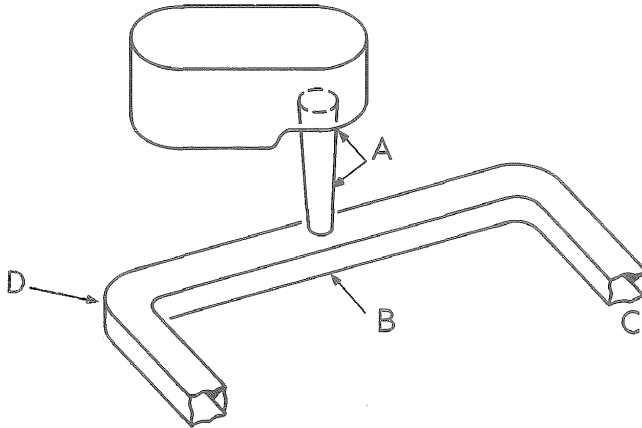


turbulence

[95]

We should absorb the kinetic energy of the molten metal by reducing its velocity and turbulence in the sprue base, before it enters the runner(s).

In which section of this gating system should the kinetic energy be absorbed? _____



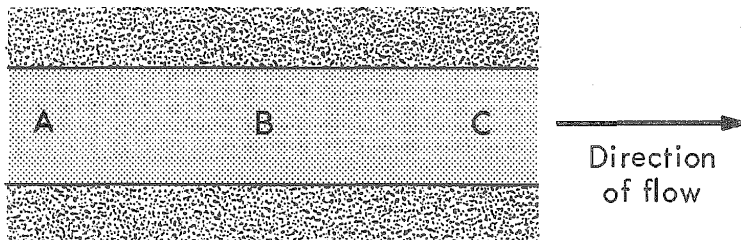
B

[96]

Kinetic energy can be absorbed partly by friction at the walls of the base and partly by internal friction.

Friction is resistance to movement, and energy must be used to overcome it.

At which point in this channel will the kinetic energy be the lowest due to the effect of friction at the walls? _____

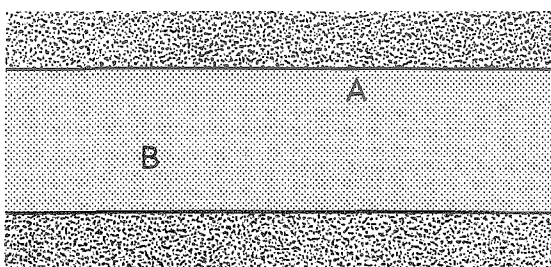


C

[97]

In addition to frictional loss at the wall surfaces there is an internal frictional loss, which occurs within the stream of molten metal. Frictional loss at the walls is greater than that resulting from internal friction.

At which point in this stream of molten metal are friction losses the greater? _____



A

[98]

The greater the surface area (walls, bottom, top) of a container, the _____ (more/less) friction there will be between the container and the fluid in it.

more

[99]

And the more friction there is between the container and the fluid, the _____ (more/less) velocity and kinetic energy the fluid will lose.

more

[100]

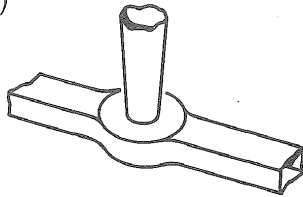
So, if we increase the size (surface area and cross-sectional area) of a sprue base, the velocity of the molten metal (and thus its kinetic energy) will be _____ (increased/decreased).

decreased

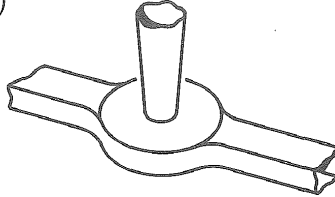
[101]

Both sprues are the same size. In which sprue base will the kinetic energy loss be greater? _____

(a)



(b)



(b)

[102]

The kinetic energy of a fluid is associated with its velocity, so if we decrease the kinetic energy, we _____ (increase/decrease) the velocity.

decrease

[103]

The more room a fluid has in which to change direction, the _____ (more/less) abrupt that change will be.

less

[104]

We know that turbulence is related to both velocity and direction change, so if we decrease either or both of these factors, we also decrease _____.

turbulence

[105]

And since turbulence causes entrapment of air and dross in the stream of molten metal, a decrease in turbulence means a _____ in entrapment.

decrease

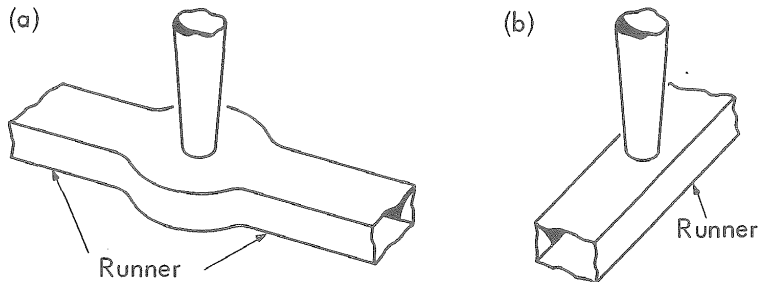
[106]

To sum up, we can decrease the velocity, kinetic energy, and turbulence of the molten metal, and the entrapment of air and dross in the stream, all by _____ the area of the sprue base.

increasing

[107]

Therefore, which sprue base will produce a smoother flow in the runner(s)? _____

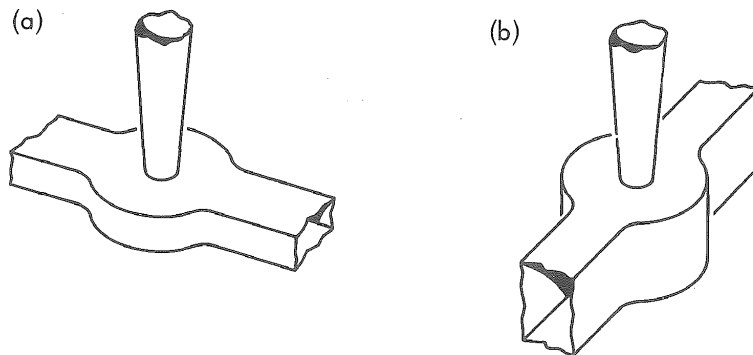


(a)

[108]

There are two basic types of sprue bases that greatly aid in reducing turbulence. One of these bases was seen in a previous frame and is called an "enlargement" base. The "enlargement" base is most effective when used with narrow, deep runners.

In which example is the enlargement base properly used? _____

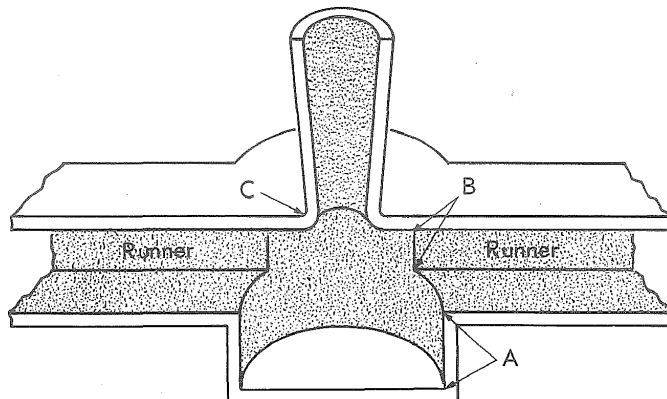


(b)

[109]

The second type of sprue base is called a "well base." The well is an extension of the enlargement below the base of the runner.

Which letter identifies the well? _____



A

[110]

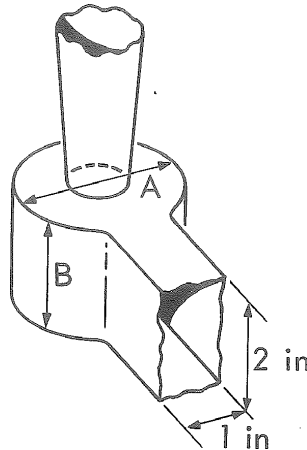
The diameter of an enlargement base should be approximately two and a half ($2\frac{1}{2}$) times the width of the runner. That is, if the width of the runner is 1 in., the diameter of the enlargement base should be ____ in. If the width of the runner is 2 in., the diameter of the enlargement base should be ____ in.

$2\frac{1}{2}$
5

[111]

The depth of the enlargement base is the same as the depth of the runner. So if the runner were $1\frac{1}{2}$ in. deep, the enlargement base would be ____ deep.

In the example shown, what would be the dimension at A ____? B ____?



$1\frac{1}{2}$ in.
 $2\frac{1}{2}$ in.
2 in.

[Note: A = the diameter of the enlargement.]

[112]

An enlargement base is as deep as the runner leading off from it. A well base, on the other hand, is twice as deep as the runner. So if the runner is $\frac{3}{4}$ in. deep, the well base will be ____ deep.

$1\frac{1}{2}$ in.

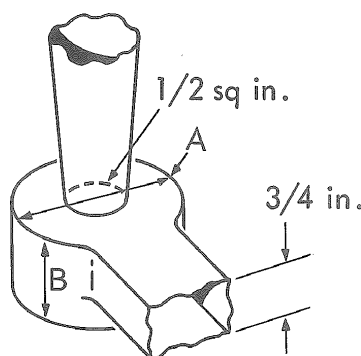
[113]

As far as the other dimension of a well base is concerned, we don't measure it by diameter. Instead, we get the cross-sectional area, or the number of square inches in the top of the well. The cross-sectional area of a well base must be five times that of the sprue exit. If the sprue exit has an area of 1 sq in., for example, the cross-sectional area of the well base must be ____.

5 sq in.

[114]

In the ____ base shown, what should be the dimensions at A ____? At B ____?



well
 $2\frac{1}{2}$ sq in.
 $(\frac{1}{2} \times 5 = \frac{5}{2} = 2\frac{1}{2})$
 $1\frac{1}{2}$ in.

[Note: A = the cross-sectional area of the top and bottom surfaces of the well base.]

[115]

How about a brief review? The size of the runner to be used is 2 in. wide by 1/2 in. deep. That's pretty shallow, so we will use a(n) _____ (enlargement/well) base, which will be _____ deep.

well
1 in.

[116]

The exit of the sprue leading into the well base has an area of 3/4 sq in. What is the cross-sectional area of the base? _____

3-3/4 sq in.
 $(\frac{3}{4} \times 5 = \frac{15}{4} = 3 \frac{3}{4})$

[117]

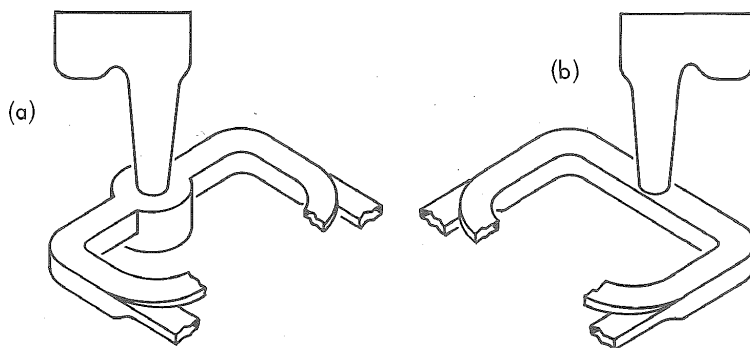
Suppose the runner is 1 in. wide and 2 in. deep. Then we would use a(n) _____ (enlargement/well) base, which would have a diameter of _____.

enlargement
2-1/2 in.

[118]

Clean-up time is the time necessary to wash trapped air or mold gases out of the gating system, and research has shown that the use of enlargement or well bases with their respective runner shapes considerably reduces the clean-up time.

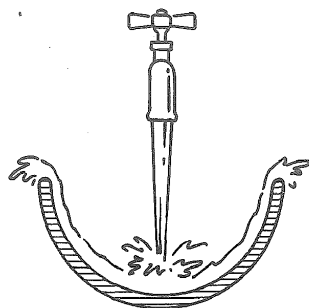
With all pouring conditions being equal, which gating system will have the faster clean-up time? _____



(a)

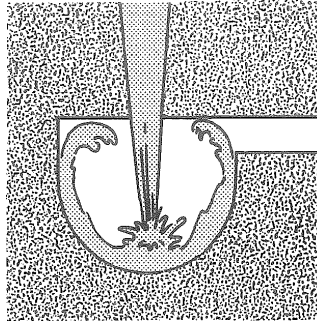
[119]

If you were to place a bowl in the shape of a perfect hemisphere of given size beneath a stream of water falling at a reasonably high velocity, the bowl would never fill. You see, the bottom of the bowl does not absorb the kinetic energy of the falling stream, but deflects the stream up the sides and out of the bowl.



[120]

Much the same thing would happen if the bottom surface of the well base in the gating system were rounded, only the top surface of the well base would force the molten metal back down into the well. The curved surface of the bottom of the well would cause severe _____.



Would this same flow pattern still exist if the gating system were full? _____

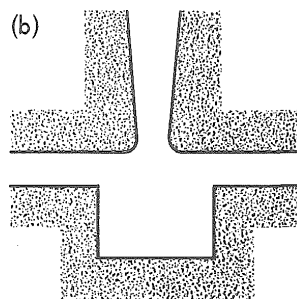
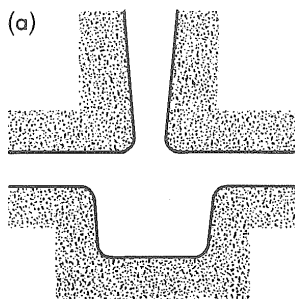
turbulence
yes

[121]

In order for the well base to do its job properly, then, the bottom surface should be flat. However, for good molding characteristics and to prevent sand erosion, the corners of the well base should be rounded slightly.

Which well base has the better design for good molding qualities? _____

From which well base will the molten metal enter the runners with the least chance of causing sand erosion? _____



(a)
(a)

[122]

As the well base fills, the molten metal acts as a cushion to absorb the impact and the kinetic energy of the falling stream.

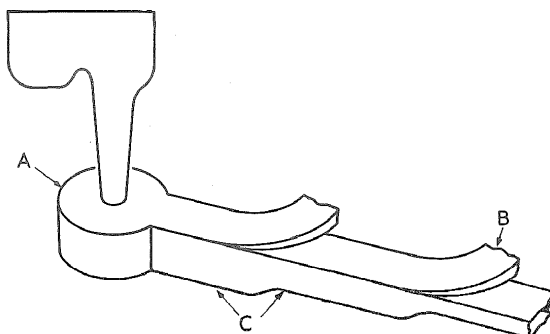
The absorption of the impact and kinetic energy of the stream reduces the _____ and _____ of the stream, and smooths the flow of metal into the runners.

velocity
turbulence

[123]

The next part of the gating system which the molten metal enters is called the runner or runners.

Which letter indicates the runner in this gating system? _____



C

[124]

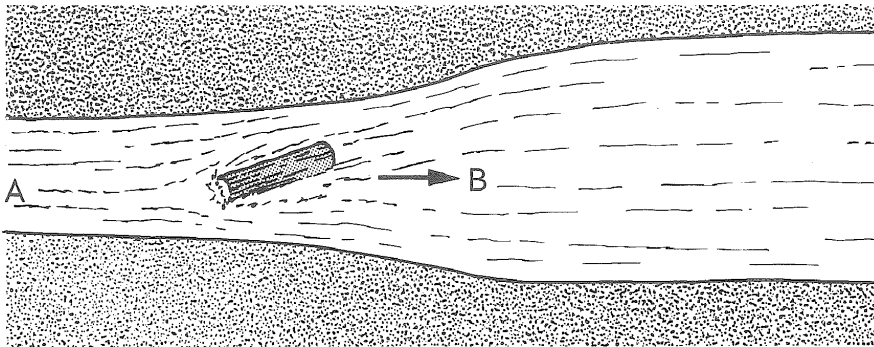
A gating system may have one or more runners, depending on the size and shape of the casting. We are going to study a two-runner system. We will examine the conditions under which the molten metal flows through the runners and the means by which the flow can be controlled. It should be remembered, however, that the same principles will apply to a system with any number of runners.

[125]

We have already discovered that, with a constant volume or flow rate, an increase in cross-sectional area, or channel size, will cause a decrease in velocity. This can be easily seen by watching a log float down a river.

With the volume or flow rate constant, in which section will the log move the slowest? _____

In which section of the river will the velocity of the water be the slowest? _____

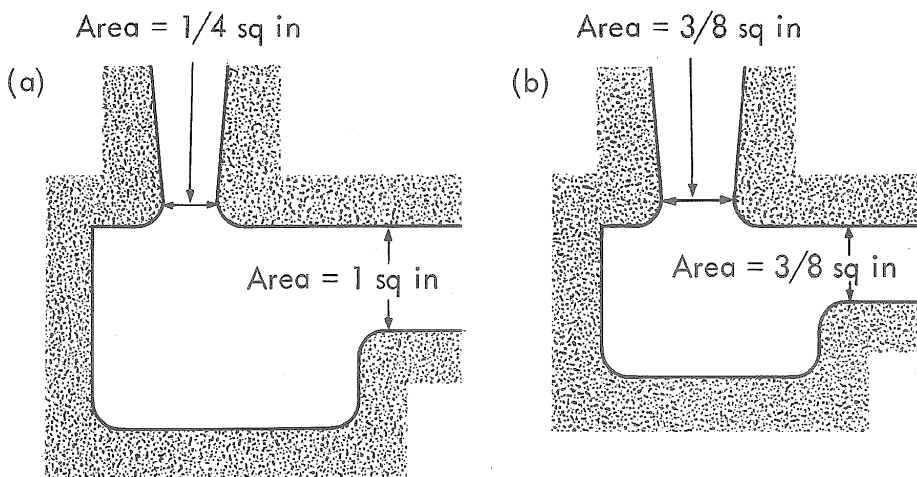


B
B

[126]

Assume that frictional losses and other conditions are equal. In which example will the velocity of the molten metal stream be reduced as it enters the runners? _____

Which sprue exit will allow passage of the larger volume of metal? _____

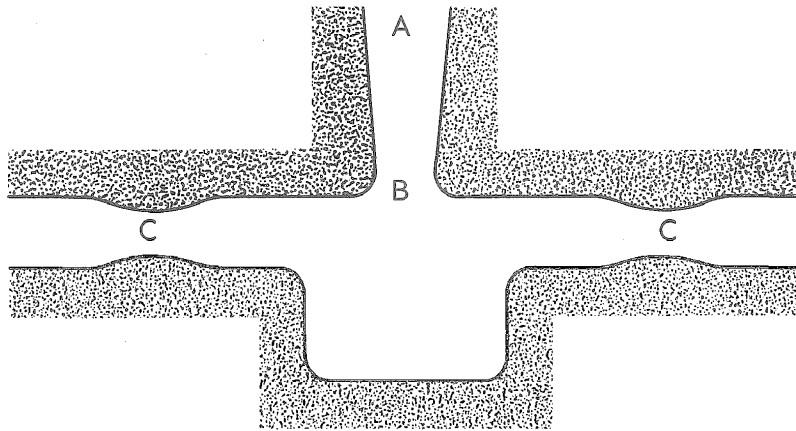


(a)
(b)

[127]

To appreciably reduce velocity in the runners, the cross-sectional area of the runners must be greater than that of the outlet of a tapered sprue or the choke in the gating system.

To reduce velocity in the runners shown here, the total cross-sectional area of the runners must be larger than that at the point(s) indicated by the letter _____.



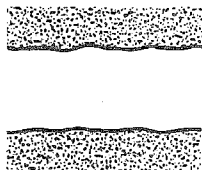
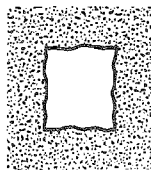
C

[128]

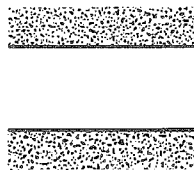
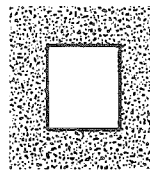
We know that an increase in velocity or a change in direction of flow can cause turbulence. A glance at a brook will show that a rough surface causes turbulence, also. Therefore the inner walls of a runner should be as _____ as possible.

The walls of which of these runners will cause the least turbulence? _____

(a)

Top view
of runnerEnd
view

(b)

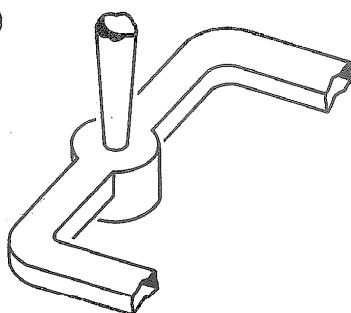
Top view
of runnerEnd
viewsmooth
(b)

[129]

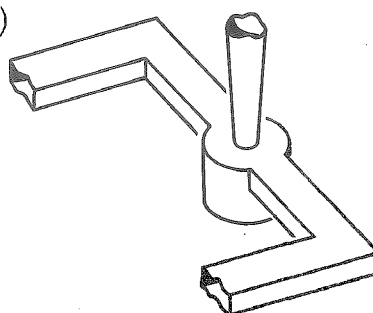
The runners should be designed to avoid any abrupt change in the direction of the flow of molten metal.

In which system will the change in direction of flow cause the least turbulence? _____

(a)



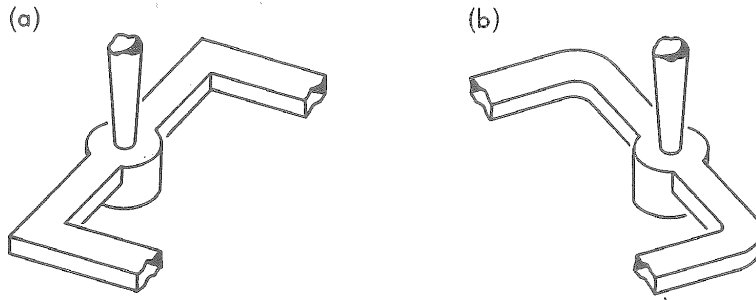
(b)



(a)

[130]

In which system will air and mold gases be most likely to be drawn into the stream due to changes in direction of flow? _____

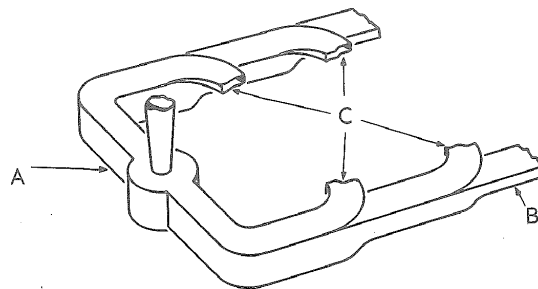


(a)

[131]

As the molten metal flows in the runners it is directed into the mold cavity through gates.

The gates in this gating system are indicated by _____.

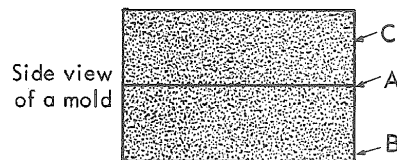


C

[132]

Before continuing, we must identify the parts of a mold. That's easy, because the mold is usually divided into just two parts: the cope, or top, and the drag, or bottom. The cope and the drag are separated by a parting line. Identify the parts of this mold:

- (1) Cope _____
 (2) Drag _____
 (3) Parting line _____

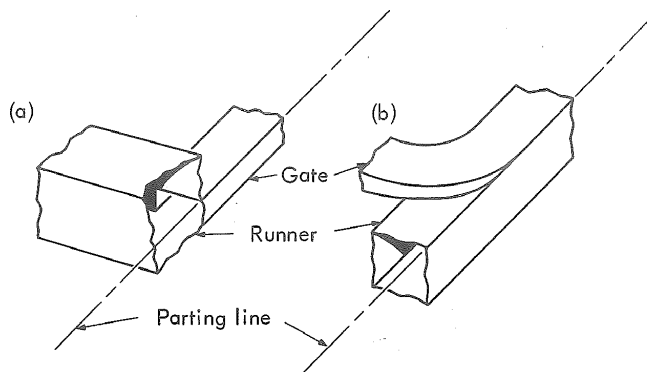


- (1) C
 (2) B
 (3) A

[133]

The runners should be filled before the gates are, and so it is best to place the runners in the drag and the gates in the cope.

In which example will the runner be filled completely before molten metal enters the mold cavity? _____

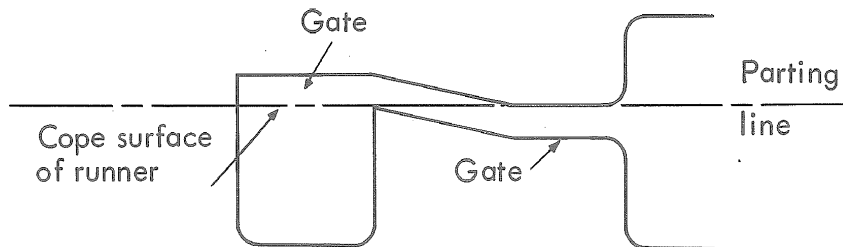


(b)

[134]

Sometimes it may not be practical to attach the gate to the cope side of the casting. When that is the case, the gate may be taken off the cope side of the runner, across the parting line, and into the drag side of the mold.

Will the runner in the illustration below be full of molten metal before the metal enters the gate? _____



Yes

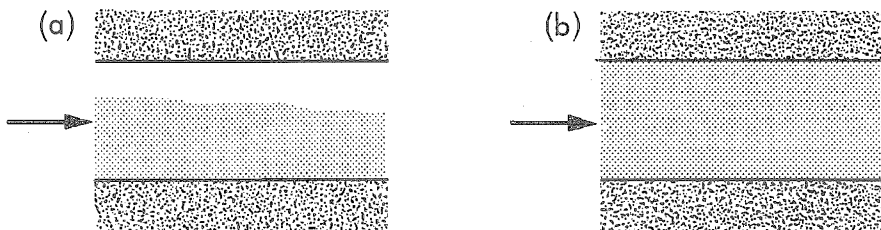
[135]

The gating system should be quickly and completely filled before any molten metal enters the mold cavity. This technique presents the following advantages.

- (1) The problem of turbulence and air entrainment is practically eliminated.
- (2) Eroded sand can be trapped in the runner system.
- (3) Oxidation of the molten metal is reduced.
- (4) Scabbing the top surface of the runner is prevented.
- (5) With velocity greatly reduced and the first gate(s) at least 6 in. from the sprue, dross and slag have a chance to float and adhere to the cope surface of the runner.
- (6) Chances for shot metal, or cold shot, are greatly reduced. (Shot metal refers to globules of molten metal that splash into the mold cavity prematurely. There they oxidize and when the mold is filled they resist fusion with the remaining metal.)

[136]

In which runner is the flow of molten metal least subject to both turbulence and air entrainment? _____ (This principle can be seen in a clear plastic garden hose.)



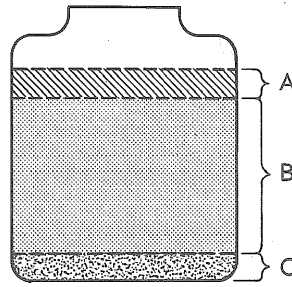
(b)

Now turn the book upside down and continue with frame 137.

[137]

Assume that a bottle of water to which sand and oil have been added is shaken violently and then allowed to stand quietly. After a period of time we find three separate layers.

Oil, being lighter than water, forms layer _____. Sand, being heavier than water, is found in layer _____.

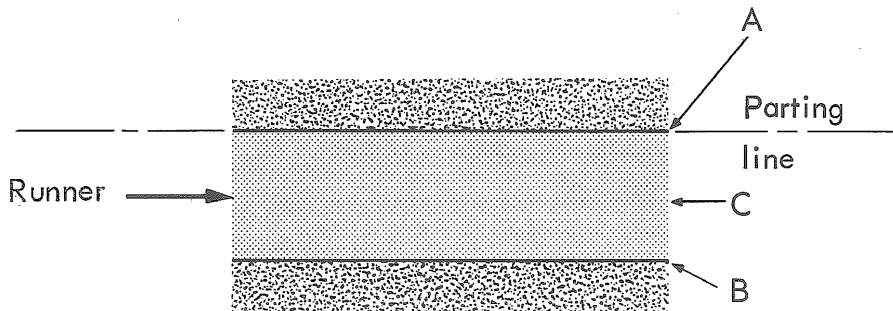


A
C

[138]

As it flows through the runners, the molten metal may slag, and may also carry particles of dross and molding sand. As the velocity of the metal decreases, so does turbulence. This allows the materials in the stream, each of which has a different specific gravity, to separate.

Dross, slag, and sand are all lighter than molten metal, and so will be found at _____.



A

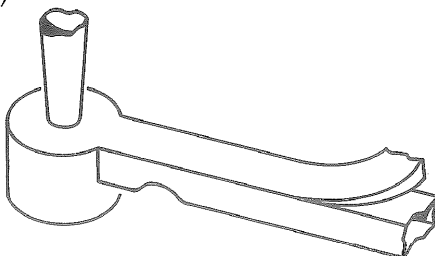
[139]

A choke located in a runner should be placed at least 6 in. ahead of the first gate. This allows time for the velocity and turbulence of the stream to be reduced before the fluid reaches the gate.

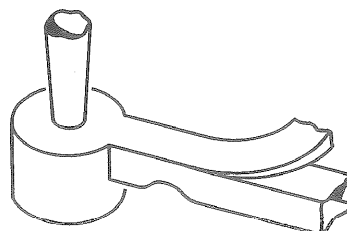
[140]

With the choke properly located in the runner, the slag, dross, and sand will have a chance to float and adhere to the cope surface of the runner as the velocity and turbulence of the stream decrease. Other conditions being equal, in which system are slag, dross, and sand least likely to enter the first gate? _____

(a)



(b)



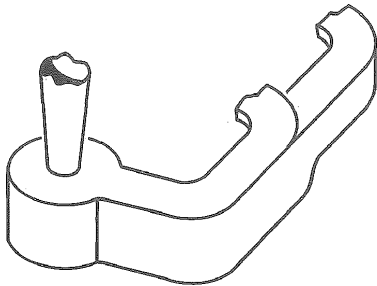
(a)

[141]

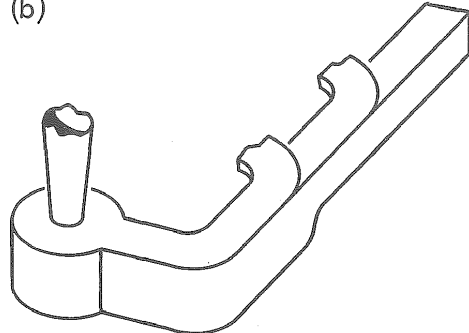
The molten metal that first enters the gating system is usually damaged by turbulence and gas aspiration. Also, this metal usually carries some loose sand grains. Runner extensions are used to prevent this metal from entering the mold cavity.

In which example will the first molten metal in the gating system not enter the mold cavity? _____

(a)



(b)

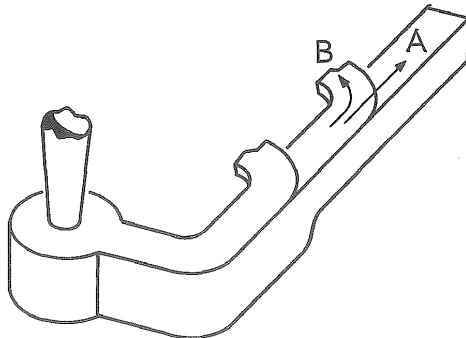


(b)

[142]

The leading edge of the molten metal stream will follow the path of least resistance.

In which direction will the leading edge of the molten metal stream flow? _____



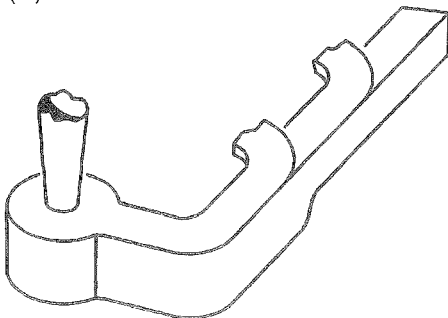
A

[143]

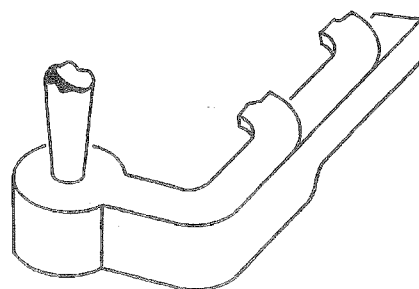
The runner extension must extend beyond the last gate far enough to prevent the backwash of damaged metal from entering the gate.

In which system is the backwash of damaged metal least likely to enter the gate? _____

(a)



(b)

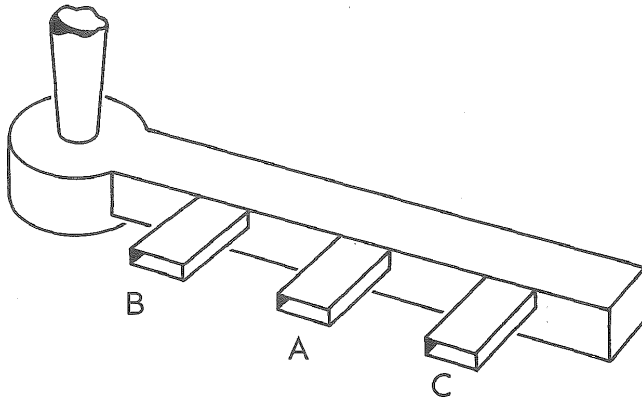


(a)

[144]

Research has shown that when multiple gates are used, the distribution of metal into the mold cavity can become uneven. Since the tendency of the stream of molten metal is to follow the path of least resistance, a large portion of the metal will flow through the last gate attached to a runner.

Through which gate will the larger portion of the metal flow?

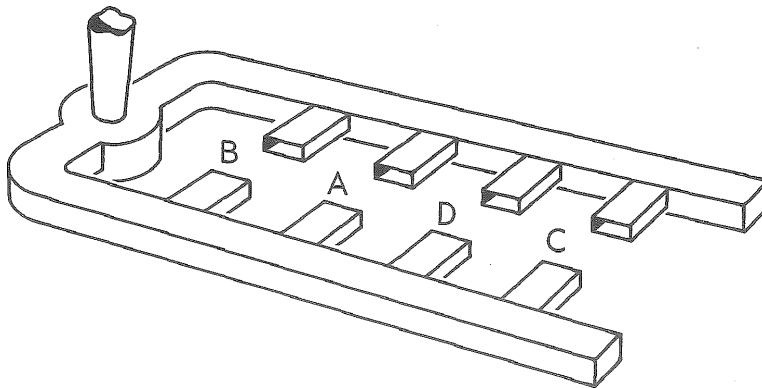


C

[145]

When the molten metal reaches the end of the runner, back pressure is created. This pressure works its way back towards the sprue base, causing molten metal to flow through the gates.

List the sets of gates in the order in which they would begin feeding molten metal into the mold cavity. _____



C D A B

[146]

Back pressure is not a problem. In fact, we will learn later on how, when properly controlled, it helps promote even distribution of metal into the mold cavity.

[147]

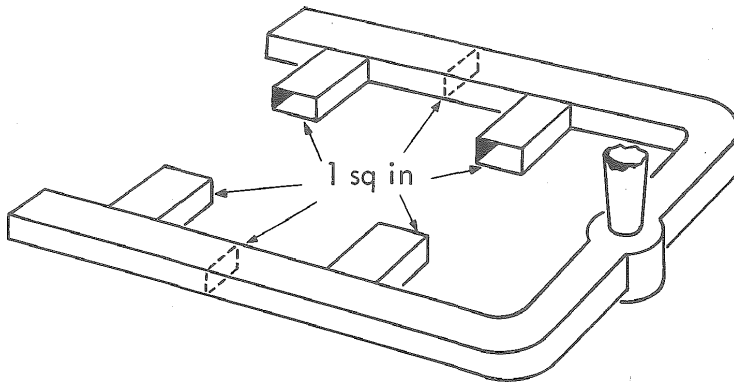
In the system shown two frames above, the gates furthest from the sprue will feed _____ (more/less) molten metal into the mold cavity than those closest to the sprue.

more

[148]

This condition will exist whenever the total cross-sectional area of the gates is greater than the cross-sectional area of the runner to which they are attached.

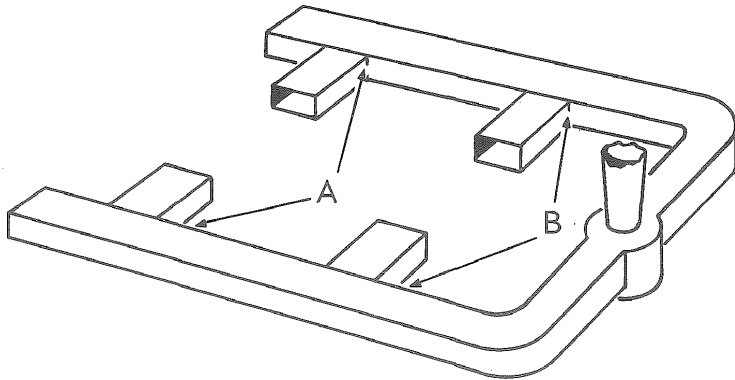
Will there be even distribution of the metal in the following gating system? _____



No

[149]

Unequal distribution is not the only problem for such a case. There is also the possibility that low-pressure areas may develop where the first set of gates are attached to the runners. In this system, at what points would the low-pressure areas be likely to occur? _____

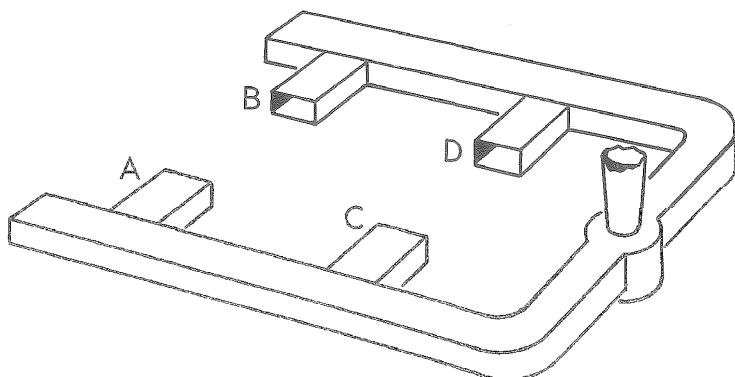


B

[150]

If the low-pressure areas exist, there is the possibility that, as the mold cavity fills, molten metal will be drawn back out of it, into the runner.

If negative pressure were created in this system, at which gates would molten metal be drawn out of the mold cavity? _____



C & D

[151]

The principle of creating a negative pressure in order to draw a liquid from one point to another is very useful in the carburetor of the gasoline engine — or when you are drinking liquid through a straw, but to have such a thing happen in the gating system during the casting of metals makes our carefully designed gates ineffective and seriously hinders the casting process.

[152]

A full gating system should flow with uniform pressure and velocity. One of the requirements for a good casting is that the molten metal must flow at a constant _____ and _____ in all parts of the runner(s) and gates.

velocity
pressure

[153]

We can maintain the flow at a constant velocity and pressure by proper use of the gating ratio, which is a proportional relationship between the cross-sectional areas of the sprue, _____, and _____ through which the metal flows.

runners
gates

[154]

You remember that the bottom part of a tapered sprue, the part that has the smallest cross-sectional area, controls the flow rate of metal into the runners and is called the _____. And you recall that when a straight sprue is used, a part of the runner near the sprue base is narrowed down for the same purpose and is called the same name, the _____.

choke
choke

[155]

So the choke may be located either at the bottom of the _____ or in the _____ near the sprue base.

sprue
runner

[156]

In working out a gating ratio, our starting point must be the part of the system that controls the flow rate of molten metal to the runners and the gates, and that part is the _____.

choke

[157]

Our gating ratio, then, is the ratio between the cross-sectional areas of the three parts of the gating system that govern the flow of metal from the sprue to the mold. These parts, in order, are the _____, the _____, and the _____.

choke
runner(s)
gates

[158]

We are going to see how the use of a gating ratio maintains a constant velocity and pressure in the runners and gates. For our study we will use a gating ratio of 1:4:4. The first number is always 1, because it represents the cross-sectional area of our starting point, the _____. The second number (4) represents the total cross-sectional area of all the runners, which in this case is four times as great as that of the _____. The third number (4) represents the total cross-sectional area of all the gates, which is also four times greater than that of our starting point, the _____.

choke
choke
choke

[159]

As you may know, there are other gating ratios used in the casting industry. We are using the 1:4:4 ratio because research has shown that this ratio is effective in achieving the goals of a good gating system.

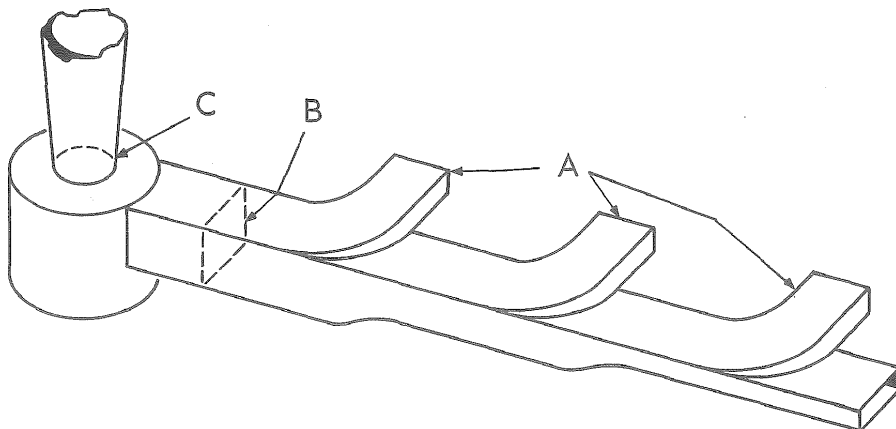
[160]

We are also going to be using the phrase "cross-sectional area" rather frequently for a while, and so will represent it by its initials, CSA. Remember, CSA will stand for _____.

cross-sectional area

[161]

Substitute the letters for the numbers and write out this gating ratio. ____:____:_____



C:B:A

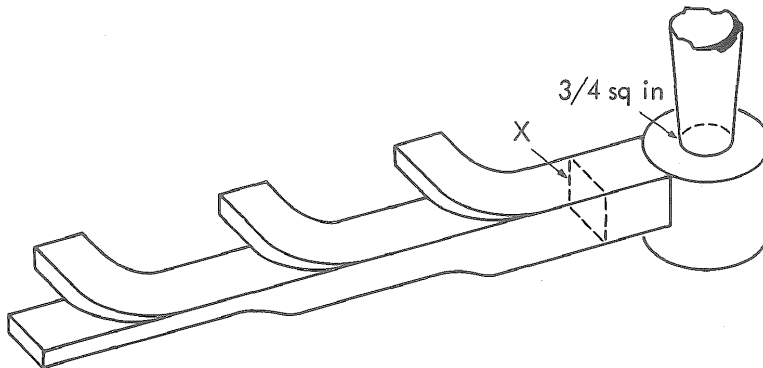
[162]

Now, using the 1:4:4 ratio, try an easy problem. The CSA of the choke is 1 sq in. The total CSA of the runner(s) is _____. The total CSA of the gates is _____.

4 sq in.
4 sq in.

[163]

Now try this. With a 1:4:4 gating ratio, what is the CSA of the runner at point X? _____

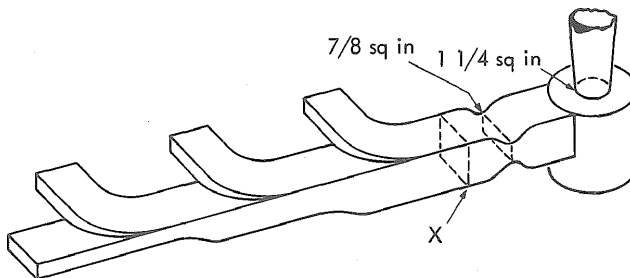


$$3 \text{ sq in.}$$

$$(4 \times \frac{3}{4} = \frac{12}{4} = 3)$$

[164]

What is the CSA of the choke in this system? _____ What is the CSA of the runner at X when a 1:4:4 gating ratio is used? _____



$$7/8 \text{ sq in.}$$

$$3-1/2 \text{ sq in.}$$

$$(4 \times \frac{7}{8} = \frac{28}{8} = 3 \frac{1}{2})$$

[165]

Until further notice, we will assume that the CSA of a runner is always measured at some point after the _____ and before the first _____.

choke
gate

[166]

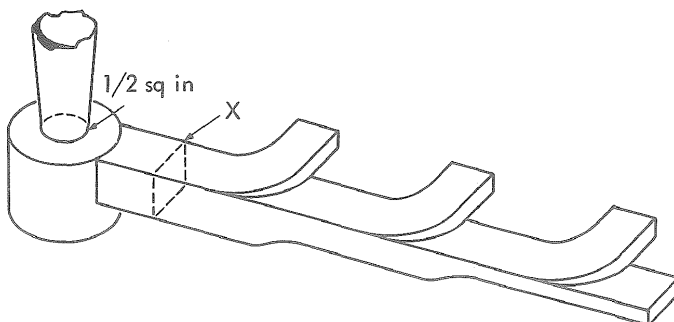
The total CSA of all gates equals the CSA of the runner at point X.

What is the total CSA of all gates in this 1:4:4 gating ratio system? _____

- A. 3 sq in. B. 4-1/2 sq in. C. 2 sq in.

What is the CSA of each individual gate? _____

- A. 2/3 sq in. B. 1 sq in. C. 3/4 sq in.



$$C. 2 \text{ sq in.}$$

$$(4 \times \frac{1}{2} = 2)$$

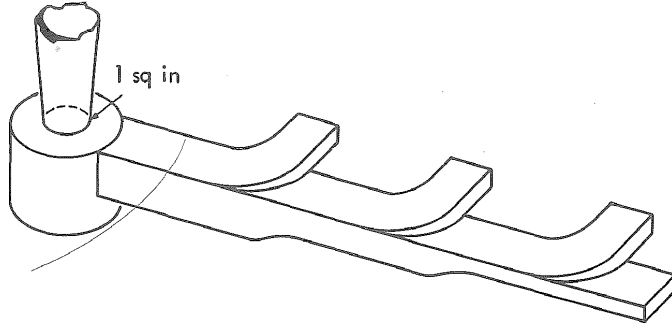
$$A. 2/3 \text{ sq in.}$$

$$(2 \div 3 = \frac{2}{3})$$

[167]

Using a 1:4:4 gating ratio, solve for the following:

- (1) CSA of runner _____
- (2) Total CSA of gates _____
- (3) CSA of individual gate _____

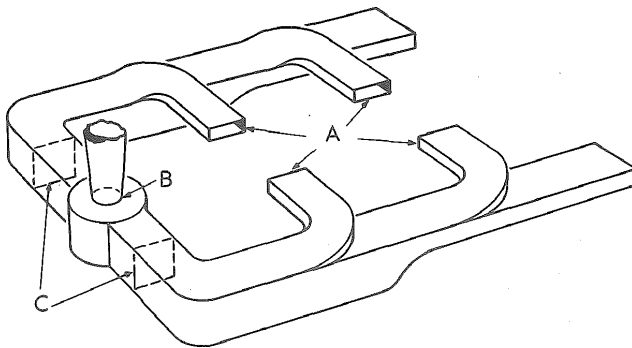


- (1) 4 sq in.
- (2) 4 sq in.
- (3) 1-1/3 sq in.

[168]

We may use this gating ratio (1:4:4) for gating systems with multiple runners.

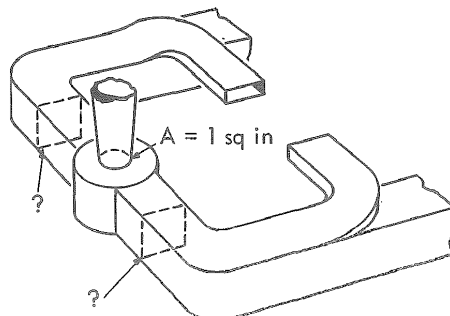
Substitute the letters for the numbers and write this gating ratio _____:_____:_____



B:C:A

[169]

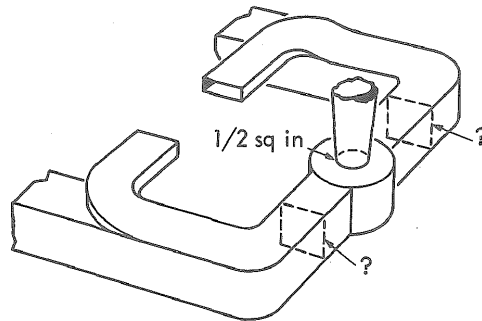
We have already established that the second number in our gating ratio represents the total CSA of all the runners in one gating system. In the system shown, therefore, our gating ratio of 1:4:4 means that the CSA of both runners together will be _____. There being two runners, the CSA of each runner will be only _____. (If this had been a three-runner system, the total CSA of the runners would have been divided by _____.)



- 4 sq in.
- 2 sq in.
- 3

[170]

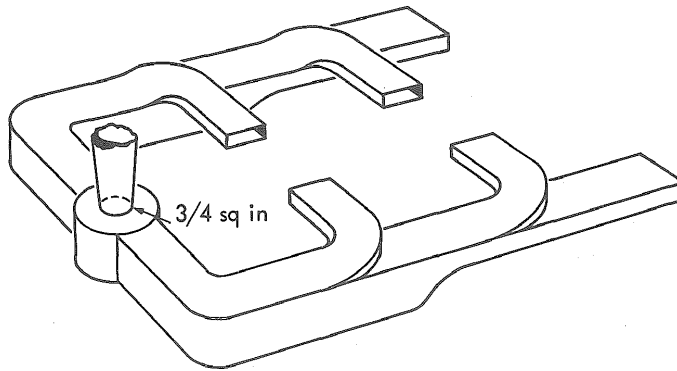
With a 1:4:4 gating ratio, the total CSA of the runner is _____, and the CSA of each runner is _____.



2 sq in.
1 sq in.

[171]

The third number in our gating ratio of 1:4:4 indicates that the total CSA of the gates is _____ times greater than the CSA of the _____.



4
choke

[172]

We might think from this that to get the CSA of each gate we need only divide the total CSA of the gates by the number of gates. But this is not true, and we will soon see why.

[173]

We get the CSA of each gate on a runner the same way we recently did for a single-runner system; we divide the CSA of the runner by the number of _____ on the runner.

gates

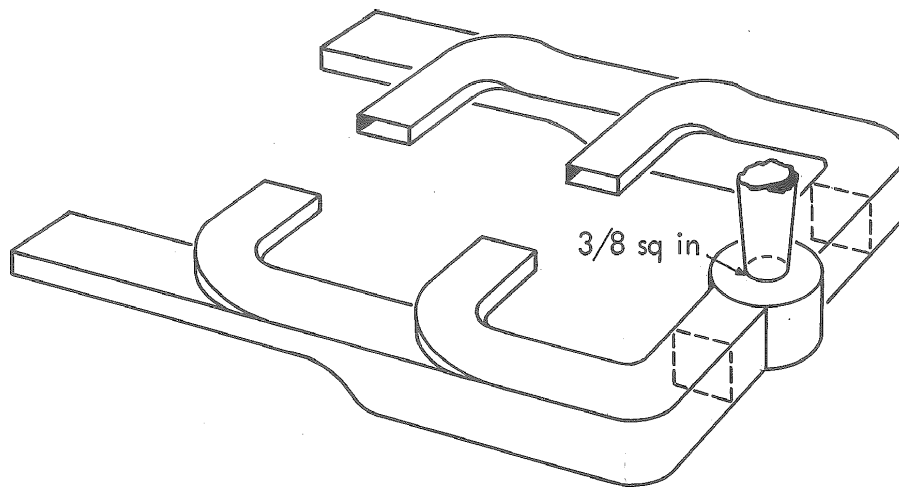
[174]

Let's start at the beginning and get the cross-sectional area of each gate in the 1:4:4 system shown here. The CSA of the choke is $3/4$ sq in. Therefore, the total CSA of the runners is _____, and the CSA of one runner is _____. Dividing this by the number of gates on one runner, we find that each gate has a CSA of _____.

3 sq in.
 $(4 \times \frac{3}{4} = \frac{12}{4} = 3)$
 $1 - 1/2$ sq in.
 $(3 \div 2 = 1 \frac{1}{2})$
 $3/4$ sq in.
 $(1 \frac{1}{2} \div 2 = \frac{3}{4})$

[175]

The Gating Ratio is 1:4:4. The CSA for each gate is _____.
 The total CSA for the gates is _____.



3/8 sq in.
 1-1/2 sq in.

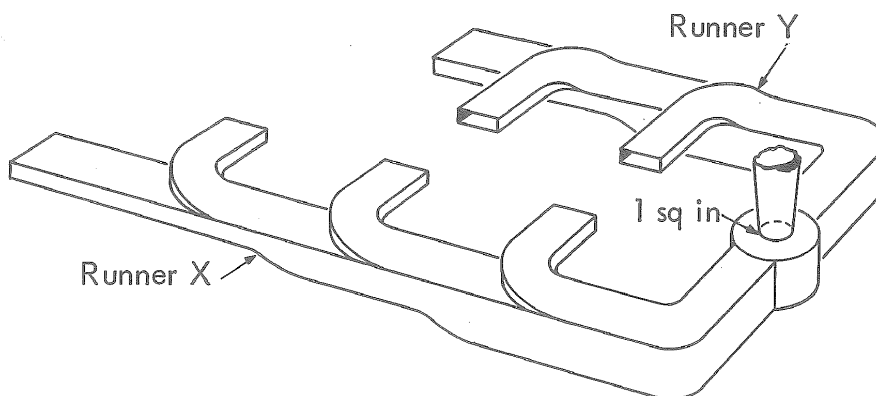
[176]

Now suppose we have a gating system with two runners and a total of five gates. The CSA of the choke is 1 sq in. and the ratio is 1:4:4, so the total CSA of the gates would be 4 sq in. If we divide this by five, we will get a CSA for each gate of $\frac{4}{5}$, or 0.8 sq in. And that is wrong.

[177]

Here is just such a system. You provide the necessary information.

- (1) Total CSA of the runners: _____
- (2) CSA of each runner: _____
- (3) CSA of gates in runner X: _____
- (4) CSA of gates in runner Y: _____



- (1) 4 sq in.
- (2) 2 sq in.
- (3) 0.66 sq in. (or $\frac{2}{3}$)
- (4) 1 sq in.

[178]

You recall that the choke may be located either at the bottom of a tapered _____ or in a runner between the sprue base and the first _____.

sprue
 gate

[179]

The large cross-sectional area of the runner between the choke and the first gate causes the velocity of the stream to _____ (increase/decrease).

decrease

[180]

Once the velocity of the stream is reduced, we want part of the stream to turn and flow through the first gate. But we know that a moving object (the stream) tends to continue moving in the same direction until some outside _____ is exerted to change it.

force

[181]

To create that outside force, we reduce the CSA of the runner just beyond the first gate. This restricts the flow of the metal somewhat, and builds up a slight back pressure. With more metal coming in behind it and a slight back pressure from up ahead, the metal at the first gate gets squeezed a little bit and tends to move to where there is no opposing pressure. So it flows _____ (where?).

through the gate

[182]

This process is repeated at each gate. That is, just beyond each gate the CSA of the runner is _____ (increased/reduced) to create a slight _____, which will cause the metal to flow through the _____.

reduced
back pressure
gate

[183]

Note that with the runner located in the drag, flow through the gates, which are in the cope, cannot start until the runner is full.

[184]

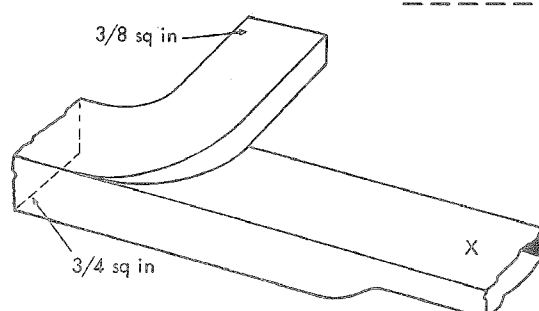
Thus the flow of metal throughout the gating system is maintained at a constant v _____ and p _____.

velocity
pressure

[185]

By how much should the CSA of the runner be reduced at each gate? Well, a gate has a certain CSA that will allow a certain rate of flow. And to maintain pressure downstream from the gate, the CSA of the runner must be reduced by an amount equal to the CSA of the gate. So we subtract the CSA of the gate from the CSA of the runner upstream from the gate. The result is the CSA of the runner after reduction.

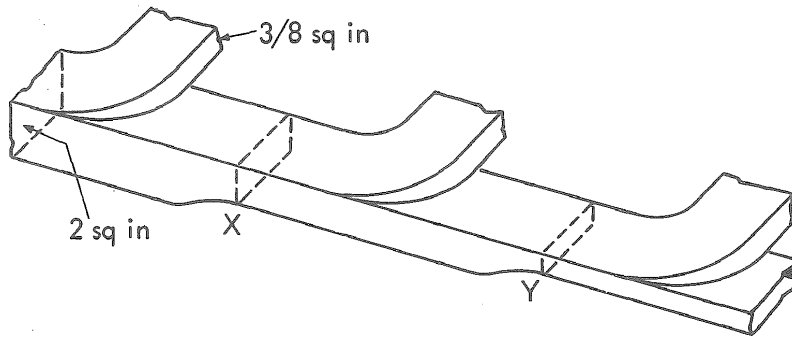
What is the CSA of this runner at X? _____



3/8 sq in.

[186]

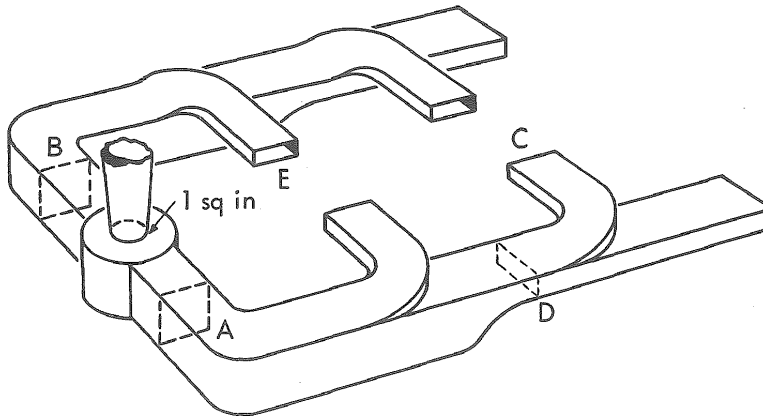
The CSA of X is _____. The CSA of Y is _____.



1-5/8 sq in.
1-1/4 sq in.

[187]

The gating ratio is 1:4:4. Solve for the CSA at: A _____, B _____, C _____, D _____, E _____.



A. 2 sq in.
B. 2 sq in.
C. 1 sq in.
D. 1 sq in.
E. 1 sq in.

Note: With this gating ratio, the CSA of the runner section on which the last gate is located is equal to the CSA of that gate.

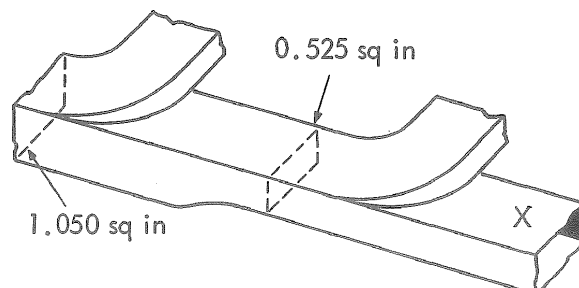
[188]

Of course, we can use decimal figures instead of fractions; in fact, in some cases we might be much better off using decimals.

[189]

The runner extension has the same CSA as the runner section in which the last gate is located.

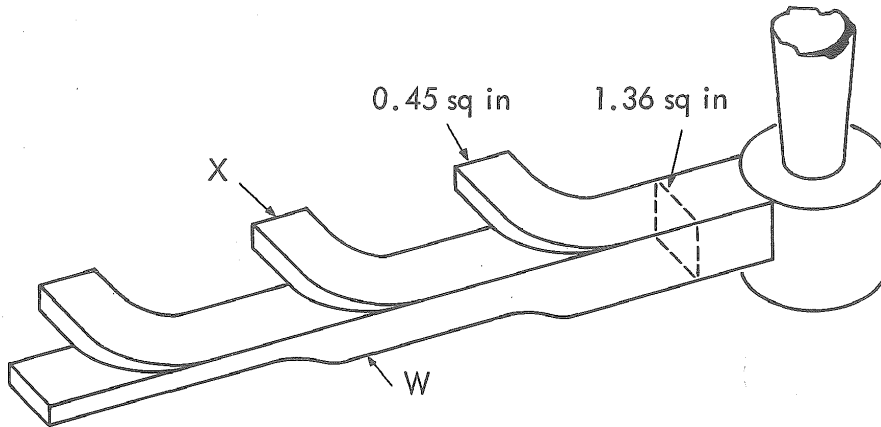
What is the CSA of the runner extension X? _____
What is the CSA of the last gate? _____



0.525 sq in.
0.525 sq in.

[190]

So far we have not paid any attention to the effect of friction in the runners and gates. It does slow down the flow of metal, however, and we must make up for it. For the gates, we figure the CSA of a gate and add 5%. For each section of the runners we figure the CSA of that section and add 5%. Try it on the system shown (G.R. 1:4:4).



The CSA of $W = 1.36 - 0.45 = 0.91$ sq in.

Five percent of 0.91 sq in. $= 0.05 \times 0.91 = 0.0455$, or 0.05 sq in.
Therefore, the CSA of W corrected for friction is $0.91 + 0.05 = 0.96$ sq in.

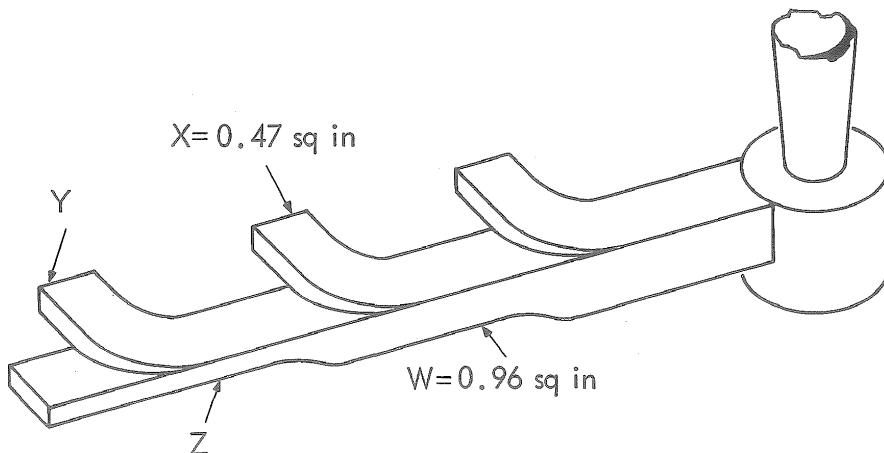
Now, the CSA of X is 0.45 sq in.

Five percent of 0.45 sq in. $= 0.05 \times 0.45 = 0.0225$, or 0.02 sq in.
Therefore, the corrected CSA of $X = 0.45 + 0.02 = 0.47$ sq in.

[191]

That's a long frame but the steps are not difficult. Now try this one, just to make sure that you got the system straight; solve for the CSA of Y and Z , adding 5% for friction loss.

To find Y , we first find the difference in CSA between the preceding runner and gate. To this we add 5%, giving Y a CSA of _____ . The CSA of Z is simply the CSA of the preceding gate plus 5%, or _____ .



0.51 sq in.

$(0.96 - 0.47 = 0.49,$
 $0.49 \times 0.05 = 0.0245,$
 $0.49 + 0.02 = 0.51)$

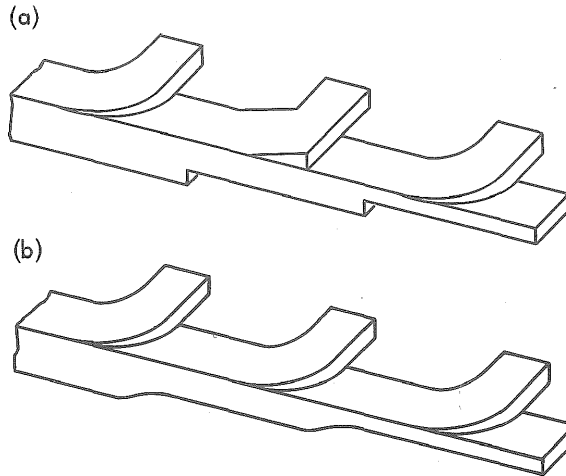
0.49 sq in.

$(0.47 \times 0.05 = 0.0235,$
 $0.47 + 0.02 = 0.49)$

[192]

All changes in cross-sectional area, and all points at which the direction of flow is changed should be provided with a generous radius. By providing these radii a less turbulent flow is maintained.

In which system will there be smoother flow? _____

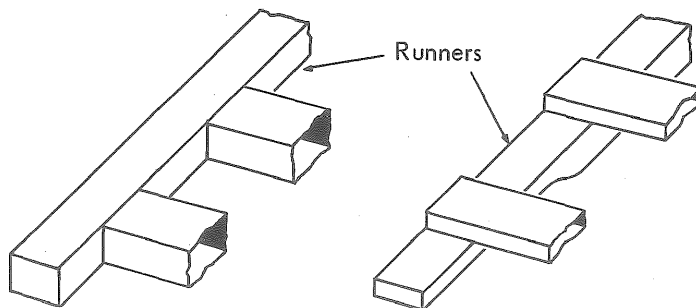


(b)

[193]

Some foundries have found that gates taken off the runner(s) at a 90° angle work satisfactorily so far as turbulence is concerned. This is true when the velocity and pressure in the gating system are held nearly constant, as in the system just studied.

Which system will have the least turbulence in its gates? _____



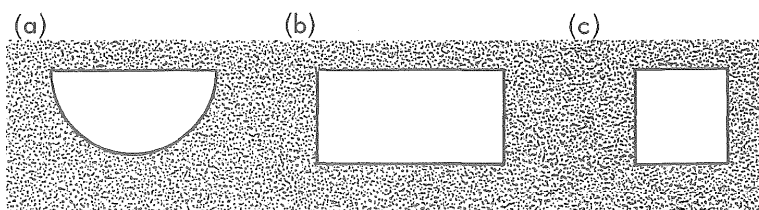
(b)

[194]

The shape of the runners and gates must conform to sound molding practices, which sometimes vary with the type of metal being cast.

The surfaces of the runners and gates must be well compacted, or rammed, to prevent sand erosion. The runner and gate with a half-round shape are best suited to meet this requirement.

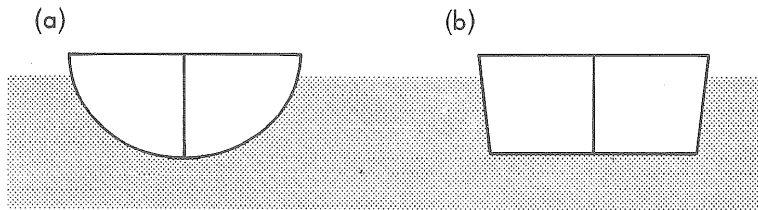
Which shape, properly rammed, will aid in the prevention of sand erosion? _____



(a)

[195]

One disadvantage of the half-round runner and gate is that they are conducive to a "rocking" action of the molten metal stream as it flows through them, and this promotes turbulence. To illustrate, imagine that these are two boats, seen head-on. Which would be least likely to rock? _____

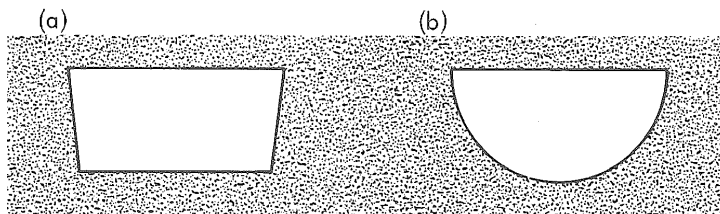


(b)

[196]

In which runner would there be the greater tendency for the molten metal stream to begin rocking? _____

(This rocking action is most pronounced during the early stages of the pouring operation.)



(b)

[197]

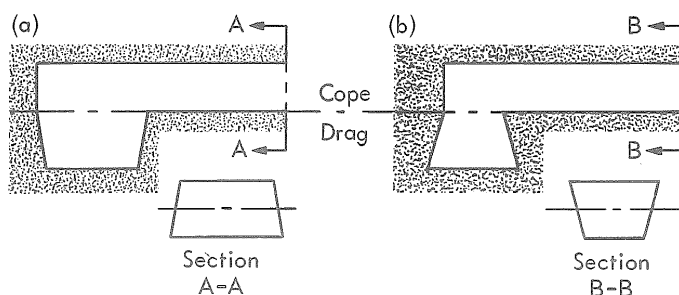
The cross-sectional shape of the gate is primarily dependent on the design of the casting, where it is to be attached to the casting, and the ease with which it is intended to be removed from the casting during the cleaning operation.

In many cases the gating system is attached to the pattern. This is good practice, because it gives uniform channels and helps prevent erosion of sand in the gating system.

[198]

When the sides of a runner or gate open slightly toward the parting line, their taper forms what we call draft. The proper angle of draft is carefully built into the runners and gates and the pattern to which they are attached so that the pattern may be removed with minimum danger of damaging the mold.

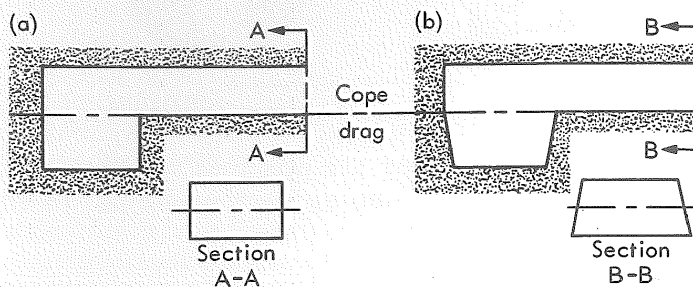
From which example below can the pattern be removed with the least chance of damaging the mold? _____



A

[199]

In which example can the pattern be more easily removed from the mold?



B

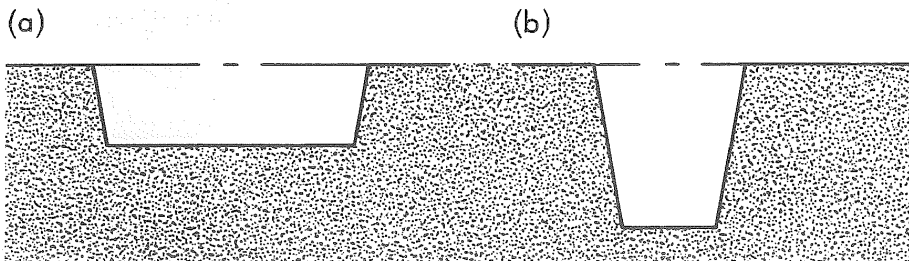
[200]

So that the gates and the runner(s) may be more easily machined, the gates are sometimes designed to be taken off the runner(s) at right angles.

[201]

Due to the differences in temperature of the various molten metals poured, the shape of the runners and gates varies. Steel, for example, calls for runners and gates that are deep and narrow, whereas gray iron and nonferrous metals can use runners and gates that are shallow and wide.

Which shape of runner would be used for steel? ____ For brass? ____

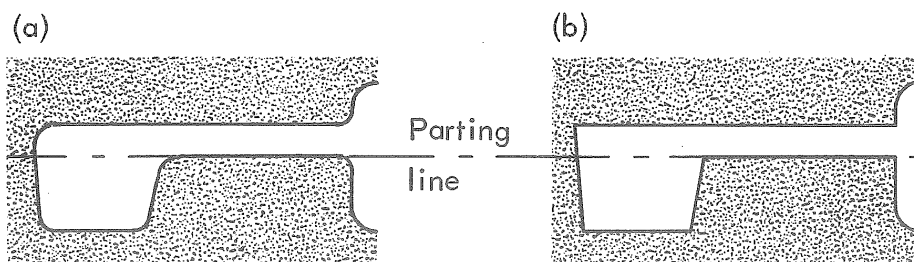


(b)
(a)

[202]

The discharge end of the gate should be rounded to prevent the edges from breaking away.

In which example is there danger that the edges of the gate may break away? ____



(b)

[203]

Another advantage of rounded discharge edges is that they increase the discharge area. An increase in area causes the velocity of the molten metal to be _____ (increased/reduced).

reduced

[204]

A reduction in the discharge velocity also reduces the _____ of the molten metal stream.

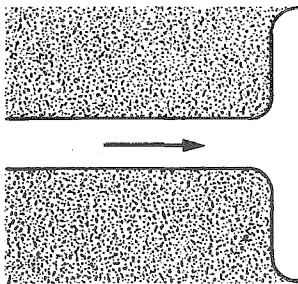
turbulence

[205]

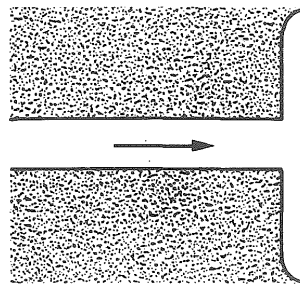
A reduction in the velocity of the molten metal stream will also reduce the chance that the stream will strike the cores and mold walls with great force. This in turn will reduce the chances of erosion of the core and the mold walls, and will also cut down on turbulence in the mold cavity.

With all flow conditions being equal, which gate will discharge the stream with the greatest velocity? _____

(a)



(b)



(b)

III THE VERTICAL GATING SYSTEM

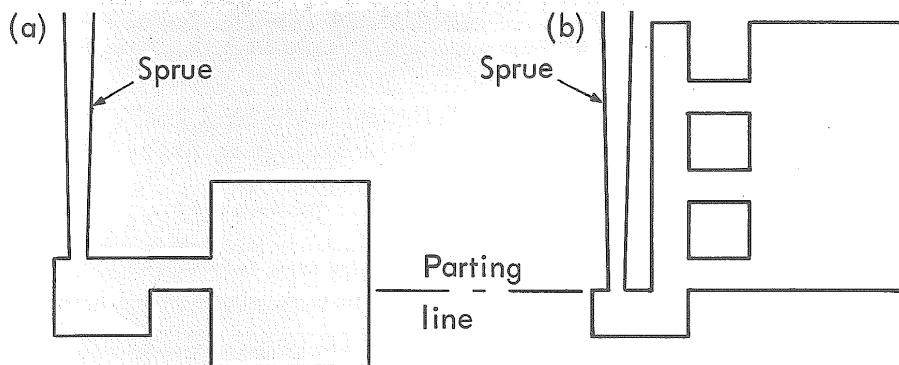
[206]

Up to now we have been studying horizontal gating systems, but there are many instances in which a casting should be, or even must be, poured in the vertical position. (One easy way to keep our directions straight is to think of horizontal as horizon-tal, level with the horizon, leaving the upright position as vertical.) And if a casting is to be poured standing on end, instead of lying horizontal, then we will have to use a _____ system.

vertical gating

[207]

In a horizontal gating system, the gates are oriented in the horizontal plane. In a vertical gating system, the gates are oriented in the _____ plane, as shown in part _____ below.

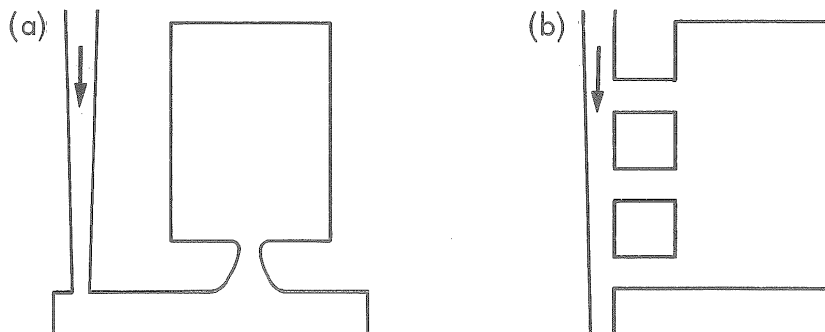


vertical
(b)

[208]

There are two common methods of vertical gating. The one we will study first is called step gating, in which the gates are positioned up the side of the mold in ladderlike steps. The other type of vertical gating system is called bottom gating because the gate enters the bottom of the mold.

Step gating is illustrated in part _____ of this figure, and bottom gating in part _____.



(b)
(a)

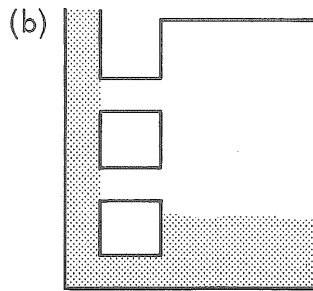
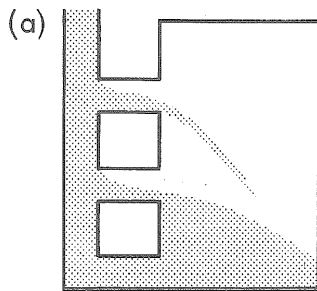
[209]

In step gating, the gates are led off a vertical runner, or they may, as shown in the frame above, be led directly off the _____.

sprue

[210]

The ideal flow of molten metal in step gating is a relatively strong but quiet flow from each step gate as the level of molten metal reaches it, as shown in part _____.



(b)

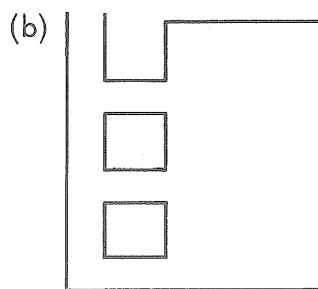
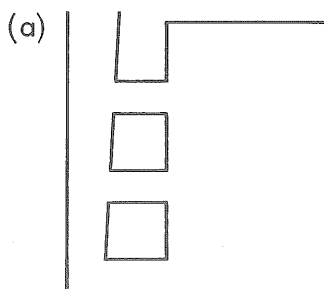
[211]

Experimentation has shown that ideal flow conditions are difficult to achieve unless special designs are used in the vertical gating system.

To begin with, when at all possible a pouring basin should be used to prevent the pouring of molten metal directly down the sprue. This alone can greatly reduce the amount of turbulence in the stream of molten metal.

[212]

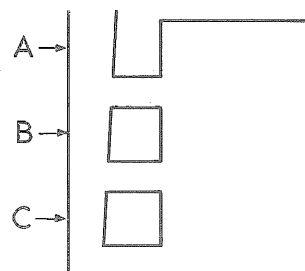
Just as in the horizontal gating system, the shape of the sprue in the vertical gating system plays an important part in preventing mold gases and air from being drawn into the stream through the sprue walls. Which of the two sprues shown below is best designed to do this? _____



(a)

[213]

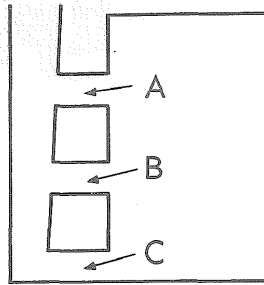
A vertical gating system often requires the use of longer sprues than would be used in a horizontal system. Where in the following example will the velocity and turbulence in the stream of molten metal be the greatest?



C

[214]

And through what gate, unless steps are taken to prevent it, will the bulk of the molten metal flow into the mold cavity? _____



C

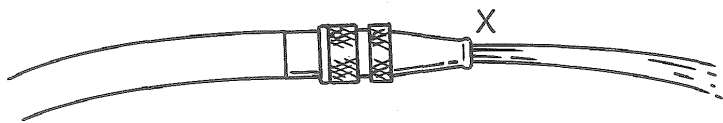
[215]

It has been observed that the greater part of the metal has a tendency to flow through the bottom gate even after it has filled the mold cavity right up to the top gate. This is a long way from an ideal flow, and we must find out why it occurs.

[216]

As the stream of molten metal falls, it creates low-pressure areas at the entrances to the top two gates. The action that occurs then was discussed earlier in this course.

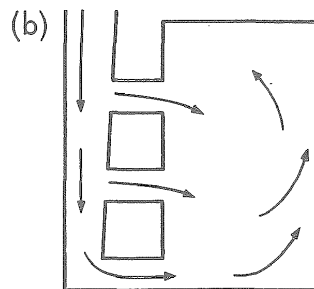
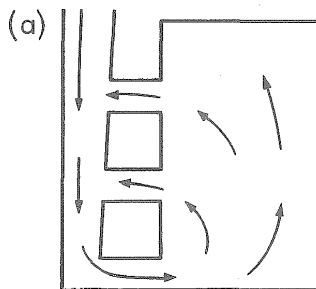
If a small piece of paper were held at X it would be drawn _____ (into/away from) the stream.



into

[217]

Assuming that the arrows indicate the flow of molten metal, which example is correctly drawn? _____



(a)

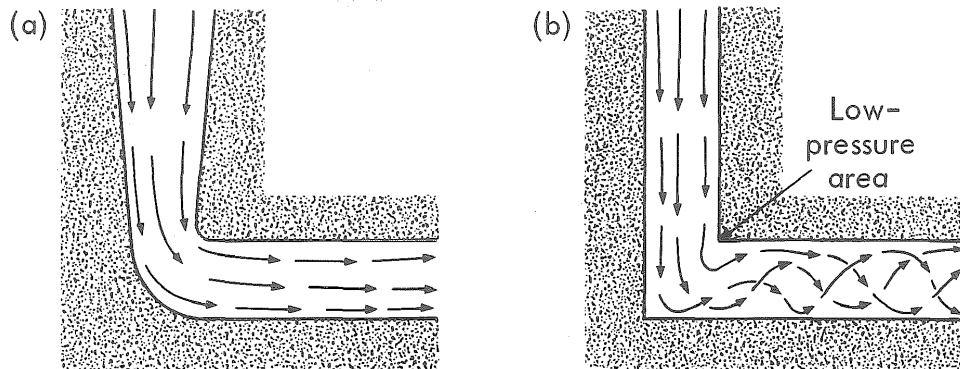
[218]

This effect will continue until the end of the pour, because the falling stream of molten metal will continue to create a _____ area at the entrance to each of the upper gates.

low-pressure

[219]

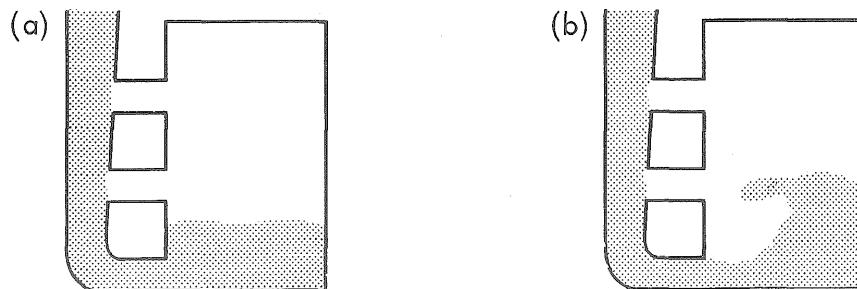
The vertical step gating system, as we have discussed it so far, has one other bad feature. On the basis of what you have learned of fluid flow, which example illustrates the most desirable type of flow at the base of the sprue and in the bottom step gate? _____



(a)

[220]

The trouble is that if a rounded corner were used, turbulence in the stream would be greatly reduced but the velocity would not. Thus the molten metal would jet into the mold cavity, causing the turbulent filling illustrated in part _____ below.



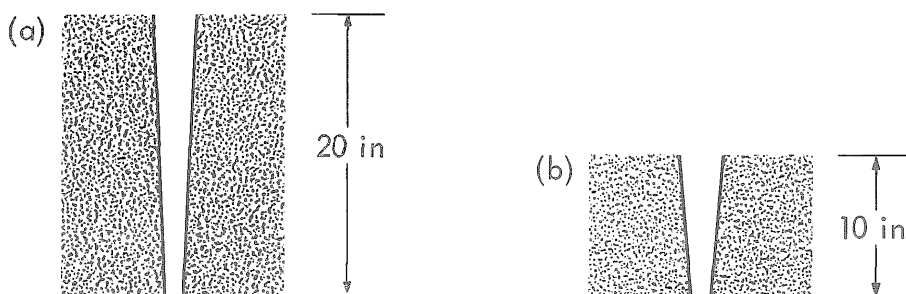
(b)

[221]

In order to achieve the desired flow of molten metal, and to feed it through the gates in the proper sequence, it was necessary to devise a vertical-step gating system that would absorb the kinetic energy of the stream without producing low-pressure areas at the entrance to the step gates.

[222]

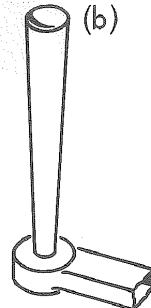
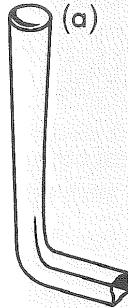
The height of the sprue created a problem that had to be overcome. Both sprues below have the same cross-sectional areas; from which sprue will the stream flow with the greater velocity? _____



(a)

[223]

Some means had to be found to reduce the velocity of the stream before it entered the mold cavity. This meant the addition of an enlargement base or well base, both of which were discussed earlier. Both sprues shown below are the same size. From which sprue base will the stream be flowing at the lower velocity? _____



(b)

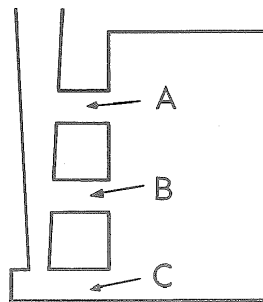
[224]

The dimensions of the enlargement and well bases are determined by the same methods discussed in the section on horizontal gating.

[225]

Even with the use of an enlargement at the sprue base, the proper sequence of flow will not take place so long as we take the step gates off the sprue.

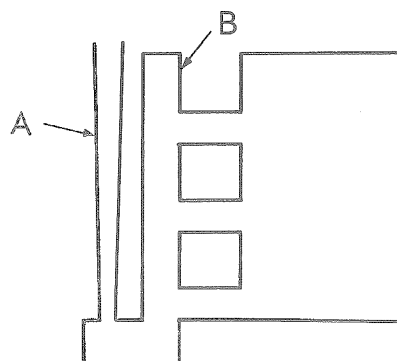
Which step gate will deliver the bulk of the molten metal into the mold cavity? _____



C

[226]

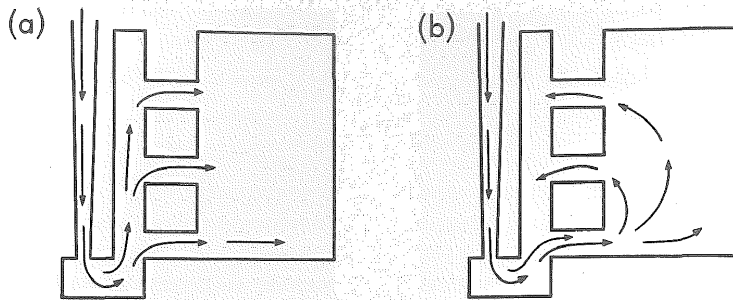
To prevent the downward movement of the stream from drawing molten metal out of the mold cavity the step gates are removed from the sprue and attached to a reverse sprue or vertical runner, represented below by _____.



B

[227]

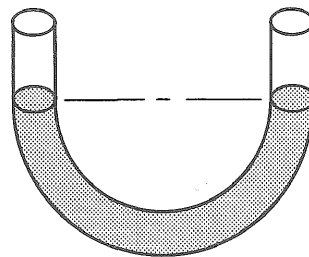
Through experimentation it has been found that the reversed sprue, or vertical runner, allows the proper flow in the gating system, as illustrated by part ____.



(a)

[228]

With the proper flow established, how can the step gates be made to deliver molten metal in proper sequence? Well, a law in nature states that a liquid will always seek its own level. This can be seen in a transparent "U" tube filled with a liquid.

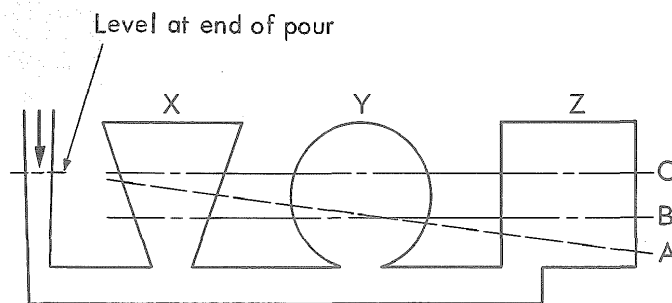


Note: The pressure above both columns of liquid is the same.

[229]

The shape of the containers does not matter. As long as equal pressures exist above the surface of the liquid, the liquid will seek its own level.

Which line indicates the liquid level in containers X, Y, and Z at the end of the pour? ____

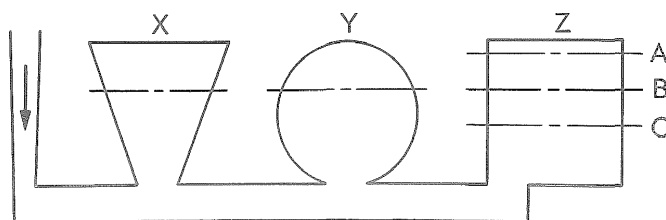


C

[230]

Even during pouring the same law applies to the level of liquid in containers X, Y, and Z.

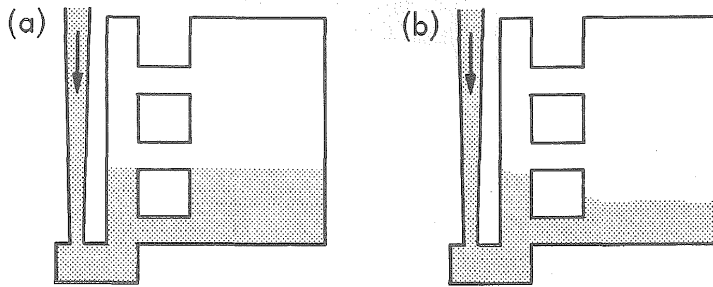
At what level will the liquid be in container Z? ____



B

[231]

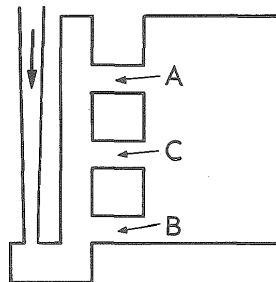
The same law holds true in a vertical gating system. Which illustration is correctly drawn? _____



(a)

[232]

On the basis of this law, what would be the feeding sequence of the following step gates? _____



B, C, A

[233]

During experiments with the vertical step gating system illustrated in the previous frame it was found that the middle step delivered molten metal before it was supposed to. Even reversing the flow of the stream did not absorb enough kinetic energy to reduce the velocity of the stream and stop the premature flow.

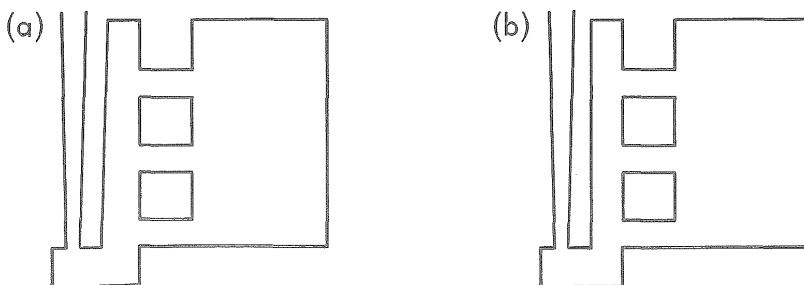
[234]

We know, from our study of fluid flow, that we can change the velocity of the flow through the runner by changing the cross-sectional area (the CSA) of the runner. So to reduce the velocity of the stream we need only _____ (reduce/increase) the CSA of the runner where it connects to the enlargement base.

increase

[235]

In which of the following examples would the velocity of the molten metal stream in the vertical runner be reduced? _____



(a)

[236]

Continued experimentation has shown that both a proper flow pattern and the proper sequential flow from the step gates can be achieved with this type of vertical step gating system.

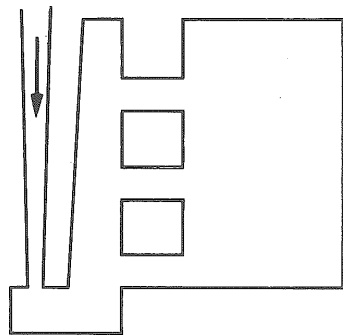
[237]

Now our vertical gating system has a tapered sprue, an enlargement base, and a vertical runner whose CSA has been increased at the end connecting to the enlargement. But there is still a problem; the first metal poured into the gating system is damaged by _____.

turbulence

[238]

Would the molten metal damaged by turbulence in this gating system enter the mold cavity? _____



Yes

[239]

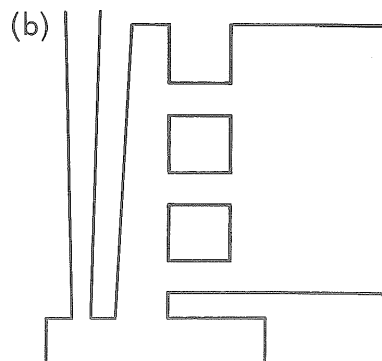
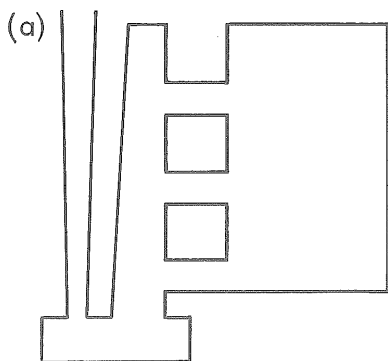
In the horizontal gating system, a runner extension is used to trap the first metal poured into the system and prevent it from entering the mold cavity. In the vertical step gating system, we can use a _____ for this purpose.

runner extension

[240]

The length of the runner extension should be such that the backwash of the initial surge does not enter the vertical runner.

In which example will the damaged molten metal be trapped in the extension? _____



(b)

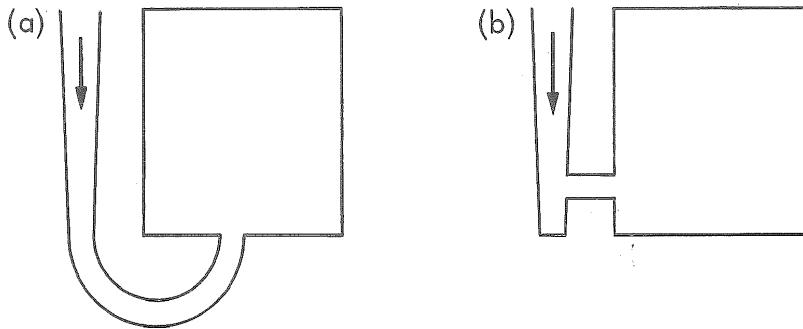
[241]

Vertical step gating is ideally suited for castings having irregular shapes and for castings poured in the _____ position.

vertical

[242]

Another type of vertical gating system is called bottom gating, because the molten metal is fed into the mold cavity from the bottom, as in part _____ below.



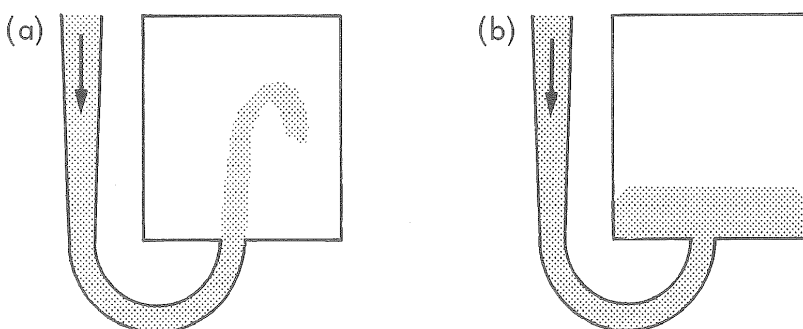
(a)

[243]

We already know, for reasons previously studied in this course, that a pouring basin (or at least a pouring cup) and a tapered sprue should be used in this gating system. Therefore, we will begin our study of this vertical gating system, which employs a bottom gate, at the point at which the molten metal stream leaves the sprue.

[244]

In many cases the molten metal is fed directly from the sprue into the mold cavity by means of a horn gate, so called because of its shape. This causes the molten metal to actually jet into the mold cavity, developing a considerable amount of turbulence, as illustrated in part _____.



(a)

[245]

This turbulent action continues until the pouring stops, and since our whole purpose is to make a sound casting, we must eliminate that _____.

turbulence

[246]

Of course, by now we have a pretty good idea how to go about it. For that tall sprue, we need either an enlargement base or a _____ base.

enlargement
well

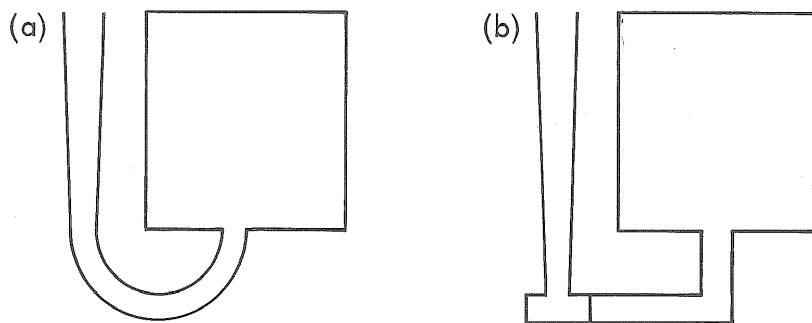
[247]

To reduce the velocity of the molten metal, and thus its turbulence, we connect the enlargement base and the gate by means of a _____.

runner

[248]

In which gating system will the molten metal stream have the lower velocity when entering the mold cavity? _____



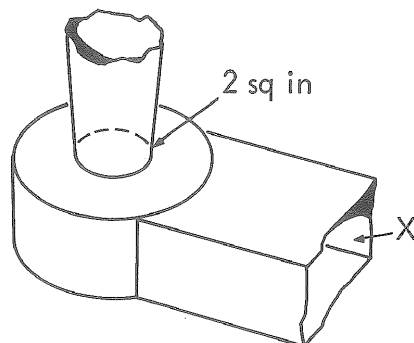
(b)

[249]

The dimensions of the enlargement and well bases are determined by the same methods discussed in the section on horizontal gating.

[250]

Experiments have shown that, for most effective stream control in a bottom gating system, the CSA of the runner should be just 2-1/2 times that of the sprue exit. So the CSA of the runner shown below will be _____.



5 sq in.

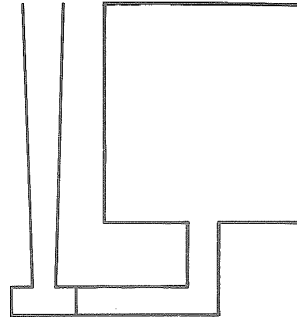
[251]

Also, any enlargement base (with the exception of a well base) should be just the same depth as the runner. If the runner is 2 in. deep, the base will be _____ deep.

2 in.

[252]

We know that when we pour molten metal into this system, the first part, which will be damaged, _____ (will/won't) enter the mold cavity.



will

[253]

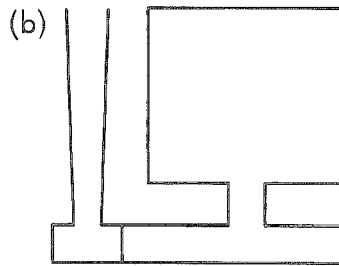
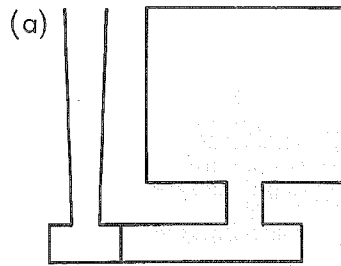
To prevent the damaged metal from entering the mold cavity, we do just as we did for the horizontal gating system and the vertical step gating system; we redesign the runner to include a

-----.

runner extension

[254]

In which runner extension will the chances of trapping the damaged metal be the best? _____



(b)

[255]

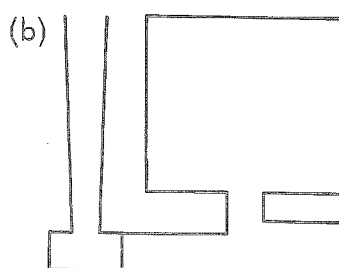
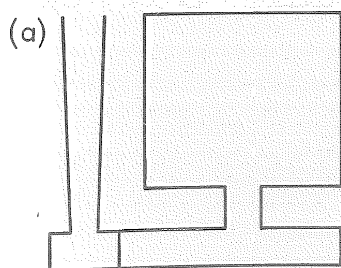
You will recall that, when we were dealing with horizontal gating systems, we established that the CSA of the runner extension must be _____ (greater than/less than/equal to) the CSA of the runner just before the last gate.

equal to
(If you missed this, please review frame 189.)

[256]

Experiments have shown that if the CSA of the runner extension is greater than that of the runner before the last gate, there will be a backwash effect that will carry some of the damaged metal into the mold.

The runner extensions shown here are the proper length. Which one will properly trap the damaged metal?

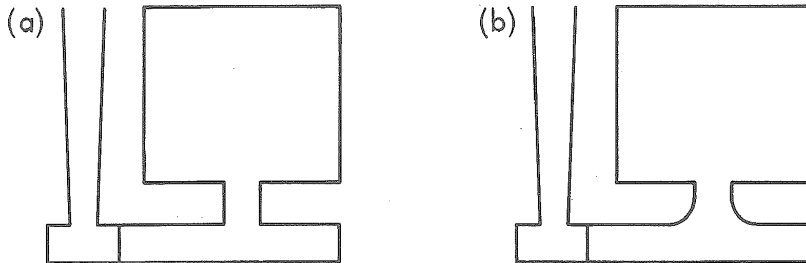


(a)

[257]

The design of the bottom gate connecting the runner with the bottom of the mold cavity is of some value in reducing turbulence.

We know from our study of fluid flow that the change in the direction of flow will cause the least turbulence in the gate shown in part _____.



(b)

[258]

When there is an abrupt change in direction of flow one other problem exists.

In the frame above, at which bottom gate are mold gases and air least likely to be drawn into the molten metal stream? _____

(b)

[259]

Even though the velocity and turbulence of the molten metal stream in the bottom gate have been reduced, the fluid will jet into the mold cavity. And we have found that the jetting action of the molten metal will cause _____ in the mold cavity as it fills with molten metal.

turbulence

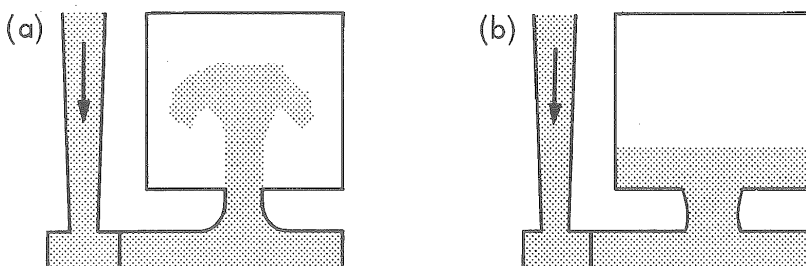
[260]

In order to reduce the jetting action of the molten metal stream, we must reduce its velocity. To do this, the CSA of the bottom gate must be _____ (increased/decreased).

increased

[261]

Which example illustrates the effect we want? _____



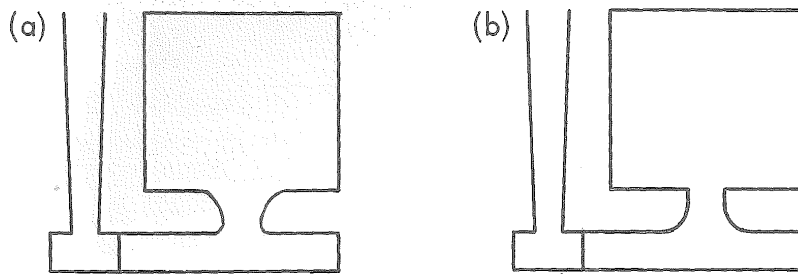
(b)

[262]

Experiments have shown that we may minimize the velocity of the stream (thus its jetting action, and thus its turbulence) by designing the bottom gate so that the CSA of its exit (into the mold cavity) will be twice as great as the CSA of its entrance (from the runner).

[263]

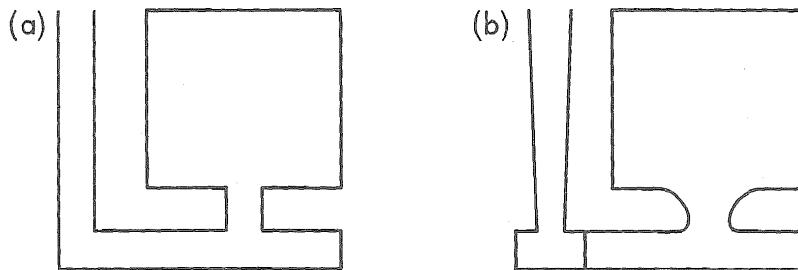
From which bottom gate will the molten metal enter the mold cavity at the lower velocity? _____



(a)

[264]

Which of the following systems will be most likely to produce a sound casting? _____



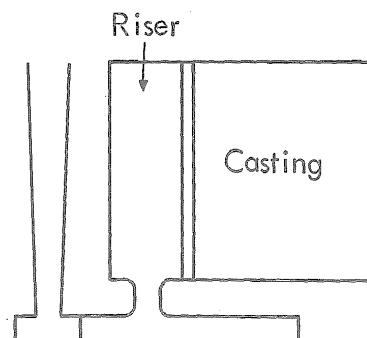
(b)

[265]

Before concluding the program, we want to mention the use of a riser, which is nothing more than a reservoir of molten metal that feeds the casting as it solidifies. We'll be brief about it, though, because the purpose and use of risers is a subject all its own, and will be covered in another course.

[266]

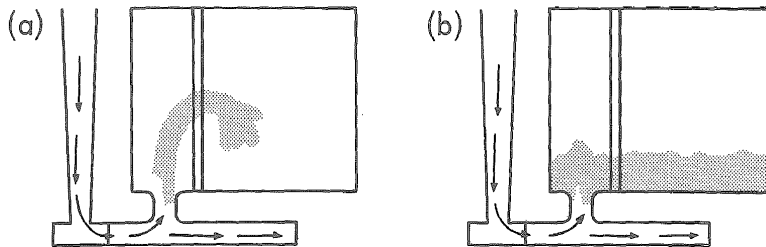
A successful innovation in the vertical casting of plates has been to bottom gate into a riser, instead of directly into the mold cavity. The molten metal flows from the riser, through the "web," and into the mold cavity. Notice that in this case, the riser looks very much like a vertical runner, and the web is really nothing more than a single narrow gate that connects the riser and the mold cavity for their full height.



[267]

The riser is connected to the casting by means of a continuous web. This type of connection introduces the molten metal into the mold cavity quietly and progressively, from the bottom to the top.

Which of the following examples is correctly illustrated? _____



(b)

[268]

The combination of a relatively large riser and large web has proven to provide a quiet flow of molten metal into the mold cavity. A test casting was poured which had a web $11/32$ in. thick connecting to a plate $3/8$ in. thick by 6 in. wide and 12 in. high. The casting turned out to be sound and defect free.

[269]

Which of the webs in the following example would be most likely to allow a quiet flow of molten metal into the mold cavity? _____



(b)

[270]

With any vertical gating system, the tall sprue, which we must use, causes our greatest problem. By the time the molten metal reaches the bottom of that sprue, it is moving at this maximum _____. And this, combined with a rapid change in the direction of flow, creates severe _____.

velocity
turbulence

[271]

In any type of gating system, the design of the individual casting determines the number and placement of the gates, whose purpose is to distribute the molten metal equally and rapidly. For example, the gating systems for large, rangy castings should use _____ (single/multiple) gates.

multiple

[272]

The number and placement of gates also controls the pouring time, which again varies with the design of the casting. Thin castings cool fairly rapidly, and so the pouring rate should be _____ (fast/slow). Chunkier castings take longer to cool, and so their pouring rate can be comparatively _____ (fast/slow).

fast
slow

[273]

Sometimes different parts of a mold should be at different temperatures. These thermal gradients, as they are called, can be achieved by proper placement of the _____.

gates

[274]

Some parts of our gating system are designed to reduce the amount of _____ in the flowing metal. All of them are carefully designed and constructed to ensure the production of a sound _____. When the molten metal is poured down the _____, it flows into the _____, which reduces its velocity. From there it flows out into the _____, losing more velocity, and the damaged part of the metal rushes on to be trapped in the _____. The sound metal flows through the _____ and into the _____ cavity, where it solidifies.

turbulence
casting
sprue
enlargement base
runner
runner extension
gates
mold

[275]

You have completed your course on the Basic Principles of Gating, which we hope you have found interesting and instructive. The second course in this series is on Solidification and Riser.

Now that you have completed the course, you may take the Post Test. Turn the book other side up, then turn to the rear of it, to the Post-Test section, and read the instructions at the beginning of the test.

From this point
This was done for a specific purpose

POST TEST

POST TEST

Note: Remove the Post Test and its answer sheet from the book. Leave the answers in the book and do not look at them until you have completed the test. Read each statement carefully and then answer by placing an X in the appropriate space on the answer sheet.

TRUE-FALSE

Examples:

Chicago is a city.

The sum of $2 + 2$ is 5.

Answer sheet

T	F
x	
	x

1. Ideally, molten metal should flow through the gating system with as little turbulence as possible.
2. The fluidity of molten metal is a major factor in determining how far it will flow before it freezes.
3. Superheat is the number of degrees of temperature a metal is raised above its melting point.
4. One of the functions of a good gating system is to reduce the amount of turbulence in the stream of molten metal.
5. The fluidity of molten metal is reduced when the metal has a narrow solidification range.
6. Heat is the energy that raises the temperature of a material.
7. Superheat will decrease the distance a metal will flow before freezing.
8. The flow of molten metal is laminar (smooth) in all sections of the gating system.
9. The greater the distance an object falls, the greater will be its velocity.
10. A stream of falling liquid is not affected by gravity.
11. As the height of a free-falling stream of molten metal is increased, its velocity also increases.

12. The flow of a stream of molten metal can be either turbulent or laminar.
13. Step gating is what we have when the gates of a vertical gating system are taken directly off of the sprue or vertical runner.
14. Flow rate is the measure of the amount of liquid flowing past a given point in a given period of time.
15. As a stream of liquid falls, its cross-sectional area increases.
16. When a stream of liquid flows from a large channel into a small channel, its velocity increases.
17. Turbulence in a flowing stream can cause the entrapment of air in the stream.
18. Turbulence in the stream, regardless of degree, can have a bad effect on the quality of a casting.
19. A flowing liquid has a natural tendency to turn corners.
20. The gating system can be divided into vertical and horizontal components.
21. The runner is usually one of the vertical components of a horizontal gating system.
22. The ideal situation is to establish the proper flow conditions as soon as possible in the gating system.
23. It is important to establish a full sprue as soon as possible in the pour, and to keep it full during the pour.
24. The term "pouring short" describes that condition in which the mold cavity and gating system are not completely full of molten metal.
25. As molten metal leaves a tapered sprue (big end up), it has developed considerable kinetic energy and is traveling at its greatest velocity.
26. When the vertical gating system is used, the shape of the sprue plays an important part in the pouring of a casting.
27. In vertical gating, it is not necessary to use a runner extension to prevent the damaged metal from entering the mold cavity.

28. Flaring out the discharge end of the gate reduces the velocity of the molten metal stream as it enters the mold cavity.
29. In vertical gating, the foundryman is usually faced with the problem of high metal velocities at the bottom of the sprue.
30. A well-designed vertical gating system should feed molten metal into the mold cavity in proper sequence.

MULTIPLE CHOICE

The following statements are not complete. Place an "x" in the space on the answer sheet which best completes the statement or answers the question.

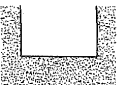
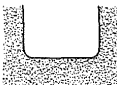
Examples:

The sum of $2 + 2$ is

- A. 3 C. 6
B. 4 D. 8

Answer sheet

A	B	C	D
	x		

31. A well base beneath the sprue is used to absorb or reduce
- A. Radiant energy C. Potential energy
B. Kinetic energy D. None of these
32. The bottom surface of a well base should be shaped like
- A.  C. 
B.  D. 
33. The part of the gating system that controls the flow rate of the molten metal is the
- A. Choke C. Pouring basin
B. Pouring basin outlet D. None of these
34. At which time during pouring is molten metal damaged the most, so that it should not be allowed to enter the mold cavity?
- A. End of pour C. Start and end of pour
B. Middle of pour D. Start of pour

35. When no steps are taken to ensure a constant pressure and velocity in a gating system, the gates _____ the sprue will feed the most molten metal.
- A. Closest to C. Both A and B
B. Farthest from D. None of these
36. The major factor in deciding the number and location of gates is the
- A. Molding sand C. Flask size
B. Metal poured D. Casting design
37. As the stream of molten metal leaves the choke, its velocity should be
- A. Decreased C. Constant
B. Increased D. None of these
38. After leaving the well base or enlargement base, the molten metal enters the
- A. Gate C. Runner
B. Runner extension D. Basin
39. For ease of molding, the best runner shape is
- A. Half round C. Rectangular
B. Square
40. The reading on a thermometer indicates the _____ of a material.
- A. Heat C. Weight
B. Temperature D. None of these
41. A metal starts to melt at 2275°F. If the temperature of this metal were raised to 2375°F, it would have 100° of what is called
- A. Gradient C. Superheat
B. Extra heat D. Pre-heat
42. An alloy that solidifies in a mushy manner, with tree-like growth, is said to have a _____ solidification range.
- A. Wide C. Short
B. Narrow D. None of these

43. The further a stream of molten metal falls, the greater its
A. Weight C. Cross-sectional area
B. Velocity D. Laminar
44. The flow of molten metal in which all "particles" proceed smoothly, parallel to the direction of flow, is called
A. Turbulent C. Normal
B. Erratic D. Laminar
45. The manner in which the liquid flows will be determined largely by its
A. Velocity C. Weight
B. Composition D. None of these
46. The part of the gating system which is used to trap the first metal poured is called the
A. Choke C. Gate
B. Runner D. Runner extension
47. It is advantageous to place the runner(s) in the drag and the gate(s) in the cope, because the runner will then be _____ filled with molten metal before any metal is delivered to the mold cavity.
A. Partially C. Completely
B. Half D. None of these
48. With a constant flow rate, an increase in cross-sectional area will cause the velocity to
A. Decrease C. Remain constant
B. Increase
49. Assuming no additional chokes, which shape of sprue can be quickly filled with molten metal?
A. Straight C. Oval
B. Tapered (large end up) D. All of these
50. The gating system plays an _____ part in the production of good castings.
A. Unimportant C. Small
B. Important D. None of these

When you have completed the test, tear out the sheet containing the answers and compare it with the answer sheet you just filled in.

ANSWER SHEET FOR POST TEST

True or False

	T	F		T	F
1.			16.		
2.			17.		
3.			18.		
4.			19.		
5.			20.		
6.			21.		
7.			22.		
8.			23.		
9.			24.		
10.			25.		
11.			26.		
12.			27.		
13.			28.		
14.			29.		
15.			30.		

Multiple Choice

	A	B	C	D
31.				
32.				
33.				
34.				
35.				
36.				
37.				
38.				
39.				
40.				
41.				
42.				
43.				
44.				
45.				
46.				
47.				
48.				
49.				
50.				

ANSWERS TO POST TEST

1.	T	18.	T	35.	B
2.	T	19.	F	36.	D
3.	T	20.	T	37.	A
4.	T	21.	F	38.	C
5.	F	22.	T	39.	A
6.	T	23.	T	40.	B
7.	F	24.	T	41.	C
8.	F	25.	T	42.	A
9.	T	26.	T	43.	B
10.	F	27.	F	44.	D
11.	T	28.	T	45.	A
12.	T	29.	T	46.	D
13.	T	30.	T	47.	C
14.	T	31.	B	48.	A
15.	F	32.	C	49.	B
16.	T	33.	A	50.	B
17.	T	34.	D		