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ABSTRACT

This workbook is part one of a self-instructional course prepared for the United States Environmental Protection Agency. The student proceeds at his own pace and when questions are asked, the answers appear on the next page. The purpose of this course is to prepare the student for the APC Training Certificate and to help him do a better job. (BT)

Air Pollution Training Institute Self-Instructional Course SI-466

Part 1
Boilers: The Basics of Preventing Air Pollution Emissions from Boilers

United States
Environmental Protection Agency
Contract No. 68-02-0321
David Sage, Inc.
New York City, New York

Part One
Boilers: The Basics of Preventing Air Pollution Emissions from Boilers

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Prepared for the
United States Environmental Protection Agency
Office of Air and Water Programs
Control Programs Development Division
Air Pollution Training Institute

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THIS IS PART 1
BOILERS: THE BASICS OF PREVENTING
AIR POLLUTION EMISSIONS FROM BOILERS

Additional units of this self-instructional course are:

PART TWO
The Basics of Boiler Operation
and Maintenance

PART THREE
Troubleshooting, Section One
Boilers: Correcting Oil Temperature

PART FOUR
Troubleshooting, Section Two
Boilers: Flame Reading

PART FIVE
The Incinerator: Section One
Basic Parts and Fundamentals

PART SIX
The Incinerator: Section Two
Maintenance and Troubleshooting

SUPPLEMENT A:
Operator's Manual, Boiler Room
Operations and Maintenance

Read This First

1. This is a workbook. Use your pencil to answer the questions.

2. This book is not a test. You can keep it.

3. Here's what this course will do for you:

   – give you your APC Training Certificate – under the law, you must have this in order to work.

   – help you avoid a summons for smoke – inspectors give these out when someone complains about smoke.

   – help you do a better job – no matter how much you already know, this course will teach you a few things.

4. Last but not least, the course will really help you reduce air pollution.

– Please turn the page.

1. Choking

We've made a lot of progress toward cleaning up the air during the past few years, but we still have a long way to go.

PUT A CHECK BESIDE THE THINGS BELOW THAT HAVE HAPPENED TO YOU.

_____ Noticing that a thick gray cloud covers the city.

_____ Being amazed at how clear the air seems to be in the country.

_____ Finding that the metal work on the outside of your building is corroding due to pollution in the air.

_____ Taking a physical exam and wondering what pollution has done to your lungs.

Too many people are having experiences like these. Smoky boilers are part of the problem.

— Please turn the page.

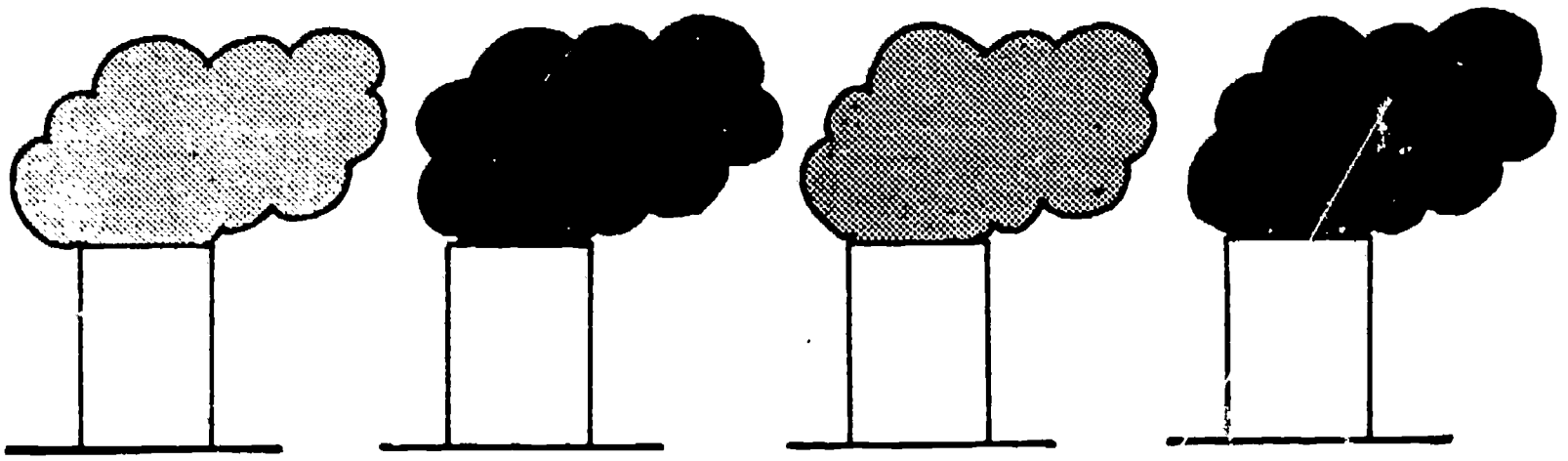
2. Smoking

We don't mind smoke, unless:

a) there is too much smoke, or

b) the smoke is too black

When an inspector goes out to answer a complaint about smoke, he first finds out how black the smoke is. Look at the four chimneys below. PUT "1" UNDER THE CHIMNEY THAT IS THE LIGHTEST. PUT "2" UNDER THE NEXT LIGHTEST, ETC.



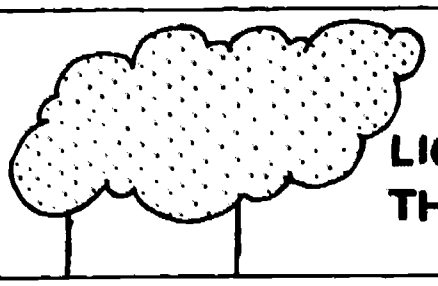
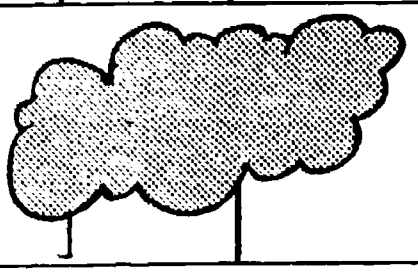
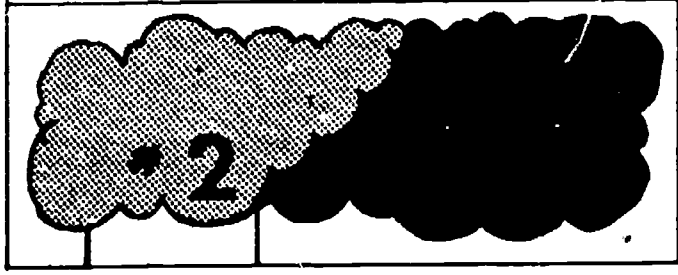
#_____ #_____ #_____ #_____

Open the envelope and take out the smoke chart. Hold it against each picture above. DO YOUR NUMBERS ABOVE MATCH THE NUMBERS AND SHADES ON THE SMOKE CHART?

If they don't correct your answers on this page.

3. Smoke Laws

Inspectors use the Ringelmann Chart to measure whether the smoke is dark enough to deserve a summons. The darker the smoke, the more pollutants it contains. Study this chart.

RINGELMANN SMOKE READINGS	NEW YORK CITY LAW
	ALWAYS O K
	O K if only 2 minutes an hour
	NEVER O K

Answer these questions:

1. **How long can you have # 1 smoke coming out of your stack without getting a summons?** _____
2. **Are you allowed to have # 2 smoke coming out of your stack?** _____
3. **An inspector tells if smoke is illegal by how dark it is and how long it's been coming out of the stack.**
   (True or False) _____

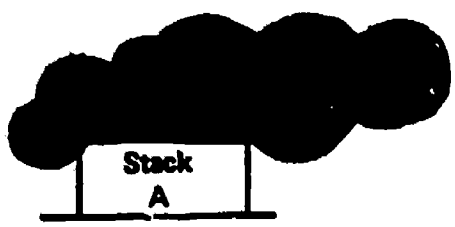
—Check your answers on the next page.

Answers to Exercise 3: 1) 2 minutes per hour 2) No
3) True

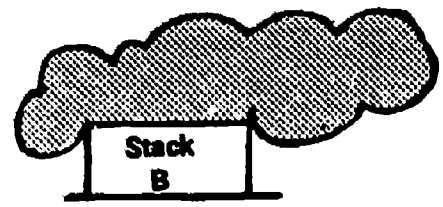
4. Smoke Reading

USE YOUR CHART.

PUT THE CORRECT SMOKE NUMBER UNDER EACH STACK BELOW.



#_____



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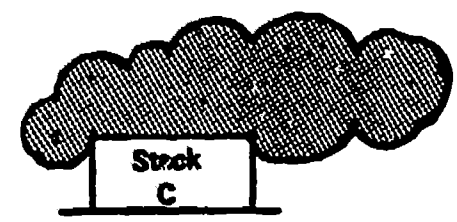


#_____

PUT THESE "READINGS" in the second column on the chart below.

STACK	RINGELMANN NUMBER (fill in from above)	MINUTES PER HOUR	VIOLATION (yes or no)
A		1 Minute	
B		3 Minutes	
C		2 Minutes	

In the last column on the chart write "YES" if the stack is a violation of the law; write "NO" if it is OK. Look back to the previous page if you need to.

After you finish the chart, answer this question:

If you were an inspector, how many summonses would you hand out from the 3 above? _____

— Check your answers on the next page.

Answers to Exercise 4:

STACK	RINGELMANN NUMBER	MINUTES PER HOUR	VIOLATION
A	# 3	1 Minute	Yes
B	# 1	3 Minutes	Yes
C	# 2	2 Minutes	Yes

You would hand out <u>three</u> summonses.

5. Review And A Look Ahead

New York City is trying to clean up the air by:

– not allowing dark smoke

– allowing light gray smoke only a short time

CHECK OFF (√) THREE THINGS in the list below that are being done to cut down on pollution.

_____ Low pollution oil is being delivered to your tank.

_____ You are taking a training and certification lesson.

_____ Your oil burning boiler will be taken out.

_____ Your boiler should be upgraded to meet certain standards.

– Check your answers on the next page.

Answers to Exercise 5: ✓ low pollution oil delivered

✓ training and certification lesson

___ oil burning boiler taken out

✓ boiler upgraded

6. Ash and Smoke

Many things go up your stack. ASH and SMOKE are two of the main ones you can see.

POLLUTANT	WHAT IT'S ABOUT
ASH	Minerals in the oil that will not burn. Even the best oil has a little.
SMOKE	Smoke – small, floating carbon bits are produced when oil is not burned completely. Good operation can cure this.

Answer these questions:

1. Which pollutant must we always get, no matter what we do? _____

2. Which pollutant is due to bad burning? _____

3. Which pollutant can we prevent completely? _____

– Check you answers on the next page.

Answers to Exercise 6: 1) Ash 2) Smoke 3) Smoke

7. More Bad News Up The Stack

Here are four more pollutants. Study the chart. Then ANSWER THE QUESTION IN THE LAST COLUMN with "Yes" or "No". Remember that you can adjust your boiler to burn the oil completely.

POLLUTANT	WHAT IT'S ABOUT	COULD YOU STOP IT? (yes or no)
SOOT	Large pieces of carbon produced when oil is not fully burned.	
SMUT	Soot and acid mixed together. If you stop soot, you stop smut.	
CARBON MONOXIDE	Formed when oil is not burned completely.	
NITROGEN OXIDES (large amounts)	Formed when oil is burned at too high a temperature with too much air.	

You should have "Yes" in all four boxes in the last column. You can reduce or get rid of all of these pollutants if you operate your boiler correctly. ASH is the only pollutant you have to have.

CHECK THE CORRECT ANSWER BELOW:

The basic cause of the pollutants on this page is:

____ bad fuel

____ bad burning

— Check you answer on the next page.

Answer to Exercise 7: ✓ bad burning

8. Review And A Look Ahead

Check off the pollutants that you can prevent or reduce by good burning:

POLLUTANT	PREVENTABLE
Ash	
Smoke	
Soot	
Smut	
Carbon Monoxide	
Oxides of Nitrogen (large amounts)	

You should have a checkmark next to every one except ash. All of these preventable pollutants are due to bad burning.

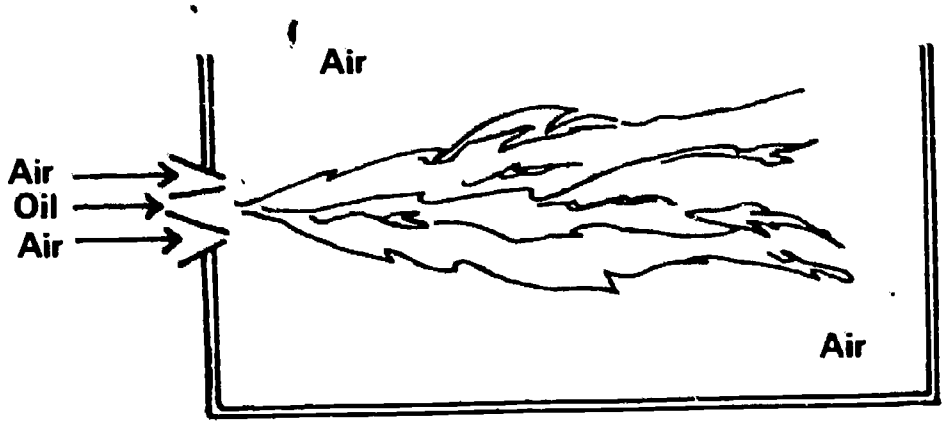
Sulphur Oxides are the last pollutants. They are formed when the sulphur contained in oil is burned. We take care of this problem by using fuel having a low sulphur content to start with.

Here's what you can do to reduce or prevent pollutants.

— Turn the page.

9. Air/Oil Ratio

Here is the right way to burn oil.

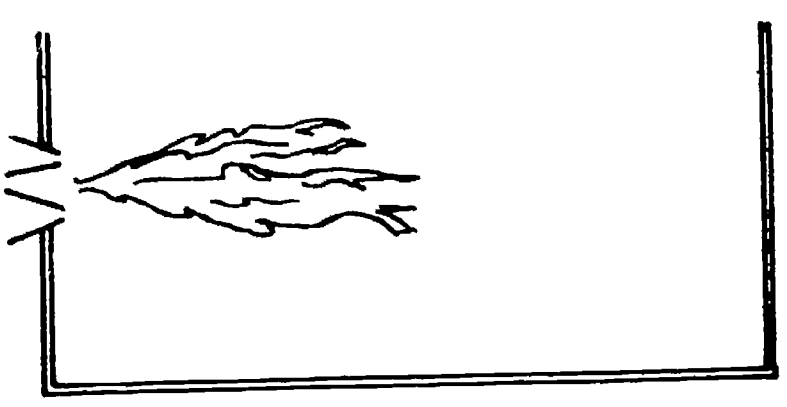


1. What are the two things it takes to make a flame?

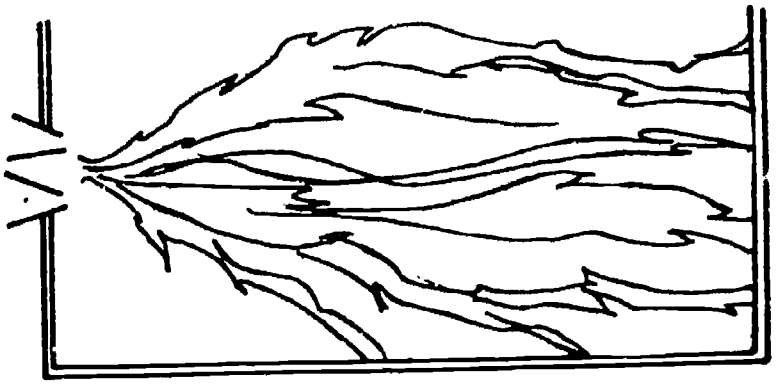
   _____ and _____

2. Does this "good flame" touch the furnace wall or floor at any point?_____

A correct mixture of air and oil will produce a good flame, which should fill the furnace without touching its walls or floor. Too much air causes the flame to become too large. UNDER EACH FLAME BELOW CIRCLE THE CORRECT ANSWER, "MUCH" or "LITTLE".



Flame Too Small
Too Much / Too Little Air



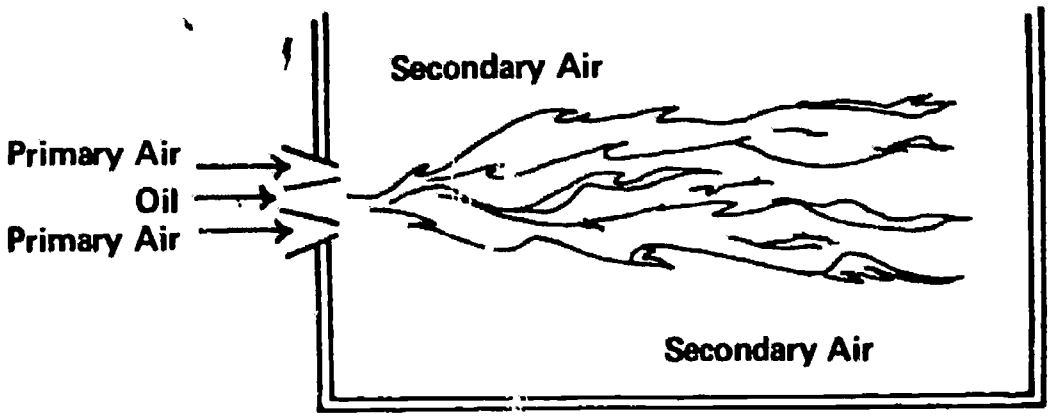
Flame Too Large
Too Much / Too Little Air

Thin flames like the one at the left result from too little air. Too much air produces a flame that is too big. Both kinds of flame produce smoke. Correct air/oil ratio is the name of the game when it comes to beating pollution.

– Go to next page.

10. Primary Air

Here's a good flame. It shows two kinds of air.



Complete these sentences:

1. _____ and _____ mix together to make a flame.

2. _____ air is FIRST mixed with oil to start burning.

Air comes in through the PRIMARY AIR SHUTTER and goes into the PRIMARY AIR FAN.

The fan pushes the air to form an AIR CONE which is forced out the AIR NOZZLE.

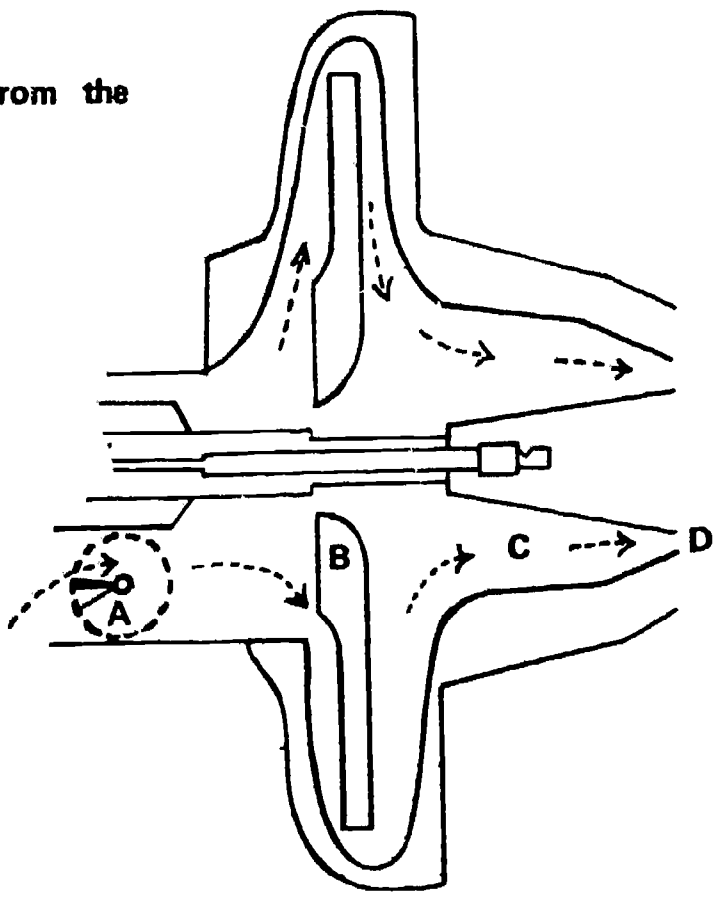
Before each part WRITE THE LETTER from the diagram that shows it.

____ Primary Air Shutter

____ Primary Air Fan

____ Primary Air Cone

____ Primary Air Nozzle



Now answer these questions:

1. The Primary Air ___f_____ moves and pushes the primary air.

2. If there is the wrong amount of primary air, you get a good/bad flame. (cross out one)

— Check your answers on
the next page.

Answers to Exercise 10:

A Primary Air Shutter
B Primary Air Fan
C Primary Air Cone
D Primary Air Nozzle

1) Fan
2) Bad Flame

11. Secondary Air

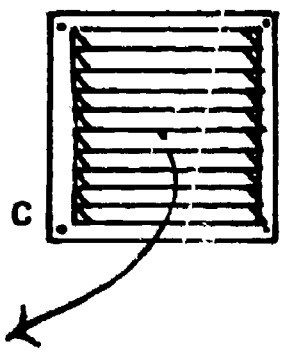
A lot of Secondary Air is needed around the flame. More Secondary Air is needed than Primary Air.

Fresh air comes in from outside through a LOUVER in the wall.

Air goes through the WINDBOX into the fire-box.

The FIREBOX is where the flame is.

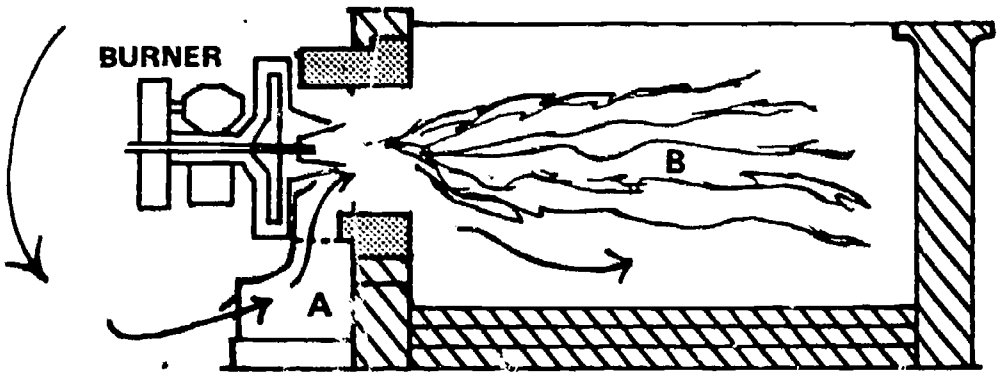
BESIDE EACH PART below WRITE THE LETTER FROM THE DIAGRAM WHICH SHOWS IT:



____ OUTSIDE LOUVER

____ WINDBOX

____ FIREBOX



Answer these questions:

1. **Name the two kinds of air a good flame needs:**

   _____, _____

2. **Do you need more Secondary or Primary Air?** _____
3. **When there isn't enough Secondary Air, what kind of flame will you get?**

   _____

4. **If the outside louver is covered up, enough** _____ **can't get in.**

—Check your answers.

Answers to Exercise 11:

C Outside Louver
A Windbox
B Firebox

1) Primary, Secondary
2) Secondary

3) Bad Flame
4) air

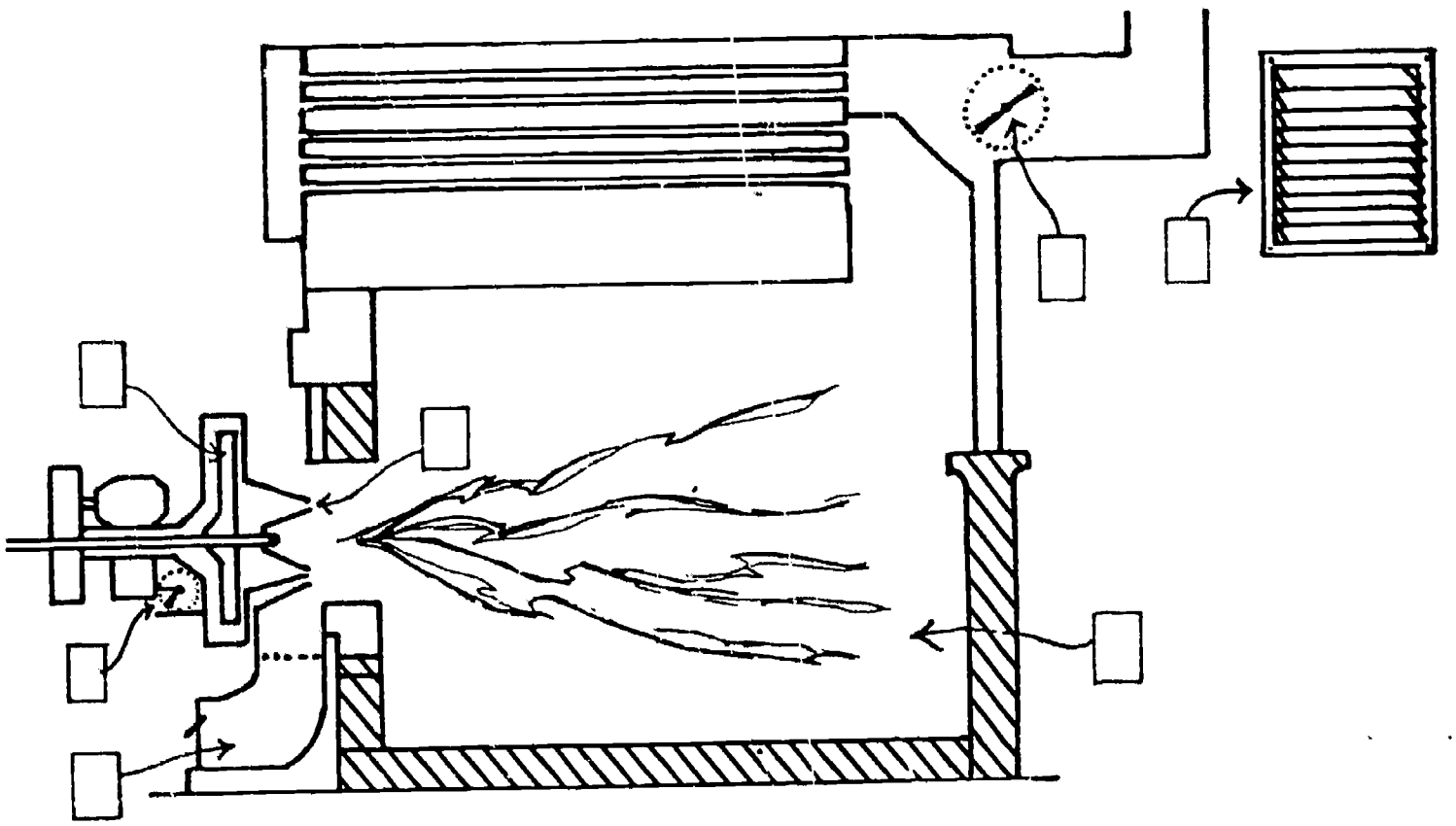
---

12. Draft Through The Furnace

There must be draft to pull air into the firebox, to help air mix with the flame, and draw hot gases up the stack. Draft is very important for a good flame.

A damper in the chimney uptake controls draft. In small plants, this damper is operated by hand. In plants burning 25 gallons per hour or more it is automatic.

Label the parts of the primary air, secondary air and draft systems on the diagram with the correct letter from the list.

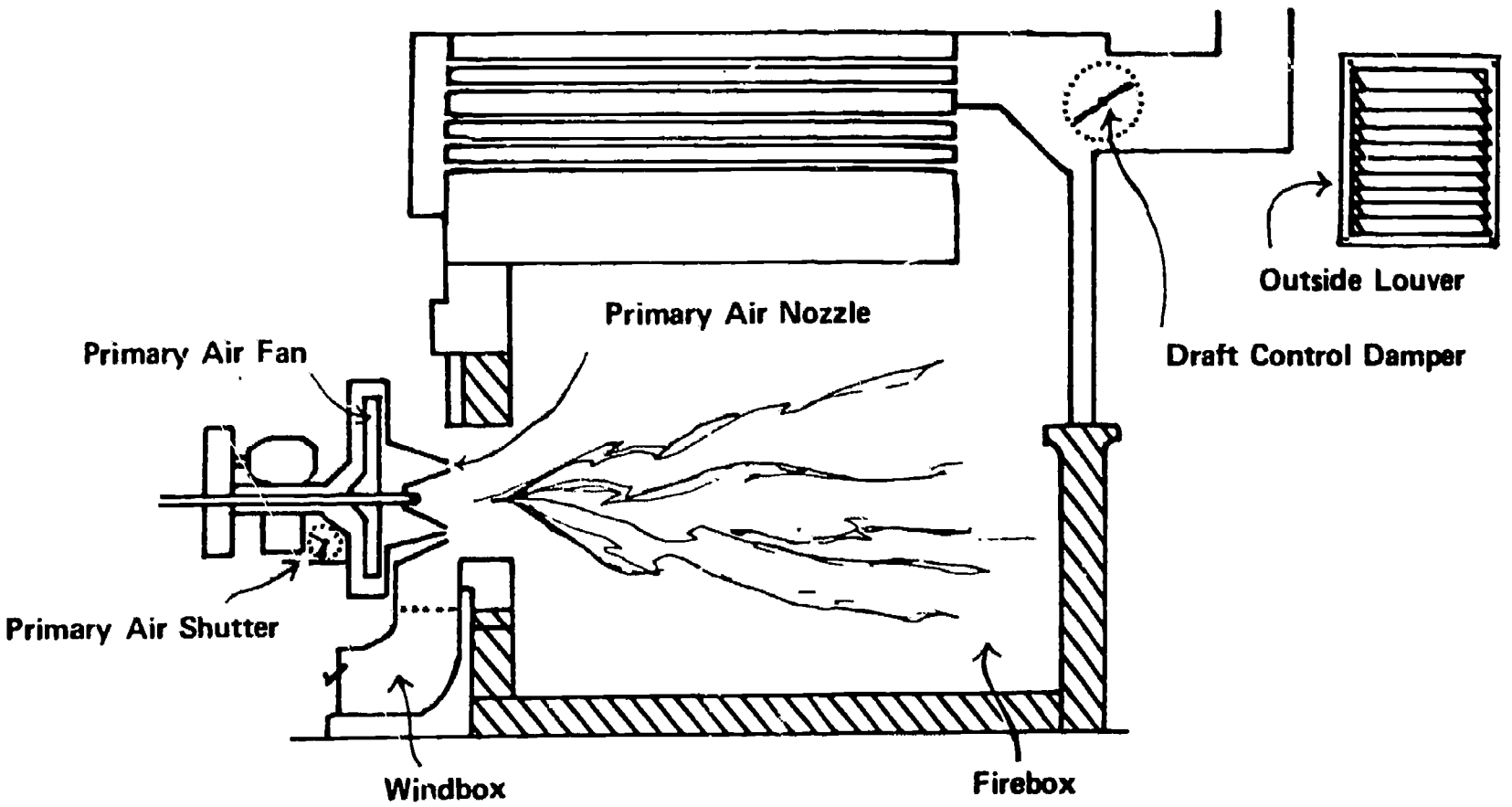


A. Primary Air Shutter
B. Primary Air Fan
C. Primary Air Nozzle
D. Outside Louver
E. Windbox
F. Firebox
G. Draft Control Damper

— Check you answers on the next page.

13. Review And A Look Ahead

The right air/oil ratio is needed for good burning. Check your diagram on the opposite page with this one.

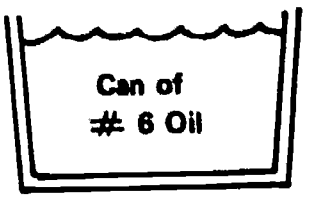


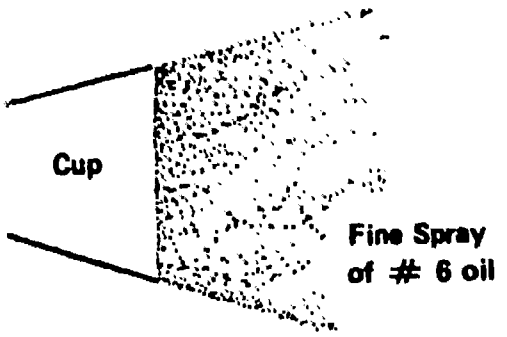
When all of these parts are working right, the flame will get the air it needs. Now for the oil.

Turn the page.

14. Getting Oil To Burn

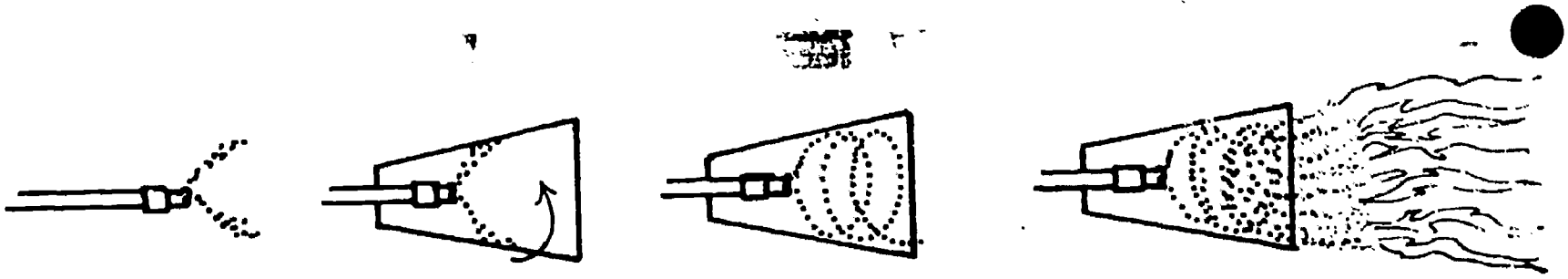
CIRCLE THE PICTURE SHOWING WHAT OIL IS LIKE WHEN IT IS BURNED.





 # 6 oil will burn only if it is sprayed into a fine mist. Most burners use a spinning cup to do this.

THIS IS WHAT HAPPENS IN YOUR BURNER:



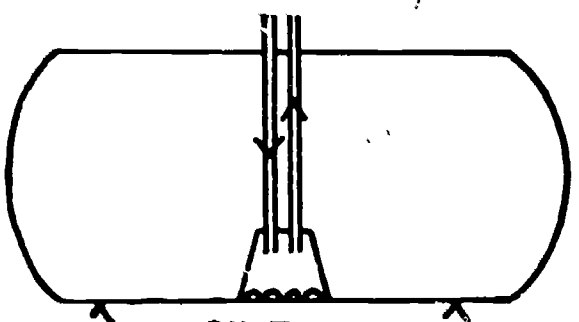
1	2	3	4
Nozzle feeds oil into cup.	Spinning cup picks up oil stream.	When cup is smooth - oil spins into a fine mist.	Oil drops are sprayed into the air coming from primary air around the cup - mixed with air and burned.

Only tiny oil drops will burn completely. When the cup is damaged, the oil drops become larger.

What happens to an oversized oil blob in the firebox? _____

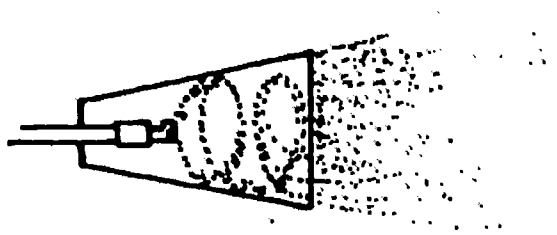
If you said "big blobs don't burn completely" or something like that, you're right.

CIRCLE COLD or HOT and THICK or THIN under each picture, which ever is right.



OIL TANK

OIL OUTSIDE THE COIL IS
COLD/HOT AND THICK/THIN



OIL CUP

OIL IS
COLD/HOT AND THICK/THIN

That's right! The oil starts out COLD and THICK and ends up HOT and THIN.

NUMBER THIS LIST IN THE RIGHT ORDER:

___ Truck delivers oil to fuel tank.

___ Oil is heated to proper temperature.

___ Oil is pumped into the cup and spun for burning.

___ Oil is pumped from tank to heaters.

Check your answers.

Answers to Exercise 14:

1 Truck delivers oil to fuel tank.

3 Oil is heated to proper temperature.

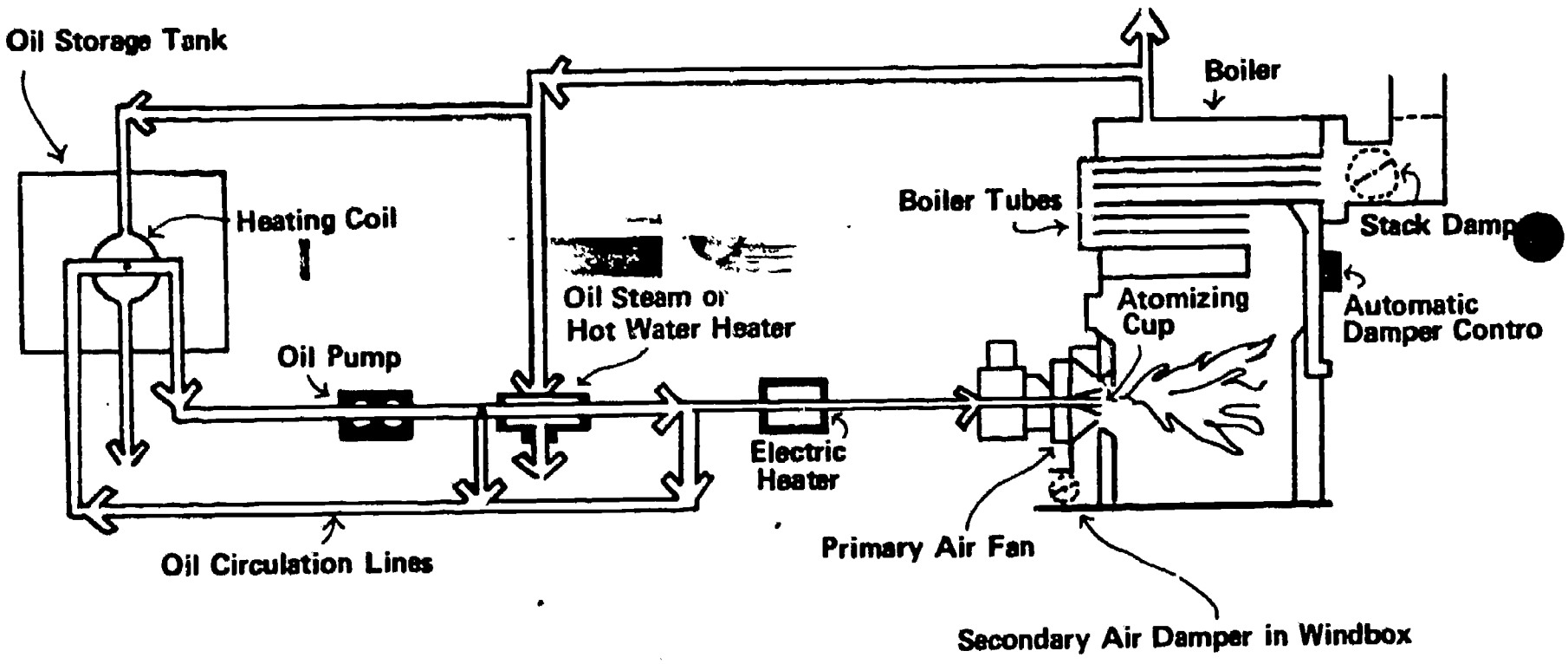
4 Oil is pumped into the cup and spun for burning.

2 Oil is pumped from tank to heaters.

15. Boiler Parts

A boiler system contains the parts shown below. Larger systems will have more parts; smaller systems may have fewer parts. In this diagram all of the parts are stretched out to show them clearly. Your equipment may be wrapped around the boiler.

Study this and answer the questions on the next page.



1. What heats the oil in the tank? _____

2. After the tank, how many oil heaters are there in this system? _____

3. What piece of equipment moves the oil through the fuel lines? _____

4. The oil is sprayed into the firebox by the: _____

5. Secondary air enters the firebox through the: _____

6. What piece of equipment gets the primary air moving into the firebox? _____

– Check your answers at top of next page.

Answers to Exercise 15: 1) Hoating Coil
2) Two
3) Oil Pump
4) Atomizer Cup
5) Air Damper in Windbox
6) Primary Air Fan

PUT A CHECK IN THE CORRECT COLUMN NEXT TO EACH BOILER PART. The first one is done for you. Pipes are used in moving the oil.

BOILER PARTS	HAS TO DO WITH			
	AIR	HEATING	STORAGE & MOVING	BURNING
1. Pipes			✓	
2. Electric Heater				
3. Cup (Atomizing)				
4. Secondary Air (Windbox)				
5. Primary Air Fan				
6. Fuel Storage Tank				
7. Steam or Hot Water Oil Heater				
8. Automatic Damper Control				
9. Stack Damper				
10. Fuel Tank Heating Coil				

– Check your answers on the next page.

Answers to previous page

BOILER PARTS	HAS TO DO WITH			
	AIR	HEATING	STORAGE & MOVING	BURNING
1. Pipes			✓	
2. Electric Heater		✓		
3. Cup (Atomizing)				✓
4. Secondary Air (Windbox)	✓			
5. Primary Air Fan	✓			
6. Fuel Storage Tank			✓	
7. Steam or Hot Water oil Heater		✓		
8. Automatic Damper Control	✓			
9. Stack Damper	✓			
10. Fuel Tank Heating Coil		✓		

Summary Of Part I:

These questions review the important things in this section:

1. A Ringelmann Chart measures how _____ the smoke is.

2. Light smoke is allowed if the length of _____ is kept short.

3. What happens if you have too much dark smoke?

   _____

4. Check the pollutants you can reduce or prevent:

____ Ash	____ Smut
____ Smoke	____ Carbon Monoxide
____ Soot	____ Nitrogen Oxides

5. When air and oil are not properly mixed, the result is _____ which results in smoke.

6. What term (including the ingredients of burning) is the key to good burning? _____ ratio

7. Name the two "types of air" used in the burning of fuel:

   _____

   _____

8. What equipment delivers the two "types of air"?

   _____

   _____

Turn the page

9. What draws the air through the furnance?

_____

10. How does air first get into the boiler room?

_____

11. What do you get if you have the wrong amount of air or if the oil is not atomized correctly?

_____

12. What form must oil be in, in order to burn? _____

13. What must be done to the oil before it can be atomized?

_____

14. Circle the correct words:

a) All boilers are the same/different.
b) The atomizing cup is the center of the burner/heater.
c) Boilers ususally have electric and steam generators/heaters.

— Check your answers on the next page.

Answers to Summary of Part I.

1. black or dark
2. time
3. summons
4. ___ Ash ✓ Smoke ✓ Soot ___ Smut ✓ Carbon Monoxide ✓ Nitrogen Oxides
5. bad burning
6. air/oil
7. primary, secondary
8. primary air shutter or fan, windbox
9. draft or damper in the chimney
10. air louvers on outside wall
11. bad burning or poor flame
12. fine, even mist
13. heated
14. a)different
    b) burner
    c) heaters