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ABSTRACT

This workbook is part four 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, after answering, he either turns to the next page to check his response or refers to the previously covered material. The purpose of this course is to prepare the student for his APC Training Certificate. This section is concerned with analyzing the flame, which may be the key to solving many boiler problems. This book gives the student tasks to do for some common, incorrect flames. (BT)

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EDUCATION & WELFARE  
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# **Air Pollution Training Institute Self-Instructional Course SI-466**

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## **Part 4 Troubleshooting, Section Two Boilers: Flame Reading**

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United States  
Environmental Protection Agency  
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David Sage, Inc.  
New York City, New York

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Part Four:  
Troubleshooting  
Section Two  
Boilers; Flame Reading

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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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# 4

THIS IS PART  
TROUBLESHOOTING, SECTION TWO  
BOILERS: FLAME READING

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Additional units of this self-instructional course are:

PART ONE  
The Basics of Preventing Air  
Pollution Emissions from Boilers

PART TWO  
The Basics of Boiler Operation  
and Maintenance

PART THREE  
Troubleshooting, Section One  
Boilers: Correcting Oil Temperature

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

## **TROUBLESHOOTING FLAME READING**

**When the smoke alarm goes off, oil temperature is the first thing to check.**

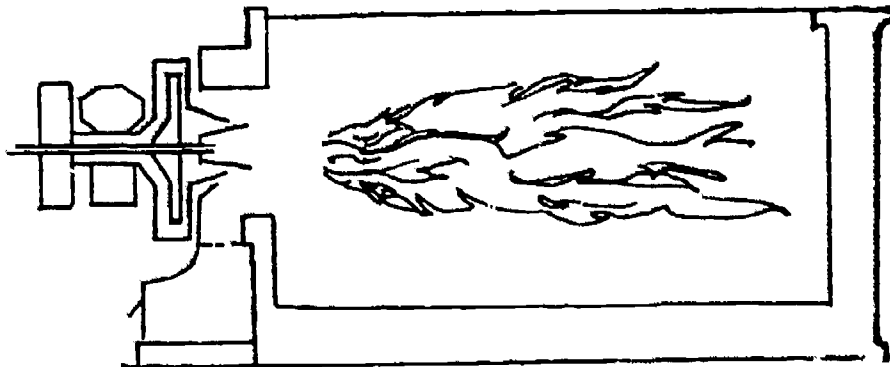
**If the oil temperature is OK, THE FLAME may be the key to solving the problem.**

**This book will give you simple tasks to do for some common incorrect flames. The corrections here assume that the oil flow is normal. Troubleshooting is complicated due to the delicate nature of the air/oil ratio. If the problem is not easily solved, call service and report what you have found.**

## FLAME AWAY FROM THE BURNER

Most boilers have a peephole. Through it you can see the flame.

Look at this flame.



**CIRCLE THE CORRECT ANSWER:**

This flame is: A. too close to the burner.  
B. too far away from the burner.

The most likely reason is that the flame above is being pushed off the burner by **TOO MUCH PRIMARY AIR**.

The **PRIMARY AIR SHUTTER** (regulated by **LINKAGE**) is taking in too much air. If you know how to set the Primary Air Shutter, adjust it carefully. The correct air/oil ratio is the key to good flames and smokeless burning. If you don't know a lot about it, call service.

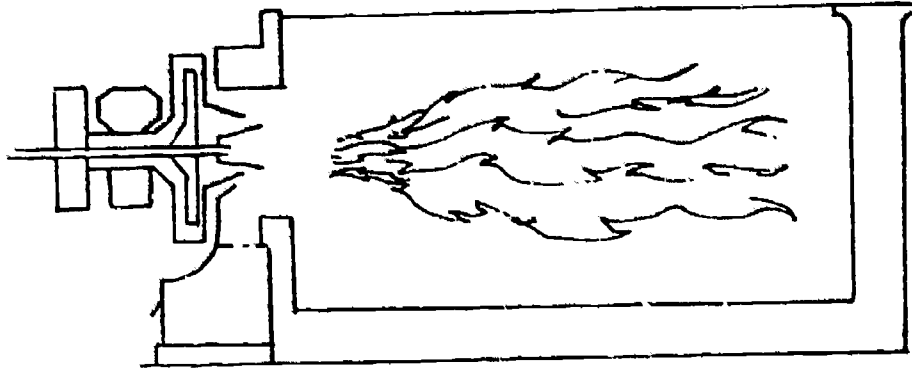
Check the parts below which may need adjustment to correct a flame off the burner:

- \_\_\_\_\_ Primary Air Shutter
- \_\_\_\_\_ Primary Air Linkage
- \_\_\_\_\_ Secondary Air Damper

— Check your answers

- \_\_\_\_\_ Primary Air Shutter
  - \_\_\_\_\_ Primary Air Linkage
  - \_\_\_\_\_ Secondary Air Damper
- 

LOOK AT THIS FLAME.



1. How does this flame not look right?

\_\_\_\_\_

2. What should you suspect when you get a flame like this?

\_\_\_\_\_

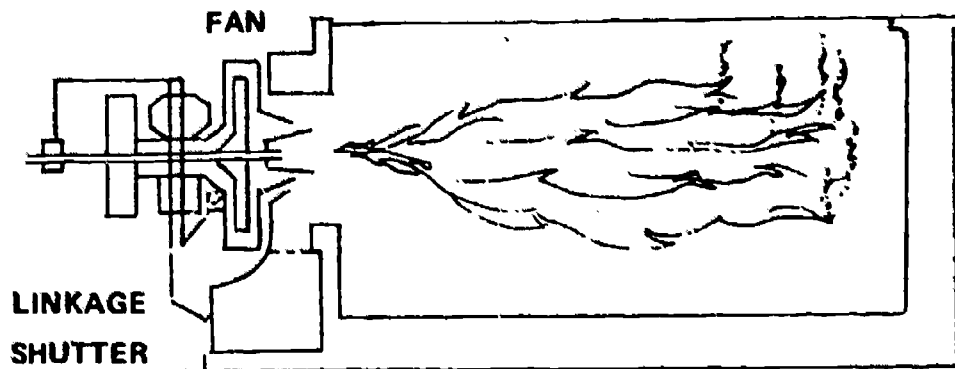
— Check your answers.

1. too far away from burner
2. too much primary air

## SMOKY FLAME

A Smoky Flame (unstable and flickering) means **NOT ENOUGH AIR**. Check the three parts of the primary air system.

### PRIMARY AIR



The **PRIMARY AIR SHUTTER** and **LINKAGE** can be lubricated and cleaned but change the setting only if you have been taught to do it accurately on your system.

You know how your **FAN** should sound. Blades may need to be cleaned; belts may need to be tightened.

**CIRCLE THE PARTS ON THE DIAGRAM THAT YOU CAN KEEP CLEAN AND IN GOOD WORKING ORDER.**

Answer these questions:

1. Do smoky flames come from too much or too little air? \_\_\_\_\_
2. When you get a smoky flame, first check the \_\_\_\_\_  
air.

— Check your answers.

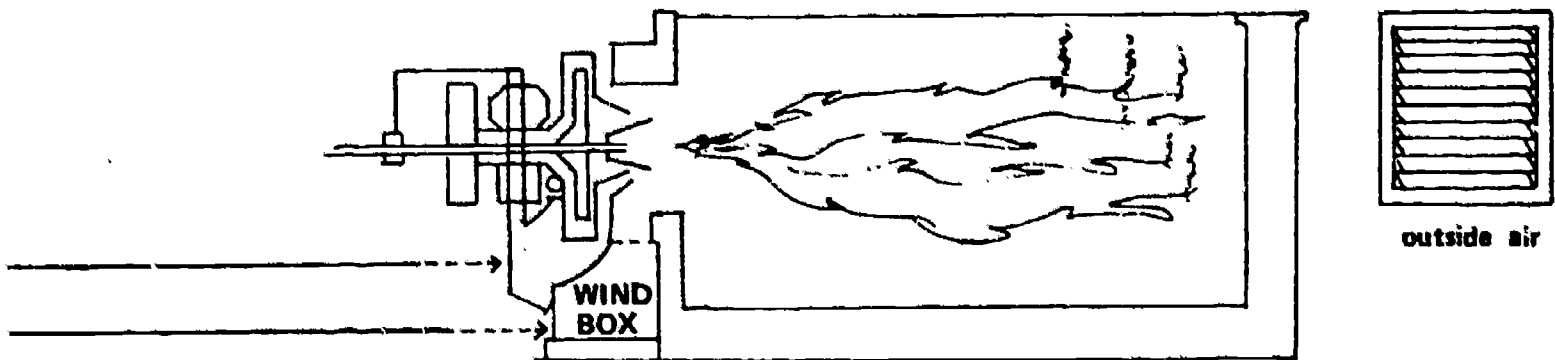


1. too little
2. primary

If the Primary Air is all right, check –

**SECONDARY AIR**

The Windbox may not be delivering enough air. LABEL THE LINKAGE and DAMPER on the lines in the diagram.



Linkage must be set properly and lubricated to move easily. It should clear the floor when in the lowest position.

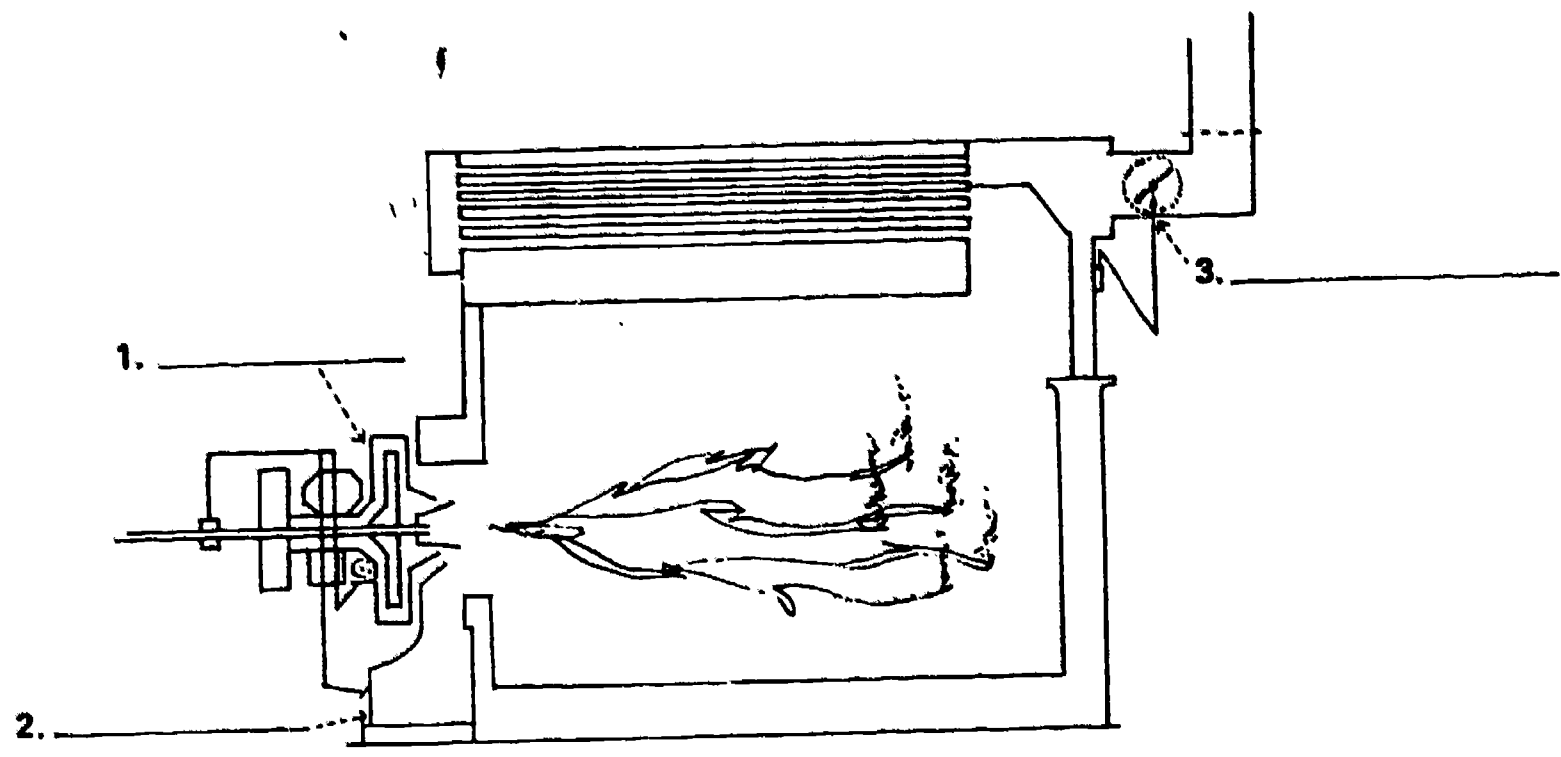
The damper should be clean.

1. If you get a smoky flame, what do you check after the primary air? \_\_\_\_\_
2. What equipment must be set and move easily to deliver secondary air?  
\_\_\_\_\_  
\_\_\_\_\_

– Check your answers.

- 1. Secondary Air
- 2. Linkage, Damper

## SMOKY FLAME - NOT ENOUGH AIR



On the diagram, LABEL THREE SOURCES OF AIR to check when you get a Smoky Flame –

- PRIMARY AIR
- SECONDARY AIR
- STACK DAMPER

The STACK DAMPER should move freely and not be blocked. You may or may not adjust this damper, but you can keep it lubricated and clean.

1. Is your stack damper manual or automatic?

\_\_\_\_\_

2. What can you do to keep the stack damper in good condition?

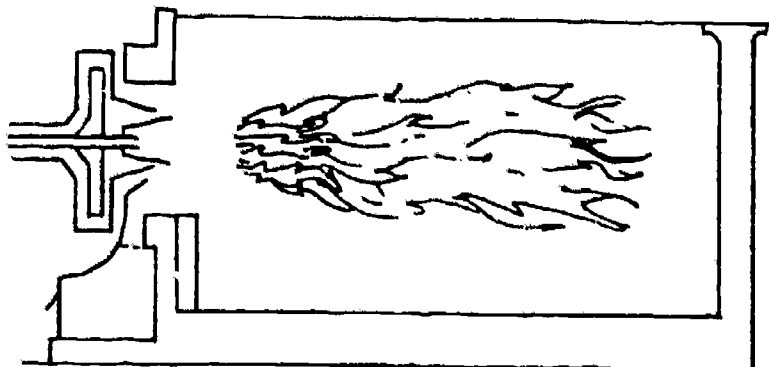
\_\_\_\_\_

– Check your answers.

1. Check your own answer
2. clean it, lubricate it

Here are two incorrect flames.

CIRCLE the correct answers beside each diagram.

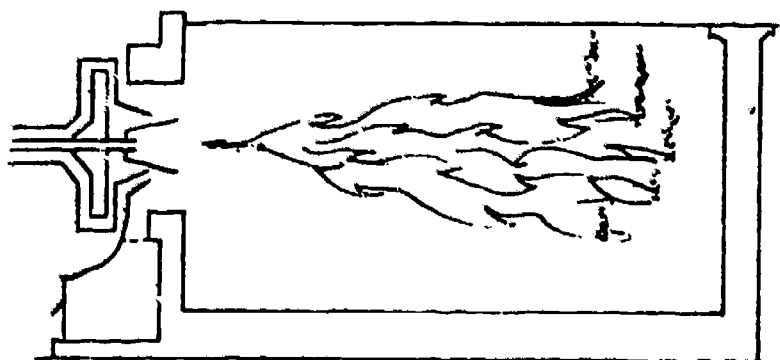


This flame is: **AWAY FROM THE BURNER**  
**SMOKY**

A cause is: **TOO MUCH AIR**  
**NOT ENOUGH AIR**

Troubleshooting

Checks: **PRIMARY AIR**  
**SECONDARY AIR**  
**STACK DAMPER**



This flame is: **AWAY FROM THE BURNER**  
**SMOKY**

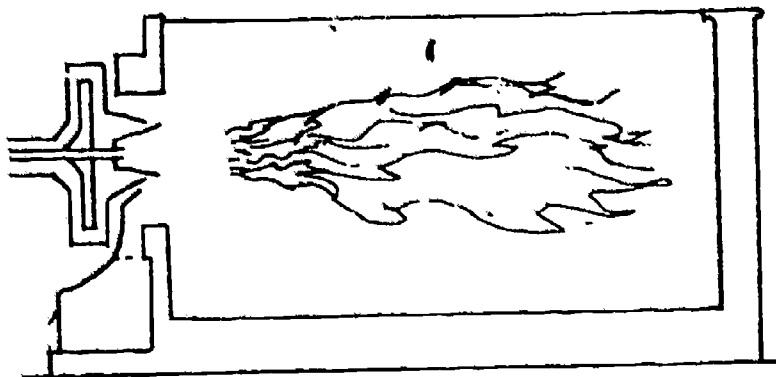
A cause is: **TOO MUCH AIR**  
**NOT ENOUGH AIR**

Troubleshooting

Checks: **PRIMARY AIR**  
**SECONDARY AIR**  
**STACK DAMPER**

— Check your answers.

**ANSWERS TO PREVIOUS PAGE.**

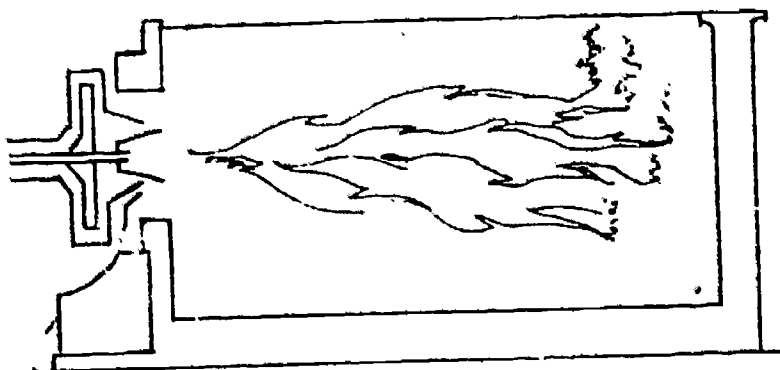


**This flame is: AWAY FROM THE BURNER**

**A cause is: TOO MUCH AIR**

**Troubleshooting**

**Checks: PRIMARY AIR**



**This flame is: SMOKY**

**A cause is: NOT ENOUGH AIR**

**Troubleshooting**

**Checks: PRIMARY AIR  
SECONDARY AIR  
STACK DAMPER**

## **HANDBOOK SUMMARY**

**TURN IN YOUR BOILER HANDBOOK TO PAGE 46.**

**Here is an incorrect flame summary for your future reference.**

**NOW, LOOK AT PAGE 47 in the HANDBOOK.**

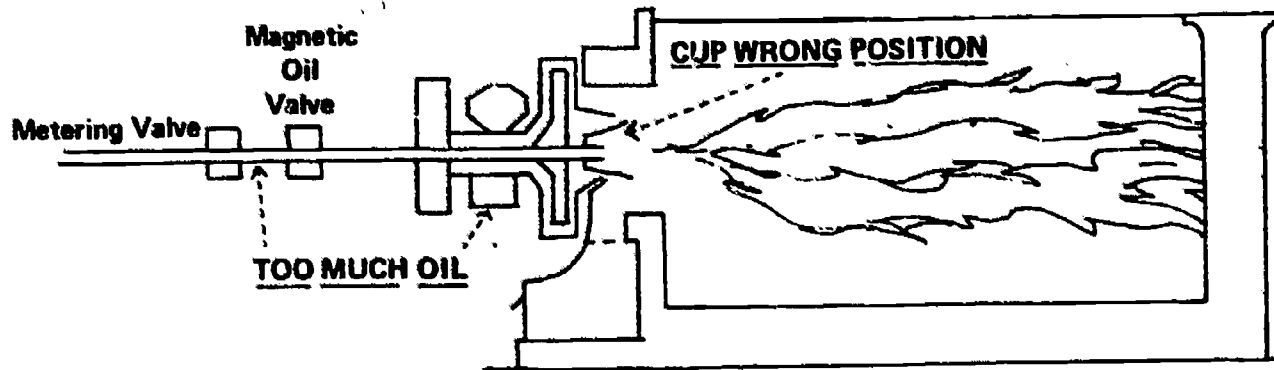
**Here is your own table of incorrect oil flames. Under each flame is space to write a probable cause of the flame, and some Troubleshooting Checks.**

**WRITE IN A CAUSE AND TROUBLESHOOTING CHECKS UNDER "FLAME AWAY FROM THE BURNER" AND "SMOKY FLAME." Use Page 14 in this book for reference.**

**After completing this work, go on to the next page.**

# FLAME TOO LONG

HITS THE WALL – SMOKY TIPS



If there is **TOO MUCH OIL** going into the burner, there will be too much flame (too long) in the firebox.

Your upgraded system should have the **OIL VALVES** shown above. The **Metering Valve** is set by the oil representative; you should change it only if you have been trained on your system.

## ANSWER THESE QUESTIONS:

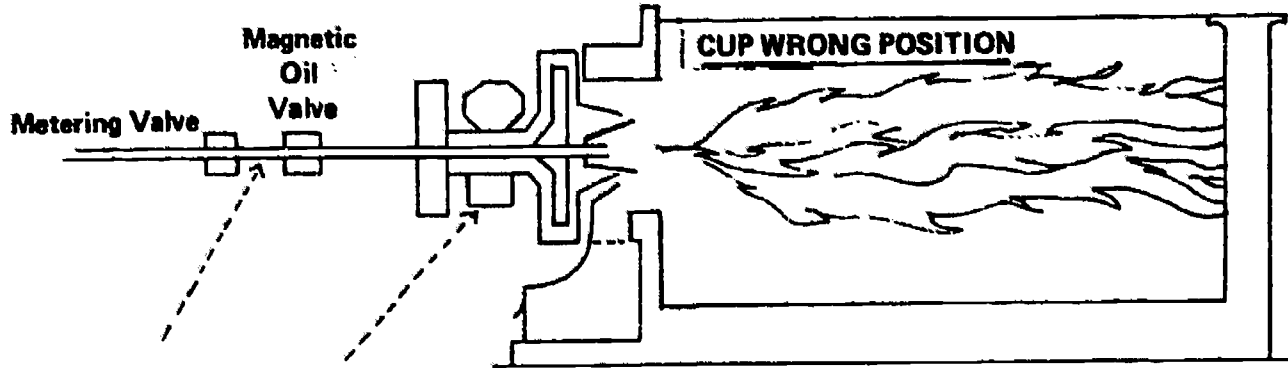
1. Too much oil may give you what kind of flame? \_\_\_\_\_

2. On the diagram, two \_\_\_\_\_ regulate the oil flow.

– Check your answers.

1. too long
2. valves

WRITE ONE CAUSE OF A LONG FLAME on the line in the diagram:



Check your answer on the preceding page.

If the CUP is set OUT FROM THE BURNER too far, it will extend the flame and cause it to hit the wall.  
REPLACE THE CUP CORRECTLY EACH TIME YOU CLEAN IT.

ANSWER THESE QUESTIONS:

1. In addition to oil valves what device shown on the diagram must be set correctly for a good flame?

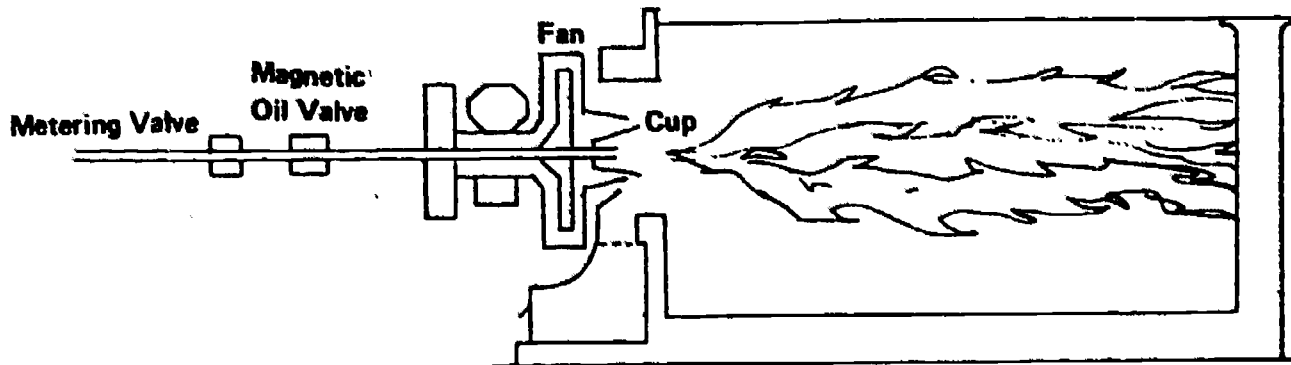
\_\_\_\_\_

2. Are you responsible for correct cup position?

\_\_\_\_\_

— Check your answers.

- 1. cup
- 2. yes



When your smoke alarm goes off, you may see a flame like the one above in your firebox.

- 1. What is wrong with the flame above?
- 2. What are two causes of this incorrect flame?
- 3. What instruments may be adjusted to correct it?

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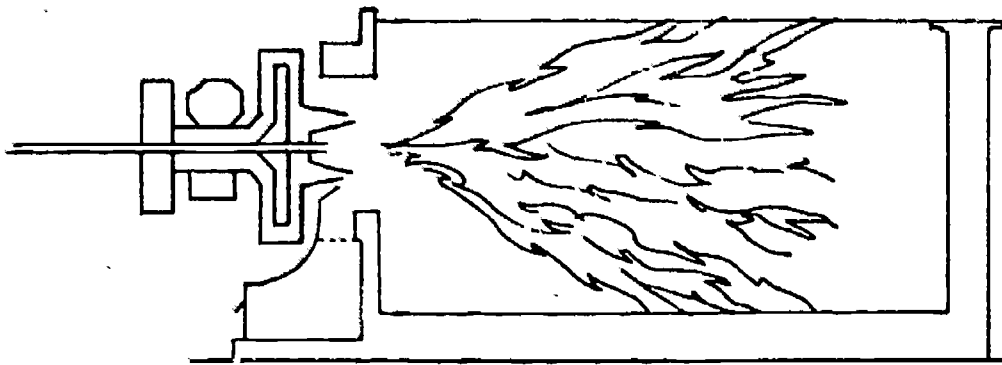
– Check your answers.



1. too long
2. too much oil, wrong cup position
3. oil valves, cup

## ANOTHER BAD FLAME

CIRCLE THE CORRECT WORD under the diagram:



Flame is too  
NARROW/WIDE

The flame may become too wide like the one above if the AIR CONE AROUND THE CUP is NOT STRONG ENOUGH. Or, the CUP could be in the WRONG POSITION.

ANSWER THESE QUESTIONS:

1. You may get a wide flame if there is not enough:

- A. PRIMARY AIR
- B. SECONDARY AIR

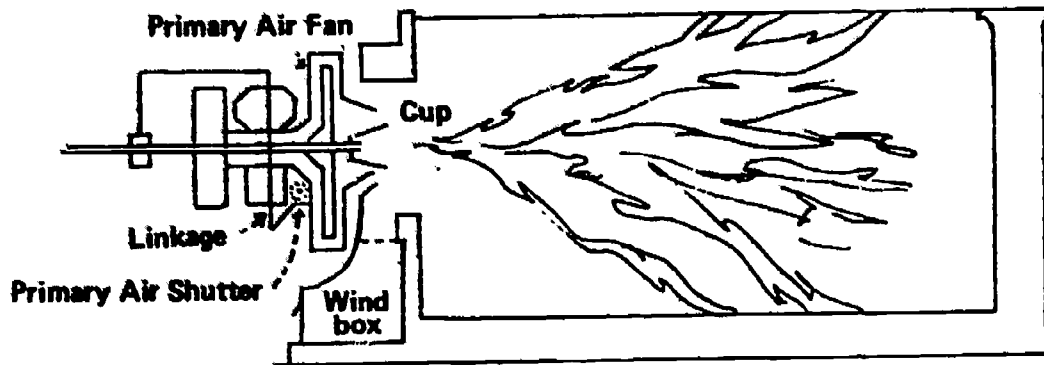
\_\_\_\_\_

2. What must be in the proper position to atomize a good flame? \_\_\_\_\_

— Check your answers.

1. A. Primary Air

2. cup



Two causes of a WIDE FLAME have been considered.

1. What equipment would you check to troubleshoot TOO LITTLE PRIMARY AIR? (see diagram)

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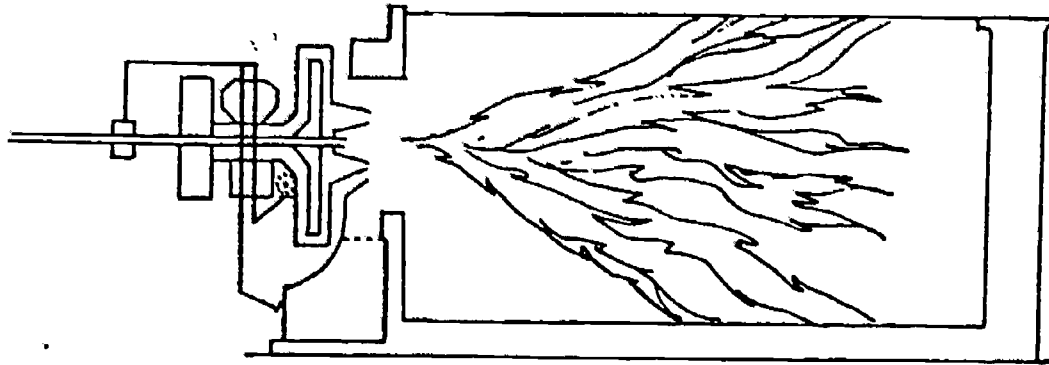
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2. If the Primary Air is OK, what other equipment would you check to troubleshoot a wide flame?

---

— Check your answers.

- 1. Primary Air Shutter  
Linkage  
Primary Air Fan
  - 2. cup
- 



When your smoke alarm goes off you may see a flame like the one above.

1. How is the flame above incorrect?

\_\_\_\_\_

2. What are two common causes of this type of flame?

\_\_\_\_\_

\_\_\_\_\_

3. What equipment would you check to correct it?

\_\_\_\_\_

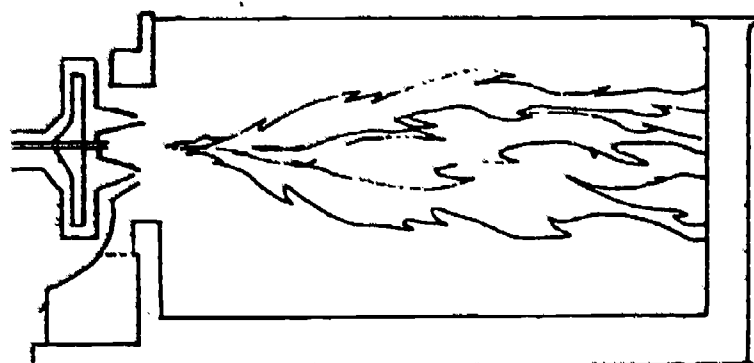
\_\_\_\_\_

— Check your answers.

1. too wide
2. not enough Primary Air  
cup in wrong position
3. Primary Air Shutter, Linkage, Fan, Cup

Below are two incorrect flames.

CIRCLE the correct answers beside each diagram.



This flame is: **TOO LONG**  
**TOO WIDE**

Some causes are: **TOO MUCH OIL**  
**TOO LITTLE**  
**PRIMARY AIR**  
**CUP IN WRONG**  
**POSITION**

Troubleshooting  
Checks: **PRIMARY AIR**  
**OIL VALVES**  
**CUP**



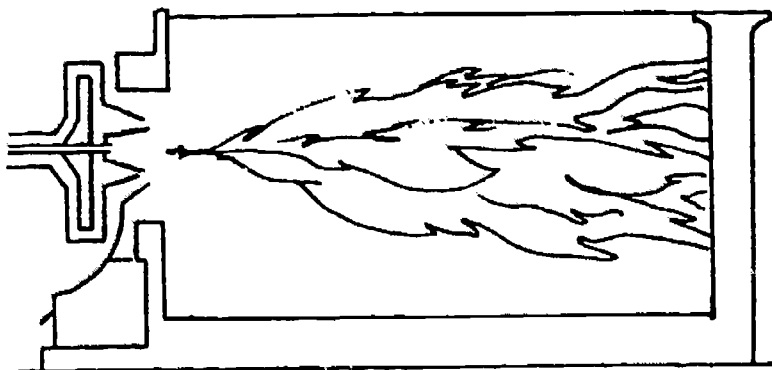
This flame is: **TOO LONG**  
**TOO WIDE**

Some causes are: **TOO MUCH OIL**  
**TOO LITTLE**  
**PRIMARY AIR**  
**CUP IN WRONG**  
**POSITION**

Troubleshooting  
Checks: **PRIMARY AIR**  
**OIL VALVES**  
**CUP**

— Check your answers. |

**ANSWERS TO PREVIOUS PAGE:**



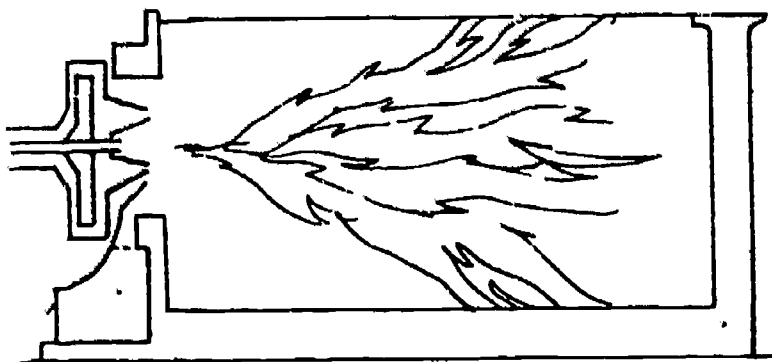
**This flame is: TOO LONG**

**Some causes are: TOO MUCH OIL**

**CUP IN WRONG POSITION**

**Troubleshooting**

**Checks: OIL VALVES  
CUP**



**This flame is: TOO WIDE**

**Some causes are: TOO LITTLE PRIMARY AIR**

**CUP IN WRONG POSITION**

**Troubleshooting**

**Checks: PRIMARY AIR  
CUP**

# **HANDBOOK SUMMARY**

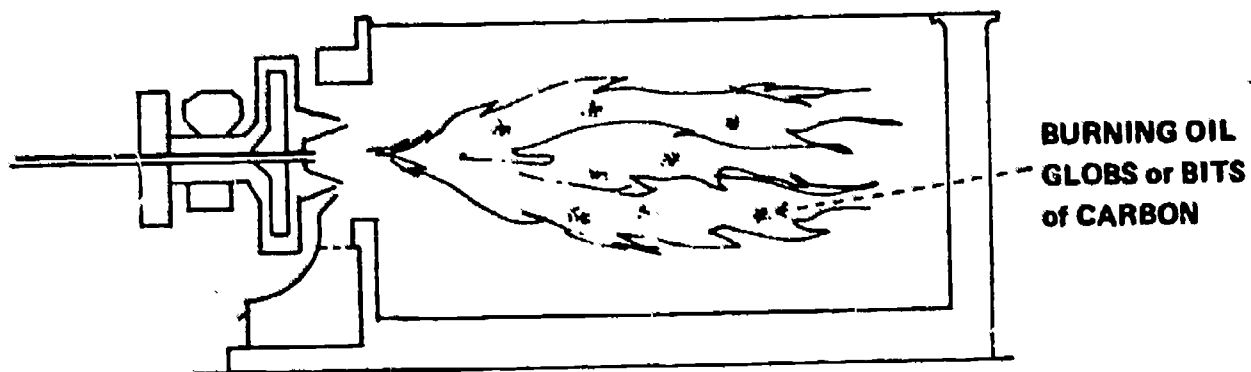
**TURN TO YOUR BOILER HANDBOOK, PAGE 47.**

**COMPLETE INCORRECT FLAME COLUMNS 3 and 4 with the information you have just learned.**

**Use page 30 in this book for reference.**

# “SPARKY” FLAME

Here are small areas where too much oil is burning and bits of burning carbon can be seen. They do not look like electric sparks but are spots where extra oil or carbon is burning.



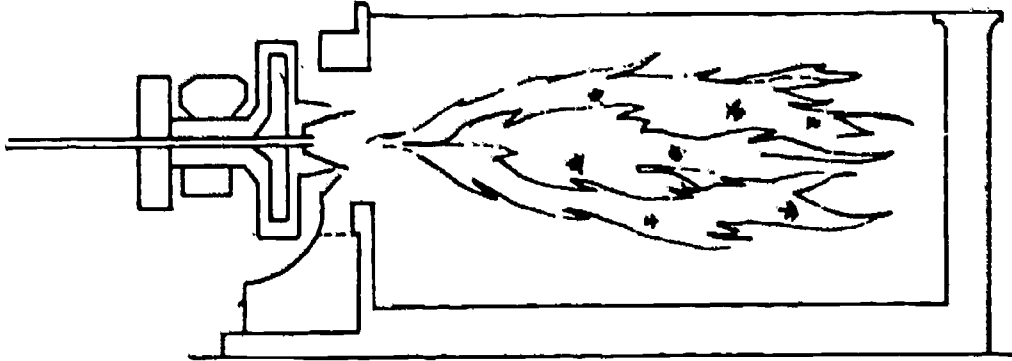
When this happens the CUP may be either DIRTY, DAMAGED, or in the INCORRECT POSITION. If cleaning and adjusting the cup doesn't help, call service.

1. "Sparks" in the flame could be bits of burning \_\_\_\_\_ or \_\_\_\_\_

2. What can you do to try to correct a "sparky" flame?  
\_\_\_\_\_  
\_\_\_\_\_

– Check your answers.

1. oil or carbon
  2. clean and adjust the cup
- 



1. Why is the flame above not a good flame?

---

2. What could be causing this flame?

---

3. What do you check to troubleshoot this flame?

---

– Check your answers.



1. has "sparks" in it
2. oil globs or carbon
3. cup (clean or adjust)

---

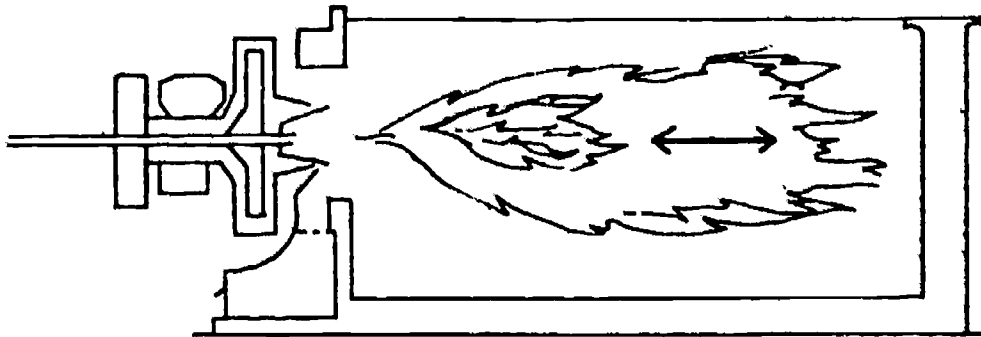
## PULSATING FLAME

A pulsating flame is one that changes in rhythm - large, small, large, small, etc. It is likely to be noisy.

Three possible causes you may be able to correct:

**WRONG AMOUNT OF OIL  
UNEVEN OIL FLOW  
NOT ENOUGH AIR**

**CIRCLE** the correct words under the picture.



To troubleshoot this flame, check the  
**AIR/OIL/CUP**

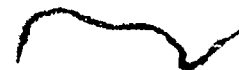
As there are many causes of a pulsating flame, it is difficult to troubleshoot. If the air and oil checks you will learn don't stop pulsation, call service.

What are two oil problems which may cause a pulsating flame?

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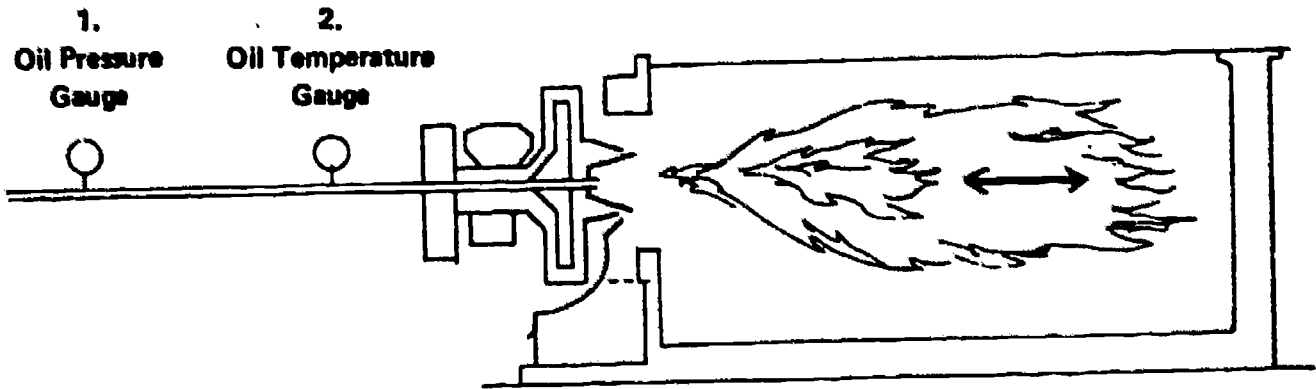
- Check your answers.



wrong amount of oil  
uneven oil flow

---

Two checks concerning oil:



What should the oil temperature closest to the burner be on your system? \_\_\_\_\_

What should your oil pressure gauge read? \_\_\_\_\_

You have this information in your Handbook. Checking OIL TEMPERATURE and troubleshooting OIL HEATERS was covered in the last section.

OIL PRESSURE checks will be taken up on the next page.

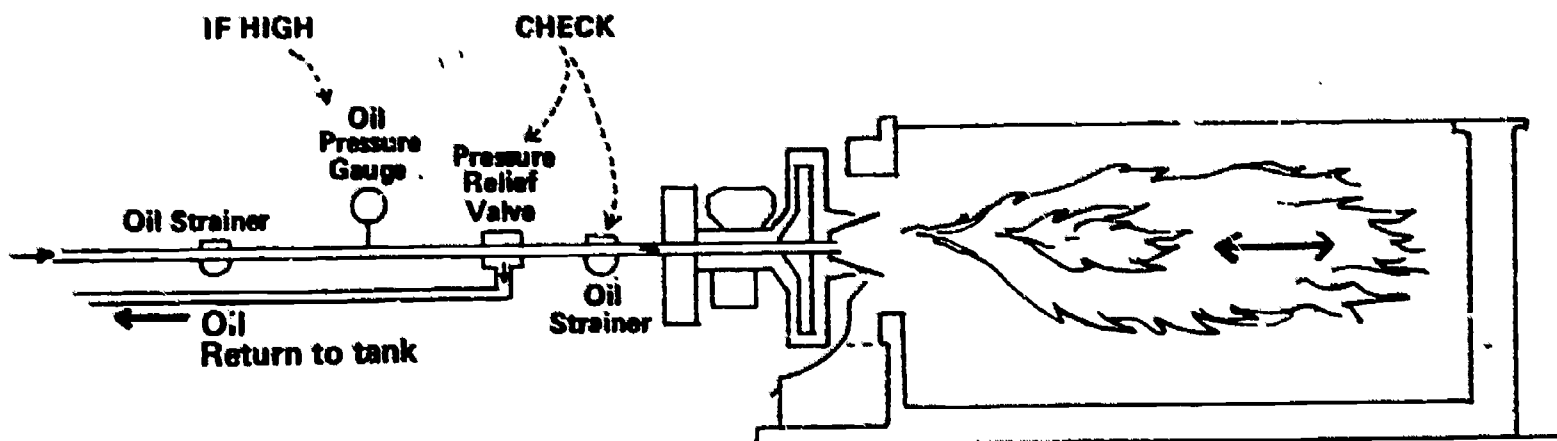
1. What is wrong with the flame above? \_\_\_\_\_

2. What two oil gauges do you check in troubleshooting it? \_\_\_\_\_

— Check your answers.

1. Pulsating flame
2. Oil Temperature Gauge
- Oil Pressure Gauge

If OIL PRESSURE is the problem, it will be TOO HIGH.



ON THE DIAGRAM:

CIRCLE THE PART that sends excess oil back to the tank.

PUT CHECKS (✓) ON THE PARTS that clean the oil but can become dirty and clogged.

If the PRESSURE RELIEF VALVE doesn't send enough oil back to the tank, it should be adjusted by service. A clogged line, perhaps at the STRAINERS, will send the oil pressure up.

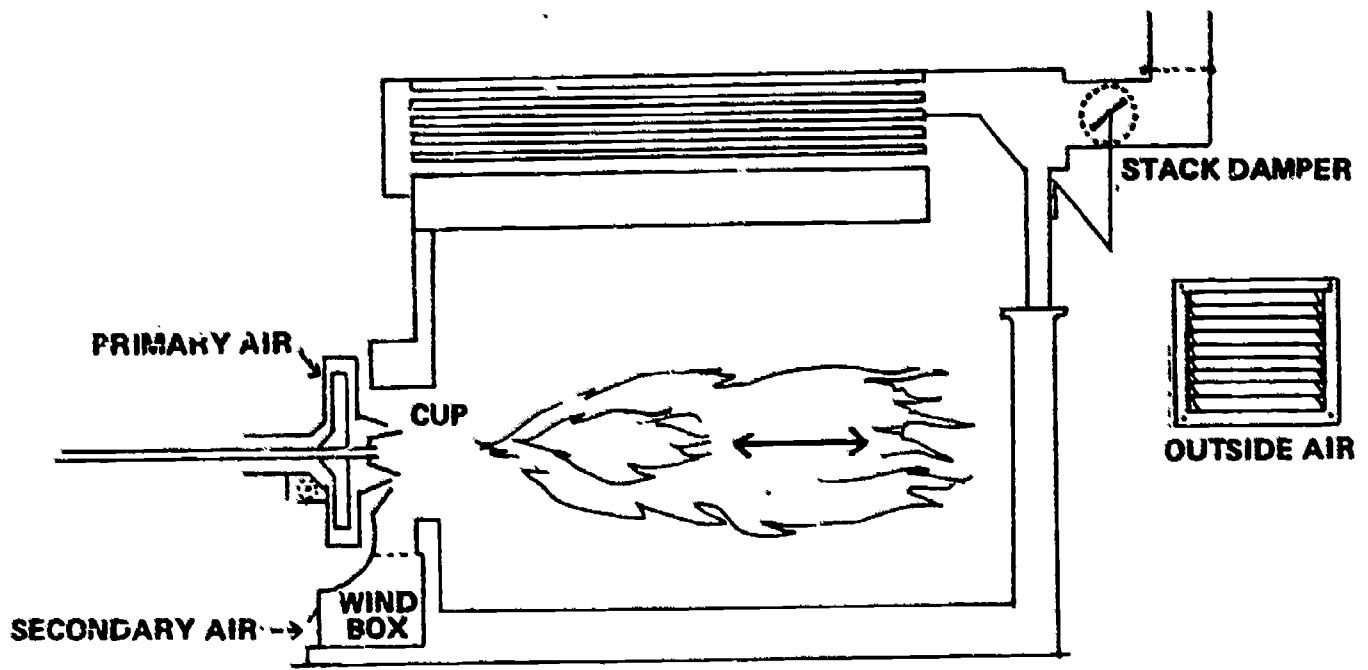
1. Where does the Pressure Relief Valve send excess oil? \_\_\_\_\_
2. Which of these can you probably take care of without calling service? \_\_\_\_\_
3. If you get high oil pressure, what two things should you check? \_\_\_\_\_  
\_\_\_\_\_

– Check your answers.

1. to the tank
2. oil strainers
3. pressure relief valve  
oil strainers

After checking the OIL TEMPERATURE and OIL PRESSURE, CHECK for TOO LITTLE AIR before calling service.

CIRCLE PLACES TO CHECK FOR TOO LITTLE AIR ON THE DIAGRAM:



To check for too little air, look at all four air sources above.

1. How is the flame above not a good one? \_\_\_\_\_

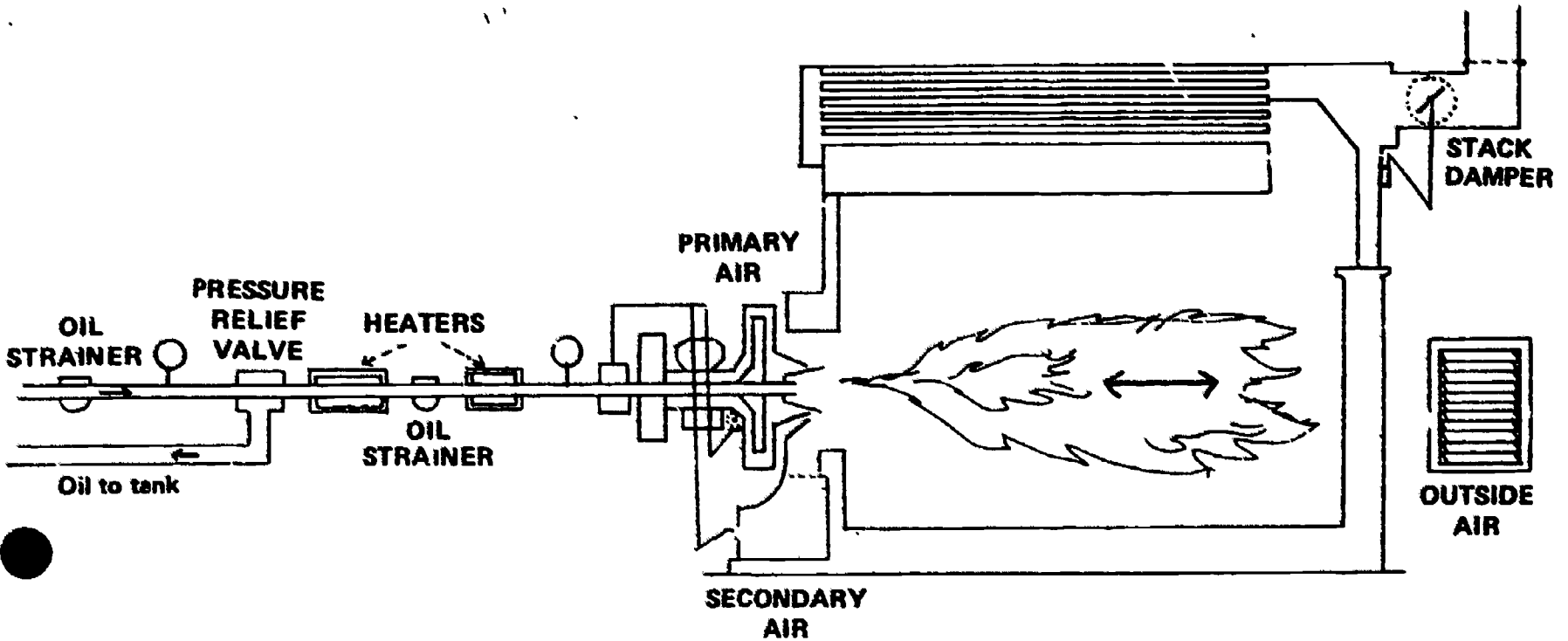
2. What are the areas to check? (CHECK THREE BELOW)

- \_\_\_\_\_ Oil Temperature
- \_\_\_\_\_ Cup Condition
- \_\_\_\_\_ Oil Pressure
- \_\_\_\_\_ Too Much Air
- \_\_\_\_\_ Too Little Air

3. How many air sources are there to check if you get a flame like the one above? \_\_\_\_\_

- 1. Pulsating
- 2.  Oil Temperature
- Cup Condition
- Oil Pressure
- Too Much Air
- Too Little Air

3. Four



FOR EACH MAJOR AREA BELOW, WRITE THE PARTS FROM THE DIAGRAM THAT YOU SHOULD CHECK BEFORE CALLING SERVICE.

**PULSATING FLAME CHECKS:**

1. OIL TEMPERATURE  
INCORRECT

Check: \_\_\_\_\_

2. HIGH OIL PRESSURE

Check: \_\_\_\_\_

\_\_\_\_\_

3. TOO LITTLE AIR

Check: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

— Check your answers.

**ANSWERS TO PULSATING FLAME CHECKS:**

**1. OIL TEMPERATURE  
INCORRECT**

**Check: Heaters**

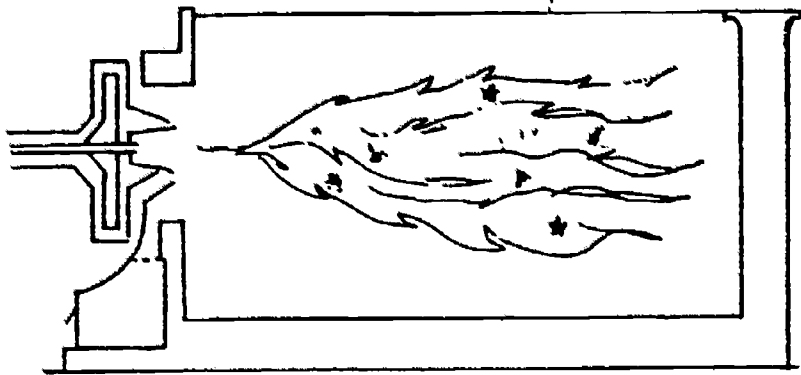
**2. HIGH OIL PRESSURE**

**Check: Pressure Relief Valve  
Oil Strainers**

**3. TOO LITTLE AIR**

**Check: Outside Air Supply  
Primary Air  
Secondary Air  
Stack Damper**

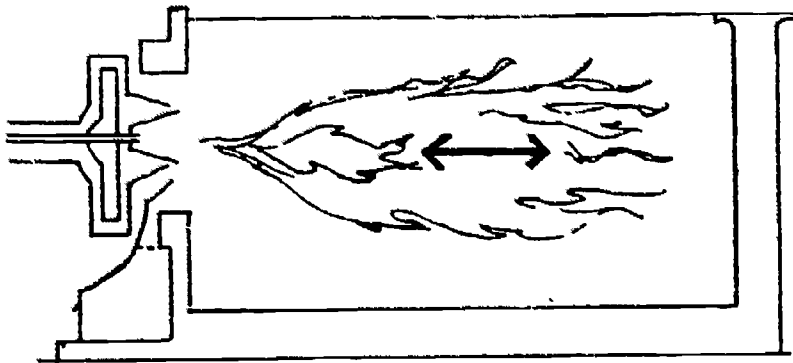
Below are the last two incorrect flames presented. CIRCLE the CORRECT ANSWERS for each.



This flame is: "SPARKY"  
PULSATING

A cause is: WRONG AMOUNT OF OIL  
BITS OF BURNING OIL  
OR CARBON  
UNEVEN OIL FLOW  
TOO LITTLE AIR

Troubleshooting  
Checks: CUP  
OIL TEMPERATURE GAUGE  
OIL PRESSURE GAUGE  
AIR SUPPLY



This flame is: "SPARKY"  
PULSATING

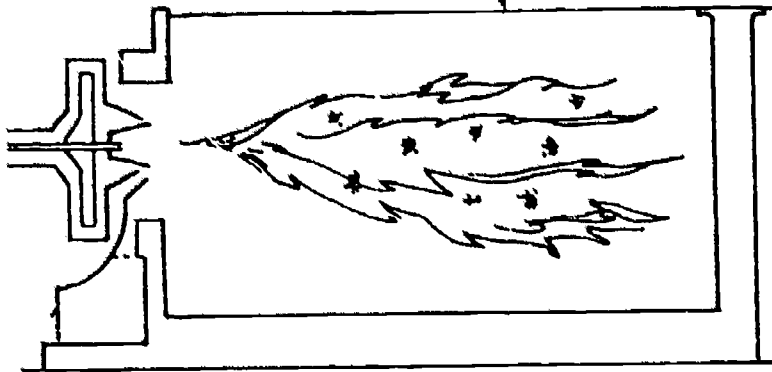
Some causes are: WRONG AMOUNT OF OIL  
BITS OF BURNING DIRT  
OR OIL  
UNEVEN OIL FLOW  
TOO LITTLE AIR

Troubleshooting  
Checks: CUP  
OIL TEMPERATURE GAUGE  
OIL PRESSURE GAUGE  
AIR SUPPLY

— Check your answers.

**ANSWERS TO PREVIOUS PAGE:**

**This flame is: "SPARKY"**

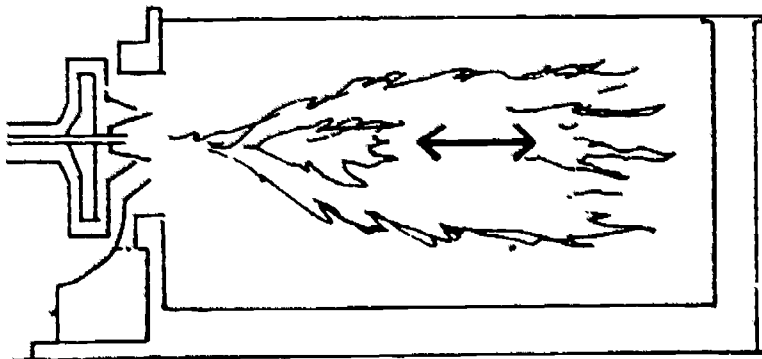


**A cause is:**  
**BITS OF BURNING OIL  
OR CARBON**

**Troubleshooting  
Checks: CUP**

---

**This flame is: PULSATING**



**Some causes are: WRONG AMOUNT OF OIL  
UNEVEN OIL FLOW  
TOO LITTLE AIR**

**Troubleshooting  
Checks:**  
**OIL TEMPERATURE GAUGE  
OIL PRESSURE GAUGE  
AIR SUPPLY**



# **HANDBOOK SUMMARY**

**TURN TO YOUR BOILER HANDBOOK, PAGE 47.**

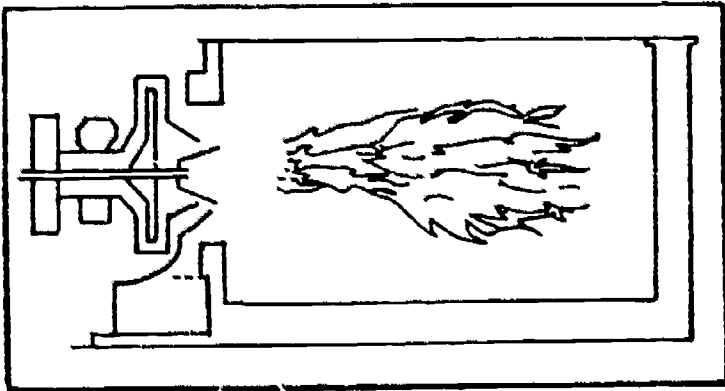
**COMPLETE THE LAST TWO INCORRECT FLAME COLUMNS with the information you have just learned. Use page 48 in this book for reference.**

**This completes some basic flame checks should your smoke alarm go off. If a problem occurs which these pages have not covered or if the problem is not easily solved, call service.**

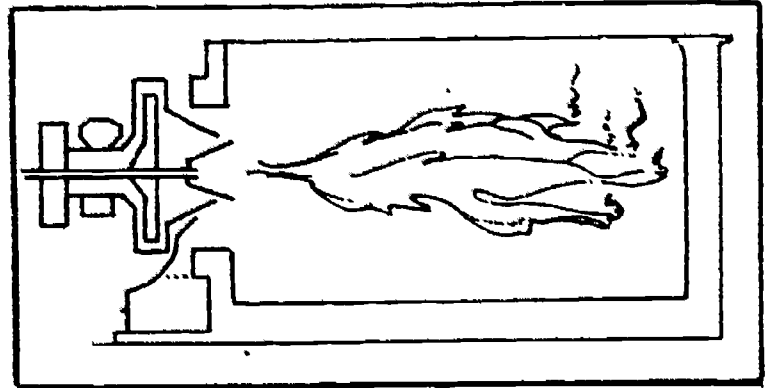
# REVIEW QUESTIONS

1. When the smoke alarm goes off, what is the key to troubleshooting after checking the oil temperature? \_\_\_\_\_

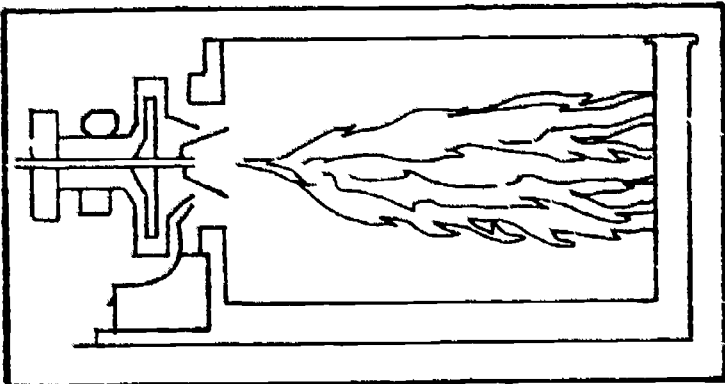
Under each, write what is incorrect about the flames below:



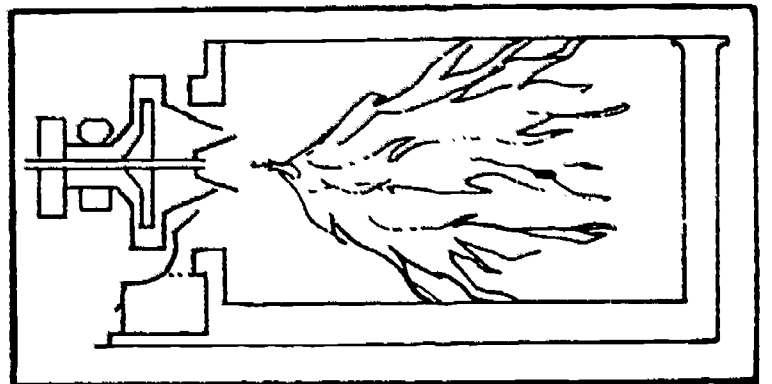
2. \_\_\_\_\_



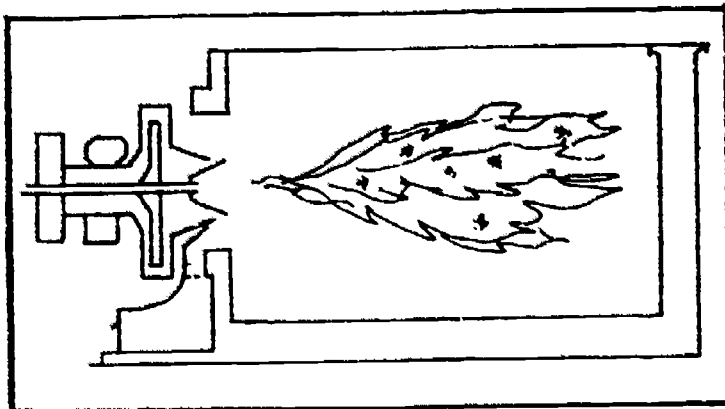
3. \_\_\_\_\_



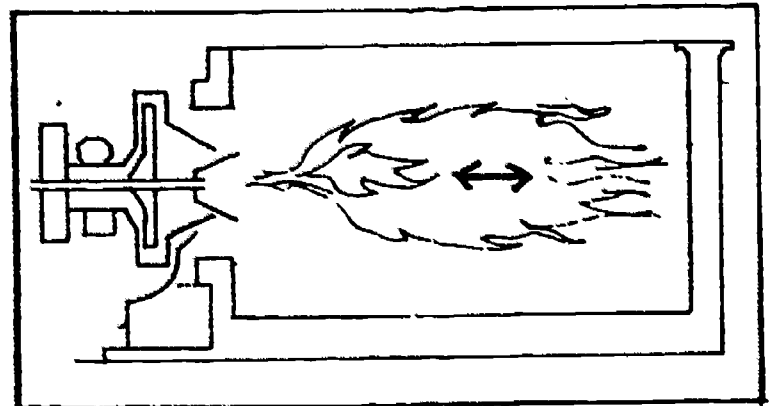
4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



7. \_\_\_\_\_

8. If the flame is pushed away from the burner, the cause is often too much \_\_\_\_\_ air. \_\_\_\_\_
9. Even though you may not make adjustments, what can you do to shutters and linkage to keep them working well? \_\_\_\_\_
10. What are three main areas (other than outside air) to check when you get a smoky flame and there is not enough air? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
11. A flame that is too long or too wide could be the result of an incorrect \_\_\_\_\_ position. \_\_\_\_\_
12. Is it too much or too little primary air that can cause a flame to be too wide? \_\_\_\_\_
13. What could be in the oil that may cause "sparks" in the flame? \_\_\_\_\_
14. What burning supply often needs adjustment to correct a pulsating flame? \_\_\_\_\_
15. What two gauges should you first check when you get a pulsating flame? \_\_\_\_\_  
\_\_\_\_\_
16. Assuming normal oil flow, what basic supply usually needs adjustment when you get smoke? \_\_\_\_\_
17. If oil temperature adjustment and flame reading don't enable you to solve a smoke problem, what should you do? \_\_\_\_\_

— Check your answers.

**ANSWERS TO REVIEW QUESTIONS:**

- 1. the flame**
- 2. flame away from the burner**
- 3. smoky flame**
- 4. too long**
- 5. too wide**
- 6. "sparky" flame**
- 7. pulsating flame**
- 8. primary**
- 9. clean and/or lubricate**
- 10. primary air**  
**secondary air**  
**stack damper**
- 11. cup**
- 12. too little**
- 13. oil globs or carbon bits**
- 14. oil**
- 15. oil temperature gauge**  
**oil pressure gauge**
- 16. air**
- 17. call service**