PREFACE

This pamphlet has been compiled as a text to be used in the Arizona Bureau of Mine's extension lectures on "Prospector’s Mineralogy." Many of the people attending these lectures, especially those most interested, have had very little, if any, technical training in mineralogy, chemistry, and allied sciences. For that reason this pamphlet has been written in as simple and non-technical language as the subject permits, yet the directions given are full enough so that anyone should be able to understand how to do the work.

The method of procedure suggested to beginners in this line of work is first to practice each specific test for each metal on a mineral that is positively known to contain that metal or to practice the tests on a piece of that metal. This practice should be continued until the beginner becomes thoroughly familiar with the various tests for that metal as well as those for other metals. These tests can then be applied to ores of unknown metallic contents if it is desired to determine whether a certain metal is present.

BIBLIOGRAPHY

Brush-Penfield—Determinative Mineralogy and Blowpipe Analysis.
Butler—Handbook of Minerals.
Butler—Handbook of Blowpipe Analysis.
Ford—Dana’s Manual of Mineralogy.
Prescott and Johnson—Qualitative Chemical Analysis.
Rogers—Study of Minerals.
PROSPECTOR'S BLOWPIPE OUTFIT

Blowpipe (8" or 10" long).
Fuel (candle, alcohol, lard oil, or some other lamp).
Charcoal sticks (4"x1"x\(\frac{3}{4}\)"").
Hand lens.
Streak plate.
2" or 3" magnet or magnetized knife blade.
Forceps (platinum tipped are the best).
3 pieces No. 26 B. & S. wire gauge platinum wire and a holder for the wire.
Iron wire, a few pieces.
Test tubes (4"x\(\frac{1}{2}\)"").
Soft glass tubing, 7 millimeter (for closed and open tubes).

DRY REAGENTS

1 ounce borax (powdered); borax glass is more satisfactory than ordinary borax.
2 ounces sodium carbonate (powdered) or baking soda.
\(\frac{1}{4}\) ounce salt of phosphorus (powdered).
2 ounces of zinc or tin (granulated).

WET REAGENTS

2 ounces hydrochloric (muriatic) acid, concentrated.
2 ounces nitric acid, concentrated.
2 ounces sulfuric acid (oil of vitriol), concentrated.
4 ounces ammonia, concentrated.
4 ounces denatured alcohol (if an alcohol lamp is used).
1 ounce cobalt nitrate solution (10%).

OTHER USEFUL APPARATUS AND SUPPLIES

1\(\frac{1}{2}\)" agate mortar and pestle.
Horn for panning.
File (4" triangular).
Hammer (blowpipe).
Anvil (block of steel 1\(\frac{1}{2}\)"x1\(\frac{1}{2}\)"x\(\frac{3}{4}\)"").
Color screen (Flint’s).
Small beakers (about 120 c.c.)
2" glass funnel.
1 package 4" filter papers.
1 ounce potassium bisulfate (acid sulfate of potash).
\(\frac{1}{4}\) ounce ammonium oxalate.
2 ounces mercury (quicksilver).
G. M. Butler's* "Handbook of Blowpipe Analysis" gives the following explanations of the flames made with the aid of the blowpipe and the directions for producing them.

Blowpipe Operations. "The blowpipe is used for the purpose of concentrating the flame into a long, slender cone which can be readily directed against the substance to be heated. It is very important that the blast be continuous and uniform, although this operation may seem very difficult at first. The blast is not produced by the lungs, but results from a bellows-like action of the distended cheeks. During the operation, air is inhaled only through the nose, and is exhaled largely through the mouth and the blowpipe. Before trying to use that instrument, distend the cheeks, and, keeping the mouth closed, breathe through the nose for a moment; then open the lips just enough to allow a little air to escape slowly, and admit air from the lungs by a kind of gulping action just fast enough to keep the cheeks fully distended. This may take some practice, but, when it is possible to allow air to escape continuously from the mouth in this way no matter whether it is being exhaled or inhaled through the nostrils, it is time to begin to use the blowpipe."

"Producing the Oxidizing Flame. Place the oil lamp so that the longer dimension of the wick is from right to left, and set its right-hand edge upon a pencil or some other low support so that it will tip somewhat to the left. Insert the tip of the blowpipe about one-eighth of an inch within and just above the right-hand side of the wick, and blow steadily parallel to the wick, directing the flame to the left, and producing a clear blue flame about an inch long. If all of the flame cannot be thus diverted to the left, or if there are yellow streaks in the flame, trim or lower the wick. If the whole flame is inclined to be yellow, move the tip of the blowpipe a trifle to the left. If it is impossible to produce a flame approaching the length mentioned above, the opening in the end of the blowpipe is too small, and this opening is too large when a very long, hissing flame is produced. In order to succeed in blowing a steady flame, the hand must rest upon some support, or the third and fourth fingers may be placed against the lamp."

"In analytical operations it is sometimes desirable to oxidize substances to be tested, and at other times the aim is to reduce them to the metallic condition; either result can be more or less readily obtained with the blowpipe."

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*Dean of the College of Mines and Engineering, University of Arizona; Director of the Arizona Bureau of Mines.
“A flame produced in the manner above described is called an oxidizing flame, but the action of all portions of such a flame is not oxidizing. The blue cone contains considerable carbon monoxide and is feebly reducing in its action, but just outside of the blue cone at the tip of the flame is an extremely hot but nearly colorless zone which is strongly oxidizing because of the free oxygen there present, and anything held in this zone about an eighth of an inch from the tip of the blue flame will be in the most favorable position for oxidation.”

“The oxidizing flame is hotter than the reducing, and the hottest part of this flame is just outside of the blue cone. In the absence of other instructions, substances should always be heated there.”

Note: The best lamp is one burning a mixture of one-third kerosene and two-thirds lard oil, but the flame from a candle, an alcohol, or any other kind of lamp or from a bunsen burner can be used instead of that from an oil lamp for this work.

“Producing the Reducing Flame. Hold the tip of the blowpipe about one-sixteenth of an inch above and to the right of the wick, and a long, yellow flame containing much unconsumed carbon will be produced. This is sometimes called the smoky reducing flame. Where greater heat is required, the inner cone of the oxidizing flame should be used. The strongest reducing action will take place at the tip of, and within the yellow cone of the reducing flame.”
Field Tests for the Common Metals

ANTIMONY

(1) Antimony can usually be detected by the dense white fumes given off and the white sublimate formed near the assay when heated on charcoal before the blowpipe.

To make this test: Transfer to a flat stick of charcoal a little of the mineral to be tested for antimony. Use about that amount of the powdered mineral that can be held on the tip of a knife blade or a piece of the mineral about as large as a kernel of wheat. Heat the mineral before the blowpipe in the oxidizing (bluish) flame until the material is thoroughly volatilized (fuses). By this treatment, most antimony minerals give off dense white fumes which often continue even after the heating has ceased. These fumes deposit as a dense white sublimate (coating) on the charcoal near the assay, the outer edges, where the coating is thin, appearing bluish-white.

This bluish-white coating of antimony must not be confused with that of lead or zinc which are very similar on the outer edges. These can easily be identified since the coating deposited on the charcoal from lead is yellow near the assay when hot or cold, and the coating deposited on the charcoal near the assay from zinc is yellow when hot and white when cold. The coating from zinc can also be further tested by using cobalt nitrate solution as explained under (1) for zinc.

Beginners practicing this test should use stibnite (antimony sulfide).

(2) Sulfides of antimony if heated in a closed tube yield a sublimate which is black when hot and reddish-brown when cold.

To make this test: Take a closed tube and fill it to about one-half inch from the end with the powdered mineral to be tested. Heat the lower portion of the tube at a red heat for some time. Antimony sulfides if present in the mineral tested will give a sublimate that is black when hot, but that on cooling changes to reddish-brown.

Beginners practicing this test should use stibnite (antimony sulfide).

CALCIUM

(1) Calcium can usually be detected by its precipitation as an oxalate.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of pow-
dered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) hydrochloric (muriatic) acid or about twice this amount of dilute (about equal parts of acid and water) hydrochloric (muriatic) acid.

This mixture either cold or on being heated will effervesce (boil) and give off a colorless, odorless gas (carbon dioxide) which will not support combustion. A lighted match or other flame if held in this gas will go out. After the effervescence has ceased add to the liquid about five teaspoonfuls of water. To this solution add ammonia until a white precipitate begins to form or until the solution smells of ammonia.* Then add a few crystals of ammonium oxalate or about one-half a teaspoonful of concentrated ammonium oxalate solution (ammonium oxalate crystals dissolved in water). This will throw down a white precipitate (calcium oxalate) if calcium is present.

Note: If barium or strontium is present in the mineral which is being tested, add to the hydrochloric acid solution potassium sulfate or some other alkali sulfate and boil for a few minutes. Filter off the residue and any precipitate that has been formed and proceed with the test.

Beginners practicing this test should use marble, chalk, or some other easily soluble calcium mineral.

(2) Sulfuric acid precipitates calcium as a sulfate in moderately concentrated solutions.

To make this test: Take a test tube or some other glass or porcelain receptacle and place in it a little of the mineral to be tested. Use about the amount of powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) hydrochloric (muriatic) acid. After all effervescence (boiling) has ceased add to this solution a few drops of dilute (one volume of acid added to about four volumes of water) sulfuric acid (oil of vitriol). This precipitates the calcium as colorless white crystals of calcium sulfate (gypsum) which is distinguished from the sulfates of barium and strontium in that it will dissolve in a solution of ammonium sulfate. Calcium sulfate is also soluble in hot water. If the solution is diluted with water to about ten times its original volume and warmed, the calcium sulfate will dissolve.

Beginners practicing this test should use marble, chalk, or some other easily soluble calcium mineral.
CALCIUM CARBONATE (LIMESTONE)

Many mining men and prospectors think that a conclusive test for the determination of calcium carbonate (limestone) is that it effervesces (boils) when moistened with hydrochloric (muriatic) acid. This effervescing (boiling) merely indicates that the mineral is a carbonate, providing a colorless, odorless gas which does not support combustion is given off. A lighted match if held in this gas will go out.

Various metals occur as carbonates, a few of the commonest being lead, zinc, copper, and iron. From this statement it is evident that this effervescence (boiling) is not a conclusive test for the determination of calcium carbonate (limestone), since the sample may contain a carbonate of some other metal. This fallacy has been responsible for failure to appreciate the importance of many valuable mineral deposits.

CHROMIUM

Chromium can usually be detected by the colors it imparts to the fluxes.

To make this test: Take a piece of No. 26 platinum wire about two inches long. Fasten one end in a holder so that when the wire is heated it will not burn the fingers. Special holders can be purchased, but a cork or a piece of soft wood into which one end of the wire is inserted can be used for this purpose. Make a small loop, about one-sixteenth of an inch in diameter, at the unattached end of the wire. This loop is easily made by winding the end of the wire around the point of a lead pencil. Heat this looped end in a flame until it gets red hot. An alcohol lamp flame is very serviceable for this work. Dip the red hot loop into some powdered borax or salt of phosphorus, a little of which will adhere to the wire loop. Fuse the borax or salt of phosphorus adhering to the wire by holding it in the flame. Continue these operations until a clear, glassy bead that fills the loop in the wire is secured. Add to this bead the mineral that is to be tested. This is done by touching the bead while it is red hot to a little of the very finely powdered mineral. If the bead made from borax and a very little of a mineral containing chromium is heated before the blowpipe in the oxidizing (bluish) flame, the bead will be decidedly yellow while it is warm, changing to a yellowish green color when cold. When more of the mineral is added the
colors are deeper, changing through reddish or yellow when warm to a fine green when cold. If this bead is heated before the blowpipe in the reducing (yellow) flame the bead assumes a fine green color when cold, but shows none of the yellow or reddish tint which is so prominent in the warm bead after heating in the oxidizing (bluish) flame.

If salt of phosphorus is used instead of borax for making the bead, and the same operations as outlined above for the borax bead test are followed, the color of the bead formed when the oxidizing (bluish) flame of the blowpipe is employed is a dirty green when the bead is warm, which changes to a fine green when the bead gets cold. If the reducing (yellow) blowpipe flame is used the colors are about the same as with the oxidizing flame.

**Note:** The chromium tests must not be confused with those for vanadium, which gives in the reducing flame almost identical reactions with the fluxes, but vanadium in the oxidizing (bluish) flame differs from the salt of phosphorus bead test in that it yields a yellow bead, while this flux never yields other than a green bead with chromium.

Beginners practicing the chromium test should use chromite.

**COBALT**

(1) Cobalt can usually be detected by the color it imparts to the fluxes.

To make this test: Take a piece of No. 26 platinum wire about two inches long. Fasten one end in a holder so that when the wire is heated it will not burn the fingers. Special holders can be purchased but a cork or a piece of soft wood can be used for this purpose. Make a loop, about one-sixteenth of an inch in diameter, at the unattached end of the wire. This loop is easily made by winding the end of the wire around the point of a lead pencil. Heat this looped end in a flame until it gets red hot. An alcohol lamp is very serviceable for this work. Dip the red hot loop into some powdered borax or salt of phosphorus, a little of which will adhere to the wire loop. Fuse the borax or salt of phosphorus adhering to the wire by holding it in the flame. Continue these operations until a clear glassy bead that fills the loop in the wire is secured. Add to this bead the mineral\* that is to be tested. This is done by touching the bead while it is red hot to a very little of the finely powdered mineral. If the beads made from either borax or the salt of phosphorus and the cobalt mineral are heated before the blowpipe in either the reducing (yellow) flame or the oxidizing (bluish) flame the color of the beads formed will be a deep blue.
Field Tests for the Common Metals

*Note: A sulfide or arsenide ore must be thoroughly roasted (pulverized and heated on charcoal at a red heat until sulfur or arsenic fumes are no longer noticeable) before using the cobalt mineral in the bead tests.

Beginners practicing this cobalt test should use roasted smaltite or roasted cobaltite.

(2) Cobalt compounds become magnetic when heated on charcoal before the blowpipe in the reducing flame.

To make this test: Mix thoroughly a little finely powdered mineral with about twice its volume of powdered sodium carbonate (baking soda). Transfer to a stick of charcoal as much of this mixture as can be held on the tip of a knife blade. Heat strongly before the blowpipe in the reducing (yellow) flame until the mixture is thoroughly fused. The resulting fused mass will contain a dark colored, more or less metallic button enclosed in the slag. This button will be magnetic when cold if the mineral used contains cobalt. Metallic iron and nickel are also magnetic; therefore a magnetic button obtained from any mineral the metallic contents of which are unknown should be tested further by applying test (1) for cobalt.

Beginners practicing this test should use smaltite or cobaltite.

COPPER

(1) Ammonia added to an acid solution of copper produces a blue coloration.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of acid. Use concentrated (strong) nitric acid or a mixture of nitric and hydrochloric (muriatic) acid. Heat until the copper has been dissolved, and then add about three teaspoonfuls of water. To this add ammonia until the solution smells strongly of ammonia. Upon the addition of the ammonia to the acid solution the color of the solution will turn blue if the mineral used in the test contained an appreciable amount of copper.

Note: If the mineral does not dissolve readily fuse it as directed in (4).

Note: In order not to crack glass receptacles, heat very gently at first, shaking the receptacle so that the solution washes around the bottom and sides.

Beginners practicing this test should use malachite, chalcopryite, chalcocite, or some other copper mineral or a small piece of metallic copper.
(2) Volatile compounds of copper color a flame green if heated therein. With hydrochloric acid the flame is colored a greenish blue.

To make this test: Take a piece of iron wire about four inches long. (Use baling wire.) Wet one end of the wire so that some of the pulverized mineral will adhere to it. Draw the wet end of the wire through the powdered mineral. Heat the end of the wire, with the mineral on it, in a flame. An alcohol lamp flame is very serviceable for this purpose. As soon as the wire and mineral are red hot the flame will be colored greenish if the mineral contains an appreciable amount of volatile compounds of copper.

If the same end of the wire is moistened with hydrochloric (muriatic) acid and more of the mineral is taken upon it, and it is again held in the flame, the flame will be colored greenish blue.

Beginners practicing this test should use malachite (copper carbonate) or some other volatile copper mineral.

Precautions:

(a) Use a new piece of wire for each copper test.

(b) Never dip a wire which has been used for this or other tests in the acid bottle. If this is done the acid in the bottle will dissolve any soluble mineral present and the acid may be valueless for further flame tests. Pour a few drops of the acid into a glass or cup and dip the wire into it.

(c) Platinum wire can be used for making this flame test, but, if used for this purpose, the copper of the volatile copper compounds alloys with the platinum making the alloyed piece of wire worthless for further copper flame tests.

(3) Iron, steel, zinc, or aluminum, if immersed in a dilute acid solution of copper, will become coated with a film of copper.

(4) Copper compounds fused with soda in the reducing flame yield a metallic copper mass.

To make this test: Mix thoroughly a little of the finely powdered mineral with about twice its volume of powdered flux (sodium carbonate alone or mixed with a little borax). Transfer to a stick of charcoal as much of this mixture as can be held on the tip of a knife blade. Heat strongly before the blowpipe in the reducing (yellow) flame until it is thoroughly fused. The resulting fused mass will contain an irregular, spongy mass of metallic copper if the mineral used in the test contained an appreciable amount of copper.
Field Tests for the Common Metals

Beginners practicing this test should use chalcopyrite, cuprite, or some other easily fusible copper mineral.

(5) Borax and salt of phosphorus beads are green when warm and blue when cold in the oxidizing flame, and saturated beads are opaque red in the reducing flame of the blowpipe. In the presence of much iron the oxidizing flame bead is green or bluish green. Bead test instructions can be found under “Cobalt.”

GOLD

The following characteristics serve for the ready detection of gold: Its yellow color; its high specific gravity (weight); its high fusibility (the high temperature required to melt it); its malleability (can be flattened out if hammered on an anvil; it can be indented by the point of a knife blade without crushing); and its insolubility [cannot be dissolved in either nitric, hydrochloric, or sulphuric acid alone; but gold is soluble in aqua regia (one volume of concentrated nitric acid mixed with three volumes of concentrated hydrochloric acid)].

Panning and Collection with Mercury. Gold in a free milling ore or in gold-bearing sand or gravel when present in quantities even lower than $0.20 per cubic yard (about one ton) can be detected by panning. To amalgamate or collect the gold with mercury (quick-silver), mercury is added to the concentrates and these are ground together in a mortar until the mercury amalgamates (collects) the gold. If this pasty amalgam is then heated on charcoal before the blowpipe, the mercury is distilled off leaving the gold as a residue. If this residue, mixed with a little borax, is then heated before the blowpipe on charcoal, there will be obtained a malleable, yellow button which can be tested as explained above in (1).

The best plan for prospectors to follow if they find ores which they believe carry gold values, but which are made up of several different minerals that make the ore difficult to pan, is to have the sample assayed for gold.

IRON

(1) Iron minerals roasted on charcoal yield a magnetic residue.

To make this test: Take a stick of charcoal and place on it a little of the finely powdered mineral to be tested. Use about that amount that can be held on the tip of a knife blade. Heat before the blowpipe in the reducing (yellow) flame. If the mineral thus heated
without a flux does not fuse, but becomes magnetic, it contains iron. If it fuses (melts) and becomes magnetic it may contain iron, cobalt, or nickel.

Beginners practicing this test should use hematite, pyrites, or some other iron mineral.

(2) Iron minerals fused with soda in the reducing flame yield a magnetic button.

To make this test: Mix thoroughly a little of the finely powdered mineral with about twice its volume of sodium carbonate (baking soda). Transfer to a stick of charcoal as much of this mixture as can be held on the tip of a knife blade. Heat strongly before the blowpipe in the reducing (yellow) flame until it is thoroughly fused (melts). The resulting fused mass will contain a dark colored, more or less metallic button which is magnetic when cold, providing the mineral used in the test contained an appreciable amount of iron. Cobalt and nickel buttons produced in this manner are also magnetic. For that reason the magnetic button should be further tested for iron by (3) and for cobalt and nickel by the tests given for those metals.

Beginners practicing this test should use hematite, pyrites, or some other easily fusible iron mineral.

(3) Ammonia added to an acid solution of iron throws down a brownish red precipitate.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) hydrochloric (muriatic) acid and a few drops of nitric acid. Heat this solution until the iron has been dissolved, and then add about two teaspoonfuls of water. To this solution add ammonia until the solution smells strongly of ammonia. Upon the addition of the ammonia to this acid solution there will be thrown down a brownish red precipitate if iron was present in the mineral used. Beginners practicing this test should use hematite, limonite, or some other iron mineral or a small piece of metallic iron.

Note: Many iron minerals are practically insoluble in the acids just mentioned. These minerals if treated as described in (2) become easily soluble.

(4) In the oxidizing flame the borax bead of iron is amber colored when warm, and yellow to colorless when cold, while in the
Field Tests for the Common Metals

reducing flame the borax bead is bottle green, providing the bead is saturated. Bead test instructions can be found under “COBALT.”

LEAD

(1) Lead can usually be detected by the yellow sublimate and the metallic lead buttons formed on charcoal.

To make this test: Mix thoroughly a little of the finely powdered mineral with about an equal volume of powdered charcoal and about three volumes of powdered sodium carbonate (baking soda). Moisten this mixture with water and transfer about that amount that can be held on the tip of a knife blade to a flat piece of charcoal or into a shallow cavity that has been made in the charcoal. Heat the assay before the blowpipe in a moderately strong reducing (yellow) flame. This treatment, if the mineral used in the test contains an appreciable amount of lead, will produce small globules or buttons of metallic lead, which are soft and malleable (can be flattened out if hammered on an anvil), and also a yellowish coating or sublimate on the charcoal, close to the assay. This coating is whitish on the outer edges, and the white portion may be confused with an antimony sublimate.

Beginners practicing this test should use galena, cerussite, or some other high-grade lead mineral or some small cuttings of metallic lead.

(2) Hydrochloric or sulfuric acid throw down a heavy white precipitate in cold nitric acid solutions of lead.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about as much of the powdered mineral as can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) nitric acid and about two teaspoonfuls of water. Boil this solution until the lead has been dissolved, and then cool to room temperature. When cold add a few drops of dilute sulfuric acid (oil of vitriol) or a few drops of hydrochloric (muriatic) acid. Upon the addition of either of these acids to the cold nitric acid solution there will appear a white heavy precipitate of lead providing the mineral used in the test contained any appreciable amount of lead. This white precipitate should be further tested for lead by using test (1).

Beginners practicing this test should use cerussite, vanadinite, or
some other easily soluble, high-grade lead mineral, the lead buttons produced in test (1), or some small cuttings of metallic lead.

The white precipitate (lead chloride) formed when hydrochloric (muriatic) acid is used can also be tested further as follows:

(3) Lead chloride is quite soluble in hot water.

To make this test: Add from ten to fifteen volumes of water to the liquid and precipitate obtained when hydrochloric (muriatic) acid is used in making test (2). Heat to boiling and boil for a minute or two. If the white precipitate from test (2) is lead chloride, it will dissolve.

Note: When hydrochloric acid is used in test (2), silver and mercury if present may also be thrown down as a white precipitate, but silver in this form (silver chloride) turns purple if exposed to sunlight and is also very soluble in ammonia. The white mercury precipitate thus obtained usually turns dark grayish on the addition of an excess of ammonia.

**MAGNESIUM**

(1) Magnesium can usually be detected by its precipitation as ammonium-magnesium phosphate.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about three teaspoonfuls of hydrochloric (muriatic) acid, a drop of nitric acid, and about four teaspoonfuls of water. Heat to boiling, and then cool to room temperature. To the cold solution add ammonia until the solution smells strongly of ammonia. If a precipitate is thrown down, filter the precipitate off and catch the clear filtered solution (filtrate) in another glass receptacle. To this clear liquid add a little ammonium carbonate or ammonium oxalate solution. Again filter off any precipitate which may form, and catch the clear filtered solution in another glass receptacle. To this last clear solution add a few drops of sodium phosphate solution. This will cause the formation of a white, crystalline precipitate of ammonium-magnesium phosphate providing the mineral used in this test contained an appreciable amount of magnesium.

Beginners practicing this test should use magnesite, dolomite, or some other easily soluble magnesium mineral.

Note: In order to allow sufficient time for the ammonium-magnesium phosphate precipitate to form it is sometimes necessary to let the solution stand up to twelve hours.
(2) Some of the white or colorless magnesium compounds, such as magnesite, when moistened with cobalt nitrate and heated before the blowpipe assume a light pink or flesh color. The following method for making this test is given in G. M. Butler's Handbook of Blowpipe Analysis.

To make this test: Hold a small splinter of the substance to be tested in the platinum forceps and heat it in the blowpipe flame to the highest possible temperature. Then examine it with a lens; if it shows any signs of fusion, this test cannot be applied. If non-fusible, moisten it with cobalt nitrate and ignite strongly in the hottest part of the blowpipe flame. It will first turn black, but after prolonged heating may assume a characteristic tint. If a splinter of the substance cannot be obtained, it should be powdered and the test conducted upon a flat cake of the powder upon charcoal. Longer heating is required by this method, however, and the results are not apt to be as satisfactory.

This test can be applied only to non-fusible, white or faintly tinted minerals, or those which become white or faintly tinted upon ignition.

A pinkish or flesh-tint coloration indicates magnesium.

Beginners practicing this test should use magnesite (magnesium carbonate).

MANGANESE

(1) Manganese can usually be detected by the colors it imparts to the fluxes.

(a) To make this test: Take a piece of No. 26 platinum wire about two inches long. Fasten one end in a holder so that when the wire is heated it will not burn the fingers. Special holders can be purchased, but a cork or piece of soft wood can be used for this purpose. Make a small loop, about one-sixteenth of an inch in diameter, at the unattached end of the wire. This loop is easily made by winding the end of the wire around the point of a lead pencil. Heat this looped end in a flame until it gets red hot. An alcohol lamp flame is very serviceable for this work. Dip the red-hot loop into some powdered borax, a little of which will adhere to the wire loop. Fuse the borax adhering to the wire by holding it in the flame. Continue these operations until a clear, glassy bead that fills the loop in the wire is secured. Add to this bead the mineral
that is to be tested. This is done by touching the bead while it is red-hot to a little of the very finely powdered mineral. If the bead made from borax and a very little manganese mineral is heated before the blowpipe in the oxidizing (bluish) flame, there is produced a bead which is opaque while it is hot, but on cooling it becomes transparent and has a fine reddish violet or amethystine color. If this manganese borax bead is heated for a time in the reducing (yellow) flame of the blowpipe, it becomes colorless when cold. The bead test is a very delicate one for manganese.

Beginners practicing this test should use pyrolusite, wad, or some other manganese mineral.

Note: Use only a very little of the mineral in this test because, if too much of the mineral is added to the bead, the color produced will be so intense that it will appear to be black, thus making the test valueless.

Note: A sulfide or arsenide ore must be thoroughly roasted (pulverized and heated on charcoal at a red heat until sulfur or arsenic fumes are no longer noticeable) before using the mineral in the bead test.

Note: If much iron is present in the mineral tested, the borax bead will have a reddish brown color.

(b) If sodium carbonate or baking soda is used instead of borax for making the bead test, and the operations just described for conducting the borax bead test are followed, the color of the bead which is formed when the oxidizing (bluish) flame of the blowpipe is employed is green when the bead is warm and greenish blue when it cools. The sodium carbonate bead made in the reducing (yellow) flame is colorless. Sodium carbonate beads are opaque.

If the blue sodium carbonate bead of manganese is dissolved in a drop of water on a piece of glass, and to this solution is added a drop of nitric acid, the solution will become pink.

(2) Many manganese minerals dissolve in hydrochloric acid with the evolution of chlorine gas.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of the powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) hydrochloric (muriatic) acid. Heat gently at first, then increase the temperature as much as possible, and chlorine gas will be given off. This gas can be recognized by its yellowish green color and by its pungent odor.

Beginners practicing this test should use pyrolusite, wad, or some other oxide of manganese mineral.
(3) Some manganese minerals when heated yield oxygen.

To make this test: Take a closed tube and pour into it a few fragments or a small amount of a powdered manganese dioxide mineral such as pyrolusite or wad. Place a sliver of charcoal in the tube a little above the mineral. Heat the tube so that the charcoal alone is heated, and it will be noticed that although the charcoal gets red-hot it does not burn, owing to the limited supply of air in the tube. Keeping the charcoal red-hot, apply the heat to the tube so that the manganese dioxide mineral is heated. As soon as oxygen commences to be given off from the mineral the charcoal will burn brightly.

MERCURY-QUICKSILVER

(1) Mercury when heated with soda in a closed tube condenses as metallic globules of mercury on the sides of the tube.

To make this test: Mix thoroughly a little of the finely powdered mineral with about three volumes of (DRY) sodium carbonate (baking soda). Place in a closed tube about one-half inch of this mixture and cover this with an additional layer of soda to a depth of about one-half inch. Heat carefully and mercury will distil off and condense as globules on the walls of the tube providing the mineral used in the test contained an appreciable amount of mercury (quicksilver). If only a little mercury is formed, it will appear as a gray sublimate (coating) composed of minute globules which may be made to unite by rubbing with a splinter of wood.

(2) Most compounds of mercury if moistened with hydrochloric (muriatic) acid when rubbed on a piece of bright copper will plate the copper, which will then appear as if it had been silver plated.

MOLYBDENUM

(1) Molybdenum can usually be detected by its reduction to the blue or black oxides of molybdenum.

To make this test: Take a small porcelain crucible or some other porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral that is to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour onto the mineral about one-half a teaspoonful of concentrated (strong) nitric acid. Heat this mixture strongly to dryness (until all of the acid has been boiled off, and nothing but a dry, white or
grayish residue is left in the bottom of the receptacle). Cool to room temperature, and then pour a few drops of concentrated (strong) sulfuric acid (oil of vitriol) onto the cold residue. Heat again until dense white fumes of sulfuric acid are given off freely and until only a little of the sulfuric acid remains in the receptacle. Cool again by blowing strongly onto the residue. On cooling a beautiful deep blue color develops on the sides and in the bottom of the receptacle providing the mineral used in the test contained an appreciable amount of molybdenum.

Beginners practicing this test should use molybdenite, wulfenite, or some other molybdenum mineral.

(2) Molybdenum can usually be detected by the colors it imparts to the fluxes.

(a) In the oxidizing (bluish) flame, borax beads of molybdenum are yellow when warm and colorless when cold. In the reducing (yellow) flame the warm and cold borax beads are colorless. These beads made in the reducing flame when saturated with molybdenum are brown when warm or cold.

(b) All salt of phosphorus beads of molybdenum are green except the unsaturated cold bead formed in the oxidizing (bluish) flame which is colorless.

(c) If several of the green salt of phosphorus beads are dissolved in dilute hydrochloric (muriatic) acid, and tin is added to the boiling solution, the solution turns brown.

Note: Instructions for making the bead tests can be found under "COBALT" or "CHROMIUM."

Note: A sulfide ore must be thoroughly roasted (pulverized and heated on charcoal at a red heat until sulfur fumes are no longer noticeable) before using the mineral in the bead tests.

Several tests for molybdenum depend on whether the molybdenum mineral occurs as an oxide or as a sulfide.

TESTS FOR MOLYBDENUM SULFIDES

(1) Powdered molybdenum sulfide minerals (molybdenite, etc.), if heated strongly in an open tube, give off sulfurous fumes and deposit a pale yellow sublimate (coating) on the sides of the tube, and delicate, hairlike white or yellow crystals on the mineral itself.

(2) Powdered molybdenum sulfide minerals (molybdenite, etc.), if heated on charcoal for a long time in the oxidizing (bluish) flame of the blowpipe, deposit a sublimate (coating) on the charcoal a short distance from the assay. This sublimate is pale yellow when
hot and almost white when cold, and often consists of delicate crystals. If this sublimate is touched for an instant with the moderately hot reducing (yellow) flame of the blowpipe it assumes a beautiful deep blue color.

(3) Molybdenite is soluble (is dissolved) in nitric acid.

TESTS FOR MOLYBDENUM OXIDES

(1) Finely powdered molybdenum oxides are partially soluble in hydrochloric acid. Tin added to this solution produces a blue coloration.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour on the mineral in the receptacle about two teaspoonfuls of concentrated (strong) hydrochloric (muriatic) acid, and heat to boiling. Boil for a few minutes, and the solution will turn green. If a little metallic tin is added to this green solution which has been diluted with water to about twice its original volume, and the solution is heated in order to start the reaction, the solution will turn blue and, finally, brown.

Note: The blue color may be of such short duration in some cases that the solution seems to turn brown without showing any blue coloration.

Beginners practicing this test should use wulfenite or some other oxide of molybdenum mineral.

(2) Molybdenum in oxide minerals can usually be detected by its reduction to the blue oxides of molybdenum.

(a) To make this test: Take a small porcelain crucible or some other porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour onto this mineral a few drops of concentrated (strong) sulfuric acid (oil of vitriol), and heat strongly until dense white fumes of sulfuric acid are given off for a minute or two. Cool the receptacle by blowing strongly onto the assay. On cooling a beautiful blue color develops around the sides and in the bottom of the receptacle providing the mineral used in the test contained an appreciable amount of molybdenum.

Beginners practicing this test should use wulfenite (lead molybdate) or some other oxide of molybdenum mineral.
(b) This test can also be made in the following manner: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral to be tested. Use about that amount of the powdered mineral that can be held on the tip of a knife blade. Drop onto the mineral a piece of paper about the size of the head of a pin. Pour onto this from three to five drops of concentrated (strong) sulfuric acid (oil of vitriol) and about an equal amount of water. Heat strongly until dense white fumes of sulfuric acid are given off freely, and then cool. The liquid on cooling turns a beautiful deep blue color that disappears if the liquid is again heated to boiling, and reappears on cooling. If about two teaspoonfuls of water are added to the blue liquid, the blue color fades out, but, if a piece of zinc and a few drops of sulfuric acid (oil of vitriol) are added to this diluted solution and the solution is again heated, the blue color reappears. On standing the color turns to brown.

Beginners practicing this test should use wulfenite (lead molybdate) or some other oxide of molybdenum mineral.

NICKEL

(1) Ammonia added to an acid solution of nickel produces a pale blue coloration.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral that is to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) nitric acid or a mixture of about one teaspoonful of nitric acid, about one teaspoonful of hydrochloric (muriatic) acid, and about one teaspoonful of water. Heat this mixture to boiling until the mineral has been dissolved. If the mineral used in the test contains an appreciable amount of nickel, the solution will turn a greenish color. If ammonia is added to it until the solution smells strongly of ammonia, the solution will turn to a pale blue color that is considerably lighter than that produced by copper.

Beginners practicing this test should use millerite or niccolite.

(2) Nickel can usually be detected by the colors it imparts to the fluxes.

(a) In the oxidizing (bluish) flame, borax beads of nickel are
violet when warm and brown when cold. In the reducing (yellow) flame the borax beads are colorless unless saturated with nickel when they are gray and opaque.

(b) The salt of phosphorus beads made in the oxidizing (bluish) flame are yellow when cold and reddish when warm.

Note: Instructions for making the bead tests can be found under “COBALT” and “CHROMIUM.”

Note: A sulfide or arsenide ore must be thoroughly roasted (pulverized and heated on charcoal at a red heat until sulfur or arsenic fumes are no longer noticeable) before using the mineral in the bead tests.

(3) Nickel minerals fused with soda in the reducing flame yield a magnetic button.

To make this test: Mix thoroughly a little of the finely powdered mineral with about twice its volume of sodium carbonate (baking soda). Transfer to a stick of charcoal as much of this mixture as can be held on the tip of a knife blade. Heat strongly before the blowpipe in the reducing (yellow) flame until it is thoroughly fused (melts). The resulting fused mass will contain a dark colored, more or less metallic button which is magnetic when cold providing the mineral used in this test contained an appreciable amount of nickel. Cobalt and iron buttons produced in this manner are also magnetic. For that reason the magnetic button should be further tested for nickel by (1) and (2), and for cobalt and iron by the tests given for those metals.

Beginners practicing this test should use niccolite or millerite.

OIL

(1) Crude oil or petroleum in rocks can usually be detected by the odor of petroleum given off when the rocks are vigorously scratched or struck together.

(2) Crude oil and petroleum can usually be detected by using ether or chloroform.

To make this test: Take a test tube or some other receptacle such as a bottle. Place in it about one-half an inch of the broken up material that is to be tested. Pour onto this material about one inch of sulfuric ether or chloroform, and cork the receptacle tightly. Shake this mixture well and repeat the shaking at intervals of about ten minutes until any oil present has been dissolved. This may take from ten minutes to six hours. After the oil has been dissolved let the mixture stand until the liquid has become clear, and then pour the clear liquid into a shallow, clean, white porcelain dish (plate).
The ether or chloroform will evaporate quickly, and leave the oil as a greenish yellow or brownish ring on the dish. This ring if it consists of oil will have the characteristic odor and oily feel of petroleum.

Beginners practicing this test should use sand which carries petroleum or a few drops of crude oil.

Note: Sulfuric ether and chloroform vapors explode when ignited. It is very dangerous to make this test in the presence of open lights and fires.

(3) Crude oil or petroleum when heated at a high temperature give off vapors with a petroleum odor.

To make this test: Use one or both of the following methods:

(a) Heat some of the material until gases or vapors are given off freely. If the material contains crude oil or petroleum the gases given off smell of petroleum.

(b) Take a test tube or some other small necked receptacle (a bottle) and pour into it about one-half inch of the broken up material that is being tested. Heat over a flame or fire until gases and vapors are given off freely. If the material contains any appreciable amount of crude oil or petroleum the gases given off have a distinct odor of petroleum and petroleum deposits on the cooler portions of the receptacle.

OIL SHALE

The carbonaceous matter in oil shale, from which crude oil is produced by destructive distillation processes, is commonly called KEROGEN. This material is doubtless the original source of much of the crude oil produced, and the distillation has been accomplished by the high temperatures generated by the tremendous pressures operating when beds of this material are overlain by thousands of feet of earth.

Kerogen, or oil shale, gives off vapors or gases with the characteristic odor of petroleum when heated at a high temperature.

To make this test, follow instructions (3) for oil. Kerogen in shale can often be detected if a splinter of the shale is heated over a match flame. If the proportion of kerogen in the shale is fairly high, the splinter will burn for several seconds after it is removed from the match flame.
SILVER

(1) Silver can usually be detected by its reduction to metallic silver.

To make this test: Mix thoroughly a little of the finely powdered mineral with about three times its volume of sodium carbonate (baking soda). Transfer to a stick of charcoal as much of this mixture as can be held on the tip of a knife blade. Heat strongly before the blowpipe in the reducing (yellow) flame until it is thoroughly fused (melted) and a metallic silver globule or button results. This button is bright when hot or cold and is malleable (can be flattened out if hammered on an anvil), but it is both harder and less easily cut than a lead button. It should be further tested for silver as explained in the following test.

Beginners practicing this test should use argentite, pyrargyrite, or some other high-grade silver mineral.

(2) Hydrochloric acid or salt precipitates silver from nitric acid solutions as a white, curdy residue.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral that is to be tested. Use about that amount of the powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about one teaspoonful of concentrated (strong) nitric acid and about one teaspoonful of water. Heat this solution to boiling, and boil until the silver has been dissolved. Cool to room temperature, and then add a few drops of concentrated hydrochloric (muriatic) acid, a small pinch of common table salt, or a few drops of strong salt water. Upon the addition of the hydrochloric (muriatic) acid or salt to the nitric acid solution there will be thrown down a white, curdy mass (silver chloride) if silver was present to an appreciable extent in the mineral used in the test. If it is silver chloride, this white curdy mass turns purple when exposed to the sunlight for a time. It is also very soluble in ammonia. Therefore, if ammonia is added to the solution until the solution smells strongly of ammonia, the white curdy mass, if it is silver chloride, will be dissolved.

Beginners practicing this test should use argentite, pyrargyrite, or some other silver mineral, the globule resulting from test (1), a small amount of silver filings or a small piece of metallic silver.

Note: In test (2) it is sometimes better to use concentrated (strong) nitric acid instead of the dilute acid for dissolving the silver.
Note: When hydrochloric acid is used in test (2), lead and mercury may also be thrown down as a white precipitate, but silver in this form (silver chloride) is very soluble in an excess of ammonia while the other two are usually practically insoluble. See note under LEAD.

TIN

(1) Tin can usually be detected by the sublimate formed on charcoal and its reduction to small metallic globules. These globules if treated with nitric acid yield a white powder.

To make this test: Mix thoroughly a little of the finely powdered mineral with an equal volume of powdered charcoal and two volumes of sodium carbonate (baking soda). Transfer to a shallow cavity in a stick of charcoal about the amount of this mixture that can be held on the tip of a knife blade and form a paste of the mixture with water. Heat before the blowpipe in a strong reducing (yellow) flame. This treatment gives a sublimate (coating) on the charcoal which is yellowish when hot and white when cold.

If this sublimate is moistened with a drop or two of cobalt nitrate solution and if the assay is then heated strongly before the blowpipe in the reducing (yellow) flame, the sublimate will assume a dull bluish-green color when cold.

This treatment also yields small metallic globules, which can only with difficulty be forced to run together into one single larger globule. These globules on cooling become coated with a white film but if cut open show a white metallic color. If these globules are treated with nitric acid, a white powder is produced which is insoluble in that acid.

TUNGSTEN

(1) Tungsten forms in hydrochloric acid a lemon-yellow residue that is soluble in ammonia.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the mineral that is to be tested. Use about that amount of the powdered mineral that can be held on the tip of a knife blade. Pour into the receptacle about two teaspoonfuls of concentrated (strong) hydrochloric (muriatic) acid, and heat to boiling. Boil strongly, replenishing the acid if necessary, until a lemon-yellow colored residue (tungstic acid) has formed in the bottom of the receptacle. If ammonia is added to this solution until the solution smells strongly of ammonia, the lemon-yellow colored residue, if it is tungstic acid, will be dissolved.
Beginners practicing this test should use scheelite or some other easily soluble tungsten mineral.

(2) Tungsten can usually be detected by the blue oxides of tungsten formed on the addition of tin or zinc to a hydrochloric acid solution.

To make this test: Follow the instruction as given in test (1) up to and including the formation of the lemon-yellow colored residue (tungstic acid) just before the ammonia is added, and proceed as follows: To the solution containing the tungstic acid add a piece of metallic tin or zinc. If no pure tin or zinc is available use a piece of galvanized iron with the zinc on it, or a piece of a tin can with the tin on it. On the addition of the tin or zinc the solution turns deep blue and later changes to brown providing the mineral used in the test contained an appreciable amount of soluble tungsten.

Note: Tests (1) and (2) should only be used on very soluble tungsten minerals (such as scheelite), as the test will take too long if used directly on rather insoluble minerals (such as wolframite or hubnerite). The rather insoluble minerals should be given the preliminary fusing treatment as described for iron in test (2). The fused mass resulting from the fusion should then be treated as just described in tests (1) and (2) for tungsten.

(3) Tungsten can usually be detected by the colors it imparts to the fluxes.

(a) All of the borax beads of tungsten are colorless except the warm saturated beads which are yellow.

(b) All of the salt of phosphorus beads of tungsten are colorless except the warm saturated beads which are yellow and the cold saturated bead made in the reducing flame, which is greenish blue.

Note: Instructions for making the bead tests can be found under “COBALT” and “CHROMIUM.”

VANADIUM

(1) Vanadium can usually be detected by the deep cherry-red color imparted to concentrated hydrochloric acid, the greenish tint given the dilute acid, and the evolution of chlorine gas.

To make this test: Take a bone-dry test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral that is to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour onto the mineral in the receptacle about one teaspoonful of concentrated (strong) hydrochloric (muriatic) acid. Almost immediately chlorine gas will be given off, and the solution will turn to a deep cherry-red color, providing the mineral used in the test con-
tained an appreciable amount of vanadium. This chlorine gas is easily recognized by its rusty green color and its pungent odor. If a few drops of water are added to this cherry-red solution, it changes to a light greenish tint. If too much water is added, the solution becomes almost colorless.

Beginners practicing this test should use vanadinite, desclloizite, or some other easily soluble vanadium mineral.

(2) Vanadium can usually be detected by the greenish color given sulfuric acid.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral that is to be tested. Use about that amount of powdered mineral that can be held on the tip of a knife blade. Pour onto the mineral about one teaspoonful of concentrated (strong) sulfuric acid (oil of vitriol). Heat the solution to boiling, and boil until dense white fumes of sulfuric acid are given off. Cool to room temperature, and when cold add very carefully from one to two teaspoonfuls of cold water to the solution. Almost immediately after the addition of the water the color of the solution will change to a light green providing the mineral used in the test contained an appreciable amount of vanadium.

Beginners practicing this test should use vanadinite, desclloizite, or some other easily soluble vanadium mineral.

(3) Vanadates with potassium acid sulfate in a closed tube give a yellow mass.

To make this test: Mix thoroughly a little of the finely powdered mineral with an equal amount of potassium acid sulfate (potassium bisulfate). Place about that amount of this mixture that can be held on the tip of a knife blade in a closed tube, and heat strongly over a hot flame. This will produce a yellow mass providing the mineral used in the test contained an appreciable amount of vanadium.

Beginners practicing this test should use vanadinite or desclloizite.

(4) Vanadium can usually be detected by the colors it imparts to the fluxes.

(a) In the oxidizing (bluish) flame borax beads of vanadium are all yellow except the unsaturated cold bead which is colorless. In the reducing (yellow) flame all borax beads of vanadium are green.
(b) All salt of phosphorus beads of vanadium made in the oxidizing (bluish) flame are yellow, and all those beads made in the reducing (yellow) flame are green.

Note: Instructions for making the bead tests can be found under "COBALT" and "CHROMIUM."

Note: A sulfide or arsenide ore must be thoroughly roasted (pulverized and heated on charcoal at a red heat until sulfur or arsenic fumes are no longer noticeable) before using the mineral in the bead test.

ZINC

(1) Zinc can usually be detected by the sublimate formed on charcoal when heated with soda before the blowpipe. This sublimate is yellow when hot and white when cold. If moistened with cobalt nitrate and heated, it assumes a green color.

To make this test: Mix thoroughly a little of the finely powdered mineral with an equal volume of sodium carbonate (baking soda). Transfer to a shallow cavity in a stick of charcoal about the amount of this mixture that can be held on the tip of a knife blade, and form a paste of the mixture by moistening with water. Heat before the blowpipe in a strong reducing (yellow) flame. This treatment gives a scanty sublimate (coating) on the charcoal, which is canary yellow colored when hot, and white when cold provided the mineral used in the test contained an appreciable amount of zinc.

If the sublimate made in the test just described is moistened with a drop or two of cobalt nitrate solution and if the assay is then heated strongly before the blowpipe in the reducing (yellow) flame, the sublimate will assume a bright green color that is best seen when it is cold.

Beginners practicing this test should use sphalerite or some other zinc mineral or a small piece of metallic zinc.

Note: A few zinc compounds (such as sphalerite, zinc blende, black jack) give the above results without mixing the mineral with a flux.

(2) Zinc is thrown down as a white precipitate by ammonium sulfide from an alkaline solution, this being the only white sulfide that is insoluble in such a solution.

To make this test: Take a test tube or some other glass or porcelain receptacle (a china drinking cup), and place in it a little of the powdered mineral that is to be tested. Use about the amount of the powdered mineral that can be held on the tip of a knife blade. Pour onto the mineral in the receptacle about one teaspoonful of
concentrated (strong) hydrochloric (muriatic) acid and a drop of nitric acid, and heat to boiling. After the zinc has been dissolved add about two teaspoonfuls of cold water and cool the solution to room temperature. To the cold solution add ammonia until the solution smells strongly of ammonia. Any iron present will be thrown down as a brownish red precipitate as mentioned in test (3) for IRON. Filter off the residue and precipitate, and catch the clear filtered solution in another glass or porcelain receptacle. To the clear, filtered solution (filtrate) add a few drops of ammonium sulfide solution. This will throw down a white precipitate (zinc sulfide).

(3) Silicates of zinc when moistened with cobalt nitrate and heated before the blowpipe assume a blue color. The following method for making this test is given in G. M. Butler's Handbook of Blowpipe Analysis.

To make this test: Hold a small splinter of the substance to be tested in the platinum forceps and heat it in the blowpipe flame to the highest possible temperature. Then examine it with a lens; if it shows any signs of fusion, this test cannot be applied. If non-fusible, moisten it with cobalt nitrate and ignite strongly in the hottest part of the blowpipe flame. It will first turn black but after prolonged heating may assume a characteristic tint. If a splinter of the substance cannot be obtained, it should be powdered and the test conducted upon a flat cake of the powder upon charcoal. Longer heating is required by this method, however, and the results are not apt to be as satisfactory.

This test can be applied only to non-fusible, white or faintly tinted minerals, or those which become white or faintly tinted upon ignition.

A blue coloration best seen when cold indicates zinc, but infusible aluminum minerals will yield the same color when treated in this way.

Beginners practicing this test should use calamine (zinc silicate).

(4) The following method for the quick determination of the grade of zinc in ore was given by G. M. Butler, Dean of the College of Mines and Engineering, University of Arizona, and Director of the Arizona Bureau of Mines, in the January, 1913, issue of Economic Geology:

"Probably the quickest method for quickly ascertaining the approximate grade of oxidized zinc ore is to place about a teaspoonful of
the finely powdered material to be tested upon a piece of iron or steel barrel-hoop, one and a half to two inches in width. This charge should be introduced into the incandescent coals of a blacksmith forge which has been blown until little black smoke is evident. The iron should be sunk into a depression in the glowing coals so that they stand a half inch or so above the sample on all sides. Then the draught should be increased until the iron is heated white hot. Oxidized zinc ore will take fire at this point, burning with a bluish flame and emitting white fumes of zinc oxide. The density of these fumes varies with the grade of the ore. Experience enables one to judge within five per cent of the zinc content by this method which, although long known and practiced in some places, is unfamiliar to those in other localities. The scheme can be applied to ore of any grade as material assaying five per cent zinc will yield visible fumes."