THE STORY OF FLUORESCENCE

Title: The Story of Fluorescence

Date of first publication: 1965

Author: Raytech Industries

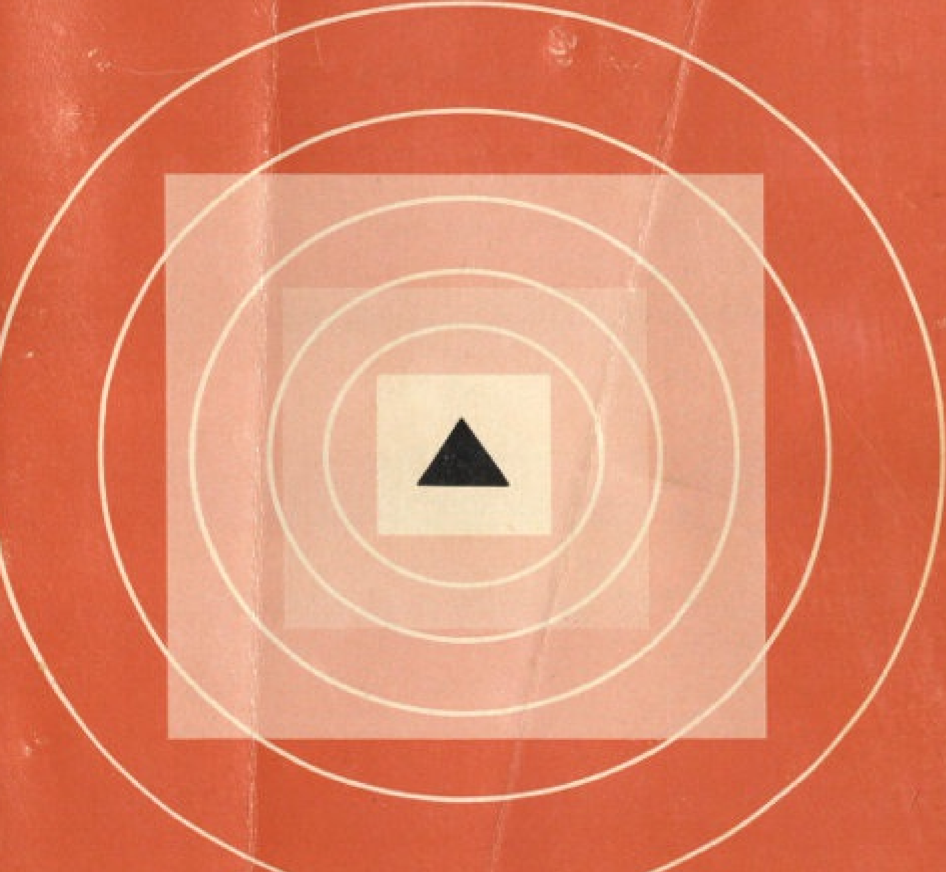
Date first posted: Dec. 30, 2018

Date last updated: Dec. 30, 2018

Faded Page eBook #20181246

This eBook was produced by: Stephen Hutcheson & the online Distributed Proofreaders Canada team at https://www.pgdpcanada.net

THE STORY OF FLUORESCENCE



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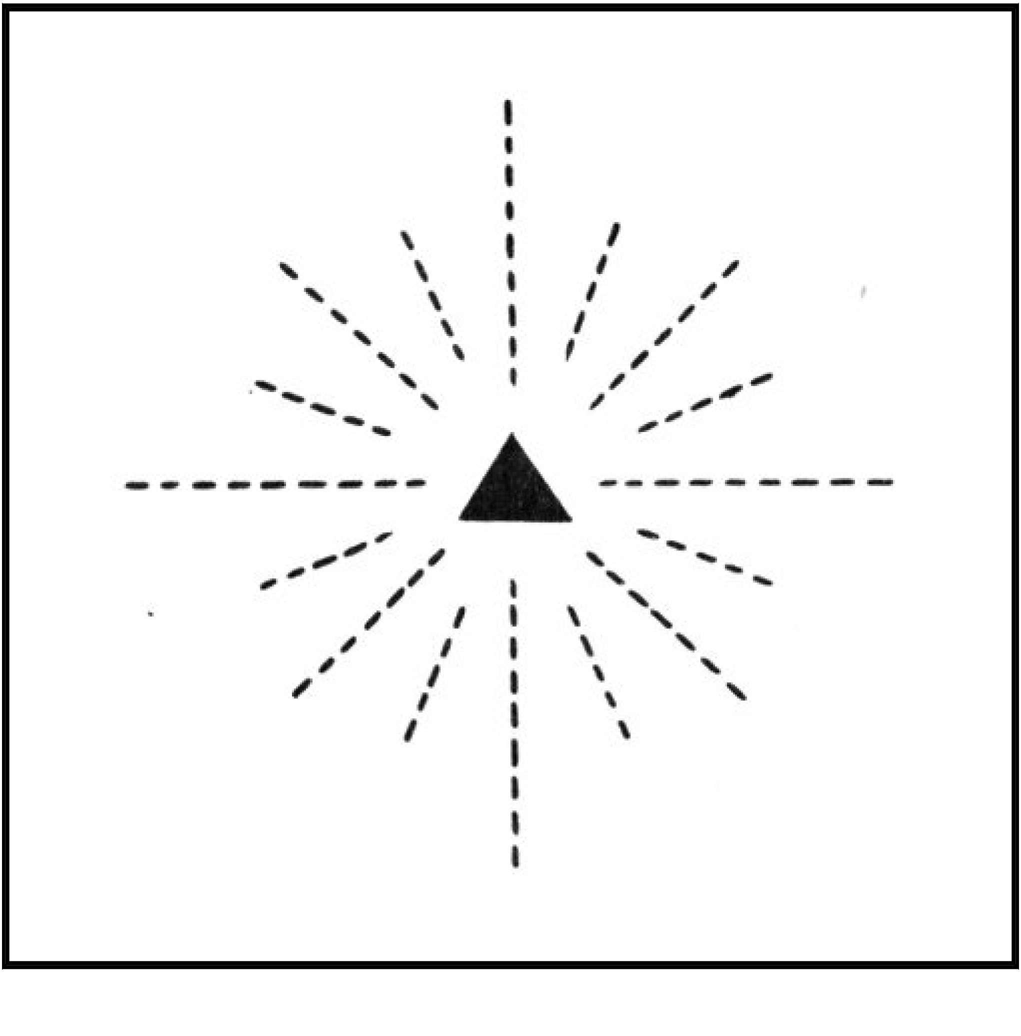


THE STORY OF FLUORESCENCE

An explanation of ultraviolet fluorescence with experiments and a descriptive list of fluorescent minerals.

PUBLISHED BY

RAYTECH INDUSTRIES, INCORPORATED

Stafford Industrial Park
Stafford Springs, Conn. 06076

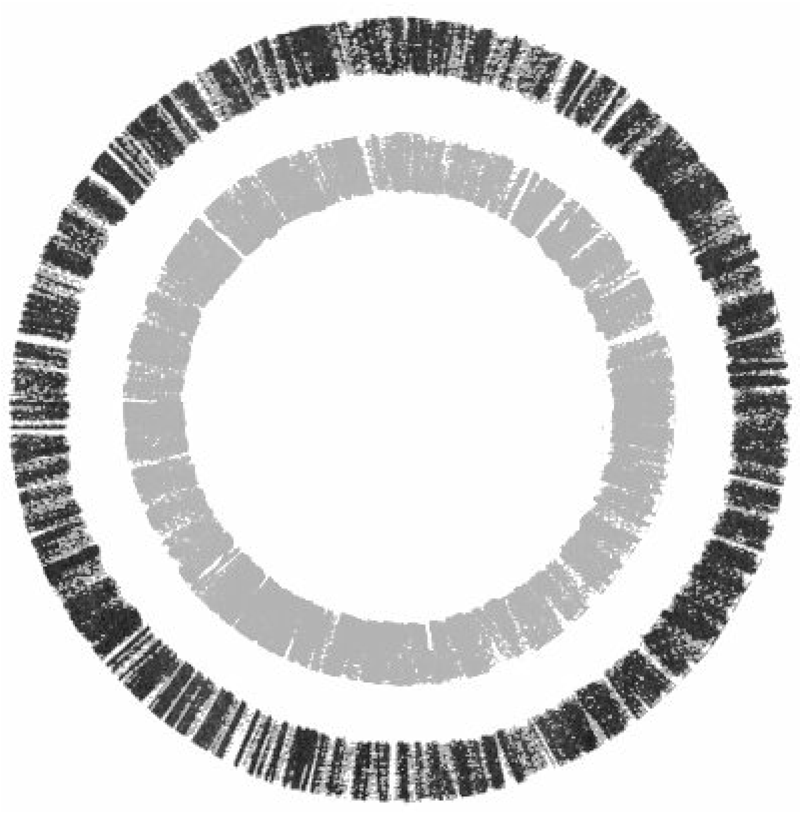
CAUTION

Be careful to limit exposure of your eyes to shortwave ultraviolet rays. These rays can "sunburn" the eyes and cause uncomfortable irritation. You should not look into a shortwave lamp when it is turned on.

Children’s eyes are especially sensitive and if experiments require their working near a shortwave lamp for extended periods we recommend the wearing of protective glasses. Any ordinary glasses will absorb the shortwave rays but if there is prolonged exposure from the side it is possible for the eyes to be irritated from the rays entering the eyes from behind the lenses. Shortwave rays are largely absorbed by most surfaces they strike but they can be reflected by polished metals and plaster and similar surfaces.

If you follow these simple precautions you should have no problem. At Raytech we have worked for many years using tens of thousands of ultraviolet lamps and have experienced nothing more than a few slight cases of eye irritation. For your information shortwave ultraviolet and longwave ultraviolet are defined on page 9 of this book. Longwave ultraviolet normally does not irritate the eyes but we would not recommend staring into an ultraviolet lamp anymore than we would recommend staring into any other light.

THE STORY OF FLUORESCENCE



ABOUT THIS BOOKLET

This booklet provides an introduction to the fascinating study of fluorescence and has been specially written to provide a clear explanation of this important phenomenon. As a basis for understanding fluorescence, color and wavelength are discussed as well as the relationship of visible light with other radiations. A number of colorful experiments are outlined illustrating the principles involved. Additional experiments demonstrate some of the practical applications of ultraviolet and fluorescence.

FLUORESCENCE AND TEACHING

Fluorescence demonstrations have a unique value in teaching. The brilliant color contrasts make vivid and lasting impressions. Interests are stimulated in many areas by experiments which strikingly demonstrate uses of ultraviolet in mineralogy, criminology, automatic postal sorting, fluorescent tracing, prospecting, invisible marking and coding, advertising, philately, and illumination. Increasing use of ultraviolet in scientific and industrial applications makes fluorescence a timely study.

INTRODUCTION

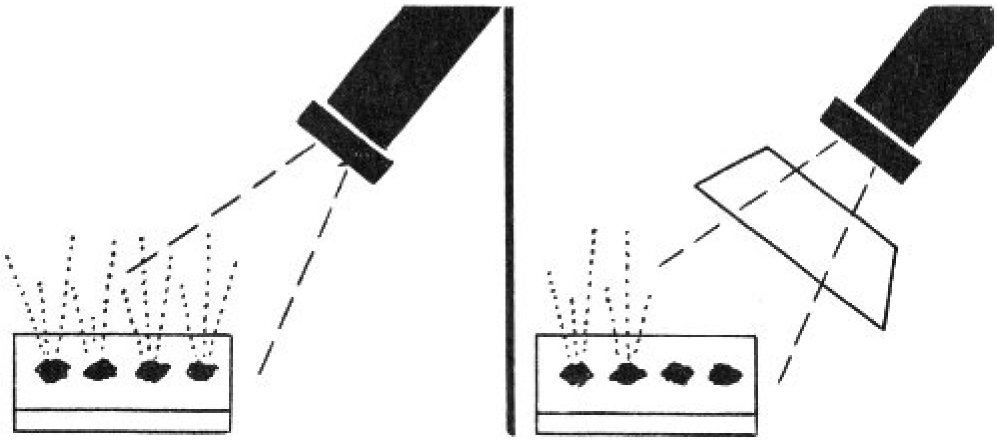
It is recommended that work with this set start with the experiment which is described immediately following this introduction. This experiment describes the cautions to be observed in using ultraviolet and also introduces the phenomenon of fluorescence which is explained in detail in the text.

Following the explanatory section is a series of illustrative experiments. After this there are discussions of the uses of ultraviolet in the fields of philately, advertising and the theatre, criminology, chemistry, mining and prospecting, and medicine. Finally, a descriptive list of the fluorescent minerals and a bibliography are included.

INTRODUCTORY EXPERIMENT

The following preliminary experiment will illustrate how ordinary clear eye glasses can protect your eyes from irritating ultraviolet rays. Harmful shortwave radiations are absorbed by plastic or glass, while the harmless longwave radiations are transmitted with little loss.

First, plug the lamp into an electrical outlet in a darkened area. **Do not look into the dark glass filter.** Remember you will not see much illumination, as the ultraviolet is invisible. The faint purple glow that you see is not the ultraviolet, but a small amount of visible light which escapes through the filter. Most of the visible light is removed by the special filter which transmits ultraviolet and absorbs visible light. Direct the rays of the lamp at the mineral specimens provided with the set. Notice the bright white, cream or blue-white colored fluorescent spots on the specimen labelled scheelite. These spots are the tungsten ore scheelite, which fluoresce only under the shortwave radiations. Take the plastic shortwave eliminator from the envelope supplied with the Broad Spectrum ultraviolet lamp. (A piece of ordinary glass can be used as well.) Hold it between the lamp and the scheelite and observe that the fluorescence is completely extinguished. All shortwave (irritating) rays are removed by the plastic. Try the same experiment on the wernerite which fluoresces yellow when exposed to longwave ultraviolet. Now place the mineral specimens inside an ordinary clear glass or jar. Shine the lamp through the glass onto the specimens. Turn on both wavelengths of a Dual lamp if that is being used. Notice that the scheelite does not fluoresce at all, but that the wernerite fluoresces with undiminished intensity. Now we have reached the point where you can finally get a safe peek at the business end of the lamp. Put the end of the lamp inside the jar or bottle (if a sufficiently large jar is not available, place the lamp behind a piece of clear glass). You can safely look at the lamp through the glass. These simple experiments that have just been completed illustrate that a material can transmit radiations of one wavelength, yet block radiations of another wavelength. This concept will be further illustrated in the sections covering color and selective absorption.



LIGHT WAVES

In the introductory experiment you have been working with one kind of invisible light. Though it may sound contradictory, there are kinds of light or radiation which the human eye cannot see—ultraviolet is one of these. Commonly, we use the word light to denote radiant energy which can be seen by the human eye. But the full spectrum of electromagnetic radiation includes both the wavelengths of light that can be seen and also the wavelengths which cannot be seen, such as cosmic rays, gamma rays, X rays, ultraviolet, infrared, radar and radio waves. These various radiations are all essentially the same kind of energy. They differ from one another in their wavelength, or frequency. The illustration titled “Electromagnetic Spectrum” shows the names of the various wavelength regions.

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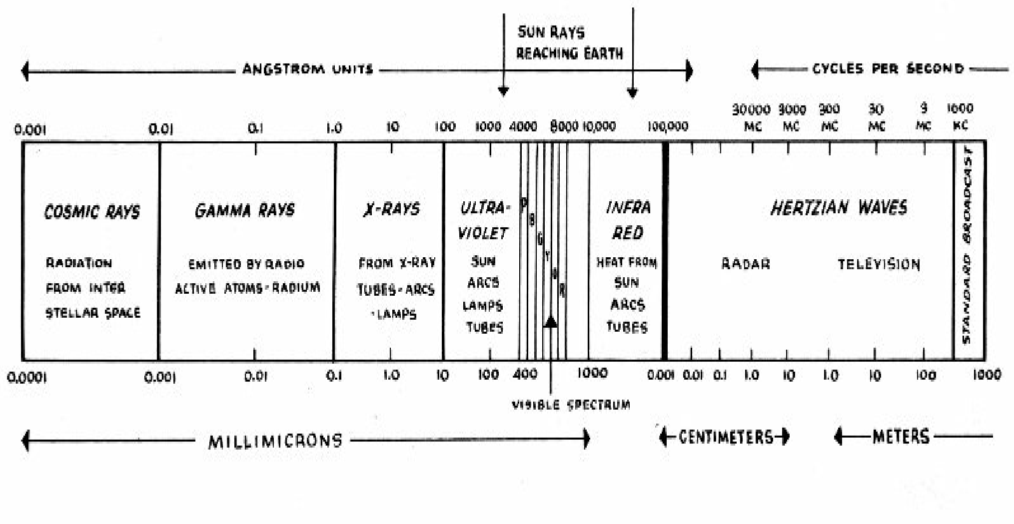
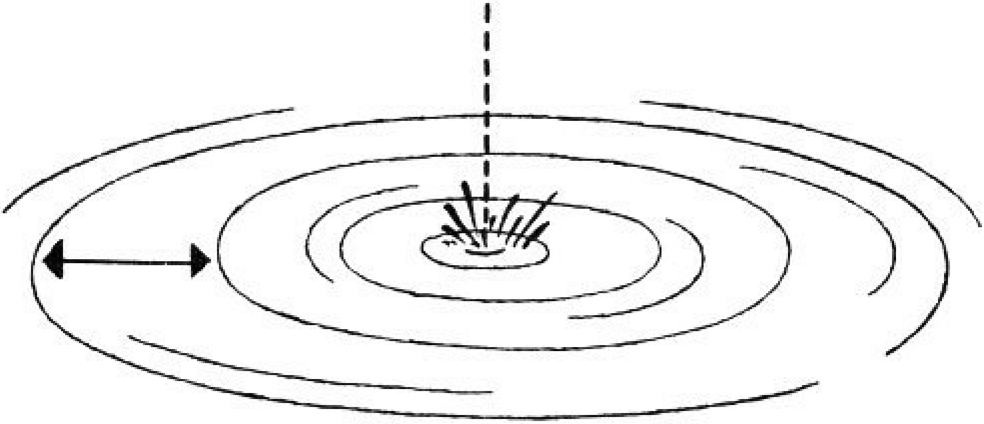


ELECTROMAGNETIC SPECTRUM

ELECTROMAGNETIC SPECTRUM

COSMIC RAYS
  RADIATION FROM INTERSTELLAR SPACE
GAMMA RAYS
  EMITTED BY RADIOACTIVE ATOMS-RADIUM
X RAYS
  FROM X-RAY TUBES-ARCS-LAMPS
ULTRAVIOLET
  SUN ARCS
  LAMPS
  TUBES
VISIBLE SPECTRUM
  P B G Y O R
INFRARED
  HEAT FROM SUN-ARCS-TUBES
HERTZIAN WAVES
  RADAR
  TELEVISION
STANDARD BROADCAST

Visible light and other electromagnetic radiation travels 7
through air, a vacuum and other transparent media, in waves. The wavelength of the energy is the distance measured from the peak of one wave to the peak of the next. The meaning of wavelength can be illustrated by throwing a stone into a pool, as illustrated in the figure titled “Wavelength”. Water pressure energy also is transmitted in waves. The distance from one wave peak to the next is the wavelength. The wavelength in the water might conveniently be measured in inches; however the wavelengths of light are much shorter and are commonly measured by the Angstrom unit.



WAVELENGTH

THE ANGSTROM UNIT

The Angstrom unit is one-hundredth of one-millionth of one centimeter, or about four billionths of an inch. The Angstrom unit is usually abbreviated a.u., A.U., A, or Å. The scientific symbol for Angstrom unit is λ, the Greek letter lambda. Another unit used to measure the wavelengths of light is the millimicron, usually abbreviated μ, the Greek letter mu. The millimicron is equal to one-thousandth of one micron, or 10 Angstrom units.

COLOR

The wavelength of light determines its color. White light is a mixture of wavelengths covering the visible range from about 4000 A to 7000 A. The color of an object depends on which color or wavelengths of light it reflects and transmits. A red apple is red because when struck with white light it reflects primarily the red wavelengths of light (6000 to 7000 A), and absorbs most of the other wavelengths. A green glass is green because it reflects the green light which strikes it. If it is transparent, it also transmits a portion of the green light. The remaining wavelengths of light are absorbed and turn to heat.

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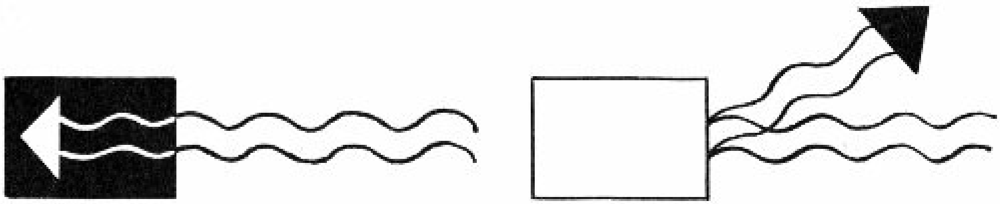
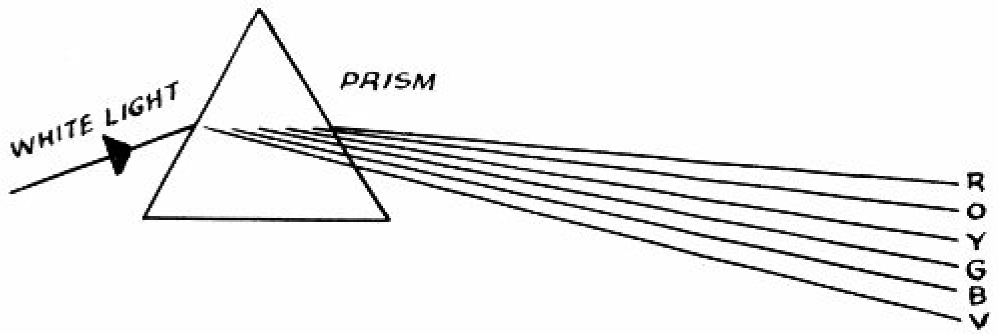


Black objects are black because they absorb essentially all of the wavelengths of light which strike them. Black clothing is warm because the absorbed light turns to heat. White clothing reflects essentially all of the wavelengths and is therefore cooler. White light can be separated into its various wavelengths (colors) with the use of a transparent triangular prism. You may have seen a similar wavelength separation when sunlight shines through a piece of cut glass. A rainbow is a similar separation of the light of the sun. The separation is caused by the reflection and refraction (bending) of the sun's rays by rain droplets.



SELECTIVE ABSORPTION

In the section titled color we found that it is the selective wavelength reflection or transmission and absorption which determines the color of an object. An object is yellow because it reflects (or transmits) yellow light wavelengths to the exclusion of all other visible light wavelengths. The concept of selective absorption is just as applicable outside the visible spectrum as it is with the wavelengths we can see. For example, the filter on the shortwave or Broad Spectrum lamp is transparent to shortwave ultraviolet, yet opaque to visible light. On the other hand, the plastic shortwave eliminator, or ordinary glass, is quite transparent to visible light yet almost totally opaque to shortwave ultraviolet. There are a great many useful applications of the fact that given substances will transmit radiations of one wavelength yet will absorb radiations of other wavelengths. Special heat absorbing glass windows will absorb heat (infrared radiations), yet transmit visible light. The human body will transmit visible light to a rather limited extent. X rays will readily penetrate flesh, yet bones and teeth are sufficiently opaque to X rays to cast shadows on X ray film. As we know, this makes possible their examination inside the living body. Chemical compounds are accurately analyzed by determining their absorption and transmission of various wavelengths of ultraviolet and infrared radiation. The fact that specific groupings of atoms in molecules will absorb specific radiation wavelengths permits precise identification of many organic compounds. Often, these compounds would be very difficult to analyze by any other method.

Examinations in the infrared and ultraviolet spectrums are made with instruments known as spectrophotometers, which allow us to determine the “color” (selective absorption) of materials outside the visible spectrum. The spectrophotometer scans the test specimen with the various wavelengths of the spectrum and determines how much of each wavelength is either transmitted or reflected and how much absorbed.

ULTRAVIOLET AND BEYOND

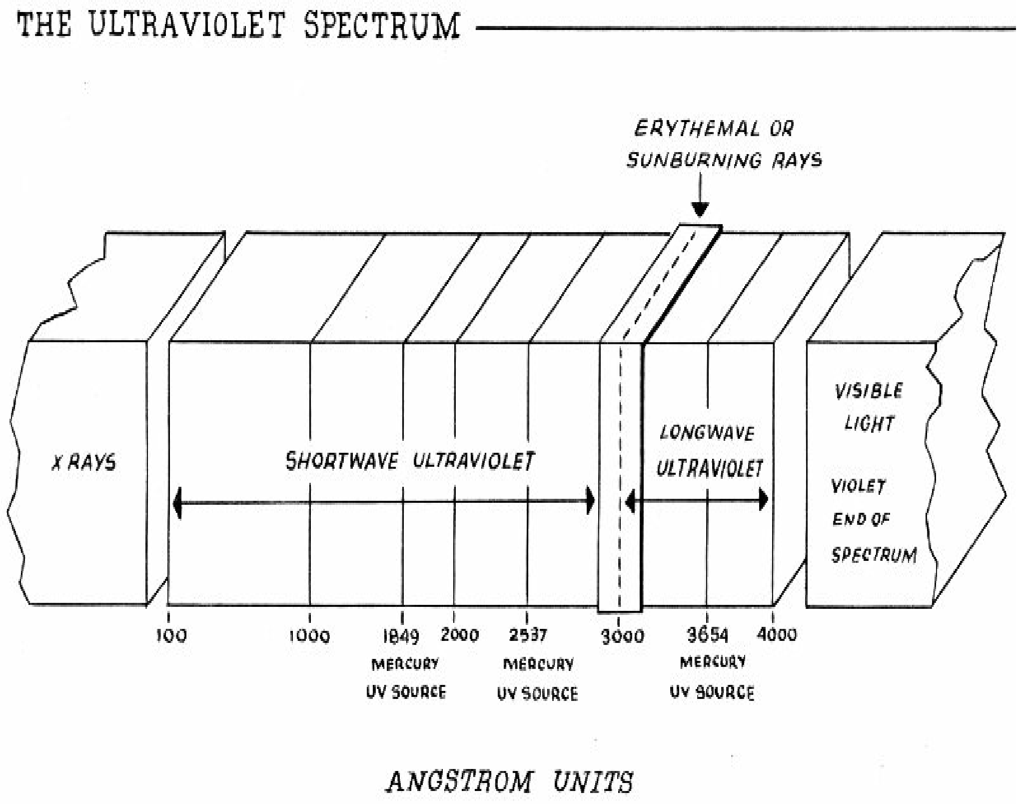
The ultraviolet region ranges from the shortest violet wavelengths of light that people can see, at about 4000 A, down to approximately 100 A, the upper end of the X ray spectrum. The X ray region extends down from the ultraviolet to about 1 Angstrom. Beyond the X rays are the gamma rays, which are emitted by radioactive particles. Further out, beyond the lower end of the gamma rays at about 1/100 A, lie the cosmic rays. These are the mysterious radiations which originate somewhere in space and which constantly bombard the earth. It is believed that this continual bombardment of all living things by cosmic rays is one of the chief causes of mutations or genetic changes in plants and animals.

LONGWAVE ULTRAVIOLET

Longwave ultraviolet includes those radiations which lie just below the visible spectrum, in the range of about 3000 to 4000 A. This ultraviolet is commonly known as “blacklight” and is widely used in industrial inspection, theatrical work, medicine, biology, and advertising. Some minerals will fluoresce with longwave ultraviolet, but most of them react better to shortwave ultraviolet radiation.

SHORTWAVE ULTRAVIOLET

Shortwave ultraviolet includes the radiations below about 3000 A. The most common shortwave ultraviolet sources (mercury arcs) emit much of their energy at the single wavelength of 2537 A. Some longwave ultraviolet and some visible light are also emitted. A small amount of ultraviolet is generated at 1849 A, but little of this energy will pass through the glass tubes used in most lamps. Any ultraviolet which is radiated at the 1849 A wavelength will be absorbed by the air before it travels many inches. As a result of the absorption of the 1849 A ultraviolet oxygen molecules in the air rearrange to form ozone, a very active oxidizing and deodorizing agent.



THE ULTRAVIOLET SPECTRUM

ANGSTROM UNITS

X RAYS <100

SHORTWAVE ULTRAVIOLET 100-3000

MERCURY UV SOURCE 1849

MERCURY UV SOURCE 2537

ERYTHEMAL OR SUNBURNING RAYS ~3000

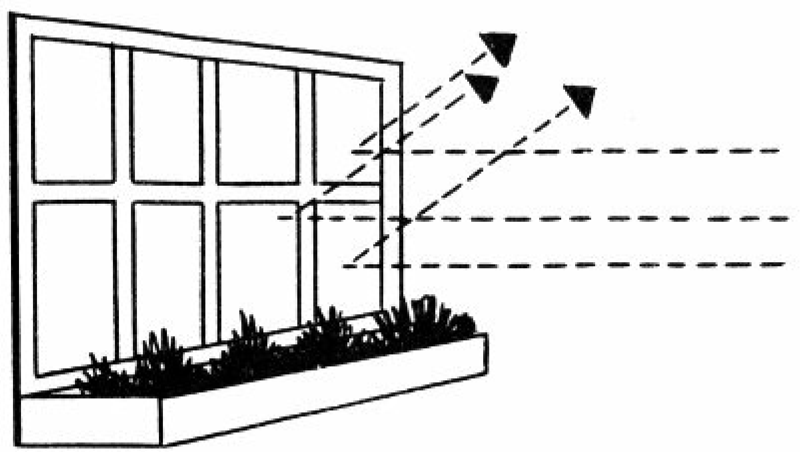
LONGWAVE ULTRAVIOLET 3000-4000

MERCURY UV SOURCE 3654

VISIBLE LIGHT

VIOLET END OF SPECTRUM

Shortwave ultraviolet (2537 A) can kill bacteria when there is direct exposure, and is used for this germicidal effect in food packing plants, hospitals, air conditioning systems, public rest rooms, etc. Also a great percentage of the fluorescent minerals react to shortwave ultraviolet. The tungsten ore scheelite, for example, is found by prospecting at night with a shortwave ultraviolet light and a battery pack. It is the shortwave radiations that are irritating to the eyes. Also they can produce a strong sunburn effect on the skin (erythema) with prolonged exposure. While longwave ultraviolet will pass through most glasses, plastics and transparent substances, shortwave ultraviolet will not go through many things. It will not go through ordinary glass. It will not go through plastics—with the exception of some thin films. This means that shortwave ultraviolet does not come through the windows of your house, cannot penetrate eyeglasses to harm your eyes, and in fact could not come through the bulb of your ultraviolet light if that were not made of a special, high silica glass.



BROAD SPECTRUM

The Broad Spectrum lamp, a patented ultraviolet source manufactured by the **Raytech Industries Co. Inc.**, emits both shortwave ultraviolet (2537 A) and longwave ultraviolet (a band from 3000 A to 4000 A) simultaneously.

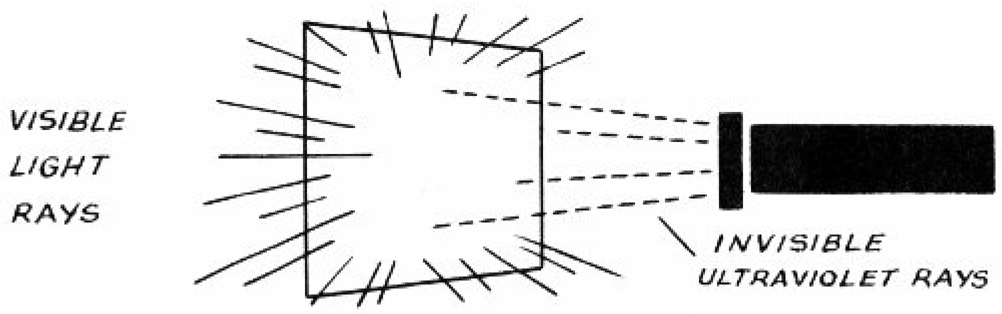
THE ULTRAVIOLET FILTER

All lamps which emit ultraviolet light also emit visible light which tends to mask any fluorescence that is occurring. Therefore it is necessary to place in front of the bulb a dark purple glass filter which will block as much of the visible 12
light as possible but which will, at the same time, transmit the ultraviolet.

Several types of dark blue or purple glass can be used as a filter on a longwave lamp. Sometimes the longwave bulb itself will be made from a dark blue glass that acts as a filter. However, a filter for a shortwave lamp must be made from a very special kind of glass, since, as we have already seen, the shortwave radiations will not pass through ordinary glass.

A DEFINITION OF FLUORESCENCE

Most commonly, fluorescence refers to the property of emitting visible light during radiation by ultraviolet. The visible light given off can be of almost any color, depending on the substance which is fluorescing and to a lesser extent on the wavelength of the ultraviolet which causes the fluorescence.



The word “fluorescence” comes from the name of the mineral fluorite, in which a visible blue glow or fluorescence, resulting from the ultraviolet in sunlight, was noted and described by Sir George Stokes in the early 1800’s. Sir Stokes made a rather comprehensive study of this phenomenon, which he called “fluorescence”.

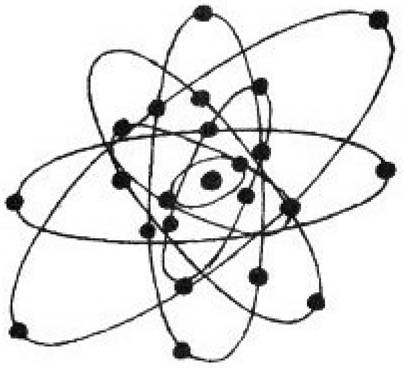
Fluorescence is caused not only by ultraviolet, but can also be caused by other radiations such as X rays and visible light. For example, a number of minerals will glow or fluoresce when exposed to X rays. Minerals have also been found which luminesce in the infrared region when irradiated with ultraviolet rays or more commonly with visible light. Some 75 different mineral species in the collection of the National Museum have been found to fluoresce in the infrared region.

Since its discovery by Stokes, fluorescence has developed great practical significance. One of its most widespread applications is in the ordinary fluorescent light. The tube of a fluorescent light consists basically of a generator of ultraviolet energy. The inside of the tube is coated with a fluorescent powder or phosphor, which the ultraviolet causes to fluoresce brilliantly, thereby producing visible light.

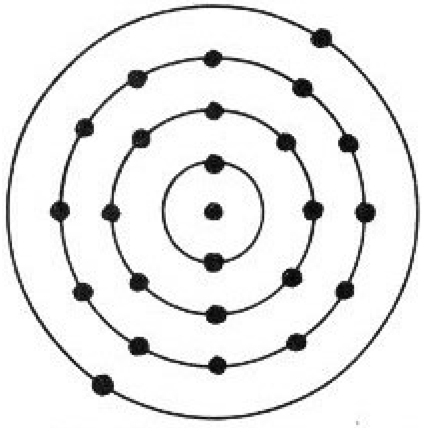
FLUORESCENT LIGHT DEMONSTRATION

You can easily demonstrate the principle of the fluorescent illuminating lamp as follows. First examine a variety of white papers until you find one that has a bright blue-white fluorescence. If you prefer, you can make your own fluorescent paper by soaking a piece of ordinary white paper in a dilute solution of Ray-Chrome Invisible Ink. This fluorescent paper will be used to simulate the fluorescent phosphor coating on the ordinary fluorescent lamp tube. Now shine your ultraviolet lamp on the paper and note the quantity of visible light radiated from the paper. This fluorescing paper can supply enough visible light to permit reading a newspaper in a dark room. In this demonstration the ultraviolet radiation normally generated inside the fluorescent tube is provided by the separate ultraviolet lamp.

INSIDE THE ATOM



ELECTRONS IN ORBIT



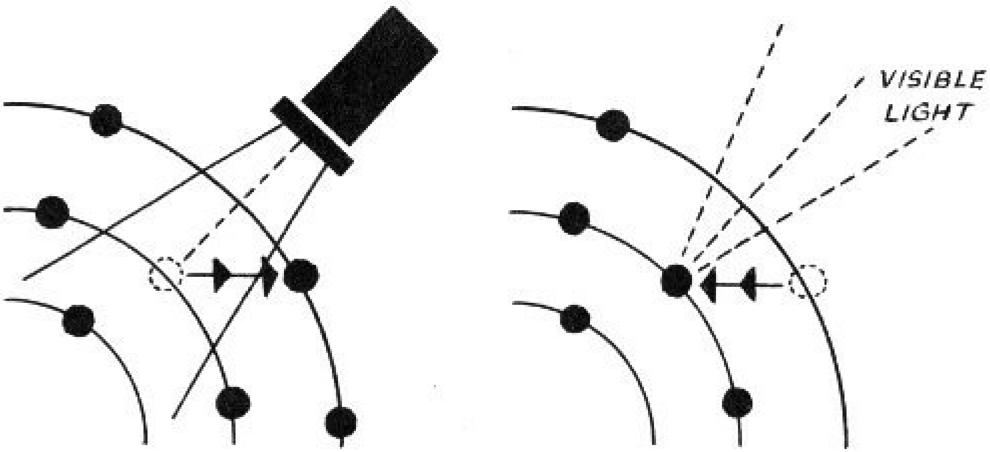
ELECTRON SHELLS

In order to understand the phenomenon of fluorescence, it is necessary first to consider the physical structure of matter. We know that everything is made up of small particles called molecules, and that molecules are made up of atoms—both of these too small to be seen. Smaller yet are the parts of an atom—the center or nucleus, and the electrons which circle around the nucleus. The orbits in which the electrons travel are of several diameters. All orbits of a particular diameter are located in a single electron shell having the same diameter as the orbits. Each shell represents one energy level. Shells with larger diameters have higher energy levels. If you could look inside an atom you would see the nucleus and the electrons circling it, as shown in the figure titled “Electrons In Orbit”. If all the electron orbits were laid flat, the atom would look like the figure titled “Electron Shells”. Some atoms have more than four electron shells, some less, but the picture illustrates enough about atomic structure so that you can understand fluorescence.

ELECTRONIC ENERGY

It has been found that an electron travelling in its orbit must have a precise amount of energy if it is to remain in that orbit. Less energy would place it in an orbit nearer to the nucleus. An excess of energy would cause the electron to move to an orbit farther from the nucleus.

THE CAUSE OF FLUORESCENCE



ELECTRON DISPLACEMENT

All kinds of radiation, including ultraviolet, are forms of energy. When ultraviolet light is directed at most substances, the energy of the light is absorbed and turns into heat. However, some substances have an atomic structure that is affected by the particular kind of energy that is ultraviolet light. In these cases the energy from the ultraviolet light, when it strikes an electron, gives that electron extra energy which

causes it to move to an orbit in a shell farther away from the nucleus (a higher energy level). This is illustrated in the figure titled “Electron Displacement”. Remember that an electron needs an exact amount of energy to stay in its own orbit in a particular electron shell, and that any change in that amount of energy will cause the electron to move either toward the nucleus or further away from the nucleus. Now when this energy from the ultraviolet light strikes the electron and causes it to move away from the nucleus, the original orbit becomes empty and the electron shell is left with a gap which must be filled to maintain the electrical balance. An electron in an orbit closer to the nucleus would not have sufficient energy to move out, so the only way for the gap to be filled is for an electron in an orbit further from the nucleus to be pulled down into the empty orbit and thereby fill the gap left in the original shell by the loss of the first electron. A replacement electron, in moving down, gives off a definite amount of its energy, and it is this energy which we see as visible light or fluorescence. The small packets of energy given up by the electrons as they drop 15
to lower energy levels are known as quanta. The radiated quanta are often called photons. What actually happens during fluorescence is that this process of energy exchange takes place rapidly with many, many electrons—some absorbing energy, some giving it off, so that the visible light we see is for all practical purposes continuous and not interrupted.

PHOSPHORESCENCE

We have just discussed how visible fluorescent light is radiated by a fluorescent material while it is exposed to ultraviolet.

Now let's see what happens when the ultraviolet light is removed. With most fluorescent substances the electrons settle back quickly into their balanced orbits and there is no further radiation of visible light. But in some materials, the electrons are slow in returning to their normal orbits. In this case, the atoms continue to give off light as long as the electrons are returning to their normal state. This continued emission of light after the ultraviolet has been removed is known as phosphorescence. Some materials will phosphoresce for only a few seconds, while others will continue to give off light (in ever diminishing intensity) for long periods. In fact, by using sensitive photographic plates, phosphorescent light has been detected as much as several years after the exposure to ultraviolet.

ACTIVATORS

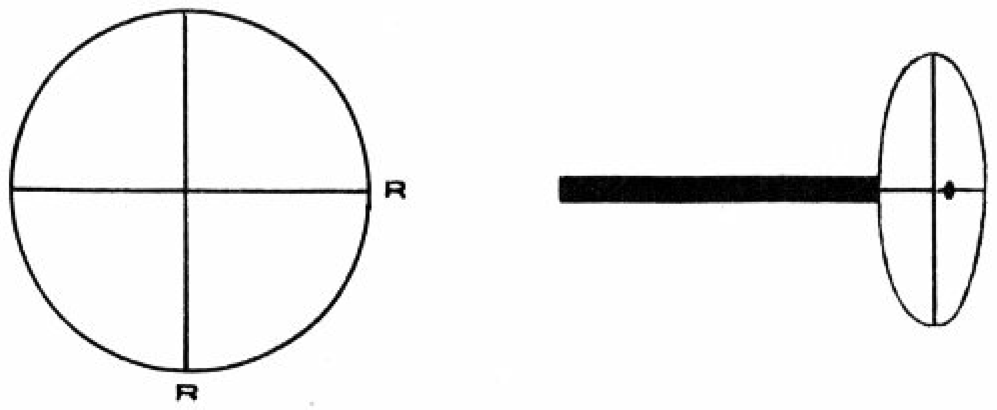
As you know, not all substances are fluorescent—in fact, most of them are not. In substances that do fluoresce, it has been found in most cases that a small amount of some impurity must be present in order for fluorescence to occur. Few chemically pure minerals will fluoresce at all. But on the other hand, the amount of the impurity is critical and if there is too much, the fluorescence will either be diminished or completely eliminated. For example, the red fluorescent calcite from Franklin, New Jersey is activated by manganese, in a quantity of about 3%. It has been found that a manganese content in the calcite of more than about 5% or less than about 1% will not permit fluorescence. The amount and type of impurity present determine the color and intensity of the fluorescence. The mineral calcite seems to be particularly sensitive to impurity activation, and specimens of calcite have been found which fluoresce in practically every color. The amount of activator can be as important as the type.

In recent years, the constant quest for ever improved fluorescent coating (“phosphors”) for fluorescent lamp tubes and television screens has resulted in a great deal of study of the effects on fluorescence of both chemical activators and crystal structure variations.

THE MAGIC PIN WHEEL, PROJECT I

A fascinating and colorful experiment that demonstrates the stroboscopic effect.

Cut from cardboard, or a heavy manilla folder, a disk 6″ in diameter. Use a compass or thumbtack and string to assure that the circle is round. With the red fluorescent crayon, draw two straight lines through the center of the circle, dividing the circle into 4 equal pie-shaped sectors. Push a thumbtack through the center of the pin wheel and fasten it to the end of a wooden stick. Leave the tack loose enough that the pin wheel will turn freely.



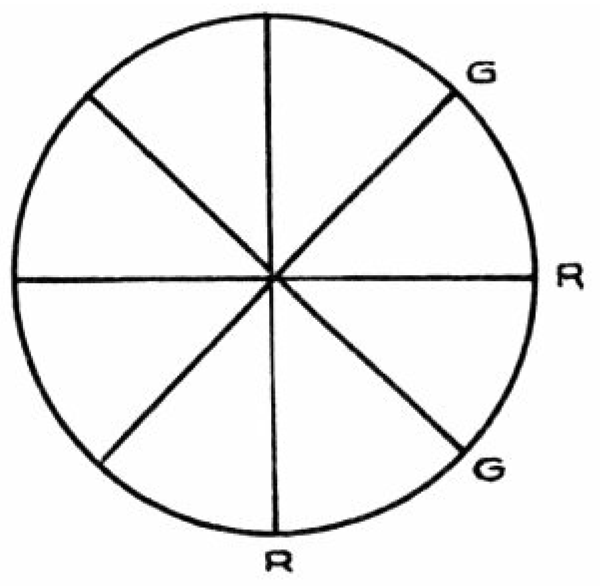
Next, darken the area where the tests will be made so that the fluorescence of the wheel shows to best advantage. Shine your ultraviolet light on the pin wheel and give the wheel a rapid clockwise spin with your finger. You will observe that the rays on the wheel seem to rotate clockwise, stand still for a moment, then change their rotation to counter-clockwise. This is the stroboscopic effect caused by the pulsing ultraviolet light. Operating on alternating current, your ultraviolet light actually blinks very rapidly, although the blinking is too fast to be seen by the eye. It burns brightly every time the electrical current reaches a peak, and then grows dim as the current level drops. With sixty cycle alternating current the light grows bright then dim 120 times each second (twice each cycle). If we could spin the wheel so that it made exactly 120 revolutions in one second, the four red lines would appear to stand still. Every time the light blinks bright, we can see the lines. When the light grows dim we cannot see the lines. If the lines are always in the same position when the light flashes, they will appear to be standing still in that position. If the wheel is turning slightly faster than 120 revolutions per second, the lines will appear to rotate in a clockwise direction. If the speed is slightly slower than 120 revolutions per second, the lines will appear each time just a little behind the position where they were on the preceding blink of the light, and will therefore appear to be rotating in a counter-clockwise direction. Because there are four evenly spaced lines, instead of just one, the lines can take each other's place and the same results can be obtained at one-fourth of 120 turns per second, or 30 revolutions per second. We cannot tell whether we are looking at the same line every time the light flashes, or whether we are looking at another line that has taken its place.

If we spin the wheel at 15 revolutions per second each ray will advance one-eighth of a revolution each time the light blinks and the four lines will appear as eight rays standing still. If a speed of 7½ revolutions per second is reached, there will be 16 radial rays. The lines we see do not appear as sharp lines, but as blurred rays because the light does not blink "on" and later "off" instantaneously. As the brilliance of the light flash fades, we see the moving ray fading in intensity. A stroboscope is a lamp that gives repeated sharp light pulses of very short duration. By adjusting the frequency of the light flashes it is possible to examine high speed rotating machine parts almost as if they were standing still. The frequency of your ultraviolet light is not adjustable. It is tied to the frequency of the 60 cycle AC current being used. Why is it not possible to get a stroboscopic effect with an incandescent light? Is it possible with a fluorescent light? Try it.

THE MAGIC PIN WHEEL, PROJECT II

Explains why the mixing of red and green light gives results the opposite of those obtained in mixing red and green pigments.

Take the same pin wheel used in the Magic Pin Wheel, Project I, and place two visible green fluorescent crayon lines through the center of the disk and spaced midway between the two red lines. Try spinning this pin wheel in front of the ultraviolet light as before. You will notice that the overall color sensation is that of a light yellow, almost white color. This is the mixture of the red light and the green light radiated by the fluorescing lines. The two colors reach your eye in such rapid succession that your eye cannot separate them but blends them both together. When we mix red light and green light we get a color near white. When we mix red and green crayons or paints we get a color near black. How do you explain the difference? If we go back to the section titled color, we see that a red colored surface absorbs all the colors or wavelengths in white light except red. On the other hand, a green colored surface absorbs all colors except green. If we mix the two colors together they absorb almost all light and produce black. This is called subtractive mixing because the red subtracts all wavelengths but the red, and the green subtracts all wavelengths but the green. Between the two they subtract or absorb practically all the light which hits the mixture. The color mixing with the pin wheel is called additive mixing because we are actually adding red light to green light and getting as a result a color close to white. A true white would require the mixing together of all colors of light.



THE MAGIC PIN WHEEL, PROJECT III

An advanced experiment for those who wish to work further with the fascinating pin wheel.

Interesting results can be obtained by examining fluorescent pin wheels spinning on an electric motor rated at a speed of 1750 r.p.m. This is just below the speed of 30 revolutions per second at which the pin wheel would appear to stand still. Try each of the pin wheel variations listed below, shining the ultraviolet light on the spinning wheel as you did in the previous experiments.

1. Draw a single radial red line from the center of the wheel.

2. Extend the line across the full diameter of the wheel.

3. Draw a second red line so that the wheel is divided into four equal pie-shaped sectors.

4. Draw two green lines midway between the red lines.

5. Make a new wheel divided into 8 equal parts similar to the last one, but place the two green lines in adjacent positions and the two red lines in the other two positions.

With what we learned in the first two pin wheel experiments, you may be able to explain the results obtained with the various wheels. Can you explain the similar results obtained whether one, two or four red lines are used?

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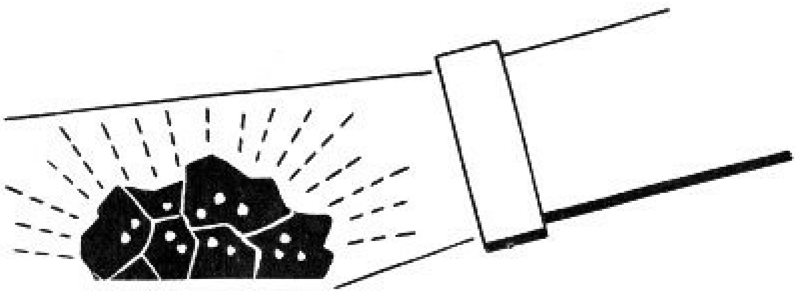
SCHEELITE

Shows how this valuable tungsten ore is located and identified by the use of ultraviolet.



Examine in daylight the mineral specimen labelled scheelite. Notice the variations in color in the specimen, and see if you can guess which areas contain scheelite, the valuable tungsten ore. Then plug in your shortwave or Broad Spectrum ultraviolet light and shine it on the specimen. The bright cream colored or blue-white spots which glow are the fluorescent scheelite. Examine the specimen again in daylight to see if now you can locate the scheelite. In daylight, it is not always easy to distinguish the various minerals in a specimen. However, as you can see, it is very easy to pick out scheelite under ultraviolet. Almost all prospecting for scheelite tungsten ore is done with an ultraviolet light at night. By using ultraviolet inspection, rich ore can be separated from poor ore, and waste rock or tailings from the mill can be checked to determine the thoroughness of the scheelite extraction process. Tungsten is a metal vital to our economy. Since it can be heated white hot without melting it finds wide use in the filaments of light bulbs and electron tubes. Tungsten also is an essential ingredient of most of the tools used for the high speed cutting of metals.

CALCITE-WILLEMITE

A two colored fluorescent ore which has been traced and sorted under ultraviolet.

When you examine the specimen labelled Calcite-Willemite under shortwave or Broad Spectrum ultraviolet, you will see the beauty of two color fluorescence—red from the calcite (activated by a trace of manganese), and green from the willemite (a zinc silicate). These brilliant fluorescent colors are caused by the shortwave radiations. Now let’s see what happens to the same specimen under longwave. You can either turn on the longwave source in your Dual light, or hold the

shortwave eliminator in front of your Broad Spectrum lamp. Sometimes this calcite from northern New Jersey will fluoresce a weak red under longwave, and sometimes it will react very little. The willemite will often react to longwave, although not always. This specimen is from a mineral occurrence that is famous the world over—the zinc deposits in Sussex County, New Jersey. Willemite, one of the 20
important ores of these mines, is fluorescent as you have seen. Associated with the willemite have been found more than two dozen other fluorescent minerals, some of them found at no other place in the world. You can imagine what a thrilling sight it must have been to look over the picking table at the mine where the ore was sorted under powerful ultraviolet lamps. This was a kaleidoscope of color—every specimen an individual design of specks, patches, swirls and bands of red and brilliant green. Specimens were found that fluoresced chartreuse, purple, golden brown, blue-white, orange and cream, often in fantastic patterns, and no two pieces were ever alike. For beauty and variety of fluorescent minerals there has never been another mine to equal that at Franklin.

PHOSPHORESCENT CALCITE

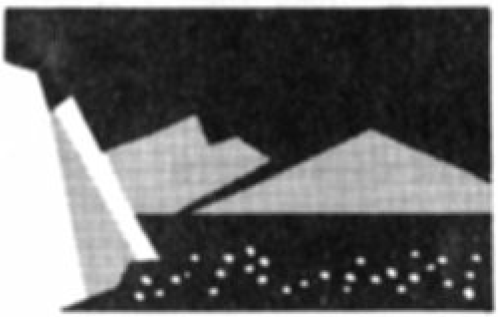
Illustrates phosphorescence—the emission of light during the slow return of electrons to normal energy levels after excitation by ultraviolet.

We have just been examining a calcite-willemite specimen containing calcite that fluoresces bright red. Now in the specimen labelled Calcite you can see the same mineral—

calcite—but with a different activator that causes an entirely different fluorescence. The Franklin calcite fluoresced red because it had a slight manganese content. The phosphorescent calcite contains a sulfide impurity which causes it to fluoresce. Many of these specimens will fluoresce one color under shortwave ultraviolet and another color under longwave. First try the phosphorescent calcite under longwave (if you are using a Broad Spectrum lamp put your shortwave eliminator in front of the filter). The specimen may not fluoresce at all, or it may fluoresce a beautiful soft pink—not at all like the Franklin calcite. Now remove the shortwave eliminator (or turn on the shortwave side of the Dual). See how the specimen turns blue. The same piece of phosphorescent calcite can now be used for another demonstration. Shine the shortwave or Broad Spectrum lamp on the calcite, holding the specimen very close to the lamp, for several seconds. Then quickly bring it out from under the lamp, and you will be able to see an afterglow called phosphorescence. This phenomenon is best observed in complete darkness. Now try the same thing under longwave. Turn the light down on the specimen, hold the specimen very close to the lamp for several seconds, and then bring it away quickly. Try the shortwave again, and see the difference. When you are testing a mineral for phosphorescence, you will get better results if you remember to hold the specimen as close as possible to the lamp for several seconds, and then **quickly** bring the specimen away so that the ultraviolet does not shine on the specimen. Some minerals have a fleeting phosphorescence that can only be seen by moving the specimen very quickly. The calcite from Franklin, New Jersey has a brilliant but extremely brief orange-red phosphorescence which you should be able to detect now that you have worked with the blue phosphorescent calcite which has a longer, easier to see, afterglow. While you are testing the calcite for phosphorescence, you will have a chance to observe how the other specimens react following exposure to ultraviolet. Do any of the other specimens phosphoresce? When testing a mineral for the first time for its fluorescent qualities, remember to test it also for phosphorescence.

Here is a question you can ask yourself (if you haven’t thought of it already)—just how long does the piece of phosphorescent calcite hold its glow? Cause it to phosphoresce again and estimate how long the light lasts. Then try timing it to see how long before the last glow fades. There have been studies made of phosphorescent willemite in which the specimen was exposed to shortwave ultraviolet and then put in a dark box. Days, and even many months later, if a photographic plate were put in that box it would register light coming from the willemite. This light was of course too feeble to be seen by the human eye.

COLLECTING FLUORESCENT MINERALS



A good group project. Tells where fluorescent minerals may be found and how to get local collecting information.

The four fluorescent mineral specimens in the set can easily trigger an interest that may lead to the building of a fine fluorescent mineral collection. Most minerals do not fluoresce; however, fluorescent minerals are apt to be found at almost any place.

If a battery adapter is available for your ultraviolet lamp, a field trip at night is the best way to locate fluorescent minerals. Where no battery pack is available, fluorescent minerals can be found by bringing rock samples to the light. This is particularly good as a group project. Gather together as many different rock samples as possible. The more varied the samples, the more likely that fluorescent minerals will be found. Sand and gravel samples are particularly good because they usually contain material from many sources. Mine, quarry and road cut samples are also good. Watch particularly for vein and crystal pockets which will be more likely to contain fluorescent minerals. There is always a chance of locating a mineral deposit of commercial or scientific value. In the back of this booklet will be found a list of most of the better known fluorescent minerals.

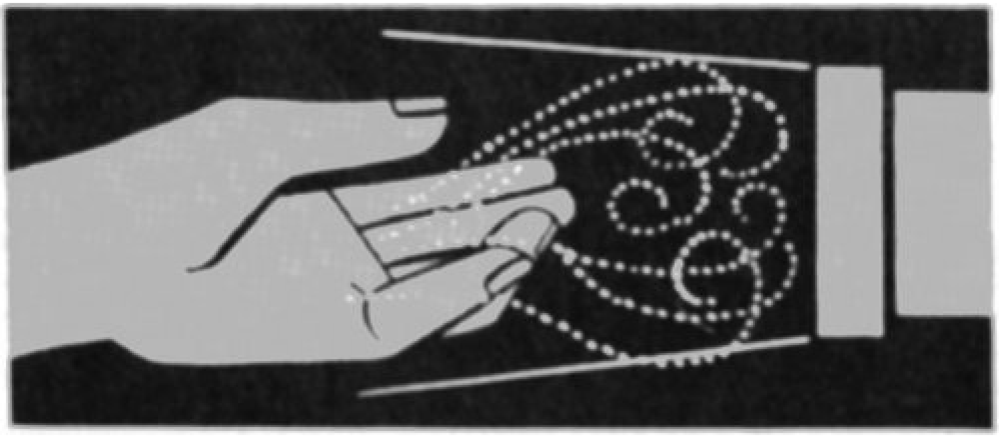
Where there is an interest in mineral collecting it is worth investing in a good reference book or two. A list of recommended literature is also included in the back of this booklet.

While much can be done by the independent collector, a mineral club is often the best source of specimens and information on where fluorescent minerals may be found. Gem and mineral shops frequently have a fluorescent display. Also there are exhibits of fluorescent gems and minerals in museums and private homes across the country.

Many collectors prefer to make a specialized fluorescent mineral collection; some of the possibilities include fluorescent crystals, fluorescent calcites in various colors, and fluorescent gemstones including such minerals as scheelite, spinel, willemite, ruby, benitoite, etc. Most collectors try to acquire large, showy pieces, but there is a great deal to be said for a collection of smaller, well-chosen, carefully displayed specimens. There is as much beauty and much less bulk and weight. Also, many fluorescent minerals are not available in large specimens and by concentrating on the smaller specimens a more comprehensive collection can be built.

AIR CURRENTS

Shows how invisible air currents can be followed with tracing powder and ultraviolet.



Turn on the ultraviolet lamp in a darkened room. Place a very large pinch of tracing powder in the palm of your hand. Hold the lamp so it is level with your palm, and shining out in front of your hand. Now blow the powder from your hand so it forms a cloud in the beam from the ultraviolet lamp. Note how the air currents cause the cloud of green fluorescence to dissipate quickly. If you move your arm slowly through the cloud you see the effect of swirling air currents. If you can turn on the lights during this experiment, you will notice the fluorescent cloud is nearly invisible in ordinary light.

Fine fluorescent particles such as those in the tracing powder will remain suspended in air for long periods of time. During air pollution studies, the movements of air currents over considerable distances have been traced with the use of fluorescent tracing powder and ultraviolet detectors.

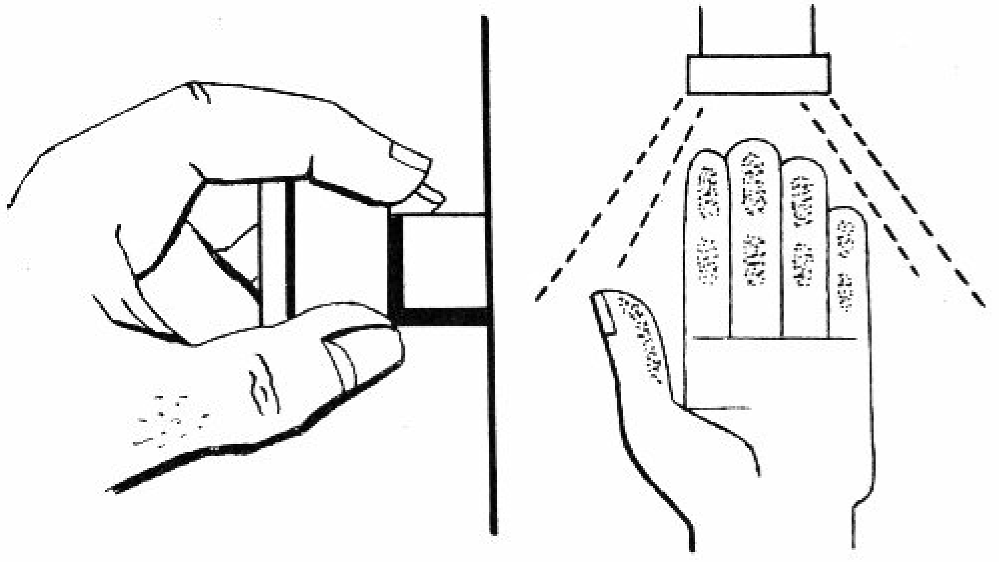
TRACING PASTE

Demonstrates the use of fluorescent paste in

criminological tracing.

Get some petroleum jelly such as vaseline. See if it will fluoresce. Check to see if other petroleum products such as oil and grease will fluoresce. Keeping your ultraviolet lamp on, mix some tracing powder with a dab of vaseline. Notice the light green fluorescence. Does it also phosphoresce? Place a dab of vaseline on a piece of non-fluorescent paper next to a dab of tracing paste. Smear them around so they become almost invisible. Examine the mixture with your ultraviolet lamp. Note the blue and the green fluorescence. This is the kind of tracing paste used in criminological work.

If this tracing paste is smeared on a lock or a doorknob, it will stain the hand of anyone opening it. An ultraviolet light will immediately detect anyone who had touched an object thus marked. Tracing paste has been used to invisibly mark fire alarm handles where there has been a problem with false alarms. After a false alarm the hands of suspects can be checked with ultraviolet. Bright green fluorescent fingers will quickly reveal anyone who has touched the alarm handle.



FLUORESCEIN

Used in sea survival kits and for tracing underground water systems.

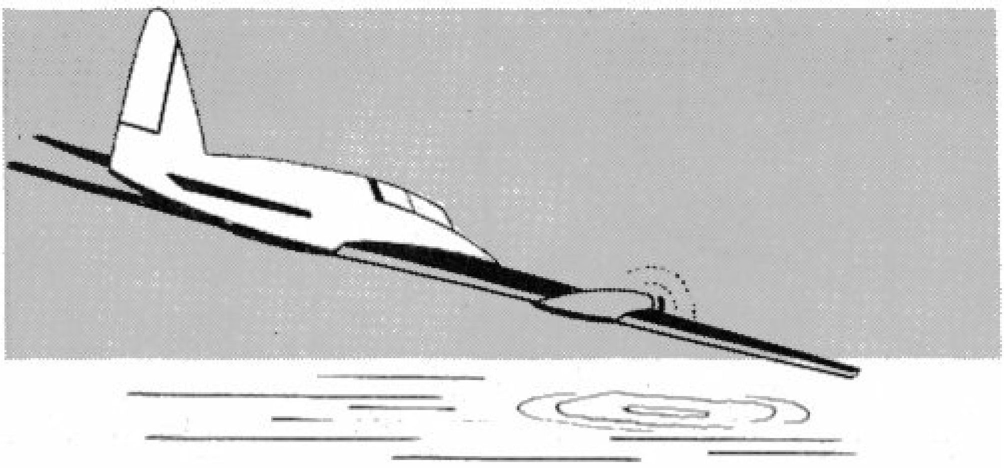
See if you can get some water soluble sodium fluorescein (uranine) from a drugstore. Only a few grams will be needed. If fluorescein is not available, a very dilute solution of mercurochrome will do a fairly good job. A few drops of mercurochrome in a glass of water will suffice. In a more concentrated solution, the red color of the mercurochrome tends to hide the fluorescence.

If you have been able to obtain the fluorescein, add a small amount to a jar of water. Examine it with your ultraviolet light. You will see a brilliant yellow-green fluorescence. Fluorescein is one of the most powerfully fluorescent substances known. It will fluoresce even in the sunlight, although it shows up much better in the darkness with ultraviolet. Fluorescein is often used as a fluorescent tracing material.

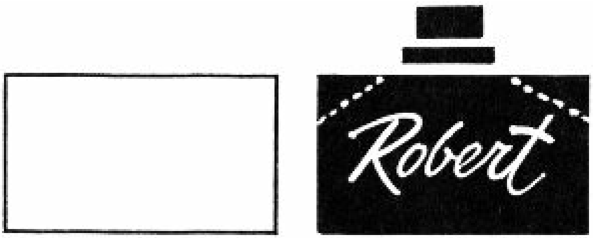
The source of underground streams and rivers has been traced with fluorescein. The fluorescein dye is added to the water where it disappears underground. An ultraviolet light quickly tells whether water coming from the ground elsewhere is the water to which the fluorescent dye has been added. The length of time it takes before the fluorescent color appears after the dye has been added at the first point is a measure of how long it takes the water to complete its underground passage.

Fluorescein is often used as a marker in sea survival kits. By releasing a quantity of the fluorescent dye into the water, a large fluorescent patch is made which can be readily seen from the air.

Leaks in pipe and tank systems are often detected by adding soluble fluorescent dyes to the fluids inside the systems. Examination with ultraviolet will then reveal fluorescent spotting wherever leakage occurs.



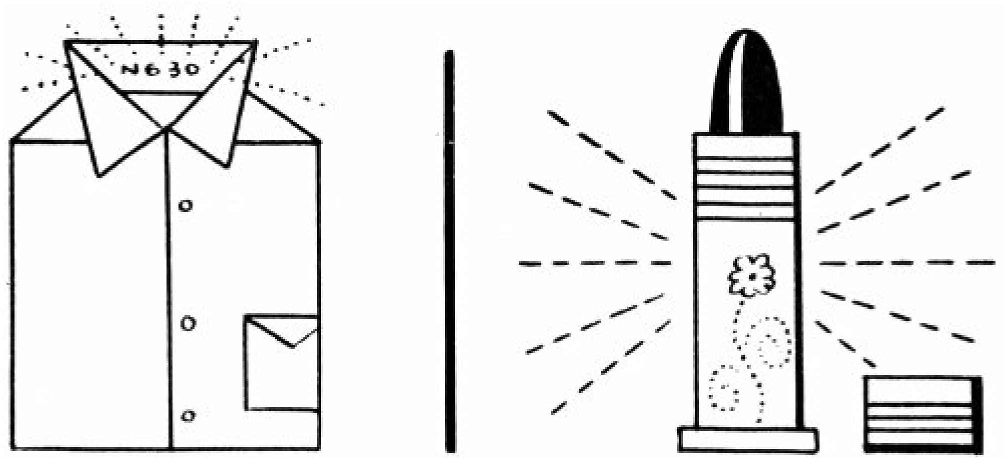
INVISIBLE INK



Shows how fluorescent compounds are used in quality control and for invisible marking and coding.

Using the invisible ink from your set and an ordinary straight pen, write your name on a clean sheet of non-fluorescent paper. You may have a little trouble doing this because the ink is invisible. When you finish, examine the paper under the ultraviolet lamp. Now try writing with the lamp on. Using this ink you can write secret messages or mark clothing for identification purposes. Laundries that advertise invisible marking make use of a similar ink and ultraviolet light. Banks and other institutions that handle valuable papers such as stocks and bonds sometimes code their documents with invisible ink. Ransom money in a kidnapping case can be effectively marked with invisible ink.

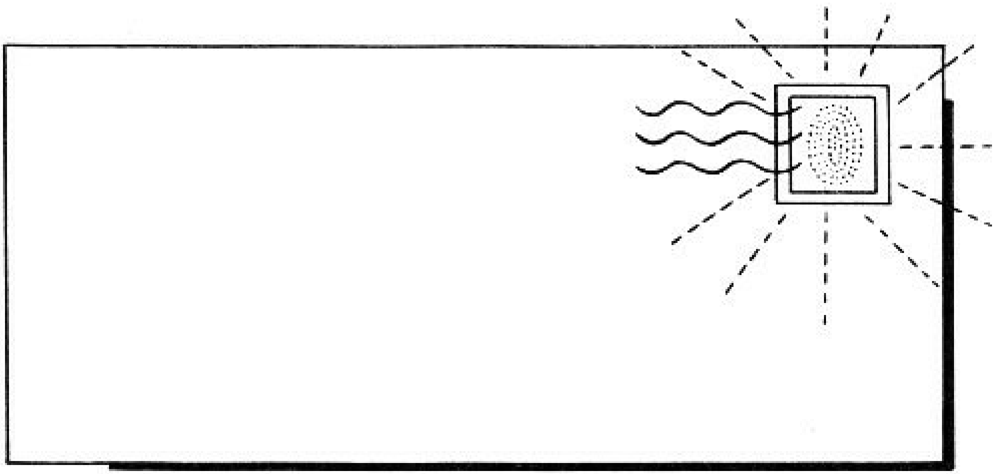
Manufacturers sometimes code their products with invisible fluorescent markings. Maps are sometimes marked with invisible ink. Military maps are often printed on fluorescent papers so that they can be examined in the dark with the use of a small ultraviolet source.



Military specifications often require that plastics and other parts be coated with a protective coating of a special varnish that will protect the parts from mildew and other fungus attack. These varnishes are mostly clear and cannot be seen in ordinary light. Ultraviolet tracers similar to the invisible ink are dissolved in the varnish. The parts can then be checked under ultraviolet to see if they are all fully covered. Shiny brass parts such as lipstick cases and lamp parts are covered with clear lacquers to protect them from tarnishing. These lacquers are transparent and cannot be seen. The only practical way to see if the parts have all been evenly covered with the protective lacquer is to put a fluorescent tracer in the lacquer and to inspect the parts under ultraviolet.

26

POSTAL STAMPS



Illustrates how invisible variations in postal stamps can be detected with ultraviolet, and how automatic postal sorting is performed with fluorescent tagged stamps.

The section at the back of this book titled "Practical Applications of Ultraviolet" has several informative sections dealing with postal stamps which you may wish to read before proceeding with this project.

Ultraviolet is used by the philatelist or stamp collector because it reveals many things not ordinarily visible. Gather together from as many sources as possible a quantity of used or new 4c Lincoln stamps and see whether you can find the three fluorescent variations. They will all appear the same in visible light. The stamp included with the Science Set is a fluorescent tagged stamp, which fluoresces bright green in shortwave ultraviolet but not in longwave ultraviolet. The regular untagged Lincoln stamps are found printed both on a bright blue-white fluorescent paper and also on a non-fluorescent paper. This paper variation can be detected with either shortwave or longwave ultraviolet.

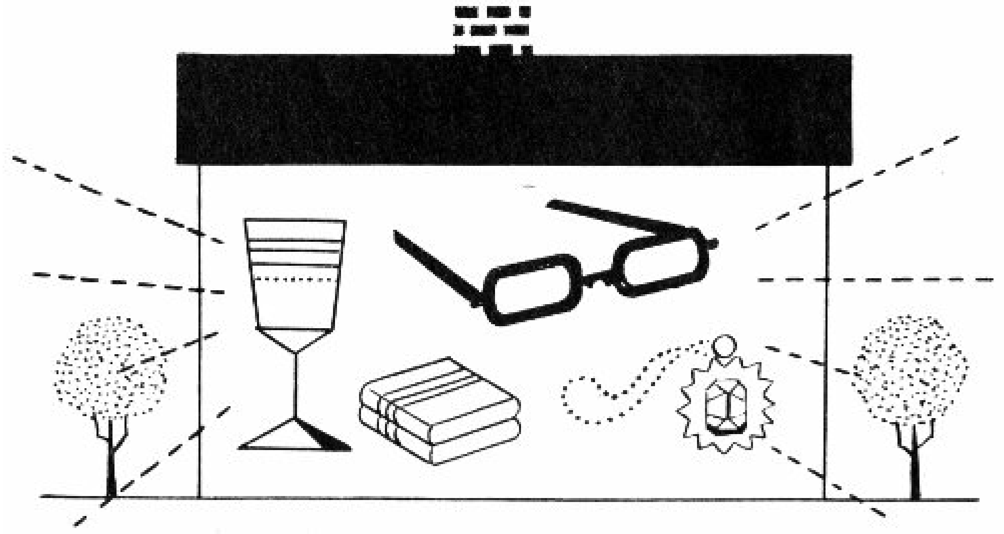
An interesting project can be made of examining as many postal stamps as available from various countries. If a stamp collection is available, see whether you can borrow that. Both fluorescent inks and fluorescent papers have been used for many stamps through the years. Examination of a stamp collection with ultraviolet will often produce surprising results.

If you have examined many envelopes during the postal stamp examination, you have probably noted the wide variation in the fluorescence of the envelope papers. This bright fluorescence of the papers presented some problem in developing automatic postal systems which could sort mail by reading the fluorescent colors of specially coated stamps. The effects of the bright paper fluorescence have been overcome in the United States by using a sorting system which detects not the fluorescence, but the color of the brief phosphorescence of specially coated stamps. Tagged airmail stamps and stickers fluoresce and phosphoresce red with shortwave ultraviolet only. 4c and 5c tagged stamps fluoresce and phosphoresce green. Observation of the phosphorescent green color of the tagged stamp provided with the Science Set will require almost complete freedom from visible light. In a well-darkened area, place the filter of the lamp directly on the tagged stamp. Close your eyes. Rapidly slide the lamp off the stamp and at the same instant open your eyes. You will see the brief phosphorescent glow which is used for automatic postal sorting.

FLUORESCENCE AROUND THE HOUSE

Ultraviolet is a powerful detector. Do you think your kitchen is spotless and clean? Try examining it with your ultraviolet lamp. The results explain why ultraviolet is so valuable in sanitary and criminological examinations. You will find many fluorescent things in the home.

Examine a variety of glassware. Eyeglasses in particular will often fluoresce. Sometimes one lens will fluoresce one color while the other lens, made from another batch of glass, will fluoresce another color.



The use of fluorescent pigments and dyes in plastics, printing inks, and fabrics is becoming more common since with fluorescent colors unmatched brilliance is often obtained. The brilliant blue-white fluorescence you see in practically all white fabrics results from the use of fluorescent dyes in detergents and bleaches. These dyes are caused to fluoresce by the small amount of ultraviolet present in ordinary light. Clothes washed in solutions of these fluorescent dyes or “optical bleaches” certainly are brighter. They actually radiate a blue-white light which hides any yellow or gray cast to the fabric. The same sort of dye is used to brighten paper. Mineral specimens are often given a spotty fluorescent appearance by being wrapped in newspaper which moved.

Besides the optically bleached fabrics and papers there are many other fluorescent things in the home. Look for bright red and yellow-green plastic toys and try these under the ultraviolet lamp. Many will fluoresce. Jewelry will often fluoresce, and ultraviolet is often used in distinguishing various types of gems. Waxes of many kinds will fluoresce. Examine under the lamp as many kinds of oils and greases as you can find. Most of these will fluoresce. Look for fluorescent printing. Brightly colored advertising is especially likely to be fluorescent. Try the common eye drop medicine Murine, and also try a dilute water solution of mercurochrome. If you have any old letters on which the writing has become faded or an old book with a faded name or date in the front, examine it under your ultraviolet lamp. The writing will often be easier to read.

Examine all you can with your ultraviolet light. You will find many fluorescent substances not described here and will probably be in for some surprises.

PRACTICAL APPLICATIONS OF ULTRAVIOLET

TAGGED POSTAL STAMPS

The recent introduction by the U.S. and a number of other countries of fluorescent “tagged” stamps for automative sorting in newly developed postal equipment has created a great interest among the stamp collectors in the use of ultraviolet in stamp identification. Actually ultraviolet has been used by knowledgeable professionals for a number of years for the examination of fluorescent stamps and for the detection of alterations, repairs, forgeries, ink variations and erasures.

In an effort to reduce the rising costs of hand sorting mail, the post office department has for some time been experimenting with equipment that can automatically differentiate between classes of mail by the fluorescent glow or more particularly the phosphorescent afterglow of specially coated stamps under ultraviolet radiation. Dayton, Ohio has been the first area to put such equipment to use. A fluorescent substance such as that used on the tagged stamps is known as a phosphor. The U.S. tagged stamps all fluoresce and phosphoresce under 2537 A (shortwave) ultraviolet. They do not react to longwave (3660 A) radiations.

A number of U.S. stamps have been issued in both tagged and untagged versions which can in no way be differentiated except under shortwave ultraviolet. Interesting examples of the stamp variations visible under ultraviolet are found in the Lincoln 4c stamp. An examination of a few random samples of the Lincoln 4c has revealed the following: Under visible light all stamps appeared the same standard purple color. Under longwave ultraviolet, one appeared dull purple, another a bright blue grey with bright blue-white borders (fluorescent paper), and the third a dull red-purple. Under shortwave ultraviolet, the first was red-purple, the second blue grey and the third, the tagged stamp was brilliant green.

Other U.S. stamps that have been tagged with a green fluorescent and briefly phosphorescent phosphor include the Washington 5c and the City Mail 5c commemorative. The 8c tagged airmail shows a bright red fluorescence and phosphorescence. Tagged, blue colored, airmail stickers show a brilliant red fluorescence and a similar brilliant but short-lived phosphorescence. These stamps were first issued in Dayton, Ohio, the location of the first automatic sorting equipment.

For a number of years some issues of Canadian and British stamps have been tagged with fluorescent and phosphorescent bars which are not as readily detected as the U.S. phosphors, and for which a powerful lamp is a considerable advantage. Germany has issued many green fluorescent stamps. Switzerland, the Netherlands and Denmark are also issuing tagged stamps. The postal labor savings potentially possible with the automatic sorting of phosphor coated stamps makes it highly likely that in time all stamps and postal stickers will be tagged for automatic sorting.

FLUORESCENT POSTAL STAMPS

While the tagged stamps are all fluorescent under shortwave ultraviolet, we speak here of the fluorescent stamps which have not been specifically tagged for sorting but which have been printed with fluorescent inks. While there is a new interest in fluorescent stamps, they are not new, having been issued through the years by many countries. They date back to the 1800’s and perhaps earlier. The characteristic of these stamps is that they glow in bright colors under an ultraviolet source.

They will usually react under either longwave or shortwave ultraviolet, whereas the tagged stamps react to shortwave ultraviolet only.

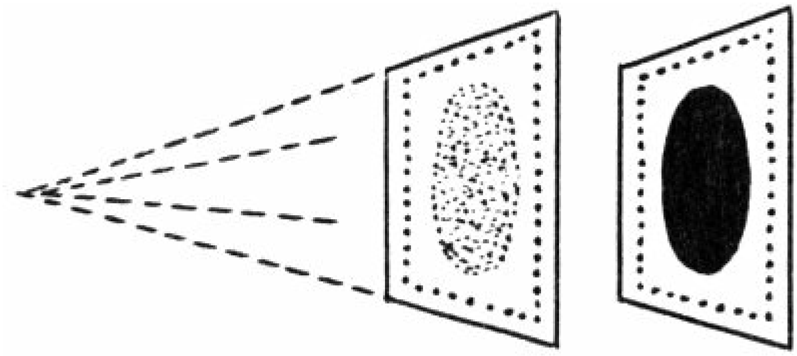
An example of a spectacular, brilliantly fluorescent stamp is the German Dove of Peace 1 mark stamp. This stamp is a drab olive green in ordinary light, but under longwave ultraviolet it glows a brilliant green showing the Dove of Peace in attractive non-fluorescent contrast.

An interesting thing often observed when examining stamps under ultraviolet is the variations in fluorescence of the paper on which the stamps are printed. Very old papers show for the most part little if any fluorescence, while modern papers vary from non-fluorescence to brilliant blue-white fluorescence which is best observed in longwave ultraviolet. It is common for the same issue of stamps to appear printed both on fluorescent and on non-fluorescent paper. As pointed out previously, the U.S. 4c Lincoln stamp not only appears as a tagged stamp but also in untagged varieties both on fluorescent and on non-fluorescent papers.

The variations in fluorescence commonly found in papers can be vividly illustrated by shining a longwave ultraviolet source on a random group of envelopes. Some will appear a dull purple, while others will fluoresce in various degrees ranging to a brilliant blue-white.

The reason so many modern papers are fluorescent is that during their manufacture they are brightened by the addition of what is known as an “optical bleach”. These so called bleaches do not actually bleach the paper but cause a blue fluorescence which is activated by the ultraviolet present in sunlight and in most artificial light sources. Fluorescent optical bleaches are almost universally found in household detergents used for the washing of clothes. Practically all white clothes now fluoresce and under a good source of longwave ultraviolet present a startling brilliance. It is these variations in fluorescence in papers, inks, etc. that make ultraviolet such a valuable tool in stamp examination.

POSTAL STAMP FORGERIES AND ALTERATIONS

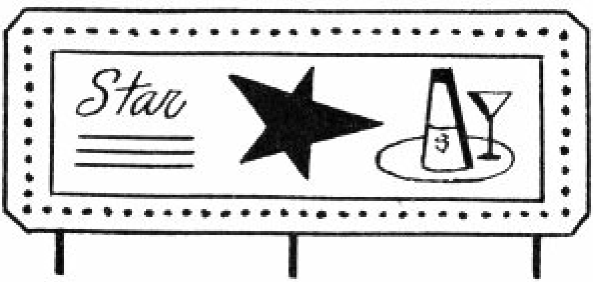


Since ultraviolet will reveal many differences in materials not seen in visible light, it can frequently be used to detect repairs, alterations and forgeries. Radly and Grant [1] report a number of interesting examples of such detection. One case mentioned is that of a very valuable Ceylon stamp on which the users frequently clipped the corners in an effort to make the stamp more attractive. Repairs have at times been made to restore these stamps. However in ultraviolet the replaced corners are readily detected by their difference in fluorescence from the original center. Other imitations recorded include a forgery of a ¼ sch. Holstein stamp of 1864 in which the ink fluoresced blue, while the original did not react at all to the ultraviolet. An imitation of a Baden number 1 issue obtained by dyeing a number 5 issue was readily detected under ultraviolet, since it appeared much lighter in color than the genuine stamp.

A more recent counterfeit, readily detected under ultraviolet, is the Ryukyu Islands overprint Scotts #16. Under ultraviolet the genuine overprints show the ink as brown-black in appearance with a slight aura caused by diffusion into the paper of the oil from the printing ink. The counterfeit overprints have a blue-black appearance and do not show the aura.

Eradications, erasures and gum changes are all liable to leave fluorescent evidence which may be completely undiscernable in visible light. The possibilities are limited only by the ingenuity and curiosity of the user.

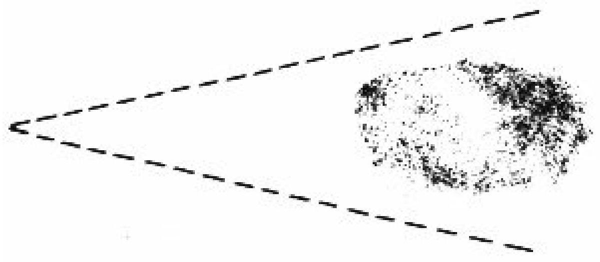
ADVERTISING AND THEATRICAL



In recent years there has been considerable growth in the use of fluorescent signs both indoors and outdoors. This growth has resulted from the continual search for unusual and spectacular advertising effects. Typically, an ultraviolet light is shone on signs painted with fluorescent paints, preferably in a somewhat darkened area. The illustrations glow like live coals in many colors, resulting in an attention-getting display. The unique effects obtainable with fluorescent painting and ultraviolet light have also piqued the interests of many artists and fluorescent murals are now found in many homes.

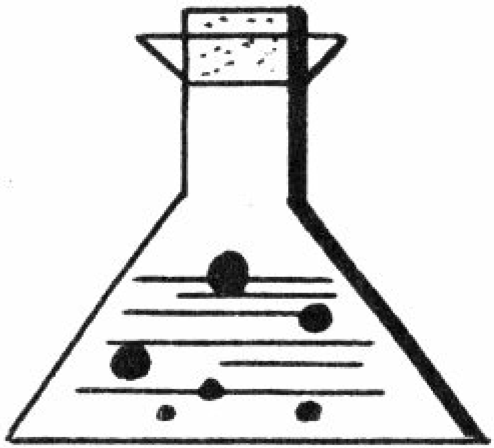
One of the most widely known uses of fluorescence in art is in the theatre. Colorful staging is accomplished through the use of concealed ultraviolet lamps and brilliantly fluorescent costumes. For example, a strange floating effect can be achieved by one acrobat in black costume carrying another player in fluorescent clothing. A skull can be painted on a player's face with fluorescent paint—in fact ordinary vaseline will do a good job. This skull would appear only when the visible lighting was replaced with ultraviolet. The variety that can be obtained with fluorescent staging is limited only by the imagination of the producer.

CRIMINOLOGY



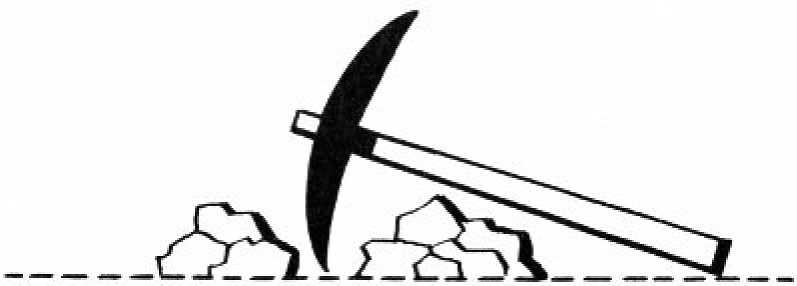
Ultraviolet has often been found extremely useful in criminology because many things which are invisible in ordinary light become plainly visible under ultraviolet. You may verify this by examining with an ultraviolet light clothing, work areas and ordinary objects which are apparently perfectly clean. You will often be amazed at the number of foreign substances which become apparent with this kind of an inspection. Indistinct fingerprints can be sharpened considerably by dusting with a fluorescent powder and examining with ultraviolet. Invisible stains from various body secretions such as urine, semen, pus, perspiration etc. often fluoresce. Because most of the modern laundry detergents contain blue-white fluorescent dyes in order to make clothing look whiter and brighter, many garments particularly white underclothing will have an intense blue-white fluorescence. The use of ultraviolet lights under water has been suggested as an aid in locating human bodies because of this common fluorescence of clothing.

CHEMISTRY



There are a number of specialized areas where ultraviolet is a powerful aid to the analytical chemist. For example, the familiar fused borax bead test can become extremely sensitive in identifying a number of the rare earth metals. It is an specially good indicator for uranium. Exceedingly small amounts of mercury can be detected by the use of a shortwave ultraviolet source and a fluorescent willemite screen. Mercury vapor absorbs ultraviolet radiation and when present between an ultraviolet lamp and a fluorescent screen will throw a shadow on the screen. Quantitative measurements can be made on a number of the vitamins and various organic substances by measuring the intensity of the fluorescence in a standardized ultraviolet light.

MINING AND PROSPECTING



Ultraviolet has been for many years a valuable tool in several phases of mining and prospecting. Many of the commercial ores fluoresce in a brilliant and distinctive manner. Most of these minerals react more strongly to the shortwave radiations.

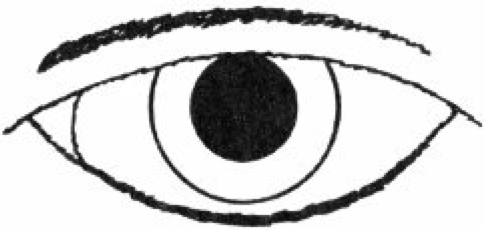
The willemite zinc ore of the Franklin and Ogdensburg, New Jersey zinc mines fluoresces a bright green color while most of the encasing calcite rock glows a brilliant orange-red. In these mines ultraviolet has been used for hand picking the ore from the waste rock. Also the ground up tailings were checked with ultraviolet to determine how effectively the ore had been separated from the waste.

A number of the secondary uranium minerals have a bright green fluorescence and it has often been found that the uranium ore was more easily traced with a portable ultraviolet light than with a geiger counter. The zirconium ore, zircon, frequently has a golden brown fluorescence under shortwave ultraviolet. It is easily identified in sands by its distinctive fluorescence. Natural petroleum fluoresces blue-white under longwave ultraviolet.

One of the most profitable uses of ultraviolet in prospecting has been for the location of the tungsten mineral scheelite which has a bright cream, white or blue fluorescence. Scheelite is usually very difficult to distinguish from the surrounding rock in ordinary light. The hue of the fluorescence of the scheelite is a measure of its molybdenum content.

A number of gems such as the diamond and ruby often fluoresce brightly. In fact the deep rich red color of the finest rubies is partly a result of their fluorescing from the small amount of longwave ultraviolet present in sunlight and artificial light.

MEDICINE



In medicine, shortwave ultraviolet has been used for its powerful germicidal and erythemal effects in treating some skin disorders. Brief treatments with these rays have much the same effect as prolonged sunlight exposure. Care must be used not to cause excessive burning.

Longwave ultraviolet has found considerable use in medicine as a diagnostic aid. One of its most common and practical uses is in locating and identifying ringworm. The ringworm fungus fluoresces brightly under ultraviolet and can be detected whether it is on a human being or on physical equipment such as chair backs, etc. The use of an ultraviolet lamp allows the school nurse to make a rapid survey of a large number of pupils for ringworm infection.

Both the white of the eye and the crystalline lens have a natural white fluorescence. Thus the use of an ultraviolet light aids in detecting lens opacities such as beginning cataracts. Corneal foreign bodies, abrasions and lesions may be located and their extent determined more readily by dropping a little of the fluorescent dye fluorescein into the eye and then making an examination under ultraviolet light.

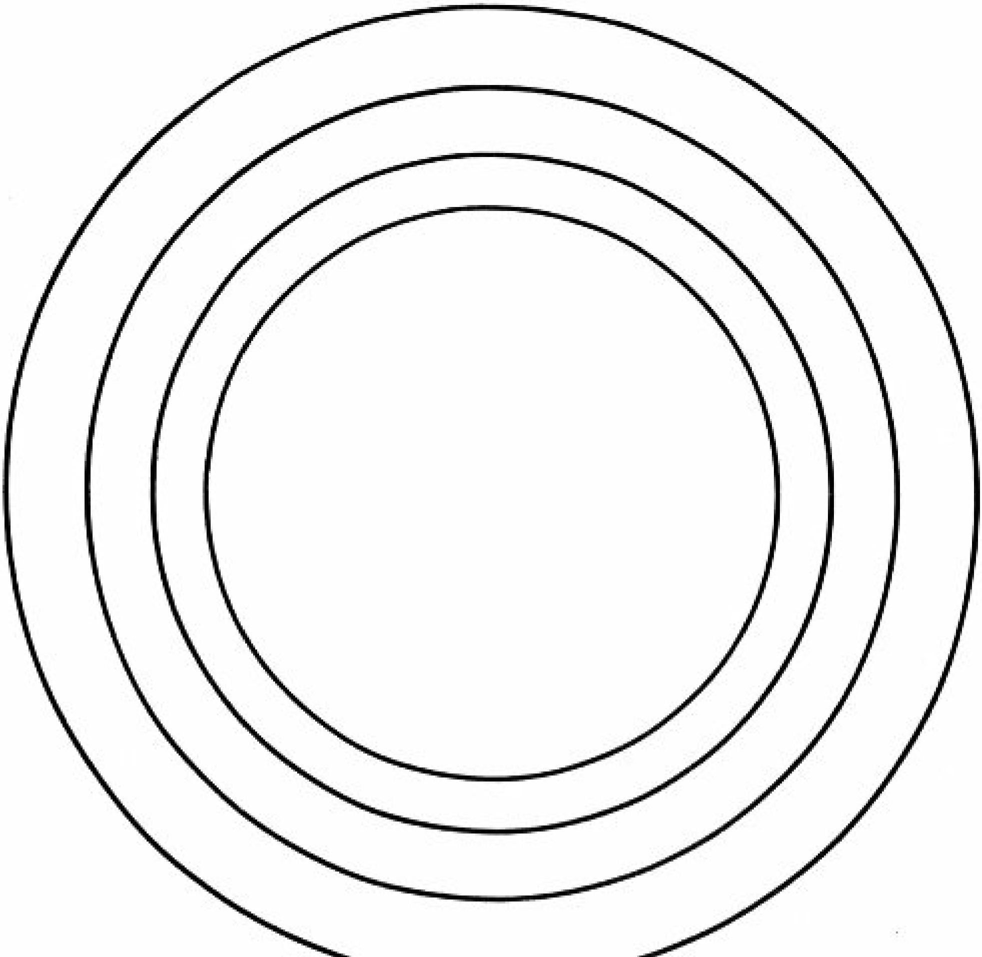
There has been some research done on the fluorescence of blood sera affected by different diseases. Apparently it is not foreign material in the blood which causes the fluorescence, but actual physical changes due to the disease processes.

In laboratory work it has been found that the presence of porphyrin in the urine causes fluorescence. There have also been some studies made on the reaction under ultraviolet
of certain substances present in the urine which are apparently determined by the store of nicotinic acid in the body.

While ultraviolet has for many years been a useful tool in the medical field for research, diagnosis and treatment, the future holds promise of even more important things to come. Work being done by the Armed Forces Institute of Pathology, Washington, D.C. and the Communicable Diseases Center, Atlanta Georgia with fluorescent staining and fluorescence microscopes holds forth the hope of eventual rapid diagnosis within an hour where present culture growth methods require from three to seven days.

Another recent development appears to permit the effective diagnosis of cancer of the stomach through the fluorescence examination of a saline stomach rinse following several days' treatment of the patient with special drugs.

THE FLUORESCENT MINERALS



The following tables describe most of the important fluorescent minerals. The tables are arranged according to the color of fluorescence and alphabetically, within each color group. The five color groupings are as follows:

Blue
Orange, Yellow, Gold
Green
Red, Pink
White, Cream

Because the fluorescent minerals of Franklin and Ogdensburg are so distinctive they are separately described and are listed alphabetically in the section titled “THE FLUORESCENT MINERALS OF FRANKLIN, NEW JERSEY”.

The following abbreviations are used:

SW—shortwave
LW—longwave
ph—phosphorescence or phosphoresces
fl—fluorescence or fluoresces

Fluorescent Color

BLUE

AMBER

A hydrocarbon Hardness 2-2½

The fossil resin, amber, which is usually yellow but also reddish, brownish or whitish in color, often fl blue-white, best LW.

BENITOITE

A silicate of barium and titanium Hardness 6-6½

This unusual gem mineral is found in only one locality, near the head waters of the San Benito River, California. The blue crystals normally occur associated with neptunite in natrolite, from which they are exposed by acid etching. Benitoite fl bright blue SW.

CALCITE

Calcium carbonate Hardness 3

Calcite, the most varied of the fl minerals, has been found fl in almost every color of the rainbow. The blue fl calcites are usually ph. They appear to be sulfide activated. While red fl calcite is fairly common in well crystallized form, blue fl calcite is usually found only in cleavable or granular masses.

The well known blue fl (SW) and ph calcite from the mercury mines at Terlingua, Texas will usually fl pink LW, especially in those specimens having a pink daylight color. Masses of cleavable blue fl and ph (SW) calcite have been found at San Saba, Texas and nearby Marble Falls. An interesting calcite from near Hurley, New Mexico fl a dull pink LW. When first exposed to SW radiation the reaction is pink, but over a few seconds duration the color turns violet. The ph is blue. It is the combination of pink fl caused by electrons which rapidly return to their normal energy levels, with the blue ph caused by the slow returning electrons that causes the apparently purple fl. The calcite from Terlingua also illustrates this phenomenon.

A blue fl and ph calcite similar to the San Saba material has been found in Indiana.

CELESTITE

Strontium sulfate — Hardness 3-3½

Many of the celestite crystals found in the sulfur mines of Sicily will fl a faint blue both LW and SW. These specimens are particularly showy where the fl celestite is implanted on an orange or pink (LW) fl calcite background. Both the celestite and the calcite usually have a brief greenish-white ph.

DIAMOND

Native carbon — Hardness 10

Gem diamonds have been found which fl in a variety of colors including green, orange, red and blue, usually best LW. Blue is the most common fl color. Diamonds react well to the longest ultraviolet rays and even to the shorter wavelengths of visible light. The blue-white color of a fine diamond is often enhanced by its daylight fluorescence.

FLUORITE

Calcium fluoride Hardness 4

Historically, fluorite is the best known fl mineral. In fact, the word “fluorescence” is derived from the name of the mineral fluorite in which the phenomenon of fluorescence was first noted and described.

Blue is the most common fl color in fluorite. Intensity is usually best LW, diminished SW.

The outstanding localities for fl fluorite are the mines of Cumberland and Durham, England where outstanding groups of fl crystals have been found in quantity and variety. The natural color of these crystals is purple, green or yellow, with the best fl usually noted in the purple crystals. A portion of the daylight color of these specimens results from their fl in the LW ultraviolet present in ordinary white light. Most of these crystals are cubic in form and often consist of parallel growths of smaller crystals. There are a number of localities in the United States where blue fl fluorite has been found. Clear green masses have been found in Arizona, New Mexico and elsewhere. Large, clear green octahedral crystals have been found at Westmoreland, New Hampshire. Blue cubic crystals come from New Mexico. In Ontario at Madoc transparent green cubo-octahedral crystals are found at many of the small fluorite mines which are worked from time to time. The fl of the Canadian material is not nearly so bright as that of the English fluorite.

A bright green fluorite which fl a brilliant blue LW has been imported from South Africa on a trial basis for use as a steel making flux. Several tons of this attractive green material have found their way onto the specimen market.

HYDROZINCITE

A carbonate-hydroxide of zinc Hardness 2-2½

Hydrozincite is a secondary zinc mineral common as thin fl coatings resulting from alteration of sphalerite, hemimorphite and smithsonite. It usually fl bright blue-white SW only.
Hydrozincite is found associated with zincite and calcite on the old mine dumps at Franklin, New Jersey. It is found associated with red fl calcite at Road Forks, New Mexico and Hurricane, Utah. It has been found in considerable quantity as earthy masses at Goodsprings, Nevada. Sometimes pockets in the earthy masses would be lined with tiny needle—like crystals of the fl hydrozincite.

Elsewhere in the United States, hydrozincite has been found at Friedensville, Pennsylvania, Linden, Wisconsin, Marion County, Arkansas, Joplin, Missouri, Cherokee County, Kansas, the Magdalena District, New Mexico and in the Tintic District, Utah.

Outstanding fl specimens of hydrozincite have come from

Mapimi, Durango, Mexico where brilliantly blue-white fl needle crystals of hydrozincite are associated with plattnerite and hemimorphite as cavity linings in limonite. This hydrozincite is unusual in that it not only fl blue-white SW but also a dull peach LW.

Further information on fl hydrozincite is given in the "Franklin" fluorescent section.

SCHEELITE

Calcium tungstate Hardness 4½-5

This important ore of tungsten is heavy, usually white, cream or gray in color, and is normally very difficult to distinguish from other minerals in the rock. However, its marked SW fl and non-fl LW make it very easy to locate and identify with ultraviolet. In fact, ultraviolet prospecting is practically the only way that scheelite is located. During World War II when tungsten was in great demand and short supply, a great deal of successful ultraviolet prospecting took place in the western United States.

In some of the Canadian gold mines the rock was checked after each blast and any scheelite ore was set aside. Scheelite has been mined in many areas of California, Nevada, New Mexico and Idaho. The dumps from practically any of the tungsten mines will produce fl specimens. Large masses of scheelite are not common. Well formed crystals are highly prized.

In the east, scheelite has been mined in Trumbull, Connecticut and also in South Carolina, but the bulk of the commercial development has been in the western states.

Fluorescent Color

ORANGE, YELLOW, GOLD

ANGLESITE

Lead sulfate Hardness 3

Anglesite often occurs in well developed crystals which fl yellow. It is found in lead mines in many countries associated with cerussite and galena.

BARITE

Barium sulfate Hardness 3-3½

Most barites which fl react with a white or cream color, usually best LW. Hot Springs, North Carolina, however, has produced an unusual barite which fl a bright golden orange. This material is gray colored in daylight and fl in thin veinlets of bright color. Occasionally bright fl bands have been found an inch or so in width.

CALCITE

Calcium carbonate Hardness 3

Calcite which fl orange has been found in the quarries at Crestmore, California. A sulfide vein at Lowville, New York has produced a calcite which fl bright orange in association with a more common red fl calcite and blue fl fluorite. Drusy crystal coatings and stalagtitic masses which fl in beautiful shades of orange, cream and pink are found in the sulfur mines of Sicily. Pale yellow fl calcite is found in several localities including crystal specimens at Bound Brook, New Jersey and cleavable masses at Marble Falls, Texas.

Caliche, a carbonate coating often found on the surface of desert stones, will often show an orange fl SW.

CERUSSITE

Lead carbonate Hardness 3-3½

Found in many lead deposits. Commonly fl yellow LW and also in X rays.

CHONDRODITE and NORBERGITE

Basic fluosilicates of magnesium Hardness 6-6½

The two minerals, norbergite and chondrodite, are similar in composition, appearance and fl and are not easily distinguished from one another. They often occur together at the same localities and are sometimes intergrown. The daylight color of these minerals ranges from white through a hyacinth red with the most common color being tan or honey-yellow. The fl ranges from bright golden yellow or yellow-orange to buff (SW) and is usually brightest in the lighter colored specimens. Fl LW is slight.

Fl chondrodite is found as scattered grains and crystals in the limestones of northern New Jersey at Sparta, Ogdensburg and Franklin. A similar occurrence in limestone is at Newcomb, New York.

CURTISITE

A carbon-hydrogen compound, probably $C_{24}H_{18}$ Hardness less than 2

The hydrocarbon curtisite has been found in the Hot Springs area of Skaggs Springs, Sonoma, California. Hydrocarbon infusions in travertine from the Clear Lake area of California have produced specimens with fantastic patterns which fl white, cream and pale green in swirls, bands, spots and flamelike growths.

DIAMOND

Carbon Hardness 10

Diamonds have been found which fl yellow and orange. See diamond in the "blue" section.

HACKMANITE

A complex silicate of sodium and aluminum containing chlorine and sulfur

Hardness 5½-6

One of the most interesting of all fl minerals is hackmanite, which is found near Bancroft, Ontario. It has also been reported from West Greenland, Kishengahr state, Rajputana, India and the Kola Peninsula, Lapland. Hackmanite commonly fl bright apricot LW and shows a similar but less brilliant fl SW.

When a block of nepheline containing hackmanite is first broken open the hackmanite will be easily distinguished by its brilliant raspberry red color. The color disappears with a few minutes exposure to daylight or artificial light. It can, however, be returned to its brilliant color by a few minutes exposure to SW ultraviolet. It will retain the bright raspberry red color as long as it is kept in the dark. On exposure to light it will once again fade. This color reversal can be repeated indefinitely. The property of reversing color with changes in light radiation has been called “reversible photosensitivity”. More recently it has been called “tenebrescence”.

MANGANAPATITE

A calcium phosphate containing fluorine and manganese

Hardness 5

Blue-green to white in daylight, manganapatite fl buff-brown to bright golden yellow SW. It is common in the pegmatites of New England and North Carolina. Excellent specimens have been found in the Portland, Connecticut area, often in association with green fl hyalite or autunite. It usually occurs in scattered grains in feldspar. The lighter colored material seems in general to fl more brilliantly.

PECTOLITE

A silicate of sodium and calcium with water of crystallization

Hardness 5

Pectolite usually occurs in fibrous masses. Specimens which fl bright yellow and cream have been found near the Golden Gate Bridge in California. Pectolite from some of the New Jersey trap rock quarries shows some fl and more often a gold ph when exposed to an unfiltered SW light.

PHLOGOPITE

A silicate of magnesium, potassium and aluminum Hardness 2½-3

A magnesium mica, usually light brown in color, phlogopite will sometimes fl buff-yellow SW. Fl phlogopite has been found at Franklin, New Jersey and at Newcomb, New York.

PHOSGENITE

A chlorocarbonate of lead Hardness 2-3

Crystals of phosgenite which fl yellow have been found at Monteponi, Sardinia.

POWELLITE

Calcium molybdate Hardness 3½-4

While its natural color varies from straw yellow and greenish yellow to gray, greenish blue and almost black, powellite is readily distinguished by its creamy or golden fl SW with no fl LW.

Powellite is a secondary mineral usually formed by the alteration of molybdenite. It has been found in the United

States in the copper and tungsten mines of Adams, Beaver and Tooele counties in Utah; also associated with copper in the mines at Houghton County, Michigan; in Nevada at Tonopah and near Oak Springs, Nye County; at Barringer Hill, 44 Llano County, Texas; in California at the tungsten mines of Inyo and Kern Counties; in Arizona in Pima and Mohave Counties; also in New Mexico in Sierra County.

SCAPOLITE (wernerite)

A complex silicate of calcium, sodium and aluminum Hardness 5-6

One of the most spectacular LW fl minerals is the yellow fl wernerite from the Grenville, Quebec area. The old original locality for this material produced a fibrous looking brilliantly fl material. The scapolite offered to the collectors in more recent years is more compact and varies in color from white to translucent greenish-yellow. The fl is a spectacular brilliant yellow. Fl wernerite has also been found at Manawaki, Quebec. While it is not often noticed, wernerite has a weak but long-lived ph after exposure to either LW or SW.

SCHEELITE

Calcium Tungstate Hardness 4½-5

This important ore of tungsten fl blue-white when pure, but when it contains sufficient molybdenum the fl is yellow. A smaller molybdenum content causes a white fl. It is not unusual to find specimens of scheelite in which the fl varies from blue to yellow—sometimes a grain only a fraction of an inch across will show separate areas of blue, white and yellow fl. There are many important sources of scheelite in California, Nevada, New Mexico and Idaho. Scheelite has also been mined in Connecticut and South Carolina. The description of scheelite in the "blue" section gives further information.

SODALITE

A silicate of sodium and aluminum containing chlorine

Hardness 5-6

Sodalite from Moultonboro, New Hampshire fl a golden brown LW. Fl sodalite is also found in a pegmatite on the Appalachian Trail at Beemerville, New Jersey.

SPHALERITE

Zinc sulfide Hardness 3½-4

Sphalerite from a number of localities shows a strong orange or golden brown fl usually best in LW. It often has a lasting ph of the same color. Sphalerite is often thermoluminescent and triboluminescent also. Fl sphalerite from Tsumeb, South West Africa, was available for many years. Similar fl sphalerite has been found at Bonanza, Colorado and Bisbee, Arizona.

Fl sphalerite has also been found in the zinc mines at Franklin and Ogdensburg, New Jersey. Bright yellow fl SW coatings of secondary sphalerite have been found at Broken Hill, New South Wales, Australia.

TERLINGUAITE

An oxychloride of mercury Hardness 2½

A rare mercury mineral, named for its locality, the mercury mines of Terlingua, Texas. Terlinguaite is often seen as bright yellow fl spots (SW) associated with the well known blue fl and ph calcite of Terlingua.

TREMOLITE

A calcium magnesium silicate Hardness 4-5

Tremolite from the talc mines of Balmat and Talcville, New York is noted for its orange LW and SW fl. This material ranges in response from non-fl through various shades of orange, pink and red. Specimens with mixed fl colors are not unusual and are often quite attractive. A similar material has been reported from Ontario. Most tremolite fl a dull gray-green or cream. It usually occurs as masses of needle crystals grown together.

ZIRCON

Zirconium silicate Hardness 7-7½

Zircon often fl golden yellow to brown SW. Frequently identified in sands by its yellow fl. Fl zircons are found in the gem gravels of Burma and Ceylon. In the United States they are found in several localities in North Carolina. Many stubby fl crystals were found in a cotton field near Statesville, North Carolina. Night prospecting with a portable ultraviolet light was the most effective way of locating these crystals. Zircon is the ore of the metal zirconium.

Fluorescent Color
GREEN

ADAMITE
A basic arsenate of zinc Hardness 3½

The secondary zinc mineral adamite commonly occurs as drusy crystal coatings colored yellow, pale green or blue green. The best green fl is seen in the pale green material. Fl is normally best SW but sometimes also good LW. The outstanding locality for fl adamite is Mapimi, Durango, Mexico where it occurs as drusy crystals lining cavities in limonite.

ARAGONITE
Calcium carbonate Hardness 3½-4

Aragonite will sometimes fl green as a result of uranium activation. It is not unusual for the tips only of coral-like aragonite growths to fl green SW. Fl LW is usually weaker or else absent.

Aragonite with green fl has been found at Organ, New Mexico, at Bird Cave near Tres Hermanos, New Mexico and at Santa Eulalia, Chih., Mexico. Magnificent fl specimens consisting of aragonite crystallizations rendered fl by the inclusion of the rare uranium mineral Novacekite have been found at Placeres de Guadalupe, Chih., Mexico.

AUTUNITE

A hydrated phosphate of calcium and uranium Hardness 2-2½

The most common fl uranium mineral is autunite which occurs widely in the pegmatites of New England and Mitchell Co., North Carolina. It is also found at Bedford, New York, near Keystone, South Dakota and at the White Signal district, Grant Co., New Mexico.

Autunite is usually found as small nearly square crystal platelets, pale yellow or green in color. Magnificent specimens of cockscomb crystal aggregates have been found at the Daybreak Mine Spokane Co., Washington. Other outstanding localities for autunite include Autun, France, for which the mineral is named, Cornwall, England, Katanga district Africa and Mt. Painter, South Australia.

DIAMOND

Carbon Hardness 10

Gem diamonds have been found which fl various shades of green. See diamond in the “blue” section.

HYALITE

Hydrous silica Hardness 5½-6½

The hyalite variety of opal often has sufficient uranium content to fl a brilliant green SW and sometimes a lesser green LW. Hyalite occurs as a thin transparent coating or as a stalactic crust.

Seams of hyalite are very common coating fractures in pegmatites and granites. They account for most of the common green fl seen in the pegmatites of New England and North Carolina and also in the nepheline deposits of Ontario. These thin, often invisible, coatings will usually react with a brilliant green fl SW.

Outstanding fl hyalite crusts have been found in the feldspar and mica mines of Mitchell County, North Carolina. Beautiful crusts, often tinted blue or green have at times reached a thickness of over 1″. More commonly these coatings are ⅛″ or less in thickness.

Hyalite is also found as a smooth botryoidal coating in cavities in volcanic rocks.

OPAL

Hydrous silica Hardness 5½-6½

Common opal from several areas of the western United States will fl green because of a slight uranium activation. The outstanding locality is the Virgin Valley, Humbolt County, Nevada where large masses of fl common opal have been found. Fl is usually best SW although some reaction to LW is common.

QUARTZ, including varieties Agate and Chalcedony

Silicon dioxide — Hardness 7

Crystallized quartz is very seldom fl; however the agate and chalcedony varieties will often fl green or yellow-green, being activated by a slight content of uranium compounds. The fl is usually best SW and rather slight LW. Agate and chalcedony which fl green are found in a number of localities in the western United States and Mexico. The well known moss agates of Sweetwater County, Wyoming will generally fl a deep green. Agate from near Medicine Bow, Wyoming shows an excellent pale green fl, depending on the amount of dark manganese inclusions. Fl chalcedony roses are found in various areas of Arizona. The southern Black Hills have produced quantities of chalcedony which fl green in association with a calcite which fl pink. Thunder egg agate nodules having fl areas have been found in both Oregon and New Mexico. Beautiful banded agate with green fl has come from Mexico.

URANIUM SALTS

A bright green fl is characteristic of a considerable number of secondary uranium minerals. This fl is usually best SW and is generally yellow-green in hue. The uncommon mineral andersonite sometimes fl a brilliant blue-green. Autunite is the most frequently seen of the fl uranium minerals and is described separately.

Schroekingerite or Dakeite, a hydrated fluo-carbonate-sulfate of sodium, calcium and uranium with a hardness of 2½, is found as small concretions in clay at Wamsutter, Wyoming—also as a coating on tunnel walls at the Hillside Mine, Yavapai County, Arizona.

Swartzite, a hydrated carbonate of calcium, magnesium and uranium, is another mineral found as a coating on the walls of the Hillside Mine. It occurs as tiny prismatic crystals which fl bright green.

Andersonite, a hydrated carbonate of sodium, calcium and uranium is another brightly fl uranium mineral found as an efflorescence on the walls of the Hillside mine. Andersonite has been found as a crumbly fl coating near Grants, New Mexico. The Grants material fl blue-green LW and brilliant blue-green SW.

The uncommon hydrated basic uranium sulfate minerals uranopilite, meta-uranopilite and zippeite all fl bright yellow-green. Of these three minerals, zippeite alone is found in the United States where it occurs in an asphaltic sandstone at Fruita, Utah and in Gilpin County, Colorado.

The uranium mineral Novacekite has recently been found associated with aragonite in the area of Placeres de Guadalupe, Chih., Mexico. These aragonite crystallizations with novacekite inclusions are often magnificent fl specimens.

WILLEMITE

Zinc silicate Hardness 5½

The most famous locality for fl willemite is the zinc mines of Franklin, New Jersey where willemite is an important ore.

Further description of willemite will be in the “Franklin” section. An excellent fl and ph willemite has also been found in Pinal County, Arizona in association with red fl calcite. Fl willemite has also been found in small quantity in some of the other Arizona mines.

Fluorescent Color
RED, PINK

ARAGONITE
Calcium carbonate Hardness 3

While aragonite usually fl orange or cream, pink fl aragonite has been found in the sulfur mines of Sicily and brilliant red fl crystals have been found at Broken Hill, New South Wales, Australia.

CALCITE
Calcium carbonate Hardness 3

Calcite is the most common fl mineral. Depending on the activator, calcite may fl almost any color but the most frequent fl is red or pink resulting from manganese activation. Usually the red fl calcites are best SW, but many are also good LW. Specimens are found which fl in shades of red varying from a soft bluish pink to a brilliant orange-red. The calcites which fl red usually have an extremely brief but brilliant orange-red ph SW.

Calcite is recognized by its low hardness, and rhombohedral cleavage. It often forms white seam coatings in rock. Crystals in great variety are common in pockets, seams and geodes.

Well known localities include the zinc mines of Franklin and Ogdensburg, New Jersey which produce calcite that fl in nearly every shade of red. Langban, Sweden is another well known locality. Outstanding red fl calcite crystals have been found in Dumfrieshire, Scotland and at Broken Hills, New South Wales, Australia. In Mexico excellent red fl calcite crystals have been found at San Louis Potosi, Charcas and Santa Eulalia. The mines at Santa Eulalia near Chihuahua city are well known for their red fl calcite crystal phantoms. Ludlow, California has also produced fl diamond shaped phantoms which result from the intermittent presence of manganese activator during the growth of the crystals. Red fl calcite crystals have been found at Bisbee, Arizona. Most of the trap rock quarries of New Jersey have produced red or pink fl calcite crystals. Calcite which fl red is found from time to time in mines and quarries almost everywhere. The well known calcite from Terlingua, Texas which is fl and ph SW will often fl a beautiful pink LW.

CALOMEL

Mercurous chloride　　　　Hardness 1-2

A secondary mercury mineral. Fl brick red. Occurs at El Doktor near Zimapan, Mexico. At Terlingua, Texas it was found in the mercury mines associated with terlinguaite which fl yellow, and calcite which fl and ph blue.

CORUNDUM

Aluminum oxide　　　　Hardness 9

Red ruby and other corundum will often fl a deep red LW. This fl is usually brightest with a hot quartz (high pressure mercury arc) type of lamp. Synthetic ruby will also fl. Fl corundum is found in Madagascar and Burma. In the United States red fl corundum is common in several localities of North Carolina and is also found in the limestones of northern New Jersey at Sparta, Newton and Ogdensburg.

EUCRYPTITE

A silicate of lithium and aluminum | Hardness 6

This uncommon lithium mineral fl a beautiful cerise red SW. It is an alteration product of spodumene and is sometimes found retaining the spodumene crystal form. Often associated with petalite which may fl white, fl eucryptite is found at Bikita, South Rhodesia, Africa, the Etta mine, Keystone, South Dakota and the Parker mine, Strafford, New Hampshire. It was first noted as a spodumene alteration product at Branchville, Connecticut.

FLUORITE

Calcium fluoride | Hardness 4

Unusual dark purple fluorite crystals which fl a dark red in LW have been found at Mapimi, Dgo., Mexico.

HALITE

Sodium chloride—common salt | Hardness 2-3

When suitable activators are present, halite will fl a pink to bright orange-red color. Amboy, California is one well-known locality for fl halite crystals. In some cases beautiful fl crystallizations have formed on sage brush where well brines have been allowed to evaporate on the desert.

SCAPOLITE

A silicate of aluminum, sodium and calcium Hardness 5-6

Square prismatic scapolite crystals which fl red SW have been found in Quebec.

SPINEL

Magnesium aluminum oxide Hardness 8

Occasionally spinel is found which fl brilliant red in LW. This fl seems more common in the red colored specimens.

Spinel is distinguished from most other minerals by its hardness.

TREMOLITE

Calcium magnesium silicate Hardness 4-5

Tremolite which fl red in shades ranging from pink to a rich fire red have been found in the talc mines of the Talcville-Balmat area of New York state. The red fl material has often been found intergrown with tremolite that fl orange. These tremolites will fl both SW and LW. The red fl material is usually best LW while the orange fl tremolite is best SW.

Fluorescent Color
WHITE, CREAM

ARAGONITE

Calcium carbonate Hardness 3½-4

Aragonite, with the same composition as calcite, but with orthorhombic rather than hexagonal crystal form, fl in many of the same colors as do the various calcites. Aragonite forms under a much narrower range of temperature and pressure conditions than calcite and is far less common.

Clusters of bright white fl (LW) aragonite crystal spikes have been found at San Luis Obispo, California. Fl aragonite (SW) spikes have been found in traprock at Deerfield, Massachusetts. Specimens from both of these localities exhibit a brief greenish-white ph. Some of the aragonite crystals from the sulfur mines of Sicily fl pink LW and white SW.

BARITE

Barium sulfate Hardness 3-3½

Barite occurs in almost every color in natural light, but its fl is most commonly white, cream or yellow. It often has a cream or pale green ph. The great density of barite (specific gravity 4.5) is one of its distinguishing features and barite has been called “heavy spar” by the miners.

An unusual barite with a very rich golden orange fl and 52
ph both SW and LW has been found at Hot Springs, North Carolina.

Barite with a dull blue-white fl and also a bright cream-white fl has been found at Franklin, New Jersey. The cream fl barite grains scattered in red calcite make very attractive specimens.

Barite crystals with white fl have been found at a number of localities. Palos Verdes, California has produced clusters of white cockscomb crystals which fl and ph. In the Badlands area of South Dakota transparent brown crystals which fl white are found associated with yellow calcite crystals in pockets in large concretions. The calcite fl cream or white, best LW.

At the Settlingstones Mine, Fourstones, England has been found excellent clusters of white fl barite crystals.

BRUCITE

Magnesium hydroxide Hardness 2½

This soft mineral is often platy or fibrous in form and frequently fl bright blue-white. Fl Brucite has come from the Tilly Foster mine, Brewster, New York and from Woods Chrome Mine, Texas, Pennsylvania.

CALCITE

Calcium carbonate Hardness 3

Calcite is the most common fl mineral and it reacts in a wide variety of colors. The “Red-Pink” descriptive section has more information on fl calcite.

Calcite which fl white is not unusual and is particularly common in caves where the stalactites and stalagmites will frequently fl white. These calcites will usually fl both LW and SW, but they are generally best LW. A brief cream white or green-white ph is usual.

Fine crystallized calcites which fl white are found at Santa Eulalia, Chihuahua, Mexico and Bound Brook, New Jersey. Calcite crystals which fl cream are found in cavities in concretions in the Badlands section of South Dakota.

Calcite or aragonite in the form of travertine and marble will often fl white.

CELESTITE

Strontium sulfate Hardness 3-3½

Celestite crystals which fl white or blue-white have been found associated with calcite and sulfur in the sulfur mines of Sicily. These colorless crystals fl both LW and SW and have a greenish-white ph. Blue celestite crystals from Portage, Wood County, Ohio have shown a similar white fl and a strong but brief green ph which quickly fades to a dim white afterglow.

COLEMANITE

A hydrated calcium borate Hardness 4-4½

One of the water insoluble minerals found in the Borax deposits of California at Death Valley, the Calico district, the Kramer district and on Frazier mountain in Ventura County. Colemanite occurs in white and transparent crystals. It usually fl white or cream color both SW and LW and generally has some ph.

DEWEYLITE

A magnesium silicate Hardness 2-3½

Deweylite is a soft mineral close to serpentine in composition. It is sometimes called Gymnite. Deweylite which fl white both LW and SW has been found in the Maryland-Pennsylvania serpentine localities. Cedar Hill, Pennsylvania has produced waxy masses of crumbly deweylite with a good white fl.

DIOPSIDE

A silicate of calcium and magnesium Hardness 5-6

The diopside variety of pyroxene is sometimes found in small fl grains and masses in calcite. The fl ranges from white to blue-white.

Fl diopside is found at Franklin, New Jersey and Newcomb, New York.

DUMORTIERITE

A basic aluminum borosilicate Hardness 7

The fibrous violet-red dumortierite from Dehesa, California fl blue-white SW.

FLUORITE

Calcium fluoride Hardness 4

While blue is the most common fl response of fluorite a white or cream fl is not unusual. Both the blue and the cream fl materials are usually fl both SW and LW, but are brightest LW.

An outstanding locality for bright cream fl fluorite is the limestone quarry at Clay Center, Ohio. Large brown cubic fluorite crystals have been found there lining pockets in the limestone. Crystals with faces as much as four to five inches across and perhaps even larger have been found at Clay Center. Smaller fl fluorite crystals have been found in other quarries in the area.

Fluorite with a good white fl has been mined in considerable quantity at Marion, Kentucky. Fluorite with a white and cream fl and ph has been found in Mexico.

HYDROZINCITE

Basic zinc carbonate Hardness 2-2½

This secondary zinc mineral usually fl blue-white SW and is further described in the “blue” section.

PETALITE

A lithium aluminum silicate — Hardness 6-6½

The lithium mineral petalite is often found in association with the uncommon fl lithium ore eucryptite. The petalite fl white SW and LW, while the eucryptite fl cerise red SW only. Fl petalite is found in considerable quantity in association with the eucryptite ore from Bikita, South Rhodesia, Africa. It is often found in minor amounts associated with the eucryptite from other localities.

SCHEELITE

Calcium tungstate — Hardness 4½-5

This important ore of tungsten is one of the few minerals that is always fl. It reacts brightly to SW and normally does not fl at all LW. The fl of scheelite ranges from yellow to white to blue-white. Further information on fl scheelite will be found in the “blue” section.

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STOLZITE

Lead tungstate — Hardness 2½-3

Stolzite is an uncommon secondary mineral found usually in the oxidized zone of ore bodies containing tungsten minerals. It usually fl greenish-white SW. Found in the U.S. at Southampton, Mass.; in Arizona in scheelite deposits south of Tombstone and also near Dragoon; near Lucin, Utah and at the Wheatley lead mines, Chester County, Pennsylvania.

TALC

A magnesium metasilicate Hardness 1-1½

Pure talc is number one on Moh's scale of hardness and distinctive in that it is one of the few minerals that can be readily scratched with the fingernail.

Much of the talc from the Balmat and Talcville area of New York state will fl cream white or pale greenish-white SW.

WITHERITE

Barium carbonate Hardness 3-3½

Most of the twinned witherite crystals from the fluorite mines at Rosiclare, Illinois fl bright blue-white LW and SW.

THE FLUORESCENT MINERALS OF FRANKLIN, NEW JERSEY

APATITE

A fluoride phosphate of calcium Hardness 5

Occurs in limestone outside the ore body. May fl gray-green SW.

ARAGONITE

Calcium carbonate Hardness 3½-4

Found as coatings and as sharp pointed crystals which formed in cavities. Fl white or cream. Best LW.

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AXINITE

A boro-silicate of aluminum and calcium Hardness 6½-7

The lighter colored axinite from Franklin has a deep red fl SW and also some fl LW. A long-lived ph is sometimes observed with an unfiltered light.

BARITE

Barium sulfate Hardness 3-3½

Fl gray-white. Sometimes bluish or bright cream white. Often associated with fl calcite in showy fl specimens. Usually in scattered grains, sometimes in masses, seldom in distinct crystals. Fl SW.

BARYLITE

A silicate of beryllium and barium — Hardness 6-7

A rare mineral. Fl blue-white SW.

CALCITE

Calcium carbonate — Hardness 3

The most common fl mineral of Franklin, the manganese activated calcite fl SW in various shades of pink and orange red. Most specimens fl slightly LW but calcite which fl brightly LW has at times been found. The calcite of Franklin and Ogdensburg has a very brief but intense ph. This ph can be easily observed in a sphere cut from the fl calcite. If the SW light is shone on the back side of the sphere as it is spun on a vertical axis it will appear as if the orange-red ph is dragged around the sphere. Associated willemite specks will often lend green streaks to the ph color.

CALCIUM LARSENITE

A silicate of zinc, lead and calcium — Hardness approx. 5

A rare mineral found only at Franklin, New Jersey, calcium larsenite fl a brilliant Chartreuse SW and a dull yellow LW. Often associated with green fl willemite, blue fl hardystonite, red fl calcite and non-fl black Franklinite to produce the world's most colorful fl specimens.

CLINOHEDRITE

A silicate of calcium and zinc — Hardness 5½

Normally a thin coating which fl a golden brown SW. Usually ph. Fl weak LW.

CORUNDUM

Aluminum oxide — Hardness 9

Red grains and crystals in limestone from Ogdensburg. Fl deep red LW.

DIOPSIDE

A silicate of calcium and magnesium — Hardness 5-6

Blue-white fl grains have been found in the Franklin limestones. Sometimes associated with fl norbergite.

FLUORITE

Calcium fluoride — Hardness 4

A brownish red fluorite usually associated with Franklinite will often fl and ph blue-green both SW and LW. Reaction is best on freshly broken surfaces.

HARDYSTONITE

A silicate of calcium and zinc Hardness 3-4

A white, gray or flesh colored mineral with a blue violet SW fl difficult to distinguish from visible light passed by the lamp filter. Often associated with other fl minerals in spectacular color combinations.

HYDROZINCITE

A basic zinc carbonate Hardness 2-2½

Occurs as thin powdery blue white (SW) fl coatings on calcite and other minerals. Often found on the old dumps where it is an alteration product of zincite.

An interesting find of hydrozincite was made when Lake Hopatcong in Northern New Jersey was drained for cleaning. During the early history of zinc mining at Franklin and Ogdensburg, New Jersey the ore was barged across Lake Hopatcong on its route to the smelter in Newark, N.J. Inevitably a portion of the ore fell off the barges and into the lake. Collectors of fl minerals had a field day when the lake was drained. Among the material found were specimens of blue-white fl hydrozincite which had, through the years underwater, been formed from the zincite which originally fell into the lake.

MANGANAPATITE

A fluoride-phosphate of calcium and manganese Hardness 5

Sometimes mistaken for svabite. Occurs as gray-green masses and crystals which fl buff-brown SW.

MARGAROSANITE
A silicate of lead, calcium and manganese Hardness 2½-3

A rare mineral found as pearly plates and scattered grains which fl a brilliant blue-white SW. Has been found intermixed with axinite in pink fl masses.

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NORBERGITE
A basic fluosilicate of magnesium Hardness 6-6½

Found as scattered grains and crude crystals in limestone. Usually dark honey yellow in color but sometimes light, almost white. Fl SW ranging in color from bright yellow for the lighter colored specimens to dull buff for the darker materials. Makes attractive specimens when associated with blue-white fl diopside.

PECTOLITE
A hydrous silicate of calcium and sodium Hardness 5

Pectolite is one of the less common fl minerals of Franklin. It occurs usually as pinkish or dull gray fibrous masses and fl buff orange SW. Pectolite has a bright momentary orange ph.

PHLOGOPITE
A silicate of magnesium, potassium and aluminum Hardness 2½-3

Some of the specimens of phlogopite mica fl a dull golden brown SW.

SPHALERITE

Zinc sulfide Hardness 3½-4

Found at Franklin and more commonly at Ogdensburg, as scattered grains and occasionally as veins. Sphalerite fl golden orange, best LW, and usually has a strong ph. Sometimes fl blue, often as blue fl and ph edges on the orange fl grains. The blue ph is usually brighter and shorter lived than the orange ph.

SVABITE

A fluorite-arsenate of calcium Hardness 4-5

The arsenic apatite, svabite, is distinguished from manganapatite only by tests for arsenic content. The fl SW varies from a bright golden brown in the light, nearly white colored svabites, to a dull brown in the gray and green specimens.

TREMOLITE

A silicate of calcium and magnesium Hardness 4-5

Found as slender light gray crystals in the local limestones. Fl dull greenish-white SW.

WILLEMITE

Zinc silicate Hardness 5½

The brightest fl of the Franklin minerals is seen in willemite. The fl is normally yellow-green and rarely yellow. The brightest fl is usually seen in the material which is apple green in natural light. Fl best SW, sometimes good LW. The 59
dark brown and red Willemite fl little if any LW and has a dull fl SW. Some of the white Willemite, especially that found at the Parker shaft as radiating white crystals, has a very bright and long-lived green ph.

Willemite is found usually in rough grains and crystals. Occasionally the crystals, especially the small ones, are clear and sharp.

WOLLASTONITE

Calcium metasilicate Hardness 4½-5

One of the most prized of the Franklin fl minerals, wollastonite is rare and brilliantly fl. The daylight color is gray or white, the fl SW is brilliant orange which in some specimens grades to a brilliant orange-yellow. Fl LW is weak. Nondescript in daylight, few specimens of wollastonite were saved when solid masses were mined in the 1930’s. A quantity of fl wollastonite specimens consisting of large scattered grains in fl calcite were obtained from the mines in more recent years. This latter material usually had associated barite which fl blue-white. Some of the earlier material was associated with green fl Willemite making truly spectacular fl specimens.

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FOOTNOTES

[1] J. A. Radley & Julius Grant, **Fluorescence Analysis in Ultraviolet Light** Chapman & Hall, Ltd., Publisher.

Transcriber's Notes

- Retained publication information from the printed edition: this eBook is public-domain in the country of publication.
- Silently corrected a few palpable typos.
- Transcribed some information within graphic images.
- In the text versions only, text in italics is delimited by _underscores_.

[The end of *The Story of Fluorescence* by Raytech Industries]