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THE ARSON INVESTIGATOR AND TECHNICAL AIDS

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In this country a major crime is committed on the average of once every three to five minutes. Arson is one of these crimes, and although the incidence of arson is not as frequent as that of robbery, auto theft, or breaking and entering, it will compare in number with the homicides which are perpetrated each year.

When speaking of the number of arson fires, we are referring to the number of known incendiary causes which have been determined as a result of an investigation by some responsible agency. Give some consideration for the moment to the large number of fires not investigated and also to the very large number which are termed "cause unknown" or of "undetermined origin" after an investigation has been completed. How many of these are incendiary? How many incendiary fires are not investigated at all? The available records do not give a true or clear picture, and it is our contention that the problem is much greater than we comprehend.

For every known crime that occurs a criminal investigation is instituted to determine the person responsible, to make his arrest, and to secure sufficient evidence to warrant prosecution. In each instance it is necessary to establish the *corpus delecti*—the body or substance of the offense. In a homicide this is easily proven by showing the deceased died as a result of an illegal or criminal act, i.e., was shot, stabbed, or poisoned. In the case of a robbery we have the victim and the subject matter of the larceny—his pocket book, money, watch, etc.

However, when we deal with the crime of arson we must begin one step ahead of the usual type of criminal investigation in that we must first prove that a crime has been committed. This might appear to be impossible when we consider that in many instances we are confronted with a mound of charred debris or a hole in the ground where a house once stood.

This is not the only obstacle which we are required to overcome. In reference to the peculiar crime of arson, the law says that every fire is presumed to be of accidental origin. In other words, the fact that a building burned does not under the law, constitute the *corpus delecti* of the crime of arson. First, it must be shown that the fire was caused by a criminal agency—the wilful and criminal act of some person.

In some instances the presumption of accidental origin may be overcome by proving that a human agency was responsible; for example, where we have multiple unconnected fires in several areas in a building. Courts will generally consider these facts as establishing a *prima facie* case of arson. In other situations it may be necessary for the investigator to prove that the fire was of incendiary origin by eliminating all accidental possibilities such as spontaneous ignition, defective wiring, careless smoking, etc.

Sufficient evidence must be collected and presented to satisfy the judge that the *corpus delecti* has been established. Once this obstacle is overcome, the major problem in arson investigation is eliminated. From there on, the investigative methods and procedures will be the same as for any other type of crime.

However, the initial determination as to whether a fire is incendiary or accidental is not an easy one. The difficulty arises when you have a situation wherein there has been total destruction as pointed out before, or where the fire itself appears to be of accidental origin but the facts brought out in the investigation tend to point to the possibility of a "set fire".

Now, the investigator must call upon all his skill, experience, and knowledge to ferret out the means and methods used by the incendiary to start the fire. But it should be pointed out that all the latest instrumentalities of technological advancements and scientific developments are available for his use—the police chemist, the scientific detector of crime, is ready and waiting to be of assistance when called upon.

Too often the investigator does not make early use of this valuable aid, and perhaps this may be due, in some respects, to a lack of knowledge of what can actually be accomplished through this medium—although this sounds strange because we read about scientific accomplishments every day in the newspapers, magazines and even in the comic sections, or hear and see them on radio and television. Perhaps the difficulty lies in the fact that not all investigators know what to do to obtain their expert assistance, nor what the chemist will expect of him when he enlists their support.

This may be a problem of mutual education. Through such programs as Purdue University's Arson Seminar and others which are springing up all over the country, the basic fundamentals of mutual understanding can be developed.

The investigator can present the attendant diversity of problems with which he is confronted, and with this knowledge the chemist can point out the areas in which it may be possible for him to apply his "know how" to these complex situations.

Developing this thought a little further, let us consider some of the aspects of a fire of which the investigator should be cognizant and which would be of assistance to the laboratory chemist. For instance, we know that frequently the color of smoke emitted from a building will be some indication of the type of fire encountered and the substances involved. We also know that fire is a combination of combustible materials, oxygen, and a source of ignition, and if the proportions are correct, we have rapid oxidation of the materials being consumed with the emission of heat and flame and little or no smoke. But ordinarily, the conditions surrounding a fire are seldom ideal, the combustion is usually incomplete, and smoke is generally present.

We are told that white smoke is generally emitted by burning hay, vegetable compounds, phosphorous, etc. Burning products having a nitro-cellulose base; sulphuric, nitric, or hydrochloric acid; or smokeless powder, generally generates a thick brownish-yellow smoke. If these products were not ordinarily contained in the burning premises, it might be indicative of some such substance being applied or used to aid the spread of fire. Some of these fumes or vapors in the smoke are highly toxic and care must be exercised when they are encountered.

Compounds having a petroleum base generally emit a heavy black smoke. This will result from the burning of gasoline, kerosene, fuel oil, tar, rubber, coal naphthalene, etc.

We can see then that the color of smoke could possibly indicate the criminal nature of a fire and could be of valuable importance in proving an arson case.

How will this assist the laboratory chemist? The fact that you tell him the smoke was of a particular color may narrow down the amount of research and tests that he might have to conduct on any material submitted to him for analysis.

Another method of possibly determining the type of substance burning and thereby reduce the work load on the chemist, is by the color of flame. As a rule, red flames are evidence of a petroleum product, orange flame indicates a possibility of large amounts of alcohol, whereas a blue flame might indicate a small amount of alcohol.

The investigator will also find that odors emitted during and after a fire can be of value in determining what flammable substances were present. Most flammable compounds and chemicals have different odors which are recognizable.

All of you are familiar with the odors of gasoline, kerosene, and alcohol which are some of the common materials used to set fires. Such odors are retained in rags and other porous substances even after having been wet. The odors of woolen and cotton materials differ greatly and are readily recognizable.

Films, toilet articles, and other materials having a nitro-cellulose base have a pungent odor similar to camphor and leave a fibrous residue after burning. Sulphur has a very distinct odor and is contained in fumigating candles. They leave a coal black glistening mass of molten residue. Phosphorus when burning produces an odor similar to wet match heads, and upon inhalation of the fumes a peculiar taste or coating is produced on the tongue. The residue left by phosphorus is similar to that of sulphur but is reddish in color and permeated by numerous bubbles.

Carbon bisulphide smells like rotten cabbage when it burns and is a dangerous liquid comparable to gasoline. It vaporizes readily, and the fumes are pungent and dangerous to firemen. The explosive limits of the vapors of this compound cover a wide range.

Manufactured and natural gas is required to be odorized by law. Odors of various moth or insect sprays are generally of a sweet or perfumed type, and most have a petroleum base and produce a gas which is heavier than air. These latter types of products make excellent mediums for use by the incendiary, and cases have occurred where the entire interior and contents of a building have been sprayed resulting in rapid progression of flame throughout the building in a relatively short period of time. Investigators should be on the alert for this type of fire especially among the "borax" type furniture dealers.

Ammonia has a very strong pungent odor which is familiar to all and has been used in the past by arsonists to kill the odors of gasoline. Firemen will experience difficulty in fighting such a fire.

There are many more chemical compounds that could be successfully used to set an incendiary fire and those which might even be consumed in the fire leaving no trace visible to the human eye.

The majority of the materials mentioned in this paper or their residues are susceptible to identification in the scientific laboratory. However, it would be almost impossible for the investigator to recognize all the numerous instances wherein he might aid the chemist. Therefore, it is incumbent upon him to present to the chemist a detailed background history of the case he is investigating, and ask his advice or better still take the chemist out to the scene and let him put his scientific knowledge to work.

If this latter procedure were feasible, the chances of successfully obtaining any evidence at the source are measurably increased. The chemist who knows his business and who has had experience in the crime detection laboratory will know how to handle and preserve any evidence found.

In making a "plant" or "set-up" with some of the materials mentioned, the would be arsonist usually arranges a trailer of some material which will propogate flame readily in a progressive manner to the area where the "plant" or "set-up" is located. Some of the more common materials used for trailers are toilet paper, newspapers, dynamite fuse, black powder, celluloid chips, motion picture film, ropes and string soaked with flammables, cotton batten, sawdust, journal waste, and any number of other items which might be mentioned in this category.

A fuse is one of the methods which is highly favored by arsonists to ignite "plants". Sometimes the investigator will find they have been used in conjunction with black powder or the new smokeless powder. If it is suspected that a fuse was used and fire fighting operations have dislodged the evidence, a careful search of the debris will disclose remnants or strands of the sheath or outer covering of the fuse, and if a diligent search is conducted, small tell-tale marks similar to tar or pitch deposits will be found on the surface of any material over which the burning fuse passed. By tracing these marks it is possible to find the point at which the fuse was ignited, and should also lead to point of origin of the fire providing further possibilities of uncovering more evidence at that location which can be presented to the chemist.

Perhaps one of the oldest standbys used by the incendiary to prolong the pre-ignition time of a "set-up" is the familiar candle. Through its use the perpetrator hopes to gain enough time to be miles away from the scene when the fire occurs in order to establish an air-tight alibi or to avoid detection. The candles are sometimes placed in several different spots in connection with several "plants" to ignite each one individually, or perhaps one may be arranged to ignite the main "plant" with trailers branching out to others.

Fortunately, candles are subject to drafts which in many cases have extinguished them resulting in the complete incendiary arrangement being preserved as evidence. We have had some instances in which the candle was completely melted and the wick entirely consumed, but still failed to provide the necessary ignition to the "plant".

One explanation for this unusual occurrence is that some candle manufacturers do not extend the wick to the bottom of the candle but suspend it about one-half inch above. When the wick is no longer supported by the body of the candle, it will frequently fall in the melted wax and extinguish itself. The "torch" who places his confidence in such unreliable means of setting a fire may be playing right into the investigator's hands.

It is often possible to recognize a "plant" in which candles have been used, providing there is not complete destruction, as the melting wax will become impregnated in the grain and pores of the wood. If you find such spots as this which appear to be greasy, it is well to take this material to your chemist for analysis and identification. Sometimes your point of origin will be recognized due to the fact that the area will be charred surrounding the spot where the candle was placed.

Through facilities of the Mutual Investigation Bureau in Chicago, some research has been done on the burning time of various types of candles, the results of which they will make available upon request.

If you are fortunate enough to find a partially burned candle which was part of a "set-up" and can obtain a similar candle from another source, the chemist can experiment with the latter to determine the burning rate which might be a determining factor in breaking down the suspect's alibi. Such experiments conducted out of court are frequently admitted as evidence.

There are many other means of procuring a fire with more certainty and less liklihood of detection than the use of candles, and these are fires in which combinations of acids and chemicals are used. In this particular field not enough research has been conducted to indicate what you should expect to find where these ingredients are employed.

Suffice to say that if the investigator during inspection of the point of origin or elsewhere should observe any burning which appears to be unusual and inexplainable, he should present this material to his laboratory expert to determine what it might be. Any peculiar colored ash which appears to be out of place in its surroundings should also be retained as physical evidence for analysis and identification. Sometimes the metallic oxides left after the fire are identifiable through chemical analysis. As mentioned before, some materials can be recognized by the odor which they produce, others by the peculiar residue which remains after the fire.

Chemicals and acids will be used more frequently by the saboteur and the person with some scientific or technical background, than the average person who usually resorts to the more common methods of fire setting. Included in the former category are the professional torches of whom there are very few today, but a serious business recession could put them back in business again on a full time basis.

Of vital importance in any arson investigation is the determination of the point of origin. It will be at that point that the investigator will usually find the evidence which he will present to the chemist for analysis and identification. Finding this point can be very difficult, but scientific experiments tell us that the "checking" or "checkering" which occurs on wood surfaces as a result of the fire, is an excellent means of locating the area in which the fire started. A more descriptive word for this phenomena is "alligatoring".

The divisions or segments of this charring will be larger at or near the point of origin. However, in many cases large alligator patterns of charring will be observed in different parts of a burned building. In these cases, it is necessary to carefully study the progress of the fire, as many structural conditions such as partitions, closed rooms, or other types of obstructions may produce similar large patterns of charring due to either its having a deterring effect on the fire, its having caused its acceleration, or perhaps the area being inaccessible to estinguishing operations during the early stages of the fire. A careful analysis of conditions is essential before concluding that more than one area showing the large pattern was the result of separate fires.

The longer a fire has been burning, the more heat it produces, and as a consequence, it will produce smaller checking in the charred surfaces of the wood. Analyse each situation and reconstruct the scene as closely as possible.

Some jurisdictions trace the path of the fire by measuring the depth of charring. But here again all the other factors mentioned will have to be taken into consideration.

During the initial stages of the investigation it is very essential that a determination be made as to whether or not the building was secure upon the arrival of the fire fighting division. This information can be best obtained by questioning the firemen themselves. It should be secured as soon as possible since during the stress and excitement of fighting the fire they are apt to soon forget which door or window was used in gaining entry and whether or not it had to be forced.

These pertinent details are of extreme importance in the prosecution of an arson case, especially if it developes that the building had been entered prior to the fire department's arrival.

Here again the laboratory will be of valuable assistance if during your inspection of the locks, windows, sills, doors, and frames you should detect marks indicating a tool was used to gain entry. These marks should be collected and preserved after photographs have been taken, and submitted to the laboratory for microscopic examination. They may be able to tell you what type of a tool to look for and what identifying marks it might show. If you are lucky enough to apprehend your suspect and find the tool in his possession, you have welded another link in the chain of evidence which will eventually lead to his conviction.

The laboratory will possibly be able to match the marks made during the entry with the tool used beyond any shadow of doubt. Flecks of paint which might have adhered to the surface of the tool can also be identified as being similar to the paint on the building.

The number of possibilities that exist in just this phase of the investigation alone are innumerable, and great care should be exercised to see that none are overlooked. Evidence of this type, when secured and properly handled, along with the testimony of an expert in the scientific field to demonstrate to the judge and jury the results of his findings, presents an insurmountable wall of evidence over which the defense will have to climb.

One must not forget that when the suspect is apprehended, he too may be carrying on his person the necessary evidence needed to clinch his conviction. His clothing may be soiled with dirt, grease, oil, or other materials which could only have been picked up at the scene of the fire. It is possible for the laboratory chemist to show that these materials are so comparable to the type of materials found on the scene that there is no question but what the suspect was there.

Scientific facts are hard to refute and when you employ them to work for you it can almost be stated as a foregone conclusion that success will attend your efforts.

So far we have talked about the chemical field of scientific detection and have not even mentioned that there are other related laboratory aids available.

Since the advent of the spectrograph the scope of scientific detection has been increased immeasurably, and this instrument is supplemented by the ultraviolet absorption analyser which is applicable to organic liquids. Only small amounts are necessary for identity, and in some cases a rough estimate of quantities may be found if necessary. A pattern may be made by the instrument within twenty minutes after the sample is inserted in the machine.

The X-ray fluorescopic analyser will identify solids particularly those containing metals and elements heavier than carbon.

Next we have the polygraph or "lie detector". There will be very few, indeed, who have not at one time or another had recourse to this instrument. It has well proven itself to be an excellent aid in supplementing the work of the investigator by eliminating the innocent and pointing the finger of suspicion at the guilty.

We have had excellent results with the use of the polygraph in Detroit. Occasionally, upon suggesting that a suspect take the test and upon taking him to the laboratory where the test is to be conducted, the suspect has broken down and admitted his complicity in the crime. Just the psychological effect caused by his fear of being caught in a lie was sufficient.

Experience gained from the investigation of incendiary fires and explosions over a period of several years repeatedly disclosed that persons intending to set a fire, while in the heat of passion, will grab the nearest combustible material available. But, give them a moment to make plans, and invariably they will resort to a flammable product of the petroleum group.

Give them a monetary motive, and we see the ingenuity of the human mind creating mechanical fire-setting devices that defy the imagination. They range from the crude Rube Goldberg contraption, to highly intricate mechanisms, all conceived with but one purpose in view—to set a fire, establish an alibi, and not be detected. Fortunately, the more elaborate the method, the greater the possibilities of discovery.

What do they use in conjunction with these fire setting devices? A flammable liquid. We must acknowledge the fact that our greatest problem will be dealing with people who are in this category unless, as said before, we are dealing with a saboteur, a professional torch, or a person with a chemical or technical background.

How are we going to detect the use of such petroleum products after a fire has been extinguished and all that is left is a pile of charred debris? We know that when flammables are poured on a wooden floor from any height it will splash and form pools in irregular patterns on the floor—some of it seeping down into the crevices and pores of the wood. We also know that the fire burns in the vapors which are generated gradually reaching floor. The crevices having a greater concentration of the liquid will burn for a longer period of time and much deeper.

What happens when the fire is extinguished? Scientific tests have indicated that if the water is applied before the fuel material has volatilized, it has a tendency to seal the fuel in the porous material. It is well to point out that although the fire may have charred the wood, it is still possible that some of the higher boiling portions of the petroleum product may still be present.

How are we going to find that flammables have

TABLE 1

Items Tested Containing Sufficient Gasoline to Dampen Materials	1 hr.	2 hrs.	3 hrs.	8 hrs.	24 hrs.
Terrazo floor covered by a light rag	15	0	0	0	0
1-Gal. Syrup can—open	100+	100+	100	0	0
1-Gal. Gasoline can—small spout open	100+	100+	100+	100	0
Rag on Floor—Test on top	45	25+	10	0	0
Test under rag	100+	100+	100	40	0
Brick—Test on top	Trace	0	0	0	0
Test at side near floor	35	35	25	0	0
Test under brick	100+	100+	100+	100+	35
5-Gal. Drum—bung open	100+	100+	100+	100+	40
Newspaper—Top	Trace	0	0	0	0
Underside	100+	50	0	0	0
Rags in Pail—(Aviation Gasoline)	100+	100+	100+	100+ (2 days—50)	100+
Wood (12″ x 2″ x 4″)—Test on top	0	0	0	0	0
Test at side near floor	30	30	15	0	0
Test under side	100+	100+	100+	100	10

been used if the characteristic burn pattern is not evident? Let me describe briefly some simple tests conducted by Dr. Vincent Hnizda, one of the head research chemists at the Ethyl Corp. in Detroit, who, with the consent of his employer, has also assisted us in numerous murder and arson cases with his scientific knowledge.

Table 1 reports tests made with the ordinary M.S.A. explosimeter inside a building with open window air circulation at 75 deg. F. These tests disclosed that wetting the rags, newspapers, or wood decreased the sensitivity of the test but increased the retention of the gasoline considerably. The terrazo floor used in the test was very dense and only slight penetration was obtained.

Now that we know petroleum products can also be detected without the aid of the eye or nose by a scientific gadget, what do we do with contaminated material when we find it? If it happens to be wood, chop it up into small pieces and place in a sealed can. If rags or paper, protect them in the same way. If it is porous material of any kind, see that it is sealed in sanitary air-tight cans and transported immediately to the laboratory.

Back in 1940 we were confronted with the problem of what to do with some petroleum-soaked articles recovered as evidence in an arson murder. Dr. Hnizda solved the problem by placing the evidence in a large glass desiccator which he connected by tubing to a series of three vapor traps with volumetric graduations which were submerged in coolants contained in wide-mouth De War flasks. The traps in turn were connected with a mercury manomoter and a small vacuum pump. This method of extraction is not new in the laboratory field, but to our knowledge it was the first time ever applied in this field of arson detection. It is based on the fact that the vapor pressure of a liquid is a function of temperature and that the quantity of material vaporized in a given time varies universally with the pressure. As the distillation progresses through and is condensed in the traps which are cooled from 32 deg. F. to −40 deg. F., the organic liquid will appear in the upper layer of the material extracted and may vary from one to a few drops or several milliliters. The volatile liquid obtained is separated and subjected to various physical tests to determine the boiling range, (which is difficult but not impossible, particularly with a volume as small as one milliliter), specific gravity, and refractive index. The infrared absorption spectrum and mass spectrum may also be obtained if necessary.

The equipment needed for vacuum distillation is not expensive and will last indefinitely under proper care. It is almost an absolute necessity in any arson detection laboratory.

In summation, it becomes apparent that there must be a close liaison maintained between the arson investigator and the crime detection laboratory experts, if the knowledge and experience of both are to be utilized to the highest degree.