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Turpentine in Arson Analysis

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ABSTRACT: Arson analysts have always struggled with the problem of finding turpentine in debris from suspicious fires. Is it manufactured turpentine or the natural product of wood? Two research projects are presented as one analyst's approach to this problem. First, in arson cases in which oleoresin was found, the species of woods were identified by microscopy. A softwood was identified in each of these cases, and 60% of the woods identified were yellow pine. Second, known samples of wood were analyzed by gas chromatography and mass spectrometry, and their constituents were compared with turpentine. Some hardwoods contained terpenes, but these would not be confused with turpentine during routine arson analysis.

KEYWORDS: criminalistics, arson, turpentine, wood

During the past ten years, fire debris from over 1500 suspected arson cases has been analyzed in this laboratory. Approximately 15% of these cases contained wood in which oleoresin was found. Each time this occurred, the question was raised: Is this manufactured turpentine, which could have been an accelerant used to start the fire, or is it a natural component of the wood in the fire debris?

Turpentine[2] is a volatile essential oil obtained from the oleoresin of coniferous (softwood) trees [*1–3*]. Oleoresin is not a natural component of angiospermous (hardwood) trees such as white oak. The three ways of producing turpentine result in different types: Gum turpentine is produced by wounding living pine trees, collecting the pine gum, and processing it into gum rosin and gum turpentine. The second type, wood turpentine, is extracted with the use of a solvent from pine stumps and chips. Sulfate turpentine, a by-product of the kraft pulping of pine wood in the production of paper products [*4–6*], accounts for well over 80% of the turpentine produced in the United States today [*4*]. Most of the turpentine available to the consumer is gum turpentine, although some wood turpentine is also sold.[3] Turpentine found on store shelves is normally imported from countries such as Brazil, Mexico, Portugal, or Honduras; where the cost of labor is low.[4]

Historically, turpentine has been commonly used as a paint thinner. Today its most common use is as a raw material used in the production of pine oil, polyterpene resins, insecticides, and fragrances [*4*].

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[2]Throughout this paper, the word "turpentine" refers to the manufactured product and the word "oleoresin" refers to the naturally occurring volatile products in softwoods used to make turpentine.

[3]Zinkle, D., U.S. Forests Products Laboratory, Madison, Wisconsin, March 1990, personal communication.

[4]Cleaver, B., PDM Trading, Wilmington, Delaware, May 1990, personal communication.

Turpentine varies in composition according to the species of pine used as well as to the geographical area from which the pine is obtained. However, the main components in all manufactured turpentine are the monoterpenes alpha-pinene (60 to 80%) and beta-pinene (up to 35%). Various other terpenes make up 5 to 20% of the composition [*4,6,7*].

Wood Identification

Identifying the type of wood in a fire debris sample can provide useful information for the analyst. Only certain species of wood contain oleoresin used to produce turpentine. Oleoresin detected in a sample that contains a softwood suggests that turpentine was not likely added as an accelerant.

Small samples of wood were saved from each case in which oleoresin was found from 1983 through 1989. Thin sections of these woods were prepared by hand for microscopic examinations. A new razor blade was used to cut three sections from each wood sample: a tangential section, a radial section, and a cross section. These sections were then examined microscopically to identify individual characteristics.

One hundred and twenty wood samples were identified in a total of 104 cases (Fig. 1). Seventy-one of these wood samples were identified as a yellow pine, the most common wood used in construction. White pine, found in 21 samples, is also frequently used in house construction. Douglas fir, found in 9 samples, is used to make plywood. White oak, the only hardwood identified, can be found in hardwood floors, but an arson analyst should be careful because subflooring is usually a yellow pine: in a fire, the oleoresin from a yellow pine subflooring may permeate into the white oak hardwood floor. Sixteen cases, including all the cases in which white oak was identified, had more than one type of wood in the debris submitted. Therefore, in every case that contained wood in which oleoresin was found, there was a softwood present that naturally contains oleoresin.

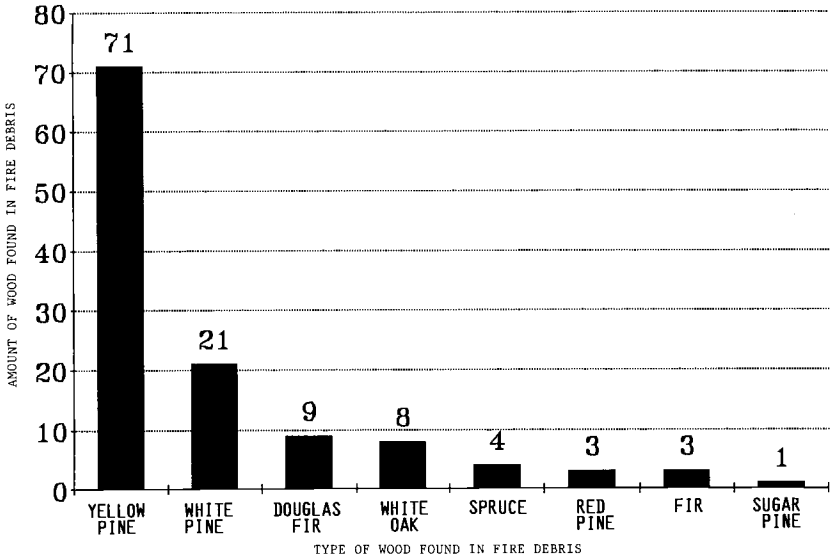

FIG. 1—*Types of wood identified in fire debris from 104 cases. Note: The use of certain species of wood in construction may differ due to geographic location.*

Comparison of Wood Constituents with Turpentine

Others have performed some work identifying terpenes in suspicious fire debris using gas chromatography[5] and or combined gas chromatography/mass spectrometry (GC/MS) [*9–13*]. It was also known that some hardwoods contain small amounts of terpenes [*14*].[6] If wood identification is to be useful in arson analysis, the next question to be answered is: How do the constituents of hardwoods chemically compare to turpentine? The second project was designed to answer this question.

Several samples of hardwoods and softwoods were obtained for the study. Each sample was partially burned and subjected to the charcoal trap/absorption elution method of sample recovery. Carbon disulfide was used as the eluting agent. The eluent was concentrated to 50 μL. Three microlitres of eluent were injected into the gas chromatograph. The gas chromatograph was a Perkin-Elmer Sigma 1B with a 15-m Supelco SPB-1 fused silica capillary column. All the sample eluents were analyzed at 50°C for 2 min, then the temperature was increased to 190°C at 13°C per minute and held for 6 min. Five softwoods were tested: yellow pine, Douglas fir, ponderosa pine, hemlock, and a cypress. All except the cypress had chromatograms similar to that of known commercial turpentine (Fig. 2). Six hardwoods were tested: white oak, red oak, birch, maple, poplar, and cottonwood. All these had very little response on the gas chromatograph and were not similar to turpentine (Fig. 3).

Next the samples were analyzed with the mass spectrometer. One and one-half microlitres of the sample eluent were injected into the GC/MS. The mass spectrometer was a Finnegan 3200 with a 15-m DB-5 megabore column in the gas chromatograph and a Super Incos data system. All the sample eluents were analyzed at 50°C for 1 min, then the temperature was increased to 260°C at 20°C/min. Alpha-pinene, the main component of turpentine, was prevalent in all the softwoods tested except the cypress (Figs. 4–8). Alpha-pinene was not identified in any of the hardwoods (Figs. 9 and 10). There was a terpene present in the white oak (Fig. 11) and the maple samples; however, its presence would not be confused with turpentine or oleoresin in routine arson analysis. The reasons for this are that the gas chromatogram would be completely different and the monoterpenes would not be present.

Report Writing

One cannot discuss this problem of turpentine in arson analysis without considering how results should be reported. The ethical duty of a forensic scientist is to assist law enforcement agencies in arriving at the truth. Therefore, when oleoresin is found, an analyst should truthfully report its presence rather than concluding, "No accelerants were identified." Yet, when turpentine is reported the investigator is likely to think an accelerant was identified in the evidence. Therefore, in all cases in which turpentine is reported and it could be a natural product of the wood, a qualifying statement should be added to the report. One way to state such a result would be: "Analyses performed on the sample in Q-1 revealed the presence of turpentine, which may be a natural product of the wood."

There are only a few cases in which a qualifying statement would not be warranted. For example, when oleoresin is found, but no wood is near the sample; or when oleoresin is found in a pour pattern on a mahogany table or some other piece of hardwood furniture. Finally, if a piece of flooring is absolutely saturated with oleoresin, but a flooring comparison sample lacks oleoresin, a qualifying statement would not be necessary.

[5]Cherry, C., Southern Illinois Forensic Science Laboratory, Carbondale, IL, Oct. 1986, personal communication and unpublished data.

[6]Wineman, P., Alcohol, Tobacco and Firearms Laboratory, Rockville, Maryland, July 1989, unpublished data.

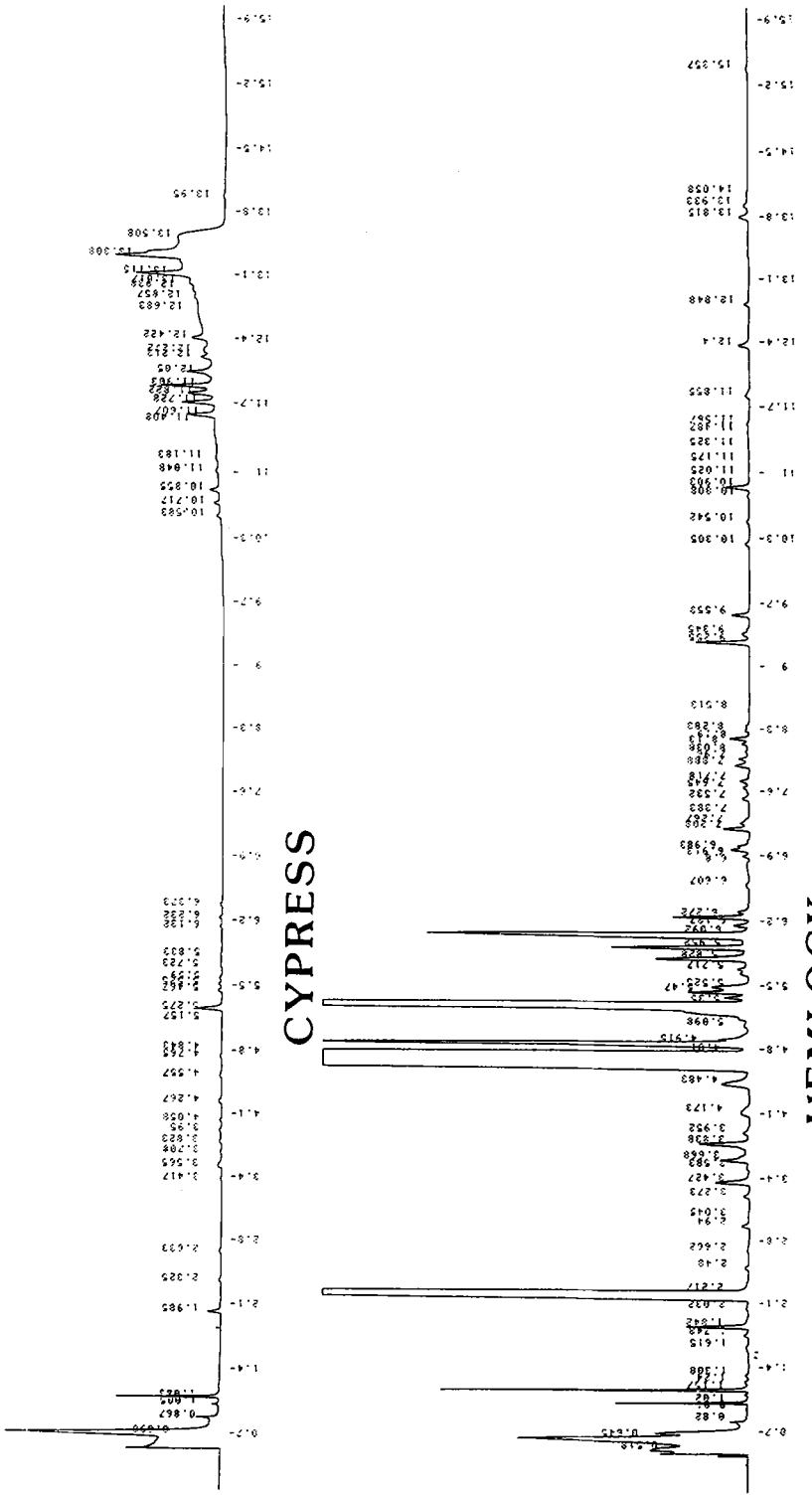

FIG. 2—*Chromatograms of a representative sample of softwoods compared to turpentine.*

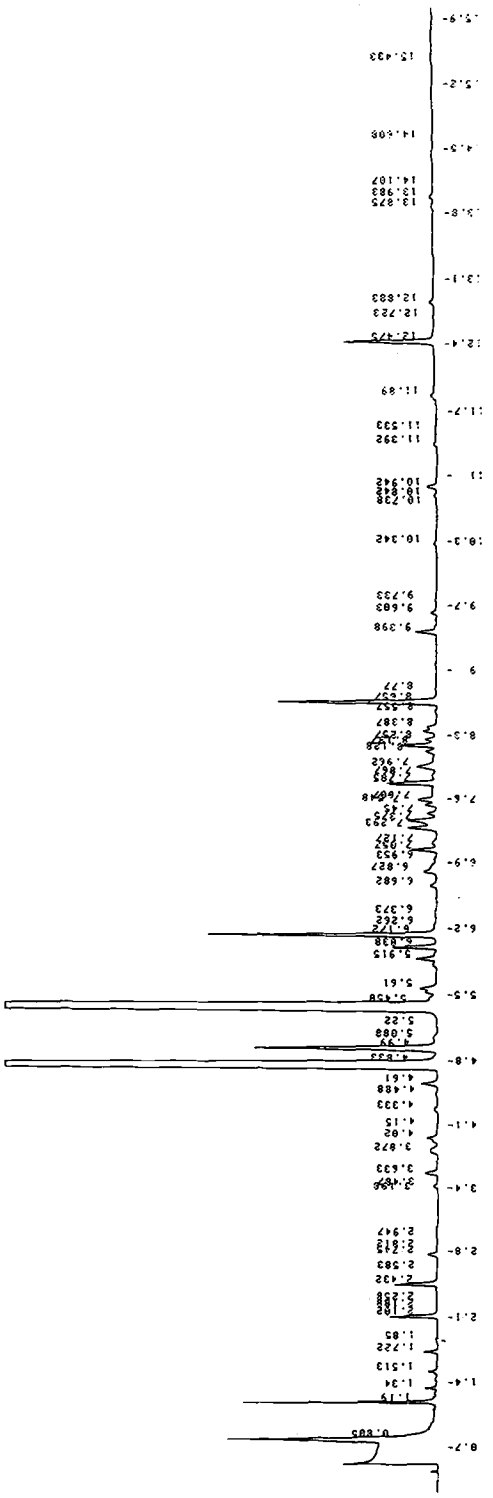

FIG. 2—*Continued.*

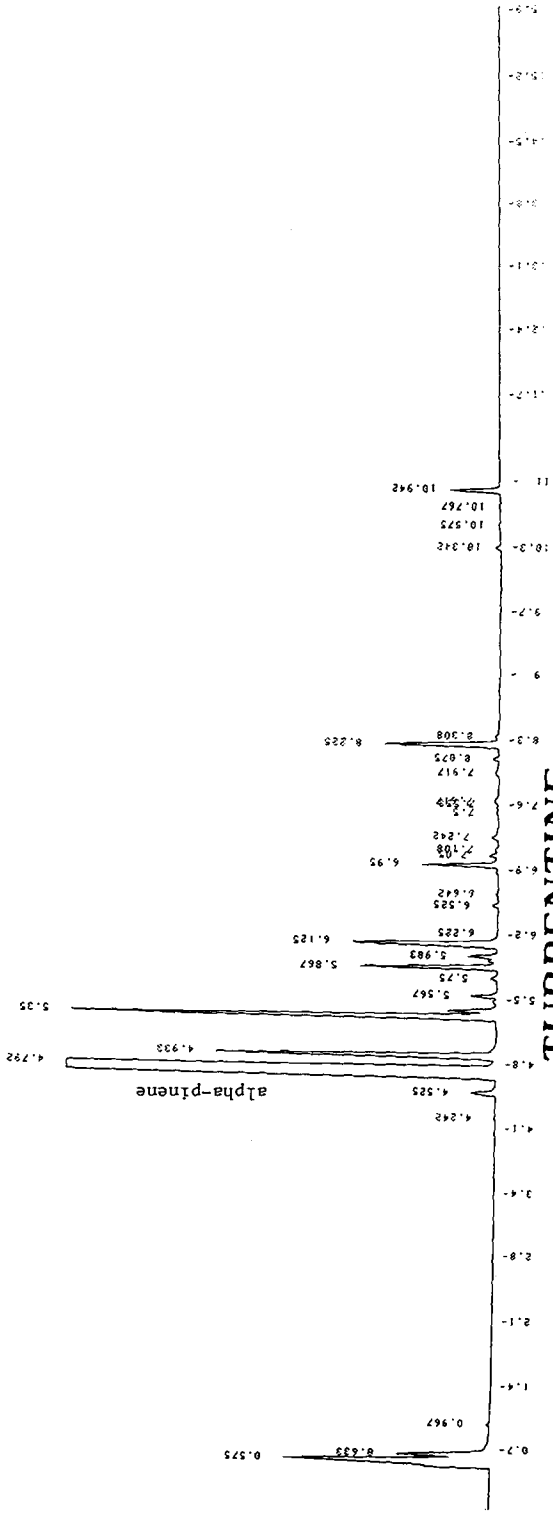

FIG. 2—*Continued.*

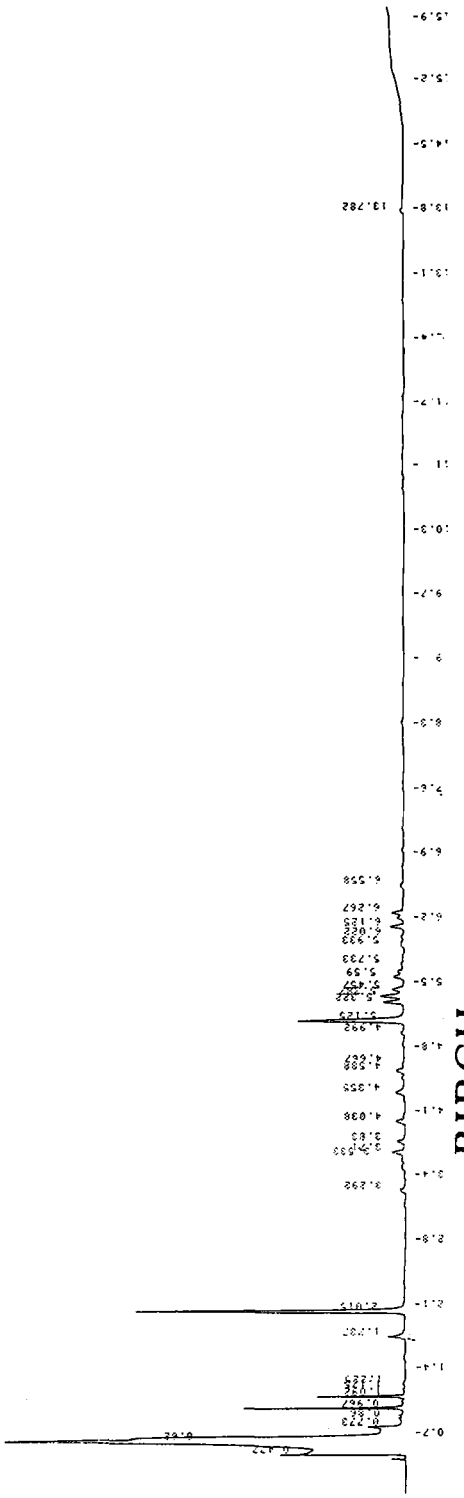

FIG. 3—*Chromatograms of a representative sample of hardwoods compared to turpentine.*

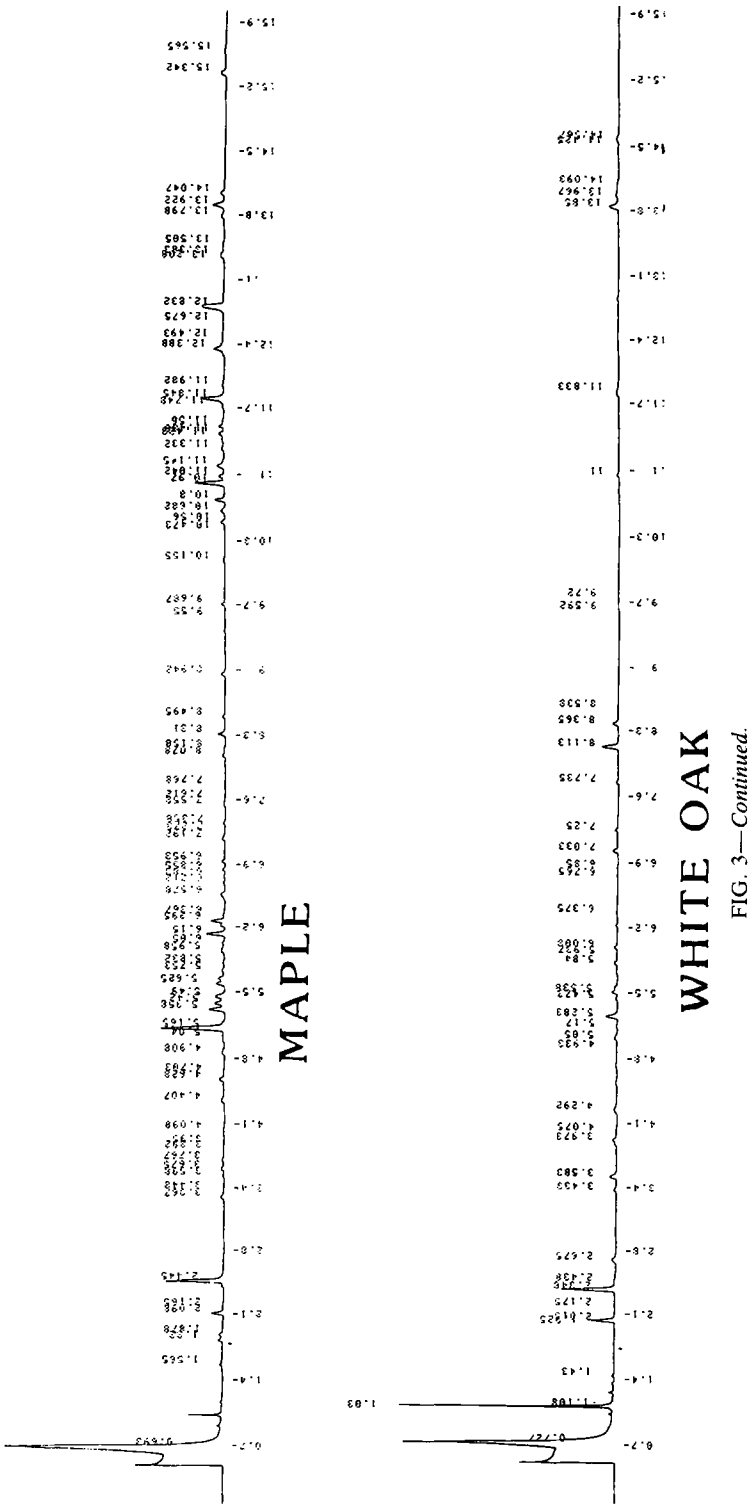

FIG. 3—*Continued.*

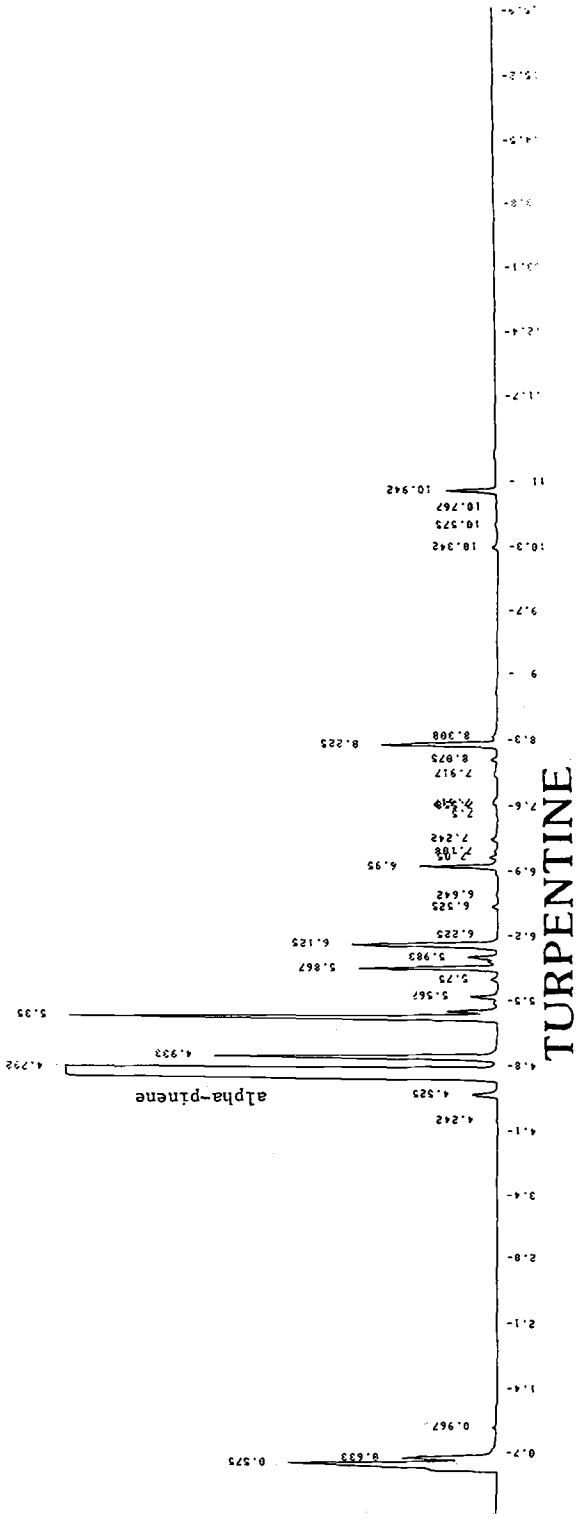

FIG. 3.—*Continued.*

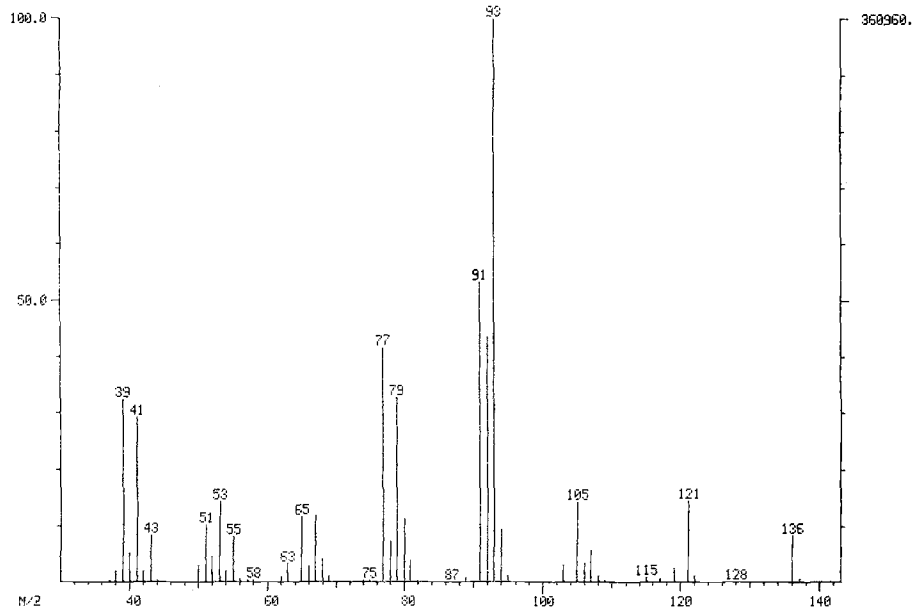

FIG. 4—*Mass spectrum of alpha-pinene.*

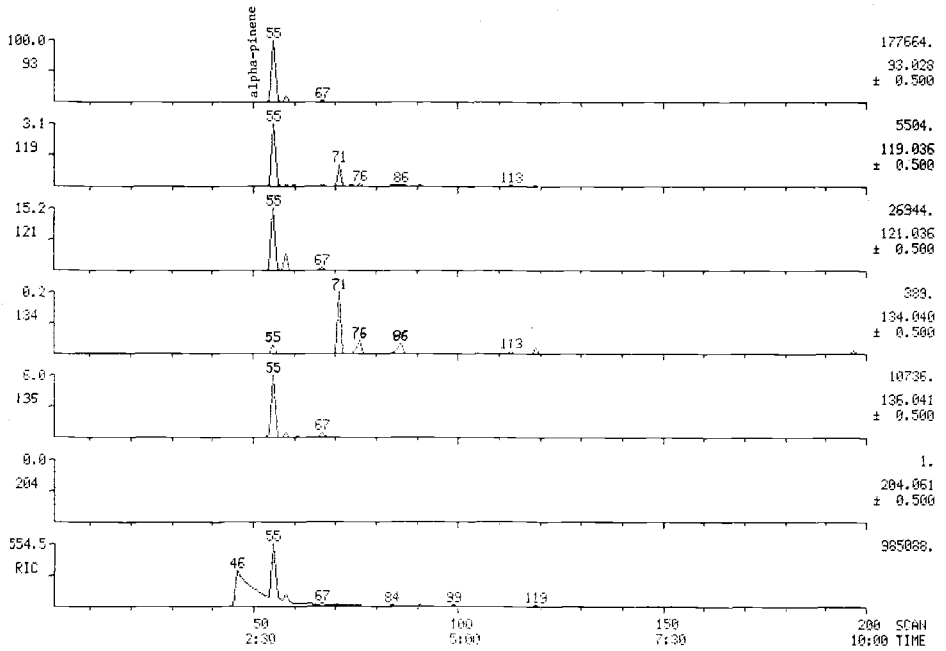

FIG. 5—*Mass chromatograms of selected terpene ions in a yellow pine wood sample. This is a representative sample of the softwoods.*

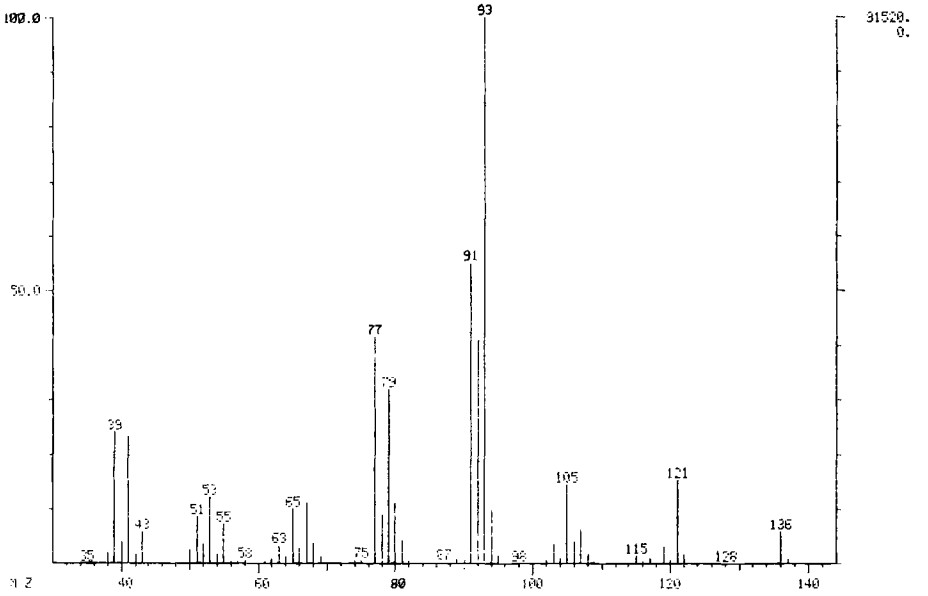

FIG. 6—*Spectrum of largest peak in yellow pine matching alpha-pinene in retention time and composition. This is a representative sample of the softwoods.*

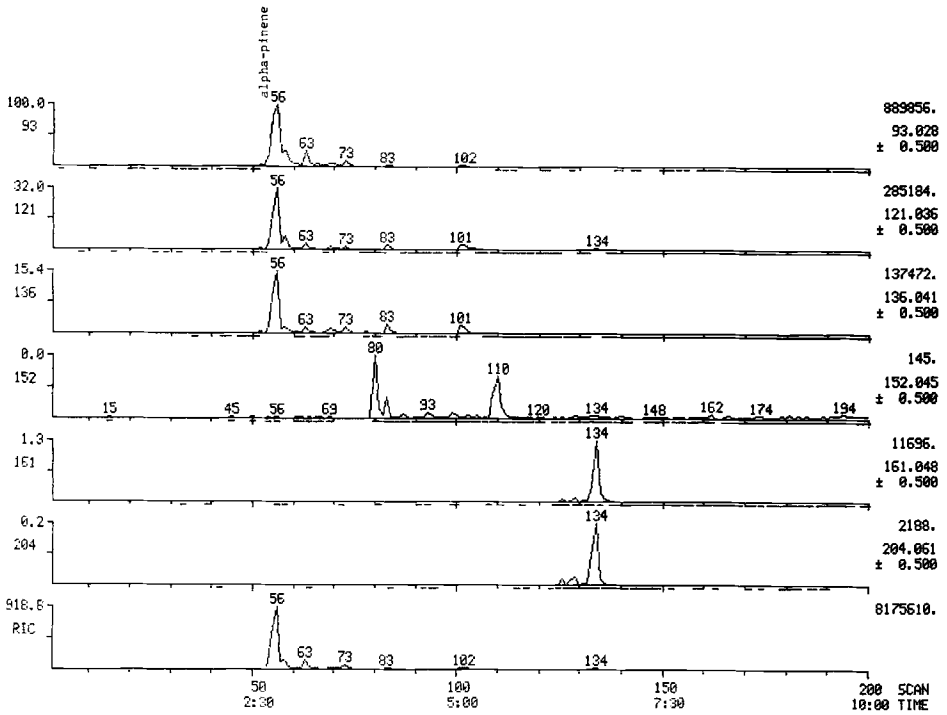

FIG. 7—*Mass chromatograms of selected terpene ions in a known turpentine sample.*

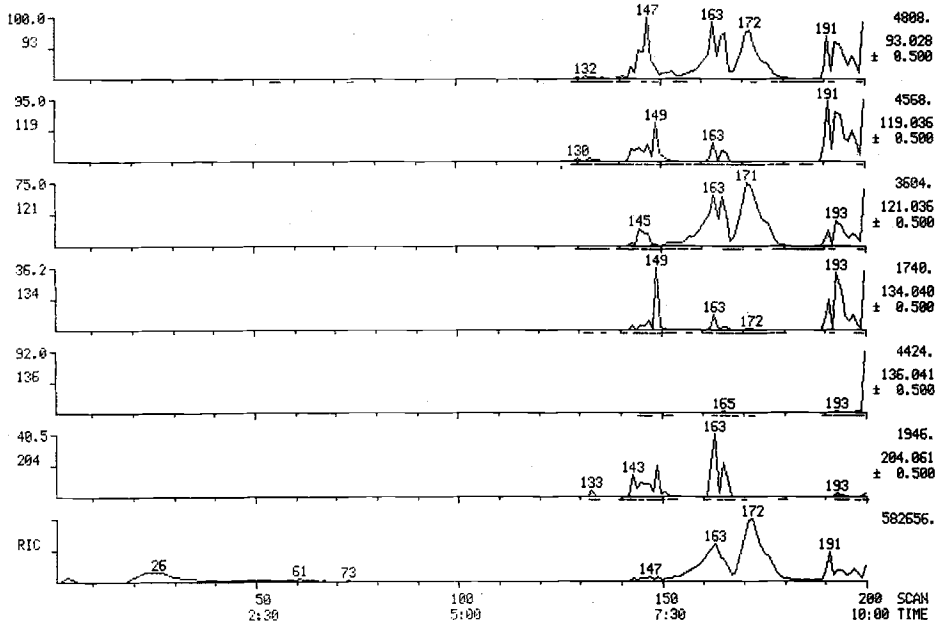

FIG. 8—*Mass chromatograms of selected terpene ions in a cypress wood sample.*

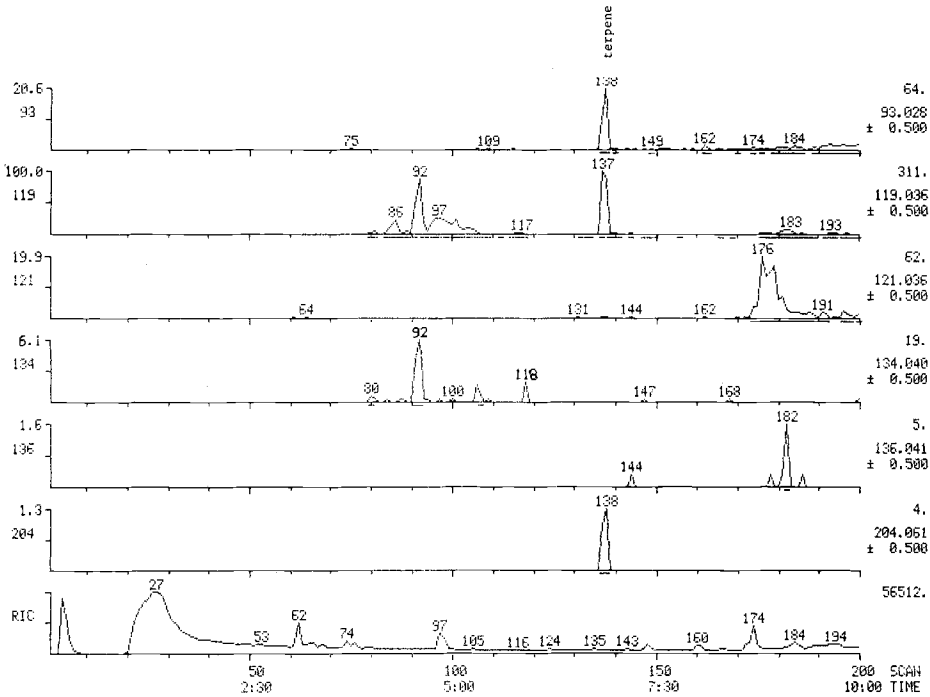

FIG. 9—*Mass chromatograms of selected terpene ions in a white oak wood sample. This is a representative sample of the hardwoods.*

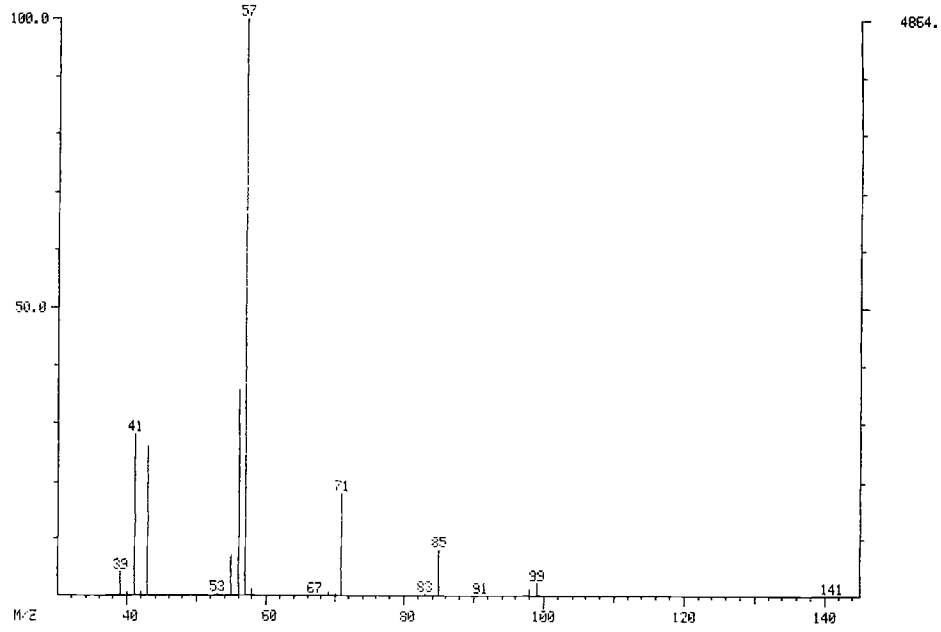

FIG. 10—*Spectrum of the largest peak near the retention time of alpha-pinene in a white oak wood sample.*

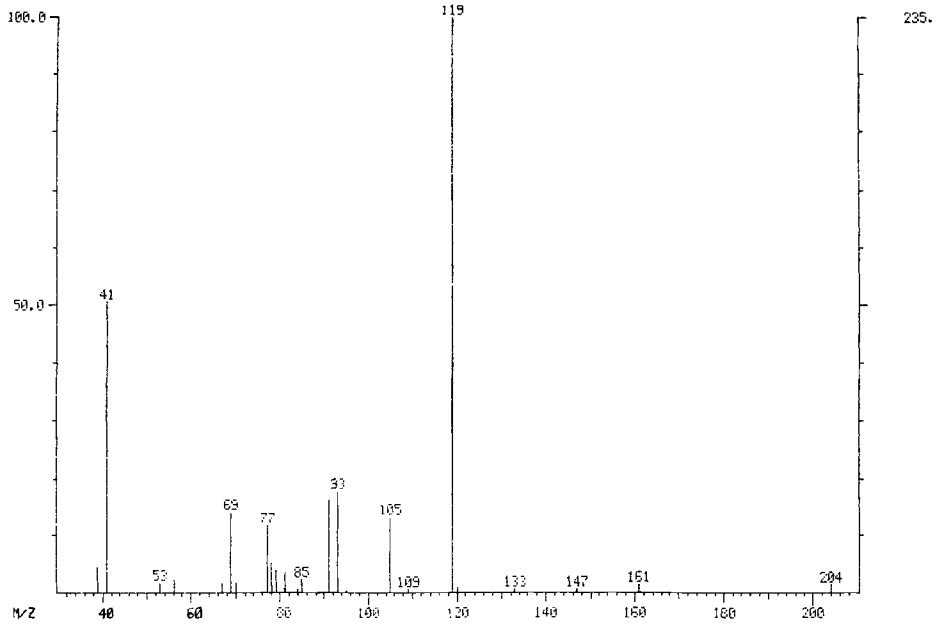

FIG. 11—*Spectrum of a terpene found in a white oak wood sample. Refer to the peak at scan 138 in Fig. 9.*

As described earlier, the chemical composition of manufactured turpentines, as well as the terpenes in wood, can differ due to the species of pine and the geographical area from which the pine originated. Also, turpentine is actually a product made from the oleoresin of coniferous trees. So perhaps it would be more accurate to report that terpenes like those in turpentine, or terpenes *un*like those in turpentine, have been identified; however, mass spectral data would be needed to identify the components properly as terpenes. Another possibility would be to report: "Analyses performed on the sample in Q-1 revealed the presence of oleoresin, which may be from turpentine or a natural product of the wood."

Conclusions

Unless importers or distributors of turpentine start adding taggants to their products, which is highly unlikely due to expense, the difference between manufactured turpentine and the natural products of many softwoods found in fire debris cannot now be established with scientific certainty. In some cases, the microscopic identification of wood can assist the analyst in deciding whether the terpenes found in a sample are from turpentine or are more likely a natural product of the wood.

Most softwoods contain turpentine constituents. Although some hardwoods contain terpenes, during routine arson analysis hardwood terpenes should not be mistaken for terpenes like those in turpentine. Finally, arson analysts should report what they find. Therefore, in most cases that contain terpenes like those in turpentine, analysts should report their presence but be careful not to mislead the investigator into believing that the presence of such terpenes confirms the use of an accelerant.

Acknowledgments

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References

[1] Hawley, G. G., *The Condensed Chemical Dictionary*, 10th ed., Van Nostrand Reinhold, New York, 1981.

[2] Windholz, M., *The Merck Index*, 9th ed., Merck and Co., Rahway, NJ, 1976.

[3] Brady, G. S. and Clauser, H. R., *Materials Handbook*, 12th ed., McGraw-Hill, New York, 1986.

[4] Goldstein, I. S., *Organic Chemicals from Biomass*, CRC Press, Boca Raton, FL, 1981, Chapter 9.

[5] Koch, P., *Utilization of the Southern Pines*, U.S. Government Printing Office, Washington, DC, 1975.

[6] Drew, J. and Pylant, G. D., "Turpentine from the Pulpwoods of the United States and Canada," *Journal of the Technical Association of the Pulp and Paper Industry*, Vol. 49, No. 10, Oct. 1966, pp. 430–438.

[7] Williams, A. L. and Bannister, M. H., "Composition of Gum Turpentines from Twenty-Two Species of Pines Grown in New Zealand," *Journal of Pharmaceutical Sciences*, Vol. 51, No. 10, Oct. 1962, pp. 970–975.

[8] Kossuth, S. V. and Munson, J. W., "Automated Terpene Analysis with an Internal Std.," *Journal of the Technical Association of the Pulp and Paper Industry*, Vol. 64, No. 3, 1981, pp. 174–175.

[9] Lowry, W. T., Stone, I. C., and Lomonte, J. N., "Scientific Assistance in Arson Investigation," prepared for Committee on New Development and Research of the American Society of Crime Laboratory Directors, June 1977.

[10] Trimpe, M. A. and Tye, R., "Mass Fragmentography in Arson Analysis," *Arson Analysis Newsletter*, Vol. 7, No. 2, March 1983.

[*11*] Smith, R. M., "Mass Chromatographic Analysis of Arson Accelerants," *Journal of Forensic Sciences*, Vol. 28, No. 2, April 1983, pp. 325–328.
[*12*] Bertsch, W., Sellers, C. S., and Holzer, G., "Analysis of Suspect Arson Samples by GC and GC-MS," *LC·GC*, Vol. 6, No. 11, Nov. 1988, pp. 1000–1014.
[*13*] Nowicki, J., "An Accelerant Classification System Based on Analysis by GC/MS," presented at the Arson Symposium of the American Academy of Forensic Sciences Meeting, Cincinnati, OH, 19–24 Feb. 1990.
[*14*] Rowe, J. W. and Conner, A. H., "Extractives in Eastern Hardwoods—A Review," General Technical Report FPL18, Forest Products Laboratory, Madison, WI, 1979.

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