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Published every Thursday. Subscription Price: United States and Possessions, Mexico, Cuba, \$6.00; Canada, \$8.50, including duty; Foreign \$12.00 a year. Single copy, 25 cents.

Cable Address, "Ironage, N. Y."

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MUCH has been written and heard about the wood in the Lindbergh ladder. But practically nothing has been said about the 44 nails that held it together. Yet these nails were identified with uncanny positiveness through the research of the author, Stanley R. Keith.

His testimony for the State of New Jersey was not presented at the trial of Bruno Hauptmann, because the collapse of the defense alibis made quick closing desirable to the prosecution. Here, for the first time, is presented, with the consent of Attorney General Wilentz, a most interesting story of identification which traces the ladder nails directly back to the nail keg in Hauptmann's garage.

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IN attempting to give an accurate résumé of the technological phase of the investigation of the nails in the ladder used in the kidnapping of the Lindbergh baby, the author is confronted with the necessity of giving precedence, in an article of this nature, to the technical considerations involved.

The opinion that the 44 8d. common wire nails used in the assembly of the 11 rungs to the side members, were components of the original contents of the keg found to have been partly used by Hauptmann in constructing his garage, as an inescapable conclusion is one thing; the laborious citation of detailed circumstances, one by one,

leading up to this point is quite another.

To the ordinary layman, nails are nails, in the absence of any positive occasion to regard them otherwise. Any references to further characterizations are apt to be construed as theoretical. Nor does the carpenter's practical contact with them serve to develop a correspondingly more intimate knowledge of nails except for type and size.

It is interesting to contrast the criminal's well defined respect for finger-print evidence in contradistinction to the highly systematic technology overlooked in the nails. The striking analogy will become more and more apparent when we regard the grip marks left on the wire by the chucking dies to be parallel in effect to grasping an article with the thumb and forefinger.

However, the impression that "nails are nails" and hence without individuality is a prevailing one. Even the nail producer considered it hopeless to identify these ladder nails with the criminal, because of their utter promiscuity in the raw material and handling phases of the production, and of the overwhelming numerical factor involved in an annual marketing during the previous year 1931 of almost eight million kegs of wire nails, 25 per cent of which were of the specific type and size found in the ladder. This means a field increment annually of 200,000,000 lb. of such nails, or as units, 20,000,000,000 items of this class!

As a basic similarity, all the ladder nails were observed to bear the letter P on the obverse side directly

below the head and just above the grips, as shown in Fig. 1, which is made up of a series of macrographs subsequently reduced in rephotographing for publication. The significance of this index letter P as a trade mark became at once obvious, as a means of fixing their mill source. Steel being synonymous with Pennsylvania, and more specifically Pittsburgh, a prompt reference to a directory disclosed the fact that the nail mill of the Pittsburgh Steel Co. is located at Monessen, Pa. This plant produced approximately 10 per cent of all the nails of this type and size marketed during 1931, thus serving as a detail, to reduce the field from 2,000,000 kegs to 200,000 kegs. This was by far too general to be of much help as an independent circumstance.

While all these ladder nails were similar in respect of their common letter P, they fell systematically within eight characteristic grip mark types, as the first sub-classification, viz: E S T V A U G H. The numerals within the parentheses beneath each such grip mark type so designated, show the number of ladder nails constituting such group values.

Even a cursory observation of the series will serve to refute the lay impression that nails are nails, constituting as they do the actual ladder nails themselves. Thus singled out, they are as distinctive in die-type as humans in individuality. A series of 100 specimens provided definitely from different assemblies while in production, for such a study, through the cooperation of J. N. Reese at the Monessen plant of the Pittsburgh Steel Co., showed no two alike after

By STANLEY R. KEITH

*Metallurgical Engineer, Montclair, N. J.
Steel Technologist for the State in the
Hauptmann Trial*

a painstaking study by the author, and incidentally approximately 5000 involved comparisons. While this study was advisable from a lego-technical standpoint, the conclusion was also obvious on the basis of mechanical experience. For no die maker can duplicate his own handiwork in absolute detail.

"Personalities" of the Ladder Nails

Returning to the more detailed comparison of the macrophotographic series of Fig. 1:

Type E: Flattened loop section of the P, which in extending downward, tends to shorten the stem. The three upper barbings curve upward at their extreme right, while the rest terminate horizontally.

Type S: Relatively new die, the P is well defined and normal in typographic form. All eight barbings are so clearly defined as to be distinctive in themselves as a whole. The sharp upward termination to the right, of the third and fourth barbings, and the characteristic horizontal wrinkle or fold in all but the first two, serve to distinguish this type further.

Type T: The flattened loop section of this P, while extending downward, does not tend to shorten the stem which is broad in contrast to that of E. The eight barbings show extended production by this die assembly, and are characterized by a common declination to the right below horizontal.

Type V: Letter P of an appreciably larger size, and located farther below the head than the others. The barbings are so distinctive in their hooked contours, that this type is at once distinguished from all the rest.

Type A: The letter P declines to the right slightly from vertical, and is so badly emaciated typographically as to distinguish it at once. Overworked barbings show extended breakdown of die. Curious moon face form of the fifth and sixth barbings, respectively outlining the eyes and mouth.

Type U: Here the loop of P is deficient in its upper section, obviously resulting from the use of a broken stencil in stamping the die. Head is particularly thin, and there are characteristically wide bars between the second and third, and between the third and fourth barbings.

Type G: The stem of the P is quite pointed. The barbings are singularly horizontal, with well rounded extremities at the right. The head is thin.

Type H: The letter P declines appreciably from vertical to the right, with a broad and singularly oblique terminating stem. Its barbings generally resemble those in S but with convex curvatures of the first S, while the sixth and seventh barbings have singularly lipped sections.

With this classification of the ladder nails taken as a basic starting point, the problem resolved itself into a research of Hauptmann's normal nail contacts with a view toward the possible paralleling of these overwhelmingly singular features, in his work-a-day world.

Hauptmann's Nail Keg

Among his personal effects brought to State police headquarters there was included an ordinary nail keg with the head removed, except for a small segment having

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three letters in red stamped thereon, as part of a word terminating with E C T. This keg contained a remainder of 42 8d. common wire nails of the same size and type found in the ladder. They all bore the common symbol P, indicating the same mill source as those of the ladder.

In this connection, it was subsequently established, when this keg was taken personally to the Pittsburgh Steel Co., that the segment letters were part of the word PERFECT, and a careful comparison of their typographic details clearly showed them to have been stamped by the same die as that used at Monessen in the preparation of their keg heads. These keg nails were thus established as the obvious balance from the original keg lot, without reference at this point specifically to the ladder nails.

A painstaking examination and classification one by one of these keg nails was made with recorded results as shown in Fig. 2. They were found to be identical in the

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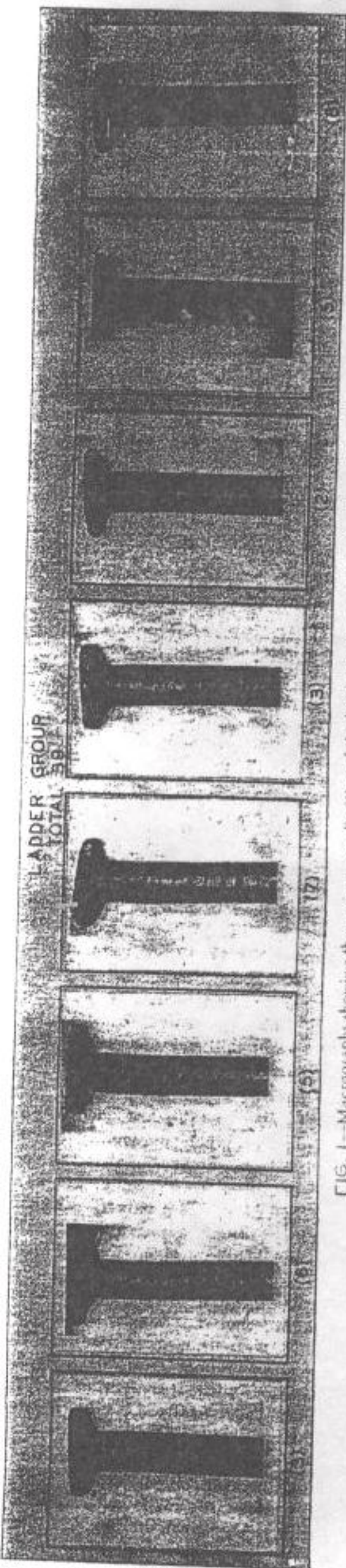


FIG. 1—Macrographs showing the various peculiarities of the ladder nails, caused by the die grip marks.

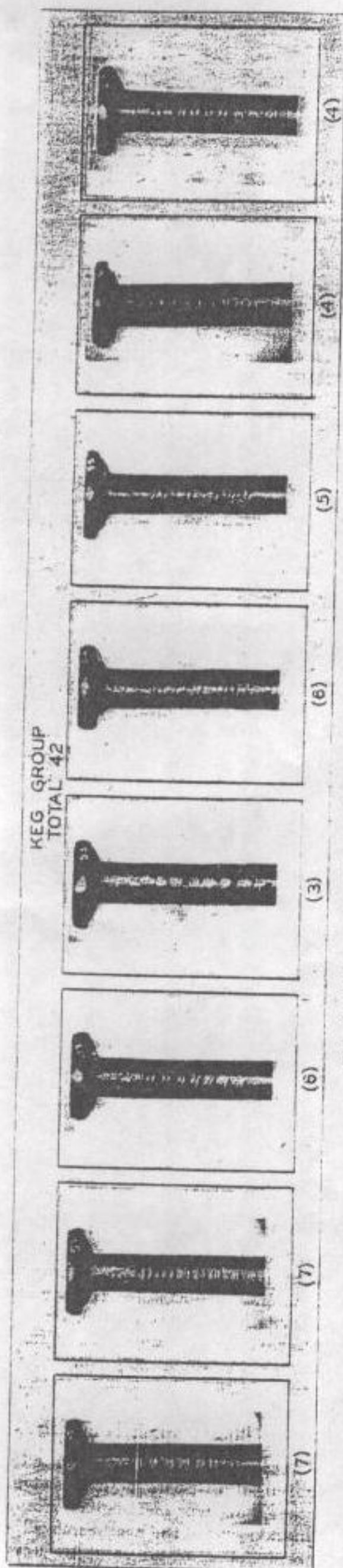


FIG. 2—Macrographs of the nails found in Hauptmann's nail keg.

minutest detail, type for type, with those of the ladder group; and in multiples as shown in parentheses underneath.

Further research among Hauptmann's miscellaneous effects offered 10 additional units, four of which were removed by the writer from a pair of his overalls. Their investigation, as shown in part recorded by Fig. 3, disclosed five of the total of eight die types, viz.: E S V U and H, and in multiples within the parentheses underneath.

Nails From Hauptmann's Garage

Extending this research still further in order to evaluate the quantity factor involved herein by the original keg's status, what would be more apt than to investigate the nails used by Hauptmann in the construction of his garage some time during the fall preceding the kidnapping? Such a normal nail demand would account for a large proportion of the keg's original contents, and from a reasonably sized recovery there could be established the group characteristics of these nails as packed at Monessen.

Unfortunately, the garage structure had been wrecked during the early stages of the search for additional ransom money, but detective Bornman recalled on questioning that a considerably sized heap had been knocked out of the lumber by him in recovering the boards for investigation purposes. Accordingly, 275 units were recovered from this spot by respading and sieving the ground. They were naturally covered with rust, but special chemical means were developed to clean them with a minimum amount of wear and tear on the grip markings. The result of their investigation are shown in part as recorded in Fig. 4. As anticipated, they too coincided precisely with the previous groups, type for type, and without exception.

In order to proceed with the final phase of this investigation, the keg was logically taken as the legitimate source of supply for Hauptmann's normal nail demands purely within the innocent province of his calling as a carpenter. Accepted as such, and without reference to the ladder group for the present, all the other nails were figuratively returned to their known original keg and the resultant numerical strength thereby attained, made the basis for further extended analysis

of their common 8 die-type status, into coil entities as the ultimate sub-division of their unit characteristics, and for the more subtle group characteristics which ensue.

Wire Coil Identities

Careful micrometer measurements for diameter and length, and accurate gravimetric determinations by the use of an analytical balance, together with an observantly constructive microscopic examination of each of these nails subjectively treated as units with respect to their wire drawn characteristics, constituted the detailed work necessary to assign the values given in Fig. 5, as indices of these technological details possessed by the lot in the premises. The coils fed to each of the respective die assemblies were thus revealed. By way of interpretation, it is worthy of note that the length is a function of the die assembly adjustment, and is the same within each die type, irrespective of the coil used. The diameters, as functions of the wire drawing die, were particularly interesting in that they disclosed the ellipticities common to each. The weights, being a function of both the wire drawing die's orifice and the machine assembly die's adjustment, tend to show consistently the effect within each die type of the variations in diameter. The fidelity with which, without exception, each unit revealed its coil characteristics, was surprising. Coil No. 11, having a double pick up, showed in unit after unit, for example, the two microscopic channels or grooves always equidistant, and always diverging at the same angle on the head and terminating precisely at the same location in the facet of the pointed end; while coil No. 12, when magnified sufficiently, showed its broad channel or groove to have the same characteristic contour and depth in all the specimens alike thus confirming the fixed form of the accumulated metallic die particle generating this defect as the common cause for each.

The group characteristics of this combined sample of 320 units accordingly reflect those of the technological lot from which they were packed, and it is the size of this packed lot that determines the final limit to which these ladder nails may be restricted as an inverse function of their criminological value.

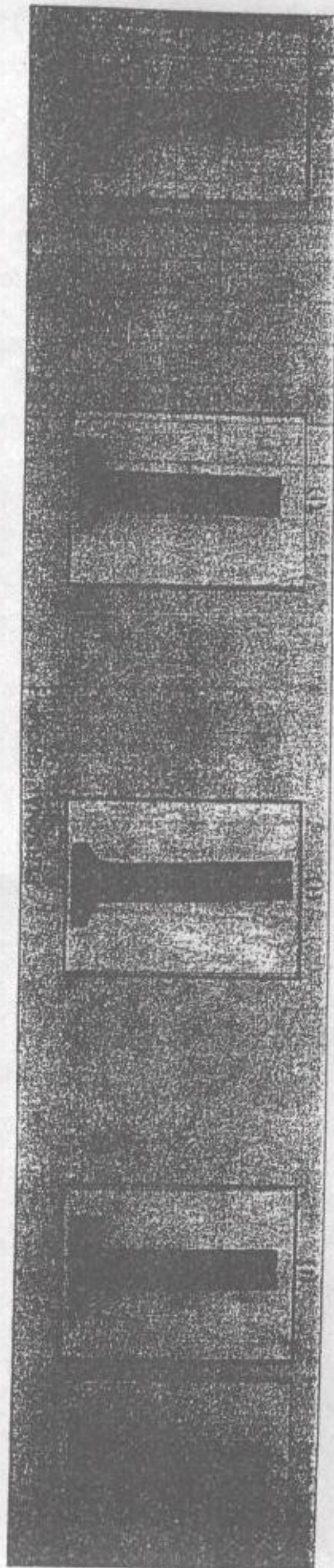


FIG. 3—Macrographs of nails found in Hauptmann's overalls.

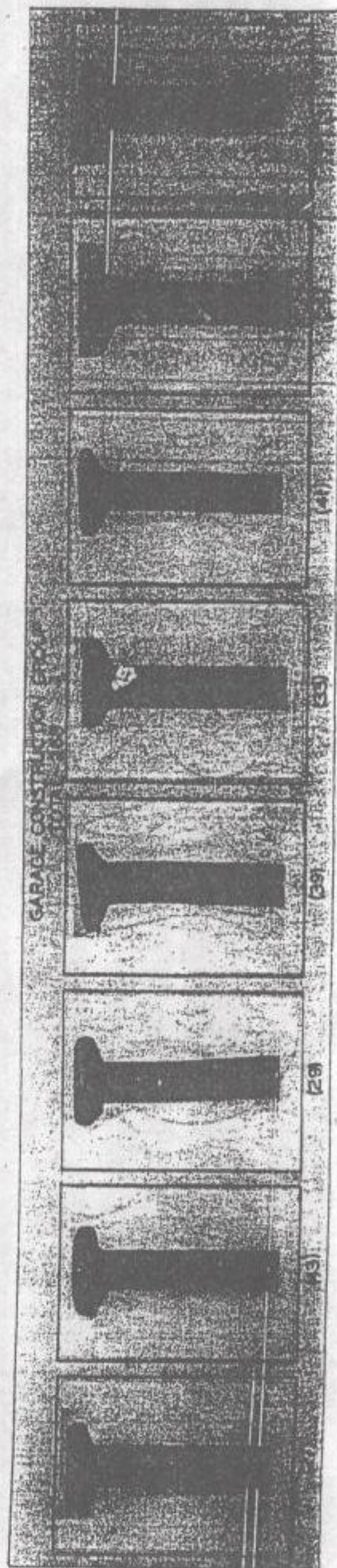


FIG. 4—Macrographs of nails used in Hauptmann's garage structure.

DIE TYPES	E		S	T			V			A		U	G		H		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	8
COIL ENTITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	16
COIL UNITS	19	20	51	8	22	5	19	9	15	20	19	47	11	18	19	18	320
PROPORTIONS	$\frac{19}{320}$	$\frac{20}{320}$	$\frac{51}{320}$	$\frac{8}{320}$	$\frac{22}{320}$	$\frac{5}{320}$	$\frac{19}{320}$	$\frac{9}{320}$	$\frac{15}{320}$	$\frac{20}{320}$	$\frac{19}{320}$	$\frac{47}{320}$	$\frac{11}{320}$	$\frac{18}{320}$	$\frac{19}{320}$	$\frac{18}{320}$	1
STRUCTURAL VALUE	$\frac{1}{17}$	$\frac{1}{16}$	$\frac{1}{6}$	$\frac{1}{40}$	$\frac{1}{15}$	$\frac{1}{64}$	$\frac{1}{17}$	$\frac{1}{36}$	$\frac{1}{21}$	$\frac{1}{16}$	$\frac{1}{17}$	$\frac{1}{7}$	$\frac{1}{29}$	$\frac{1}{18}$	$\frac{1}{17}$	$\frac{1}{18}$	1
GROUP INTEGER	17	16	6	40	15	64	17	36	21	16	17	7	29	18	17	18	AVERAGE
DIE TYPE UNITS	39		51	35			43			39		47	29	37		8	
PROPORTIONS	$\frac{39}{320}$		$\frac{51}{320}$	$\frac{35}{320}$			$\frac{43}{320}$			$\frac{39}{320}$		$\frac{47}{320}$	$\frac{29}{320}$	$\frac{37}{320}$		1	
STRUCTURAL VALUE	$\frac{1}{8}$		$\frac{1}{6}$	$\frac{1}{8}$			$\frac{1}{7}$			$\frac{1}{8}$		$\frac{1}{7}$	$\frac{1}{11}$	$\frac{1}{9}$		1	
GROUP INTEGER	8		6	8			7			8		7	11	9		AVERAGE	
COIL ANGLE	21.4°	22.5°	57.3°	9°	24.8°	5.5°	21.4°	10.1°	16.9°	22.5°	21.4°	52.8°	12.4°	20.3°	21.4°	20.3°	360°
DIE ANGLE	43.9°		57.3°	39.3°			48.4°			43.9°		52.8°	32.7°	41.7°		360°	

FIG. 6—Reconstruction, by group classification, of the original contents of the Hauptmann nail keg. All of the ladder nails were found to fall into these classifications.

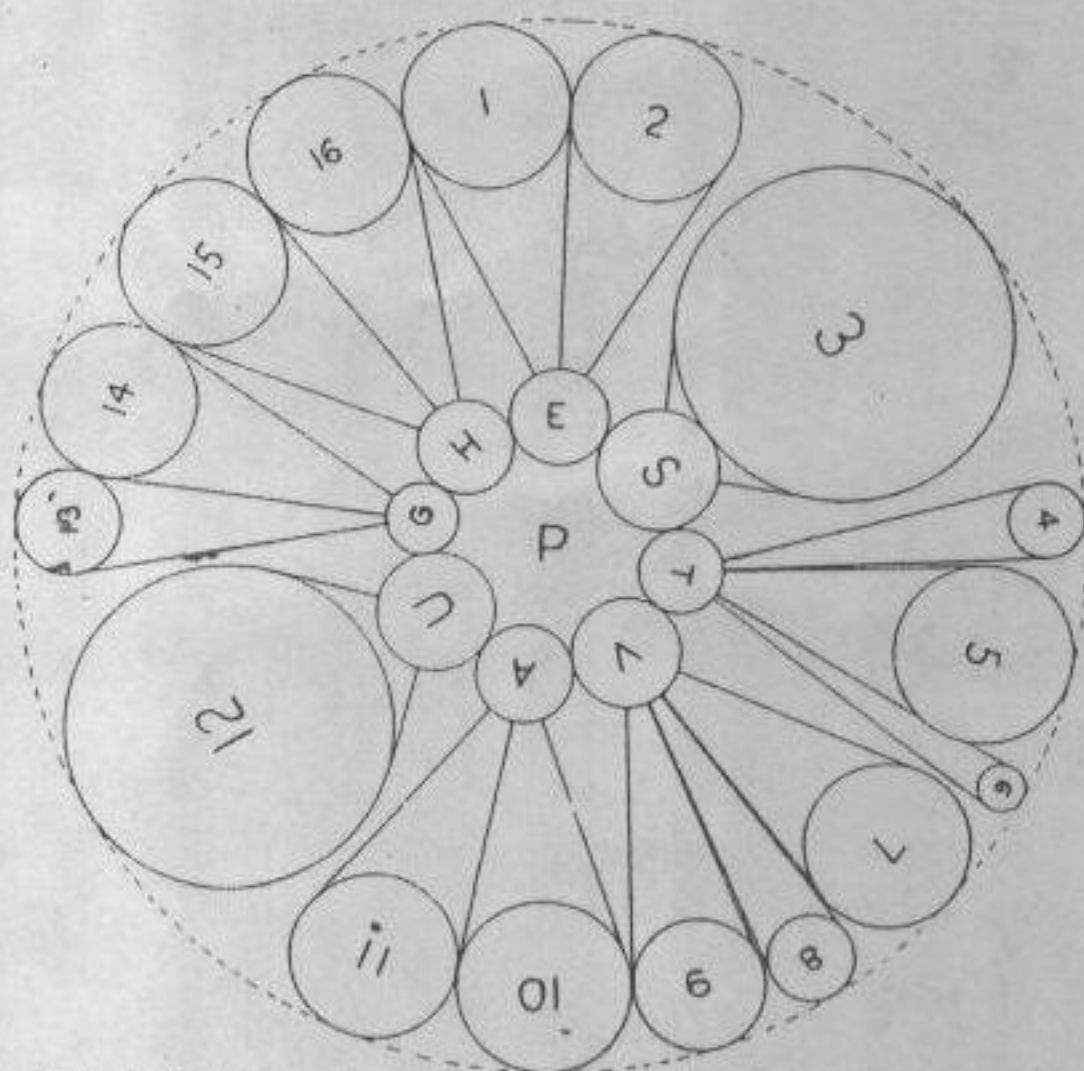


FIG. 7—Technological pattern of variations in coil proportions in the basic group with numerical strength of 320.

Fig. 6 is a tabulation of the mathematical factors involved in the procedure followed by the author ultimately to attain this end. By structural value is meant their total composite value in the basic group; while its reciprocal, group integer, is the index of the probable numerical strength of the group, required to develop this particular detail. Coil angle and die angle are notations used in the graphic representation of all these factors, in Fig. 7, whereby their proportional values in the group are shown in degrees along the total circumference of the circular graph as group unity.

It will be observed at once by their size, that there is a pronounced variation in their probable occurrences, illustrated as conceived when spun as a roulette. The factor in value involved is that of magnitude. To develop therefore the presence, as a detail of coil No. 6 constituting its remotest item, an intimate mixture of nails from this group will have to be at least equal to 64. Where the numerical strength is less than this minimum,

Die—Types	E		S	T			V			A		U	G		H	
Coil Numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Diameter Numbers	132½	134½	134½	136	136½	138½	133½	134	134½	134½	134½	135	133½	134½	134½	136
Length Numbers	2.63	2.63	2.67	2.64	2.64	2.64	2.68	2.68	2.68	2.66	2.66	2.68	2.60	2.60	2.63	2.61
Weights in Gms.	6.00	6.06	6.87	4.90	4.91	4.96	4.88	4.91	4.93	4.83	4.85	4.90	4.85	4.87	4.95	4.98
Wire—Die	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Double Pick Up	Heavy Pick Up	Smooth	Smooth	Pick Up	Smooth

FIG. 5—Identification of coils used in making nails found on Hauptmann's premises, as classified into die type groups.

for example 44, their mathematical probabilities will be shown, as in Fig. 8, to be that of the order of their prominence.

Having thus analyzed their probabilities, we may now construct a graph of this lot, without the details of magnitude, in order to make it comparable with fractional groups numerically too weak to justify anything like a dependable resolution to such a degree. Fig. 8 represents such a graph of this basic lot, by showing the related coils within their specific die type symbols, and may be taken as the pattern of the original mixture of the keg's contents as packed at Monessen.

It is to the unit and group characteristics of this lot that we shall now refer the ladder nails, to show their complete identity.

Ladder Nails Coincide With Basic Lot

Without tabulating here the details of diameter, length, weight and wire die conditions of these ladder nails, it will suffice to an-

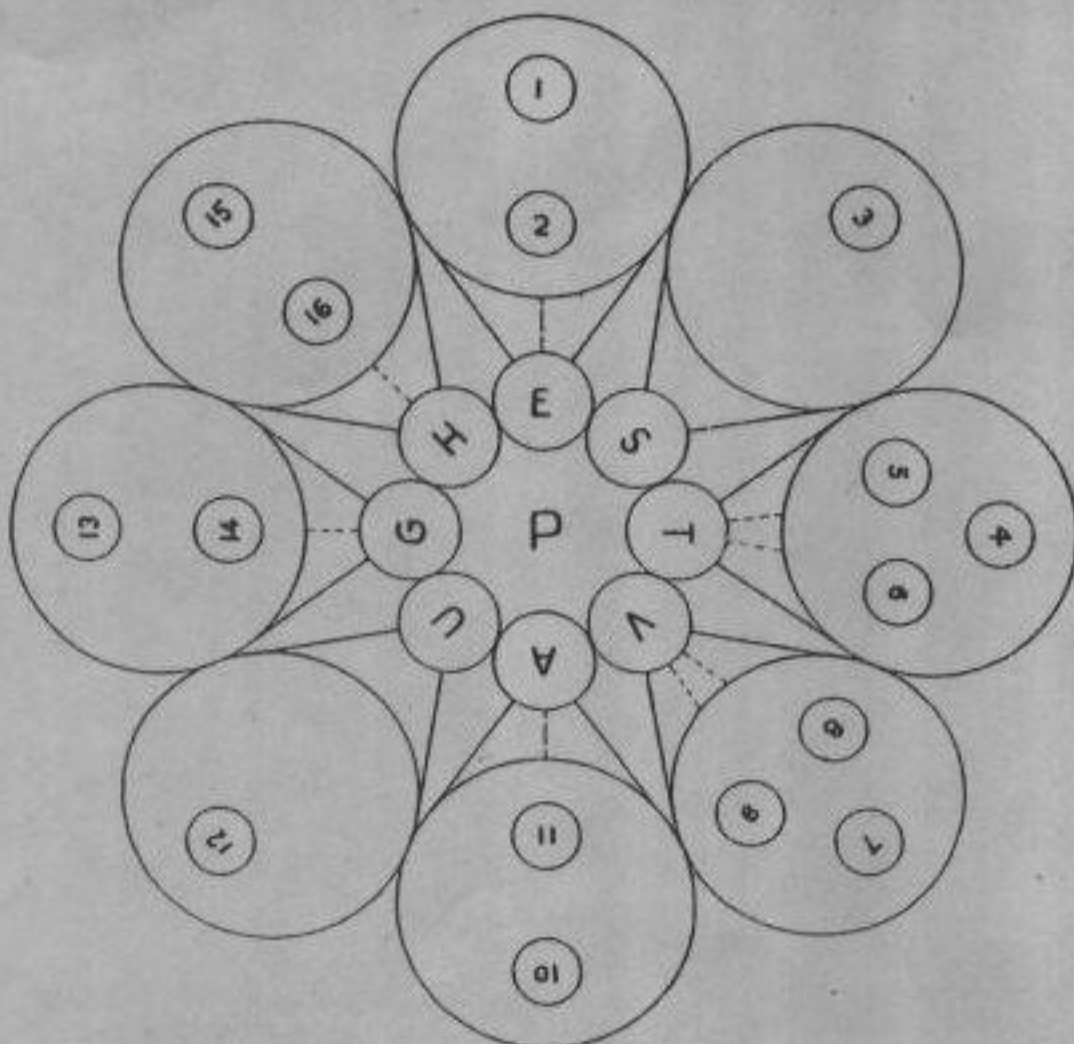


FIG. 9—Technological pattern of specific lot of nails on premises.

DIE TYPE	S	U	V	E OR A	H	T	G	
COIL ENTITY	*3	*12	*5	*2 or *10	EITHER *1, *7, *11, *15		EITHER *14 or *16	*9, *13, *8, *4, *6
STRONGER MEMBERS, CONSISTENT AS DIE TYPES & COILS					WEAKER MEMBERS, COIL SELECTIVITY ONLY			

FIG. 8—Where the number of nails is less than 64, as for example in the case of the 44 taken from the ladder, the probable distribution above is expectable. (Compare this with Fig. 11.)

nounce that they coincided, without exception, with the values found for the basic lot, as indicated in Fig. 5, thus establishing to their remotest degree of comparison, their complete unit identities therewith. The fidelity with which they showed their group identity to this same lot, is perhaps the most singular factor in the entire investigation.

The missing coils shown by dotted lines as locations in Fig. 10 for the ladder group, when compared structurally with that of the basic lot in Fig. 9, actually follow the predicted probability for the numerical strength of 44 nails postulated in Fig. 8, as will be observed in comparing the order of prominence with that actually followed by the ladder nails indicated in Fig. 11. This is equivalent to saying that not only in every positive way, but even negatively by virtue of the absence of certain coils in the ladder nail group, this ladder group was identified as a component of the keg lot.

Figs. 12 and 13 are graphs of the two lesser components of this basic

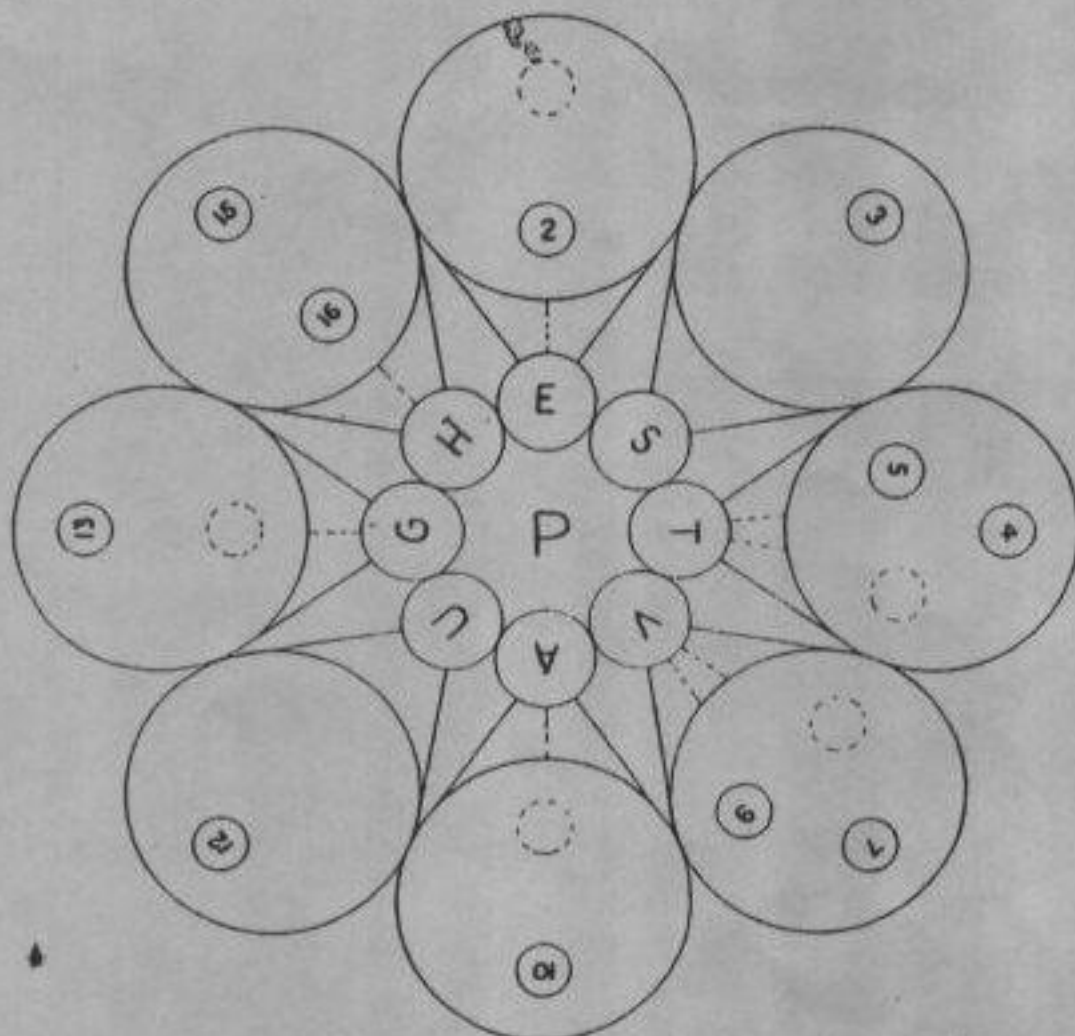


FIG. 10—Technological pattern of the 44 nails in the Lindbergh ladder.

DIE TYPE	S	U	V	E	A	H	T	G	
COIL ENTITY	*3	*12	*5	*2 AND *10	*7 & *15	*16	*9, *13	*4	
STRONGER MEMBERS CONSISTENT AS DIE TYPES & COILS						MISSING: *1, AND *11, *14, *8, *6			

FIG. 11—Order of prominence of the ladder nails. Compare this with Fig. 8.)

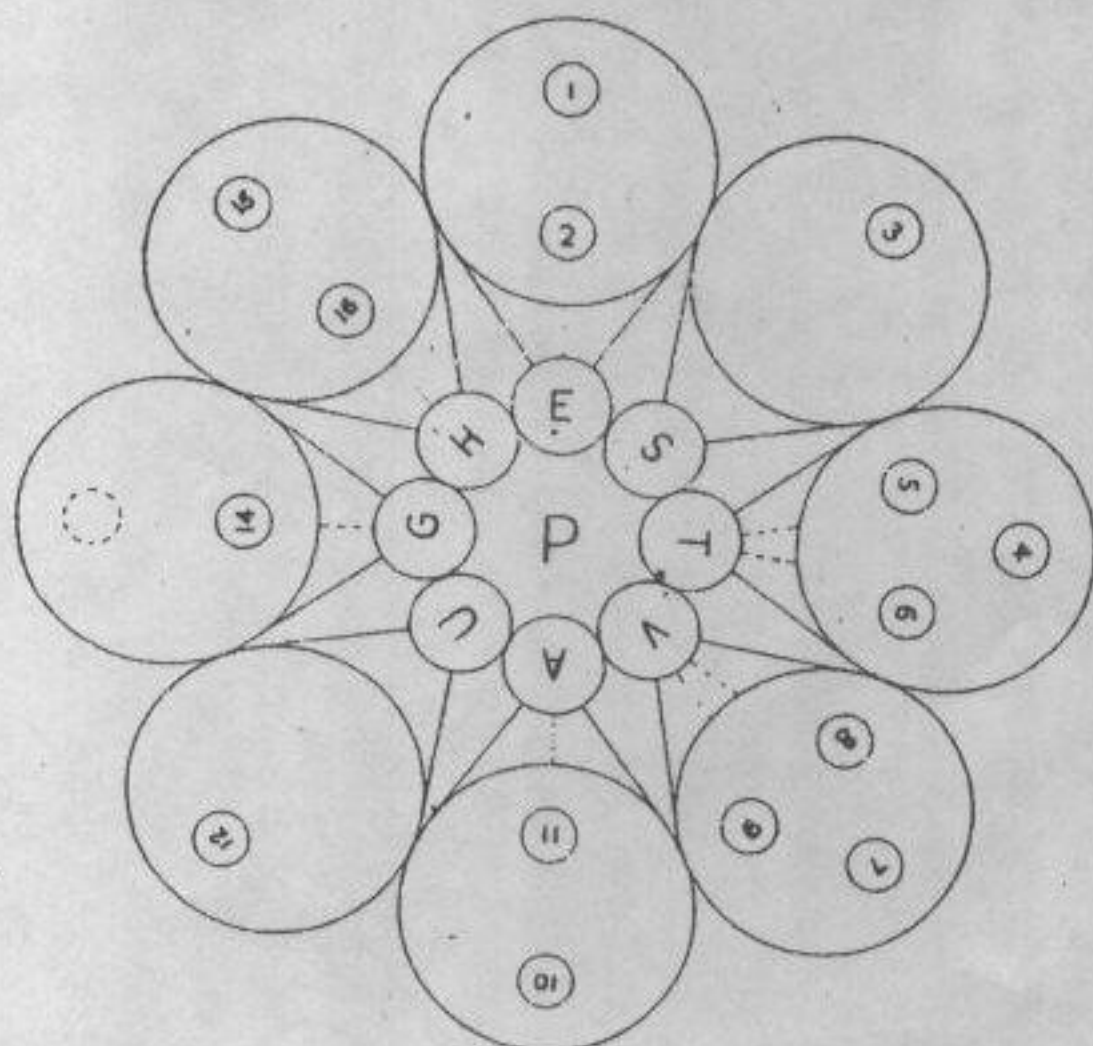


FIG. 12—Technological pattern of the nails found in Hauptmann's nail keg.

lot, viz: The keg group of 42 nails, and the personal group of 10 nails. The low numerical strength of the latter involves the absence even of die types, as shown by dotted locations. No new units occur, it will be observed.

The inescapable conclusion is that these ladder nails hail from the same technological lot as that of the contents of the keg used by Hauptmann.

It was to determine the size of this lot, by means of the size of their tumbling barrel, that the writer took occasion at this point to visit the Monessen plant, and at the same time to make a check of the findings as a whole. Investigation of mill practices as relating to the use of 8 die assemblies frequently in such an 8d. setup, and the size and handling of coils, together with the tote box charges into the buggy feeding the 16 keg tumbler, amply confirmed the details disclosed in the investigation as basically correct. In the same sense that approximately every 8 hr. there is a new die introduced

into the series by replacement, so too there is a new coil added to the setup every 8 min. Since tumbling serves, unintentionally of course, to integrate such a composition every hour, into a transient mechanical mixture of these varying and progressive phenomena, it follows that each successive discharge from the tumbler is strikingly individual after an hour's tumbling into a composite mixture of coil combinations within the closed series of die types. As a corollary, there could not therefore be more than these 16 kegs of such nails, ever produced before, or ever to be produced subsequently. Even the same state of repair of the dies is observed to be a common property of this lot.

The remarkable degree in exclusiveness, to which this technological lot is undeniably borne as a circumstance, is shown by its relationship to the total production of this type and size of nails. It is of the order of only half of one thousandth of one per cent!

The care with which the State
(CONTINUED ON PAGE 71)

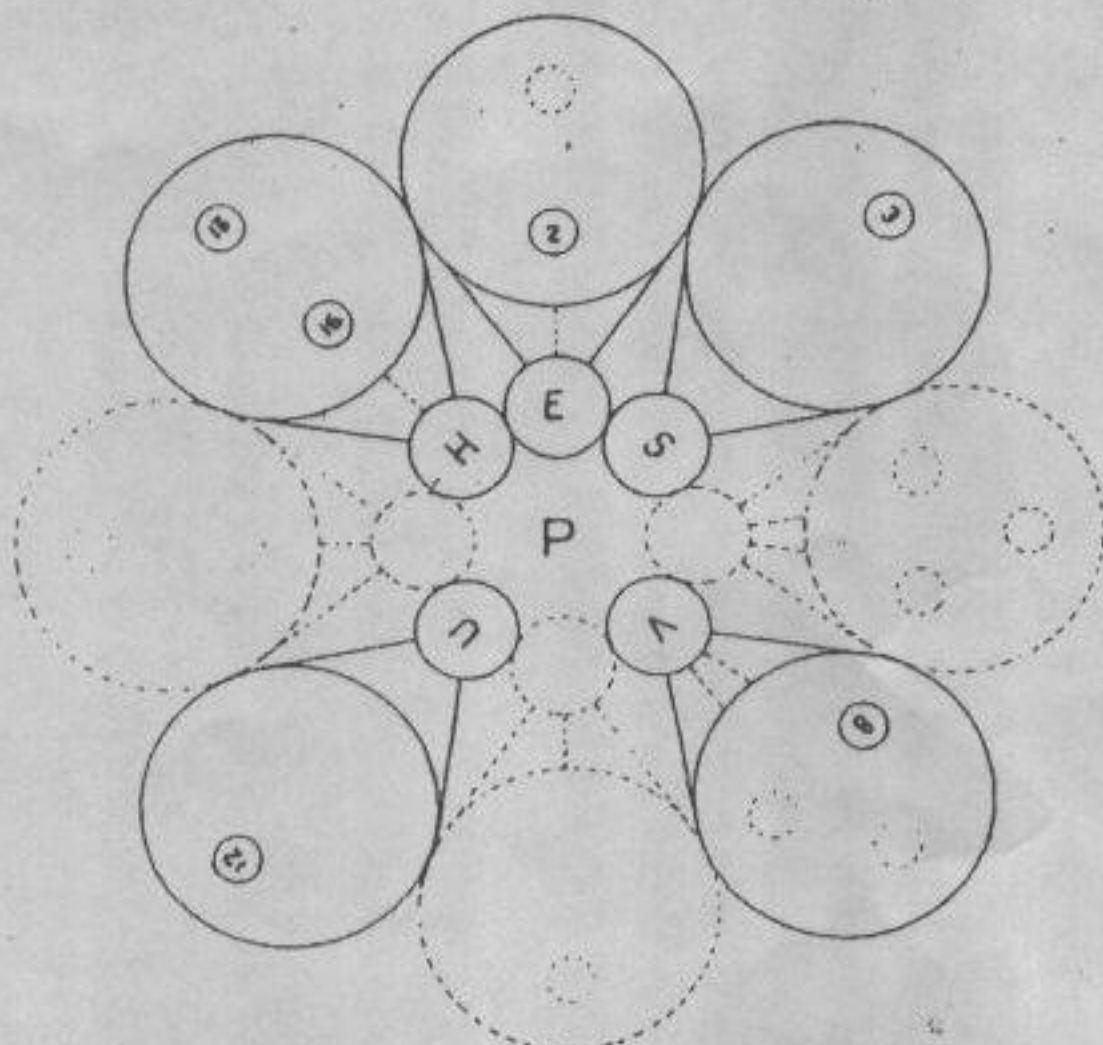


FIG. 13—Technological pattern of the nails found in Hauptmann's overalls.

Identification of Lindbergh Ladder Nails

(CONTINUED FROM PAGE 22)

jealously protected the results of these findings, awaiting the propitious moment, is illustrated by the guarded references necessary at the time the writer was prematurely called to the stand in order

to facilitate the ladder's admission as evidence without disclosing at that time the nature of this nail evidence. The sudden and unexpected collapse of the defense alibi testimony so influenced the subsequent course of the State's presentation of this evidence, which was being withheld as the final surprise blow, as to involve its final omission

altogether, in the interests of a prompt verdict favorable to the State in a quick closing. Its disclosure now is with the consent of Attorney General Wilentz, and with the desire on the writer's part, to complete the reported references thereto, in the published and broadcast statements generally made at the time.

THE IRON AGE, October 17, 1935—71

**this article was contributed
to the LKH Public Forum
by
Michael Melsky**