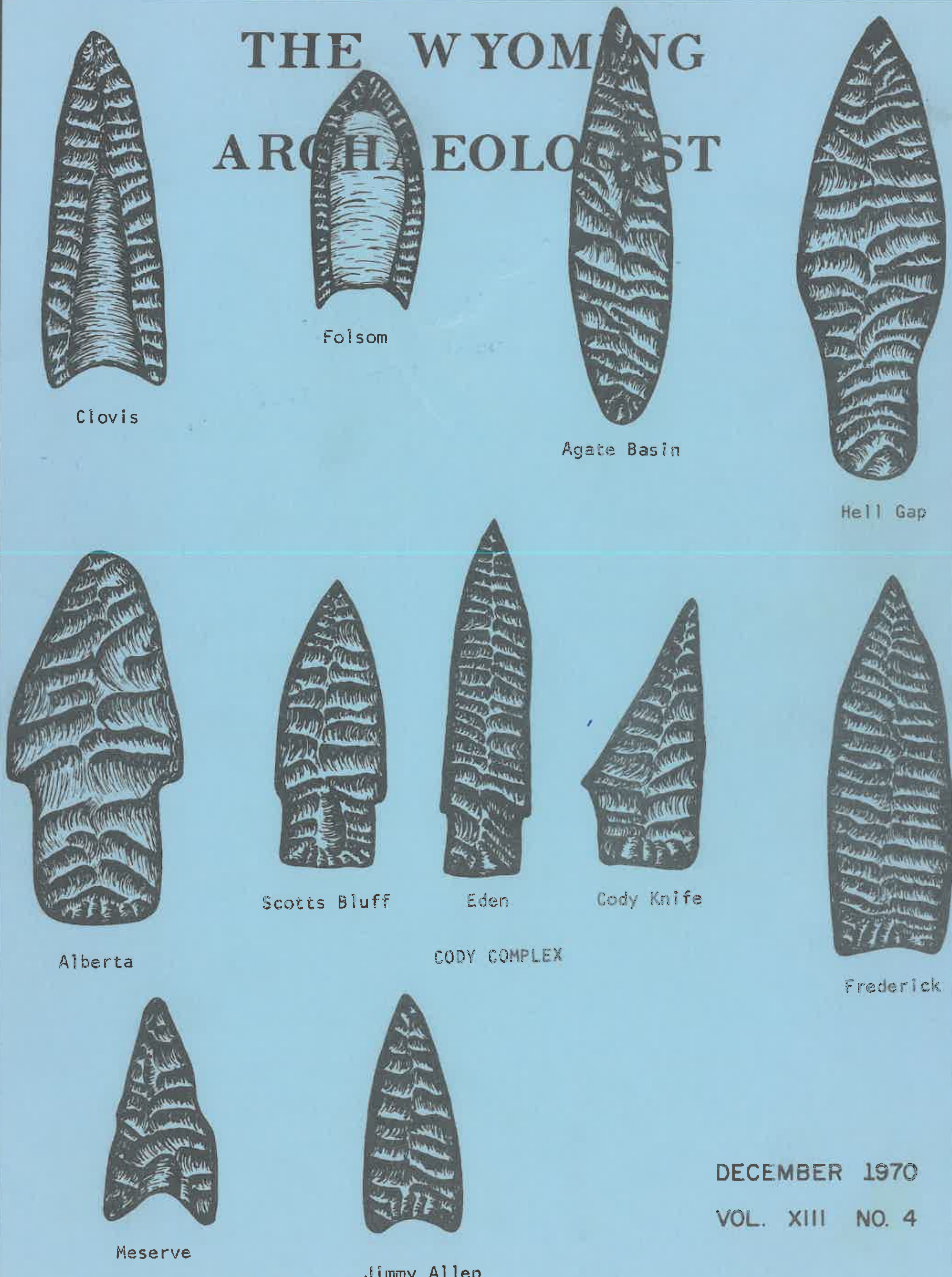
THE WYOMING ARCHAEOLOGIST



DECEMBER 1970

VOL. XIII NO. 4

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DECEMBER ISSUE CONTENTS

EDITOR'S NOTES

Our thanks to all those in the Casper Chapter, who by taping and transcribing, made possible the report of the workshop. Despite the icy roads, all were unanimous in agreeing that this must be a yearly project. To ease the burden on Dr. Frison and staff perhaps we should appoint a small working-committee to assist as this project will grow in attendance like loco weed in a prize pasture.

Again, we are indebted to John Witthoft for this fine feature on the "History of Gunflints". I hope to find some such flints in my scraper collection and would like to hear from anyone that does.

Hope to see you all at the April State Meeting.

PRESIDENT'S LETTER

Dear Fellow Member:

The first fall meeting of the Wyoming Archaeological Society was held on the University of Wyoming campus at Laramie, during this past November. In spite of the bad weather and roads, over 80 members from all over Wyoming attended. This meeting was sponsored by the Department of Anthropology and we thank Dr. George Frison and his cohorts for presenting a most successful program. The meeting was concerned with showing the amateur archaeologist the investigative techniques and interpretations used by the professional archaeologist in site work. A late Shoshone site near Farson was used as an example. Most of the material from the site, e.g., animal bones, artifacts and pottery were displayed. The step by step process of interpreting the material was shown by Dr. Frison.

It is hoped that this is the first of many similar programs that can be held annually at Laramie.

Papers of incorporation have been filed with the Secretary of State for the Wyoming Archaeological Foundation. This non-profit organization will be an adjunct to the Society and its sole purpose will be to raise and disburse funds for archaeological investigations. We hope to have it functioning within the year.

The annual state meeting will be held in Casper on April 3rd. We hope to have a meeting that is as successful as last year's. We anticipate an interesting program and group of speakers, some of whom will be from out of state. I urge all of you to attend.

Best Wishes,

JOHN ALBANESE

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A HISTORY OF GUNFLINTS

By John Witthoft*

(Reprinted from Pennsylvania Archaeologist, Bulletin of the Society for Pennsylvania Archaeology. Vol. XXXVI, June, 1966, Numbers 1 and 2.)

ABSTRACT

A technological and sociological history of gunflints is outlined. Data from archaeological and historical sources are used to clarify the hitherto little known proveniences of gunflints and of other fire-stones. Gunflint typologies are discussed. A review of the scientific principles concerning the fire-stone operation is offered, and interpretations regarding their past utility and performance are formed on the basis of experimental studies. Gunflints are shown to be useful keys for dating contact period and historic American Indian sites. As aids to students of history, gunflints are good indicators of the trade relationships that were operative among flint-bartering peoples on a worldwide basis. The manufacture of gunflints is discussed as a valid example of trade specialization and European socio-technological genesis. The techniques of gunflint manufacture recapitulate in their development the evolution of Old World prehistoric lithic traditions.

PROLOGUE

The archaeologist who finds gunflints in an Indian site of Colonial times or in debris from a settler's house is often at a loss to explain what he has. There is little relevant literature that dates from periods contemporary with the manufacture of flints. A few recent papers deal with late phases of the industry; most of these unfortunately can mislead the antiquarian in matters of interpreting flints as they come out of the ground. Today we see a turning away from published sources and those immediately interested have begun to work from the flints themselves, paying attention to context, typology, and lithic material. This paper

* John Witthoft was formerly with the Pennsylvania Historical and Museum Commission in Harrisburg and was for many years State Anthropologist for Pennsylvania. Mr. Witthoft is now Research Associate in the American Section of the University Museum, University of Pennsylvania, Philadelphia, Pennsylvania. In this capacity among other activities, he is writing a book on the nomenclature, classification, geological genesis, and characteristics of flints and of related stones.

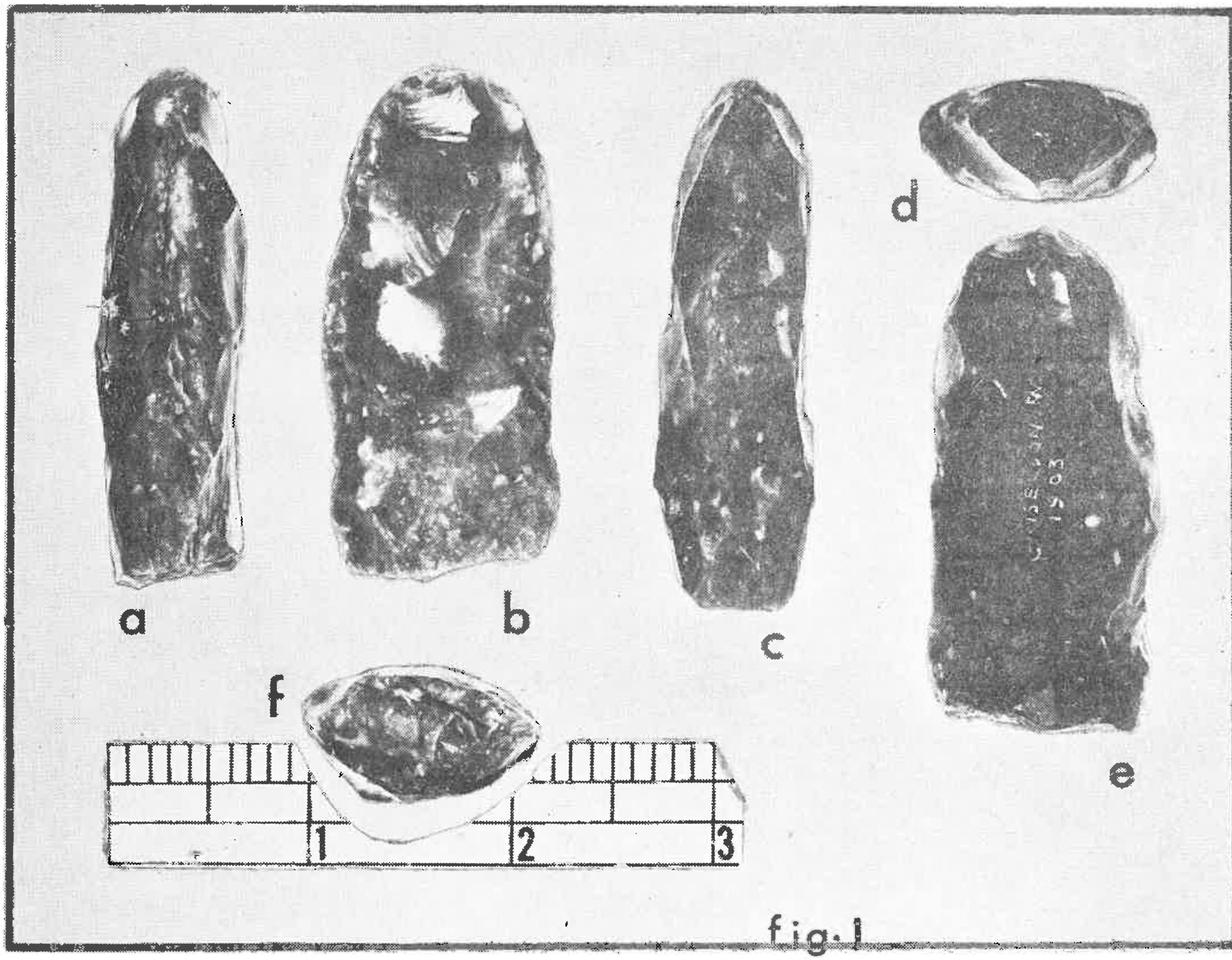

FIGURE 1

Six views of an Iron Age fire-flint, found at Chiseldon, Great Britain, in 1903. It has a blue-grey patina (developed in acid soil); patches of iron rust are preserved near the tip. All of the edges are battered and split into by strokes against steel. It probably was shaped by bifacial chipping from a massive blade of black flint. Penna. State Museum Collections, No. A64-3-85, length 2-1/2 inches.

summarizes results based upon the close study of objects and newly gathered field data.[1]

We all know and use the term "flintlock gun;" this term itself carries with it many assumptions about weapons of the past. If we turn our attention to the actual weapons of olden historic times, and if at the same time we learn to ignore preconceptions, we may put off becoming lost in a realm of not-knowing. The English word "flintlock" seems first to have been recorded in the year 1683, at least eighty years after European men are known to have first clamped flints into the vises of their weapons. We also know that the term "firelock gun" was standard after 1547, and was long used to refer to many different kinds of weapons.

INTRODUCTION

The English of the seventeenth century recognized two types of shoulder-arms, matchlock and firelock guns. When in use, the serpentine (or vise) of a matchlock carried a length of smouldering "match" or slow fuse. The match had always to be previously lit from tinder, the tinder fire in turn having come from a hand-held ignition kit. Early firelocks, invented in a bewildering variety between 1480 and 1620, were little machines designed to ignite gunpowder within the gun. A matchlock gun has to be lighted, but a firelock gun makes its own fire.

A final standard form of flintlock mechanism became stabilized before 1620; its mechanical train then remained practically unchanged for the following three

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1. I have drawn upon the specimens and ideas of innumerable colleagues in archaeology and geology, and have a heavy debt of gratitude to many for the loan of collections. Robert Ditchburn has aided me in many ways, but especially in experimental and technological studies. These would have been impossible without his series of identical standardized lock replicas made of lost-wax casts, and without his skill in the working and heat-treating of metals. My colleague, Eric de Jonge, has given me indispensable guidance and advice. His refined knowledge of the literature, guild-crafts, dialects, and history of Europe led me into many fields of study which I never would have anticipated.

My citations and bibliography are minimal, and critical papers republished in Hamilton (1960) are not included. However, the student will find every paper of significance known to us if he will combine my bibliography with those of Hamilton (1960), Pfeiffer (1912) and Evans (1872). I attemped to avoid duplicating the ground which they covered, and tried to avoid embellishing this report with documentation which they include but which is not central to my discussion.

FIGURE 2

Two firelocks with Nordic Flints still gripped in the vise, from the Strickler Site, Susquehannock of 1630-75, Cresswell, Lancaster County, Pa. a-b is a flintlock of the conventional or fully evolved type, which persisted with little change from about 1620 until almost 1920. This lock is part of an incomplete gun found in a grave with glass beads and other objects which we would date to the 1640's. It is an exceptional and early example of a flintlock; the lockplate (A) has the same shape as the lockplate of a snaphaunce. Its cock (B) has the form of the earliest flintlock cock. It has a perforation, the function of which is unknown. Its notched near stem shows a survival of the ratchet-spur on the cock of the doglock. However, this lock had no provision for a dog to catch the notch and hold the cock in safe position. An iron rod, perhaps a frizzen pick, thrust through the hole in the cock would effectively block the cock from falling from half-cocked position; I believe this was the function of the perforation in cocks of the earliest flintlock stage. The sere mechanism (C) is vertically-acting, and engages two notches in the tumbler (D). The lock is corroded together on half-cock, the safety position in which the sear enters a deep notch from which it cannot be released by the trigger. This lock was accompanied by a half-octagon barrel with a large Y-shaped rear sight and a wire front-sight, both of brass. The barrel is five feet long, of calibre 80. Trigger and trigger-guard were missing, but ramrod thimbles of brass were present. The dashed lines on the inside of the lockplate mark the edge of the cut-out in the wooden stock which received the lock. The lock had been attached to the stock by three nails. This gun represents a large military musket of the 1630's.

c-i are various views of a so-called "Jacobean" or "English" lock, one of the forerunners of the flintlock. This lock, without other gun parts, was in a grave with glass beads which we ascribe to the 1630's; the lock was probably made prior to 1620. It shows several primitive details not before noted on "Jacobean" locks.

c-d are outside and inside views of the lock as found, corroded together on half-cock. The hook-shaped cock (B) is the most primitive style known on "Jacobean" locks. A stop (E) is bolted on the outer surface of the plate (A) to prevent the cock falling too far forward when released; otherwise, the end of the mainspring (F) would become disengaged from the tumbler (D). The lock is on safety at half-cock, with the sere (C) having its beveled tip caught under the beveled overhung end of ratchet-tooth (g-G) which forms part of the inner base of the tumbler (d and g-D); the sear cannot be forced out of its interlock with the tumbler by force from the trigger, but only by drawing the cock farther back. The sear-action is horizontal, and is a mechanism carried over from the mechanical train of the wheel lock. g is a view of the sere from below, with the section of the plate (A-A) indicated by a dotted line. In this small detail, the lock is set on half-cock, as in d. The tip of the sere is caught under the tooth of the tumbler (G), but the external tip of the sere (H) does not engage the cock because the inner face of the cock is deeply recessed within the dotted line (c-I) to receive the sere-tip. When the cock is raised to full-cock, the beveled hollow within the cock passes over the beveled face of the sere tip, pushing the sear inward to disengage the half-cock stop and letting the cock pass over the sear-tip. At full-cock, the external tip of the sear rides directly against the perpendicular edge of the cock, being restrained by it as seen in h. The tumbler is provided with a stop (d-J) to prevent the cock being drawn too far. The sere is pivoted on a tab projecting from the inner face of the plate upon a rivet, the tab riding within a slot in the plate-side of the sear. The trigger presses upon the spur of the sear (d-L), forcing both sear tips out of line of contact with any part of the tumbler or cock; however, when fired, the end of the sear rests upon a high step (J) on the tumbler, being stopped at the same position at which the cock is restrained by the external stop (c-E).

Cock and tumbler are pivoted upon an axle which is welded into the cock. Its square inner part carries the tumbler, which is held in place by a pin through the axle. The sear-spring, which is compressed by pressure of the trigger upon the sear-spur, is riveted to the plate.

The battery and pan show some curious features which we have seen only on the earliest locks using flint. A bridle bridges the bolts which hold the battery and the feather spring to the plate, reinforcing their position. The battery was made in two pieces, a feature which we have seen only on archaeological locks from sites of the early seventeenth century. The lock was assembled with a gap between the pan and the base of the battery, whereas in later locks the base of the battery forms the pan cover and fits directly upon the pan. A small plate of steel, forming a separate pan-cover (e, f, i-P) was filed to a precise fit between the (e, f, i-Q) battery and the pan (e, f, i-R), and was then soldered to the battery, becoming a part of it. Details of the battery-pan assemblage are shown in e-f, looking from above and obliquely upon the inner face of the lock. The pan was made separate from the lock, and fitted against its inner surface with the powder cavity projecting outward through a rectangular cut-out in the plate. The battery is more narrow than the pan cover. The pan cover was tightly fitted to the pan, being slightly recessed into the pan at its inner edge.

h-i are reconstructions showing the position of cock and battery when the lock is on full-cock and when the lock has been fired. The cock had a long, strong throw which stroked the flint against the upper part of the battery; the forward thrust of the cock was stopped before it could contact the soldered joint between the battery and the pan-cover. The separate pan cover could be more easily fitted to the pan by filing than could a one-piece battery. However, we believe the separate cover is a carry-over from wheel locks and snaphaunces, whose pan covers are not attached

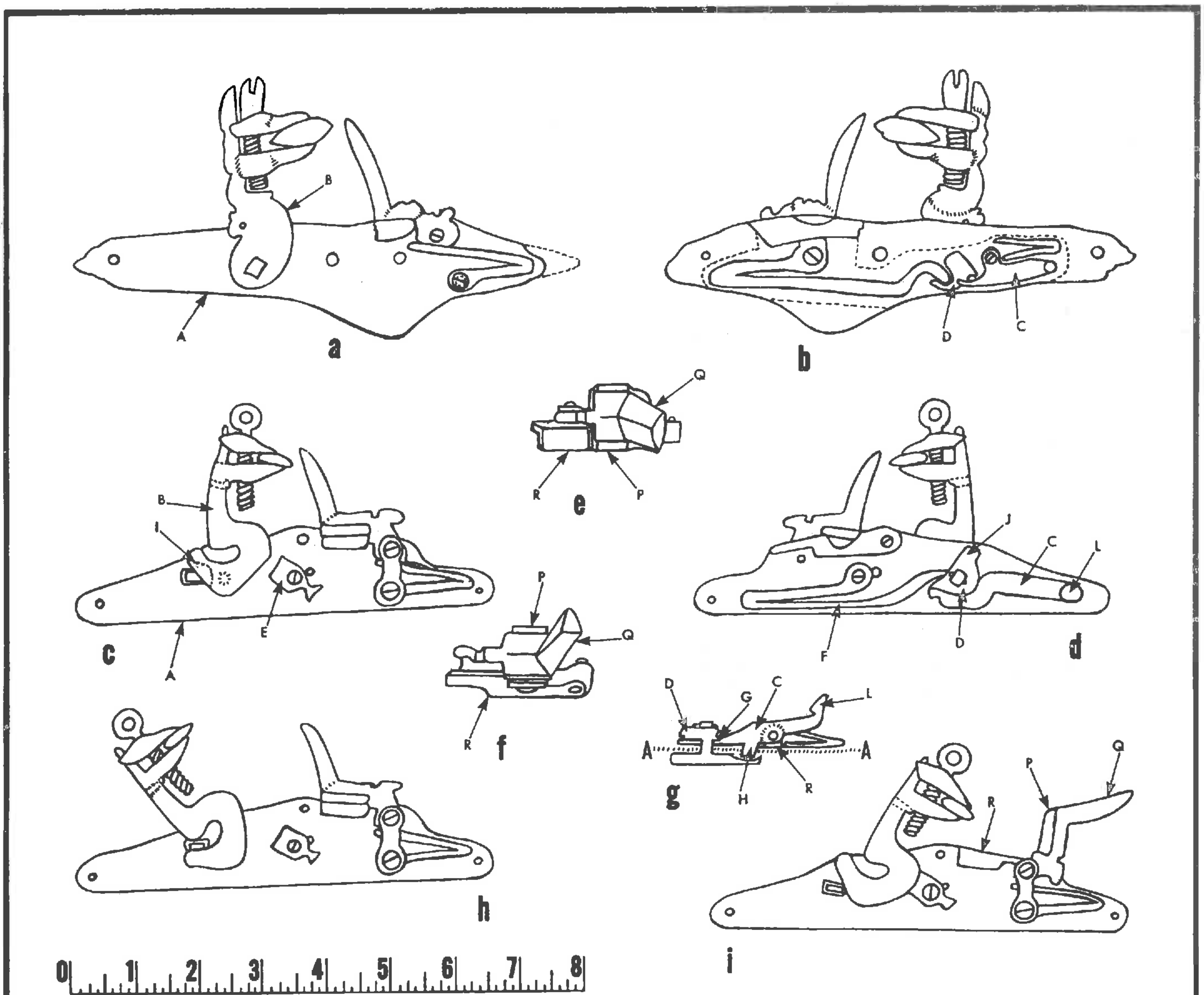


fig. 2

to the battery, but which are slid off of the pan, when the gun is fired, by a special mechanical linkage.

Editor's note: See Figs. 26-41 in: "Guns" by J. C. Blaine and R. K. Harris, pp. 33-86, "The Gilbert Site" Bulletin of the Texas Archaeological Society, Vol. 37 for 1966 published Dec. 1967.

hundred years, and consequently it was virtually the same on the last African trade guns as it was in the earliest "French" locks (Fig. 2 a, b). There are many unsolved problems in archaeology and in the history of technology having directly to do with firelock mechanisms; I shall discuss several of them. These particular problems are of special importance to American archaeology since guns became as significant to the Indian as they were to the white man.

Early firelocks were merely devices that served to mechanize standard firemaking techniques. Among firelocks, there were three main groups. The first, now called "wheel locks," stroked a toothed steel wheel against a slab of iron sulfide. The mechanics and prior history of the sulfide principle are obscure. Fragments of wheel lock guns are rarely found in American sites, although they were made from 1480 to 1700. Observations concerning the so-called "pyrites locks" have been placed at the end of my study since the information is of little direct archaeological significance and the implications follow another direction.

The second group of firelock guns, today called "transitional flintlocks", were widely used by Indians. The third group, "fully-evolved flintlocks," supplanted transitional flintlocks before 1650. The development of effective firearms coincided with the first great wave of European expansion into the New World. Our eastern Indians were "armed to the teeth" with firelock weapons before 1650. Gun parts are consequently abundant in sites and have become so useful for dating purposes that their identification details are of local interest. Among gun parts, gunflints form the largest surviving portion of any archaeological sample; they also show significant changes through time.

Firearms found in American sites of the early seventeenth century have broad implications. They form a developmental series during a stage when there was a great response by technology to military markets. They follow a period of transition during which elaborate custom-made arms were replaced in abundance by cheap and efficient stock-factory products. They show evolutionary trends from complex mechanisms to simple ones, from many parts to few parts. They also, for the first time, give us fresh insight into a crucial period in European social history. We now have, from American Indian sites, a good cross-section of firelock weapons prevalent during the Thirty Years' War (1618-48). Early Indian trade guns were the same weaponry which nearly ended civilization in Europe.

The Thirty Years' War was fought back and forth across Europe by mercenary armies who trained unpaid levees into professional brigands. They recruited itinerant form labor and cast-offs from city slums, desperate and alienated youth. Each army was a brotherhood in arms, selling its services to the highest bidder among the princes and bishops of Europe, each provisioning itself by forage and loot, eating up the countryside. Each army honored only its own officers; each was a murderous gang of thugs.

Devasting the land in the process, such armies fought the first war based upon firelock guns and upon the stockfactory production of these arms. We have not seen any dated sample of guns from resultant European battlefields, but we can now fill this gap with machines of the same age from a secondary source: the American Indian between 1630 and 1650. Rare wheel locks, scarce snap-haunces, abundant Jacobean locks and dog-locks, and a majority of fully-evolved flintlocks illustrate the terrible fire power common during the Thirty Years' War.

FLINT AND STEEL IGNITION

Fire-making by the stroke of flint upon steel may have been an ancient invention, but it was entirely a matter of empirical knowledge until the late seventeenth century, when, having examined dust from the steel, Robert Hooke (1665: 46) discovered the principle. The dust consisted of tiny, perfectly spherical drops of steel with polished surfaces. Molten steel torn from the battery forms drops; these drops are rounded by surface tension as they fall, much as happens when drops of molten lead fall from the shot-tower.

Flint is harder than steel and therefore can cut chips from it, but steel is extremely tough and elastic and so it resists shearing. Thus in fire-making, while the flint cuts a shaving from steel, frictional forces in the process are so great that the hot chip is immediately melted. The harder and tougher the steel, the greater the heat and the thinner the shaving. Ancient batteries that we have tested show a Rockwell B hardness of 52 to 54; this is extremely hard. Modern batteries which we have heat-treated to Rockwell B 56, are the best we have used.

As molten steel falls from the flint edge, it passes through air and as it does so the carbon burns out of it, in this way further raising its temperature. Therefore the higher the carbon content, the greater is the heat evolved. Burning carbon and burning iron produce the brilliant white color of a good spark. The red spark which comes from a soft battery is due to material that has only partially melted, that has cooled into an imperfect spiral, and has not been hot enough to ignite.

Although flint and steel were used in the hand long before the invention of fire-locks, few details are known. According to Pliny, the Romans made fire with the stroke of flint (silex) upon a key (clevis). Abraded steel keys are described in the literature. The beautifully made fire-steels of the Middle Ages and the Renaissance are stylistically related to keys and may well have evolved from a composite tool of earlier origin (Ladislaus Edler Von Benesch, Das Beleuchtungswesen Vom Mittelalter bis zur Mitte des XIXjahrhundrets, ..., Vienna, 1905, Pl. 55-56). The kind of flints that went with these are not known to me, if they were indeed even used against flint. Many and various ancient tools have been falsely identified as fire-flints. The early stages of gunflint manufacture and of the commercial mining of flint seem undocumented. All data regarding these areas of inquiry prior to 1780 have come out of the ground, and thus far very little information about them even of slightly later date can be found in printed sources.

Our collections include an archaeological fire-flint from England (Fig. 1). Its contexts are unknown. It has a slight blue patina. Edges show shatter, scarring, and batter from steel. Remnants of a crust of iron rust indicate that it had originally been buried with a fire-steel, and provide proof of its Iron Age date. It is thick, bifacially-flaked, and massive. I suspect that this form of the fire-flint persisted from its first use during Roman times until the sixteenth century in Europe, but I have little direct evidence to support the idea.

In his discussion of ancient fire-steels, Von Benesh (1905: 20-25) calls attention to datable miniature paintings which include fire-making sets of the fifteenth century in their depictions. These paintings show leaders of the Order of the Golden Fleece, a knighthood founded on January 10, 1429/30 by Herzog Philipp the Good of Burgundy. The Golden Fleece consisted of twenty-five Roman Catholic nobles, and extended throughout the Austrian and Spanish empires. The fire-kit was one of the heraldic emblems of the Order, and the paintings include it as a repetitive symbol, worked as a pattern upon drapes, tiles, and borders.

In each case, the fire-steel is shown with an amorphous yellow lump against its working edge. In one painting, a tiny golden sheep is substituted for the fire-stone. Evidently the sulfide was symbolically equated with the golden fleece sought by Jason, and the use of sulfide against steel was similarly equated with some tedious allegory of chivalry (Fire without and ice within). The virtual absence of flint from archaeological samples of Medieval and Roman times likewise suggests that flint was not used as part of the fire-kit. A fire-steel must be much harder to work against flint by contrast with sulfide; consequently flint may not have been the preferred material in the beginning.

In the heraldic symbolism of later centuries, a flint is substituted for the sulfide in the emblems of the Order of the Golden Fleece. I believe that flint was replacing sulfide in fire-kits of the late fifteenth century. We are sure that the flintlock gun mechanism was derived from the fire-flint, but I cannot believe that firemaking by flint and steel was an ancient technique; it is my feeling that it was first made possible by the advances of Renaissance metallurgy.

The present state of our knowledge leads us to suppose that the earliest sulfide gunlocks were contemporary with the early years of the Order of the Golden Fleece. We believe they were inventions of the Moor. A unique specimen of primitive firelock pistol, apparently made between 1400 and 1485, is preserved in the Historical Museum at Dresden, Germany (Demmin 1893: 124, 951; Feldhaus 1914:

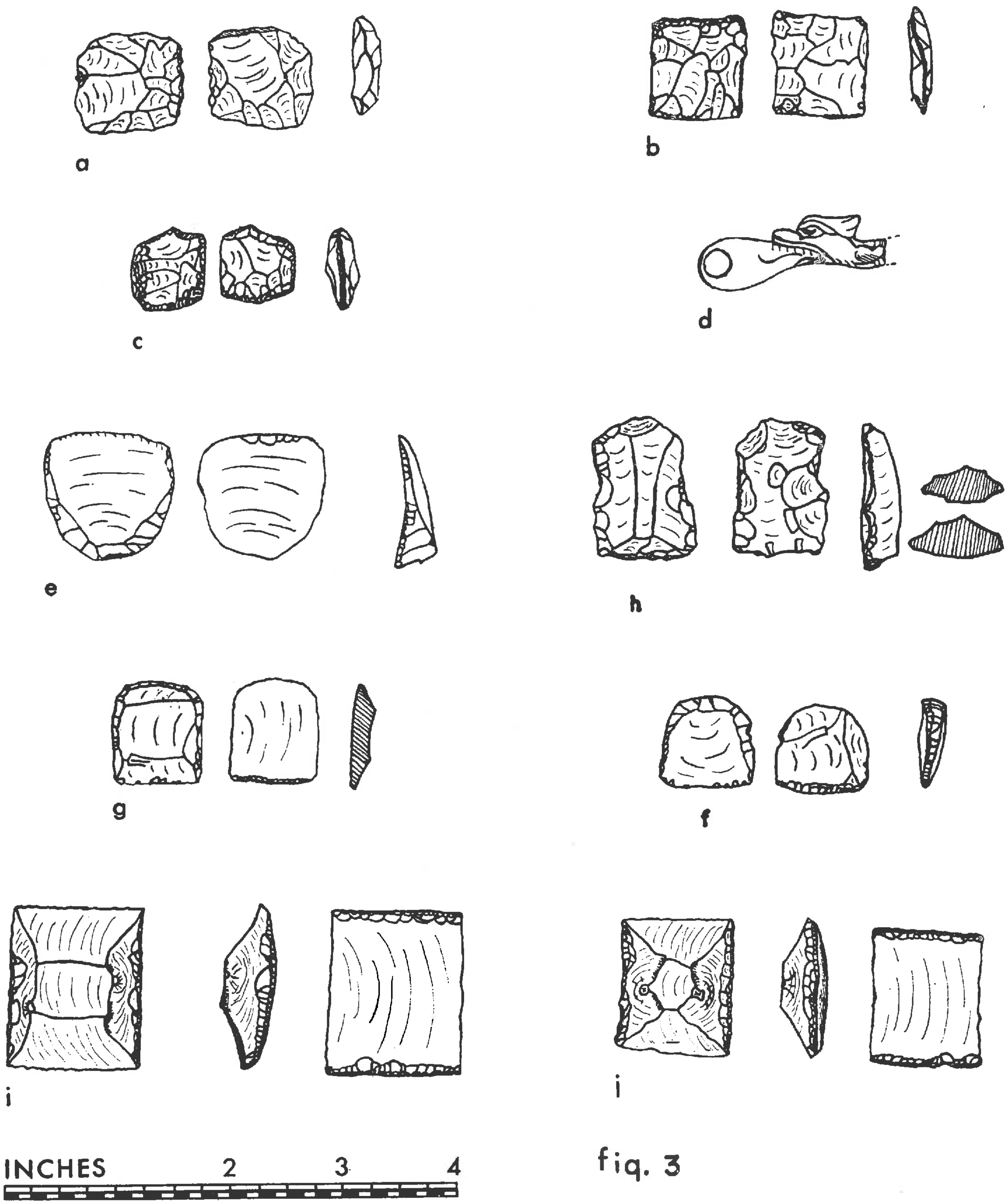
FIGURE 3

The four stages in the evolution of flint types. a, is a Nordic flint which is in the cock of a gun from grave 30, Strickler Site (Pa. State Museum, No. 438). b, is a Seneca gunflint of western New York Onondaga Chert, from the Pittsburgh area (No. H20).

c, is a Seneca gunflint of the same type, but much rechipped and worn out in use, from the Locy Site at the western edge of Lawrenceville, Tioga County (Ti 23/1). d, is the front part of a dragonhead sideplate from the same site. This engraved brass plate is from the surface and is the only example of its kind that I have seen from a Seneca site. Stylistic details indicate that this specimen is the oldest known dragon plate. The Locy Site has two components, one is of the Castle Creek. The other is Seneca at about 1640, with pottery like that of the Warren Site in the Genesee Valley. The only Seneca flint tools found here are gunflints, all of native manufacture. This site was apparently an encampment used by war parties going against the Susquehannock towns; it lies directly beyond the end of the Indian trail known locally as the "Ridge Road," that extended from Hornell, New York, to Lawrenceville, Pa.

e, is an unused Clactonian flint found with the body of the murdered Indian who had been secreted in the Pemberton Family Cemetery at Pennsbury. It was probably sized for a musket. f, is a slightly used Clactonian flint sized to the Kentucky Rifle, from the Harrisburg area (Pa01). Both are of grey outwash flint pebbles from northern Europe, and represent the second stage in flint technology.

g, is a slightly used French blade flint for the rifle, from Wyomissing Spring, Berks Co. h, is a French blade flint for the firesteel, from Fort Le Boeuf, Waterford, Pa. (S190). Both represent the third stage in flint making. i and j, from the collections of the University Museum, Philadelphia (12101 and 12088), are British flints made by Fred Snare in 1893; i is a double-edged musket flint, j a double-edged carbine flint. They are of black Brandon flint, with demi-cones of percussion that characterize the fourth stage.



fiq. 3

443-44; Held 1957: 46-47). A spring-loaded clamp for the stone is poised alongside the touch-hole and over a steel rasp. The rasp was drawn under the sulfide to ignite the powder. Only this unique example, known as "the monk's gun," has survived, and yet such simple weapons were probably commonplace until the development of the wheel lock in the 1480's.

English sulfide fire-stones came from the base of the Chalk in East Anglia. Quarries for this raw material there and elsewhere have not yet been studied. Duke Julius of Brunswick found a mine for fire-stones near Seefen in 1586, and it came to pass that his health became threatened by sulfide fumes inhaled while working the stone. This appears to be the only old reference to the working of sulfide fire-stones (Beckmann 1846: II-539).

European Names for Fire-Stones

Technological terms and names for materials are often used today with specific meanings which have been only recently defined. Their etymology as well as older meanings are often obscure. This is the case with regard to words for fire-stones. The following account, based upon the standard encyclopedic dictionaries, is a tentative one, requiring further comparative research.

Flint is an ancient word, present in Old and Middle English; similar forms occur in Old High German, Middle High German, Middle and Modern Dutch, Danish, and Swedish. It was the name used to refer to a cobblestone, a nodule, or another block of hard stone. It did not survive into Modern High German, only into northern German dialects. In modern German, Flinte means a gun, and represents the abbreviation of a loan-phrase from English or Dutch into German. Flintenstein is literally a "gun stone". Feuerstein is the standard name for flint in German, Feierstein in Pennsylvania Dutch.

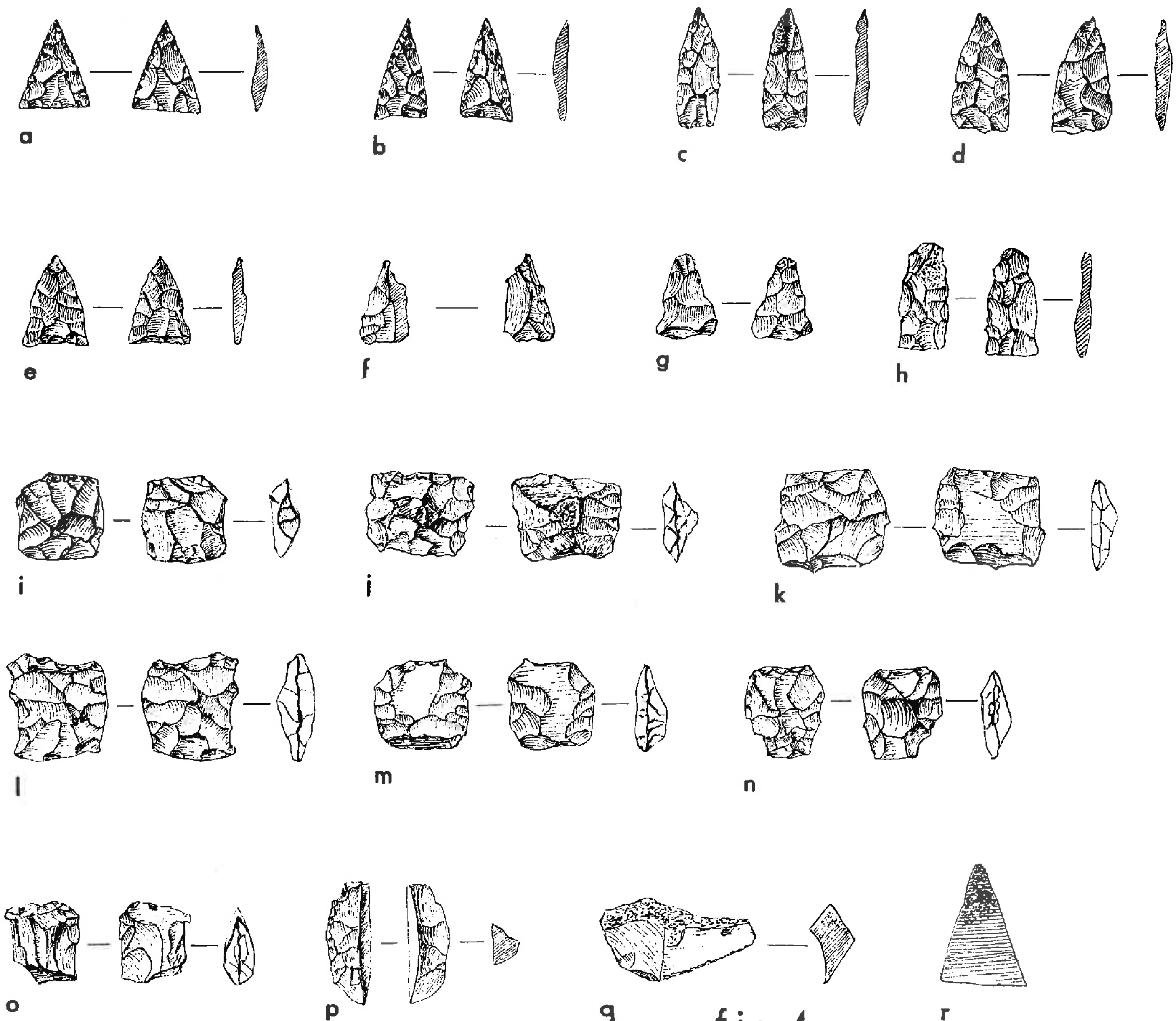
English flinder (with cognates in Norwegian and Dutch) is probably related. It is used today by British archaeologists as a term for flint chips, but its old meanings were "to shatter" and "a splinter." Plinthos, the Greek (and Latin) cognate to English flint, was a tile or a brick. Apparently the root was originally the word for any hard stony chunk, and was later given new and very restricted definitions. The north European change in meaning seems to have come about in the fifteenth century.

Caillou has been the standard French name for flint for the past two centuries. Prior to that time, it was the name for any cobblestone, nodule, or boulder. French flint-workers applied this name to the nodules they mined, and the term was transferred to their product. Silex, the French word for silica, was taken from the Latin word for pebble or cobble and redefined by eighteenth-century naturalists.

FIGURE 4

An Indian tool kit made up of eighteen pieces from a Susquehannock grave of about 1640, from the middle cemetery at the Strickler Site (Pennsylvania Archaeologist, Vol. 32, pp. 120-21, 1962), in the collection of Henry W. Heisey, Washington Boro, Pa. These were found clumped with a steel knife, and the corrosion had to be chemically removed before the tools could be identified, or even counted. These drawings are by Margaret Day Dilks.

a, brown pebble jasper, probably from the Madisonville Complex of central Ohio. b, black pebble flint, probably from the Monongahela Woodland area of western Pennsylvania. c, black flint, probably from the Fuert Complex of central Ohio. d and h, pink and white limestone chert, probably from the Middle Mississippi Complex of western Kentucky. e, black flint with an included chalcedony vein, of Elk River Flint from northeastern Maryland, probably from a site of the Townsend Complex. f and g, impact-broken Susquehannock arrowheads of pebble quartz, such as are found on the nearby Schultz Site of about 1570. i, black chalcedony gunflint, of the pebble material found on the Sherman's Creek in central Pennsylvania. j, Elk River Flint from northeastern Maryland. k, m and n, Newark jasper gunflints from northern Delaware or northeastern Maryland. l, o and p, Nordic Flint gunflints, two of them incomplete, made in Europe of material from Jutland. q, a spall from a flint beach-cobble with deep white crust, picked from a ship's ballast heap along the coast and used as a knife. r, a sheet brass arrowhead. c, is one and one-eighth inches long.



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Modern German Kies is the name for gravel or shingle, and is sometimes used in chemistry as a name for pyrite. Kies is the ancient German name for a cobble, Kiesel for a pebble. In the eighteenth century, Schwefelkies, "sulfur cobble," was used, while Lebenkies, "living cobble," was in use during the sixteenth century. In older literature, however, Kies may be either a cobblestone or a nodule of iron sulfide.

Vernacular terms used for flint and for iron sulfide had undergone such strong change in meaning that their significance in older texts is ambiguous. They refer only to a stone that is both sub-spherical and hard. Because of these vaguenesses the materials used in ancient fire-making are not identifiable through texts.

The modern mineralogical terms pyrite and marcasite have no roots in popular speech; they have been adopted from the esoteric jargon of alchemy. Equation of alchemical terms with modern mineralogical designations is sometimes impossible. Pyrites were metallic ores that could not be smelted but from which the alchemist could manufacture sulfuric acid. They included ores from which fire could be struck, and the term pyrites was extended to include some minerals from which phosphorus could be extracted. The Neo-Greek word pyrites was used for a variety of minerals, iron sulfide being but one of them. The name was more current among alchemists of northern Europe.

Marcasite was a term of southern European alchemy, found in Arabic, Middle Latin, Italian, Spanish, and French. As far as I can determine it was used to refer to non-smeltable sulfide ores, usually iron salts. When the word marcasite was introduced into northern alchemy, it was consistently used with a meaning different than pyrites. As a result the identification of the specific minerals involved became even more confused by contradictions that arose.

Indo-European languages lack any old roots which pertained specifically to the striking of fire. The development of local terminologies from general root origins suggests the recency of fire-striking. The background for this becomes apparent when we turn to broader comparative studies, to root-reconstructions, to mythology, and to ritual, and find that the oldest and most persistent kindling technique, fire-drilling, was a method coeval with the divergence of these languages.

THE EARLIEST GUNFLINTS IN NORTH AMERICA

The earliest gunflints in the Northeast occur in Indian sites that date to immediately after 1620; they are associated with a bewildering variety of lock-types: snaphaunces, doglocks, Jacobean locks (Fig. 2 c-i), and conventional flintlocks (Fig. 2 a, b). The vast majority of flints used in these early guns were made by Indians who were still making other stone tools for themselves. Flints made by Indians were copies of those imported from Europe, and can be distinguished from European flints only

FIGURE 5

Gunflints from the surface of the Oscar Liephart Site, Long Level, York County, in the collection of Joseph Wallace. His series from this Susquehannock site of 1630–75 includes 114 gunflints; the number of each type is included in parentheses in the following listing.

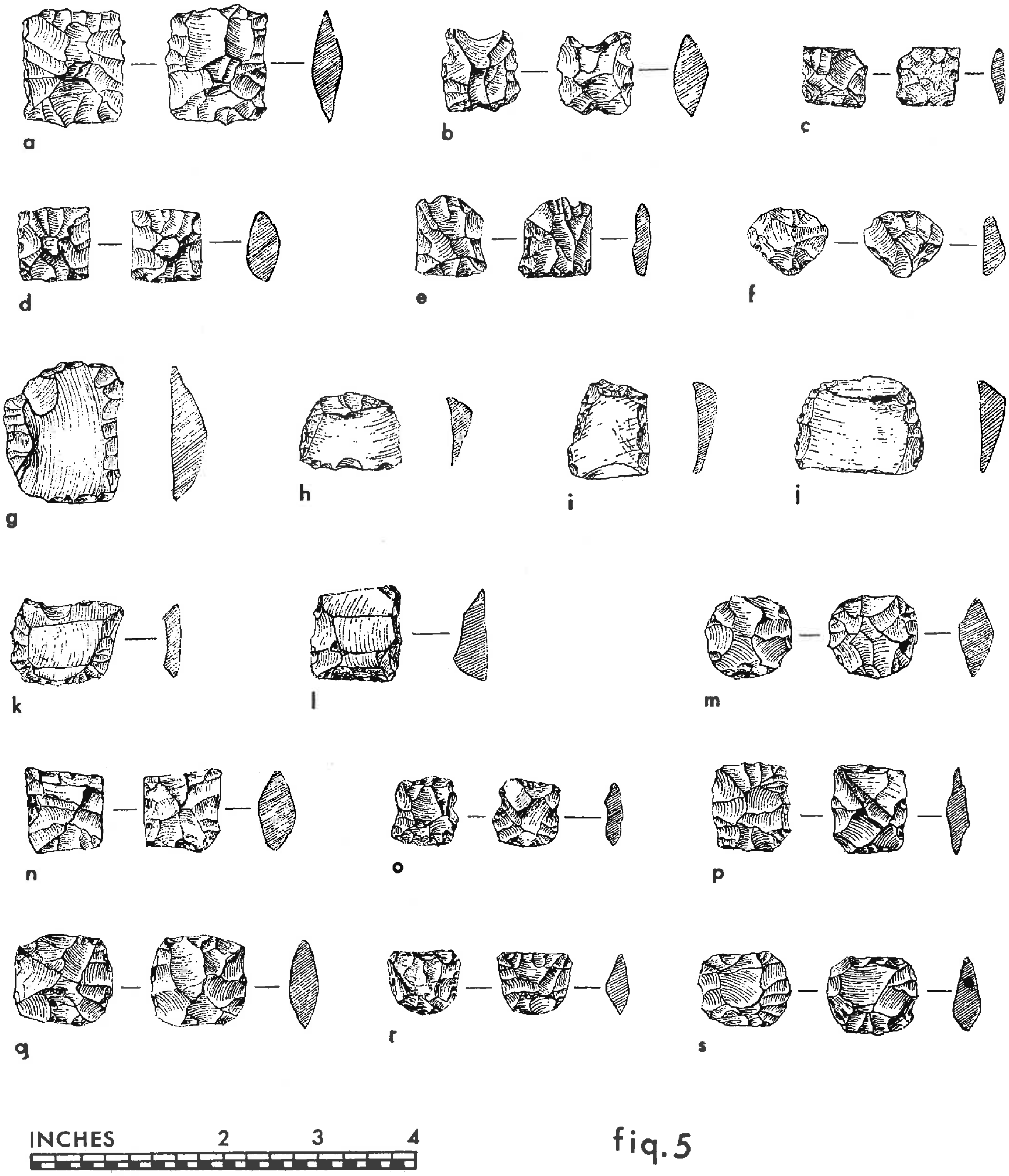
a–f, are European-made flints of Nordic stone (24 examples).

g–j, are European-made Clactonian flints from Riss outwash pebble material (10 examples).

k, is a French blade flint (3 examples). These may have been dropped by later hunters, but three of this type and material were found in a grave at the Liephart Site by Donald Liephart. Unless this was a later intrusive grave, this would be the earliest context known for a French blade flint.

l, is a British blade flint, doubtless dropped at a much later date than the Indian occupation of the Liephart Site (1 example).

m–s, are Indian-made flints chipped from chert river pebbles of the Susquehanna outwash (74 examples).



fiq.5

by the lithic material used and by the more expert flint-knapping techniques practiced by the native Americans (Fig. 3 b, c; Fig. 4 i-k, m, n; Fig. 5 m-s).

On Long Island, most gunflints were made from quartz pebbles. The Seneca made practically all that they used from western New York Onondaga Limestone Chert; their flints are noted for their delicate parallel flaking. The Susquehannock used a great variety of material. After 1720, the Conestoga[2] hunted archaeological spearpoints and broke them into fragments for use in their guns. Native manufacture of gunflints in the Northeast had actually come to an end by 1675; by this date, the flint arrowhead was itself obsolete and Indian skill at flint-working and the making of chipped stone tools had been lost. Indian-made gunflints characterize the period 1630–1675 in the Northeast. In more remote parts of the West, especially on the upper Missouri, they were still being made after 1800.

Each of our early North American gunflint samples includes a small minority of pieces made in Europe (Fig. 3 a; Fig. 4 l, o, p; Fig. 5 a–f.) When compared to native gunflints, these show little variation. They were formed from a single material, the Nordic Flint of Jutland, best known as used to make the superb Bronze Age daggers of Denmark. This is a mottled chalk flint. Danish flints show no traces of pebble surface indicating that they must have been directly flaked from outcrop or mine material. It seems likely that the flint-knappers reopened extensive Neolithic and Bronze Age flint mines.

Nordic flints were bifacially flaked by coarse percussion chipping. They are square to rectangular and pillow-shaped, with their edges bilaterally symmetrical rather than beveled toward one face. Most of them are tiny. Their technology can be characterized as "Abbevillean." They are found clamped in the vises of guns, are associated with fire-steels, and occur as parts of tool kits in grave lots. With the exception of occasional nodules of ballast rock carried by Indians from the coast they are the only European flint that I have seen in contexts that date prior to 1675. The thick bilateral edges common to Nordic flints seem to be well suited to the high angle at which the vise drives the flint against the battery in early guns. In later locks, the flint grazes and scrapes along the battery at an acute angle; in early locks the angle of blow is quite obtuse.

FLINTS OF ALBANIA

Other bifacially-flaked gunflints are known. Nineteenth century flints from Albania, associated with Turkish and Arabic guns and with Turkish fire-making sets, are of the same form, but the few examples I have seen are larger. They were

2. The Conestoga were a community of Seneca who settled near present Lancaster, Pa., some time after 1679, absorbing a remnant of original Susquehannocks. The Conestoga were slaughtered to the last person by the Paxton Boys in 1763.

made of a slightly granular, waxy yellow flint. The antiquity and origins of this industry are unknown. Turkish locks have a very high striking angle, one of the features that makes them look superficially like a miquelet lock. I suspect there is a functional relationship between the shape of the flintedge and the striking angle. In both turkish guns and early flintlocks, a high striking-angle seems to be a manufacturing carry-over from the snaphaunce. Snaphaunce locks from Indian graves in North America contain bifacially-flaked Nordic flints. Mediterranean locks, even those produced in recent times, have the high striking angle best adapted to Albanian flints. Like the snaphaunce, they require a forcible blow from the vise to throw open the pan-cover and to draw a spark from the small steel of the battery. The Albanian industry was studied by Evans (1887) during the last century.

Albanian shops also made teeth for the trillo (tribulum in Latin); the threshing sledge of classical antiquity. This is a broad ash plank, turned upwards at the front, dragged over grain on the threshing floor by oxen. Its flat base was armed with flint teeth, now replaced by stainless steel teeth in the two areas where it survives, Spain and the Balkans. Our word tribulation comes from its Latin name, and means "to be torn by the trillo" (Witthoft 1955: 23).

A model (one-fourth size, with fullsized teeth) is preserved in the collections of the Commercial Museum of the City of Philadelphia, and was made in the Dardanelles area prior to 1892. It is equipped with flakes of Albanian flint. Because of their uniformity, the teeth are obviously a standard shop-product. They are triangular in outline (two inches long) and triangular in cross-section (three-fourths of an inch wide), closely resembling the flake of a Mousterian point. Each was set edgewise, its point forward, into a slit made in the green ash. As the ash dried and shrank, the flint chip was gripped tightly in its slot. I have never seen another Albanian trillo flint, but they may be present and should be looked for in archaeological collections from southern Europe.

Albanian flints are not well known and yet their history is of considerable importance. If, as we suspect, the investion of gunpowder and other early inventions having to do with making firearms were discoveries of the Moor, Albanian flints might represent the ancestor of all European gunflints.

Albanian flints pose a critical problem in the New World. We have been able to identify the flints used by the nations of northern Europe. They first used Nordic flints, then they used Dutch flints, later French flints, and finally British flints; this sequence was never disrupted by political or military alliances. Gunflints represent only the verities of international commerce and technical superiority. What gunflints did the Spaniards use in their miquelet locks during the great age of native slaughter and New World conquest in Central and South America? I have seen very few examples, and all of these were found on the surfaces of

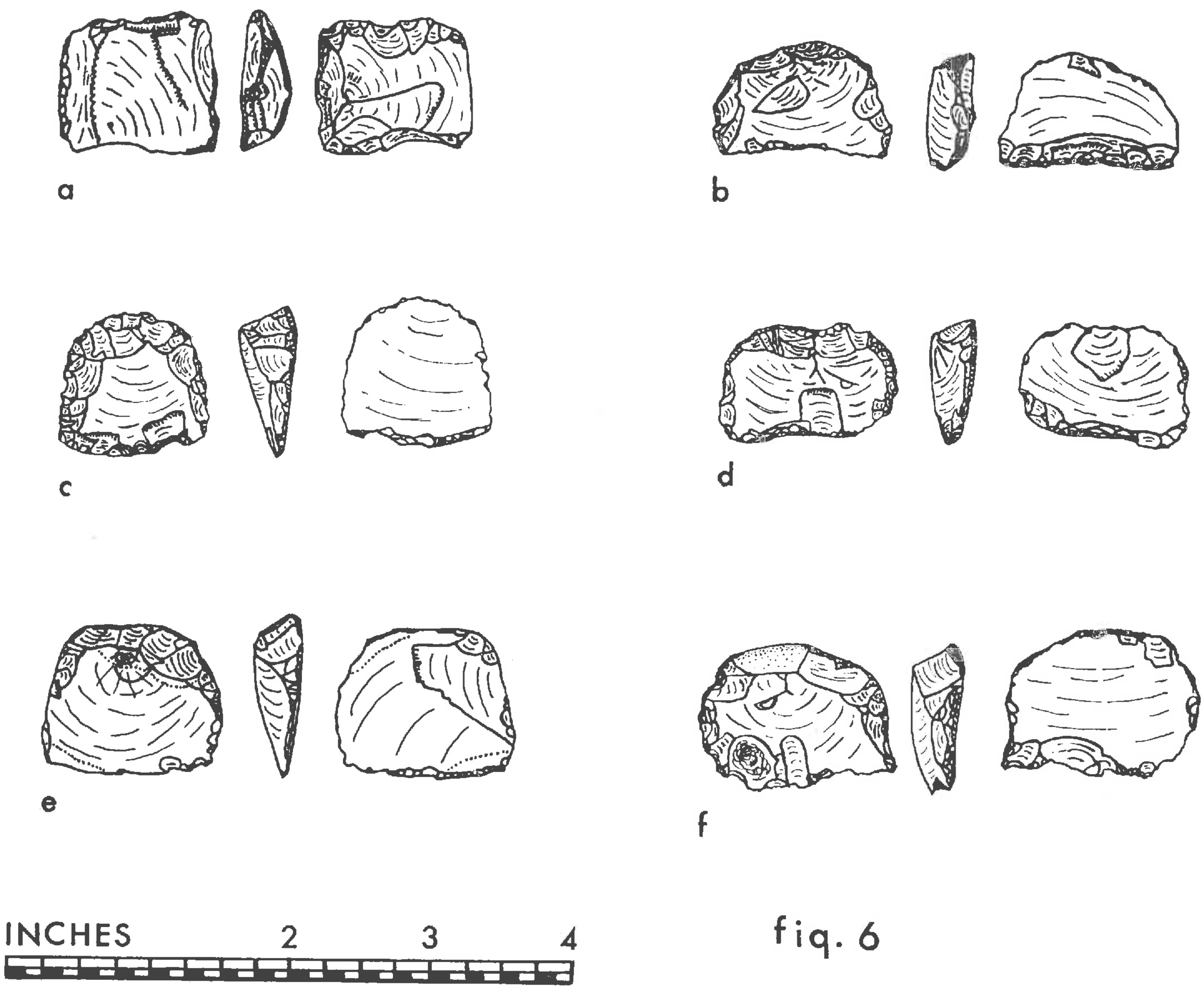


FIGURE 6

Wedge-shaped Clactonian gunflints of north European pebble flints, from the site of Old Kuskuskies, the Wyandott town of about 1748-50 at West Pittsburgh, Pa. From the collection of Marco Hervatin.

Spanish colonial sites in Latin America. Nevertheless, they are classic Albanian flints.

GUNFLINTS OF THE EARLY EIGHTEENTH CENTURY

At some time between 1650 and 1700, bifacial flints of Nordic stone became obsolescent, and were replaced by a new type made from a different material. T.M. Hamilton (1960: 73-79), following my notes, has named these "gunspalls", a term for which I have little enthusiasm. The new wedge-shaped gunflint type first appeared in the seventeenth century, perhaps as early as 1650. In its turn it became obsolete by 1770. During this time span its earlier and later stages overlapped other types and it was in competition with them.

The preponderant gunflint of the early 1700's is a wedge-shaped flake struck from a flint pebble. Many examples show traces of the cobble rind. None shows any trace of the cortex of an outcrop-nodule. The material includes a broad range of drab, mottled grey-black to dark grey to grey to tan to whitish cherts. This range in material conforms to the range found in flint pebbles of the Riss glacial outwash of the north European Plain, and not to that known for any other outwash. The Low Countries must have been the source. A single early author (Beckmann 1846: II-538) mentions the former manufacture of gunflints in the Netherlands, at Stevensklint in Zeeland.

In our samples, the majority are of a grey to grey-black chalk flint containing scattered tiny white voids. A few have concentric agate-like zones of black chalcedony. This material corresponds to the Cretaceous flints in the area of the Belgian coal-fields. A small number are of other colors; a yellowish shade predominates among these. A large minority are of a non-translucent, dull, grey to tan to brown, chert of different character. This material is well-known in modern commerce as "Belgian honestone" or "Belgian agate". It was formerly used for fine-grained hones, much like the "India stones" of modern mechanics. It is still widely used as grinding balls in the tubemills of the chemical and ceramic industries, retailed as natural till pebbles sorted to size. It is properly a novaculite (chert filled with microscopic voids, of an open spongy texture) much like the hone material of Arkansas. The Belgian stone is known for its tough, non-brittle character.

"Belgian honestone" is found only in Riss Outwash of the Low Counties where its original geological contexts are not indicated. It was probably carried by glaciers coming from Scandinavian centers, and originated in areas now beneath the sea or obliterated by Pleistocene erosion. Pebbles of chalk flint from the same outwash match the materials of our other wedge-shaped flints. Thus I attribute the same origin to all wedge-shaped flints.

Dutch gunflints were made in a "Clactonian" technique (Baden-Powell 1949). The convex, rounded face of each flake was formed by the cleavage which broke flake from core, quite the opposite of what one might assume at first glance. Flaking must have been done with a heavy steel hammer with the pebble resting directly upon a steel anvil. The angle formed by intersection of the striking platform with the core-face of the spall ranges between 95 and 140 degrees, with a median of 123 degrees (on specimens where the platform has not been modified by secondary chipping). These ranges indicate a "Clactonian" industry in the most severe definition of the term. Flakes were removed by heavy blows, with an average rotation of about 30 degrees between flakes drawn from a discoidal core. Thirty per cent of the flakes have a two-faceted platform; the rest show a plane platform. About 10 per cent show scars on their concave surfaces from the removal of two earlier flakes off the core; the rest show only one flake scar as a mark of prior flaking from the core. Thus each pebble produced relatively few gunflints for the volume of the core.

Flaking blows were so heavy that an occasional specimen has had a cone of percussion driven out of the gunflint (Fig. 8 d). Three per cent show a partially-cleaved cone of percussion still imbedded in the flint. A distorted, broadened part of the impacted cone forms the top surface of the flint; the rest of the cone subtends an angle of 60 degrees within the flint. This indicates that the flaking blow was a vector at an angle of 30 degrees to the plane of the striking platform. This is characteristic of Clactonian flaking done upon an anvil of dense, elastic material.

The appearance of wedge-shaped gunflints and the consequent obsolescence of bifacial flints represent a revolution in gunflint technology. It also marked the death of an industry in one area and its birth in a nearby region. Change to the "Clactonian" technique represented a cultural advance, for wedge-shaped flints were made more rapidly, with less effort, and from more readily obtained material. They were trimmed into final shape by slight retouch and had a thin, acute striking edge, easily rechipped to a more obtuse angle. Their striking edges ranged from 3 degrees to 25 degrees before retouch and averaged 8 degrees. Unused examples have a raw edge, so we assume from this evidence that the striking angle was shaped by the user; setting the flint in the vise and nipping it with the heel of the battery is a well-known method for edging gunflints. At the time of the emergence of wedge-shaped flints, locks had evolved in the direction of a more acute striking angle between flint and battery; the new flints were better adapted to a grazing stroke than were earlier bifacial flints. At the same time, centers of European gun manufacture had become concentrated in the Netherlands, where the stock-factory was a forerunner of the Industrial Revolution. Wedge-shaped gunflints were made right in the areas of mass-production of firearms.

Wedge-shaped gunflints gradually relinquished their place to prismatic French flints. The earliest date for French flints is uncertain. Every large sample of

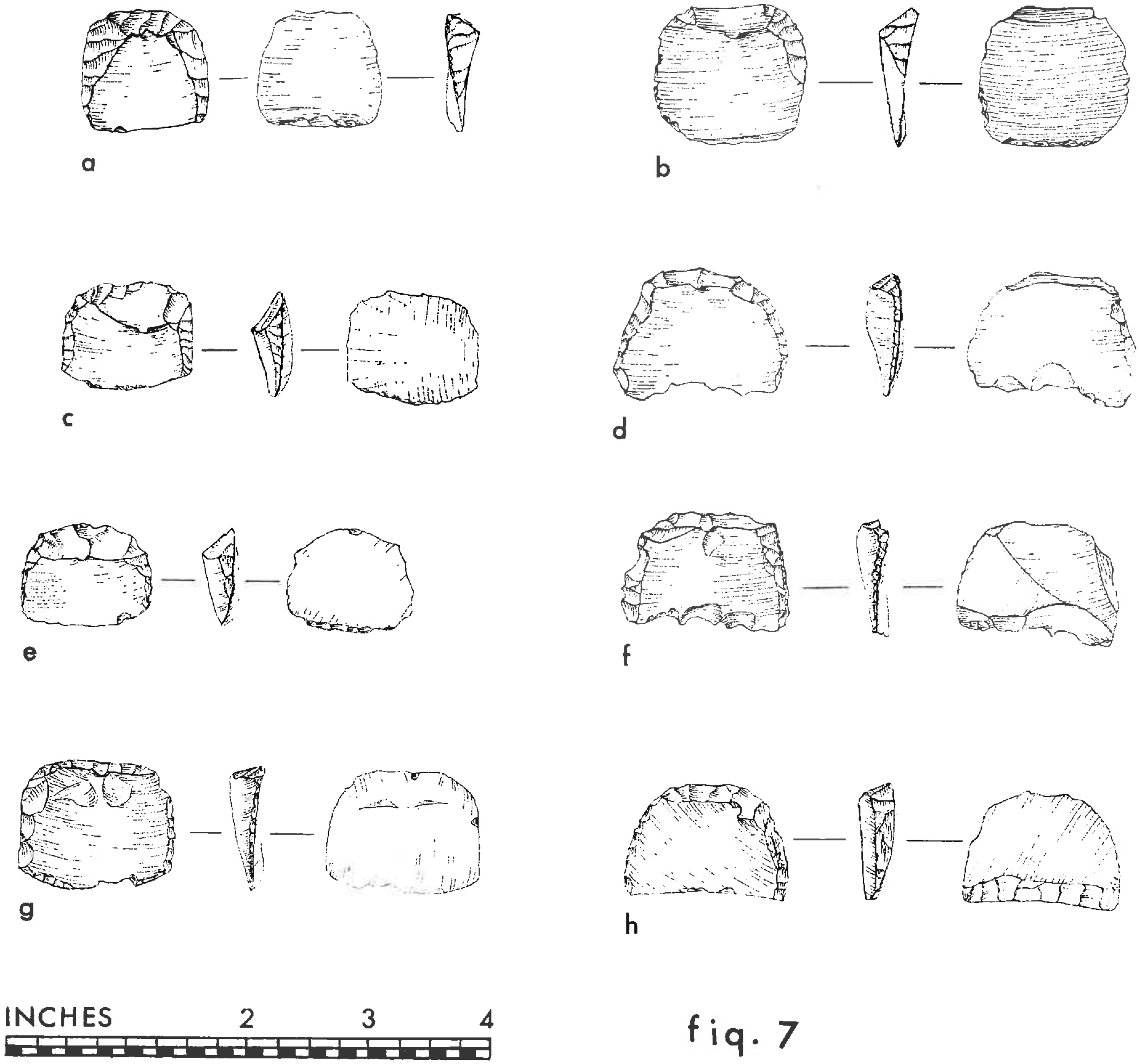


FIGURE 7

Wedge-shaped flints in Clactonian style from the 1962 excavations in a French component at Fort Michilimackinac, Mackinac Island, Michigan, located in the collections of the Mackinac Island State Park Commission. Catalog numbers are included (below) for these drawings by Margaret Day Dilks. All illustrated examples are of north European pebble material.

a-MS2 1816; b-MS2 1962; c-MS2 1857; d-MS3 1898; e-MS2 1960; f-MS2 1940; g-MS2 1778; h-MS2 1926.

wedge-shaped flints includes a few French flints, but generally so few that they may simply represent later cultural contamination of the sites. I believe that a few French flints may have been made before 1675, but that they were not an ordinary article of commerce until later than 1740. Judging in terms of the evidence from military sites in North America, by 1775 the French flint was the only type made.

FRENCH FLINTS OF THE EIGHTEENTH CENTURY

French flints are of extreme interest because in the way they are made, they represent the independent invention or reconstruction of a refined blade-technique that had first appeared with the Upper Paleolithic and had then been lost during Bronze Age times. This manufacturing method again constitutes a cultural advance because the technique is beautifully adapted to produce a highly standardized form, and to obtain the largest number of standard units from a nodule of mined flint with the least wastage of material or labor. The appearance of French flints meant that, in skill, a great leap forward had been accomplished.

French flints were made from long straight strap-like flakes, properly and technically called blades. Blades were struck from cores shaped out of nodules dug from the chalk. We suspect that French workmen first found the proper stratum of flint-bearing chalk within Upper Cretaceous beds by reopening Neolithic shafts and drifts they could have discovered while reworking ancient workshop debris. It is barely possible that the first French gunflint-workers actually used archaeological blade-tools and cores as models. French blades of the eighteenth century were five to seven inches long, and were snapped into four or five pieces. The broken-off ends of these segments were then shaped and blunted by a dulling vertical percussion retouch (by backing, as the technique is called when describing Upper Paleolithic tools). Early French gunflint blades were snapped into comparatively long sections, which were finished into wide flints. Perhaps the sectioning technique was not yet perfected, and narrow segments were difficult to make. At any rate, most older French flints were too wide to fit the usual gunlocks of that time, and were only adaptable to fire-making and to the massive locks of military muskets.

Dated samples are available from the Wyandotte Town (1748-50) at West Pittsburgh, Pa.,[3] from Fort Leboeuf (1755-57) at Waterford, Pa.,[4] and from French Fort Michilimackinac (1715-61) in northern Michigan.[5] These collections include a majority

3. Collection of Marco Hervatin, West Pittsburgh, Lawrence County, Pa.

4. Thirty-five Dutch and ten French flints in collections of the Pennsylvania State Museum, Harrisburg.

5. Twenty-four French and 144 Dutch flints from a sealed layer of the French period excavated in 1963, in the collections of the Mackinac Island State Park Commission, Mackinac, Michigan.

of wedge-shaped flints, most of them in small sizes to fit the normal fowlers and trade guns of that time, a few of them sized to the Charleville Musket. French flints are a small minority, more than a third of them with concave edges shaped by use against the fire-steel. Prior to 1760, French flints were designed more for fire-making. Dutch flints more for guns. However, many Dutch flints also show use against the fire-steel.

British sites of the same age are not yet as well studied. Samples from Fort Ligonier, Pa., a British depot of the 1750's, include a small minority of French flints.[6] However, Dutch and French flints from Ligonier are primarily large sizes designed for the Tower Musket. Ligonier was visited by British regular troops; on the other hand the French posts were largely staffed by Indians and voyageurs. A small sample of about 50 flints from Fort Stanwix at Rome, N. Y., comes from two stratigraphic units.[7] The lower unit (1757-68) produced only wedge-shaped Dutch flints; the upper unit, associated with the refitting of the fort in 1777, produced only French blade flints. Even small gunflint samples are very sensitive in distinguishing between military occupations of the French and Indian War and those of the Revolution. Neither horizon is known to include any British flints. They apparently were not yet being made in Great Britain.

American military sites of the Revolution, whether British or American, exhibit a uniform monotony with regard to gunflints found in them. Practically all are French blade flints, although a single wedge-shaped musket flint was discovered in excavations at Valley Forge (Fig. 9 e). We believe that this unique specimen was carried back to service in the Continental Line in the vise of an older musket owned by a veteran of the French and Indian wars. Flints used in muskets of the Revolution normally have a single edge, with the rear of the flint backed to a semi-circular outline. Smaller French flints for rifles and for pocket pistols occur in fair numbers, but British flints are scarcely in evidence.

In seventeenth century sites, there is no typological difference between a gunflint and a flint used against a fire-steel. They can only be distinguished from one another by use-marks. A type difference first appears with French blade flints; those for the fire-steel are often double-edged and average wider than gunflints. Those for the gunlock have their back edge blunted to a semi-circular outline. Prior to 1760, the majority of French flints were designed for the fire-steel. Not until the Revolution do we see any evidence of French concentration on the making of gunflints rather than on the manufacture of flints for the fire-steel.

6. Collections of the Mellon Foundation at Fort Ligonier, Pa.

7. Excavated by Duncan Campbell and Robert Ditchburn for the City of Rome in 1965.

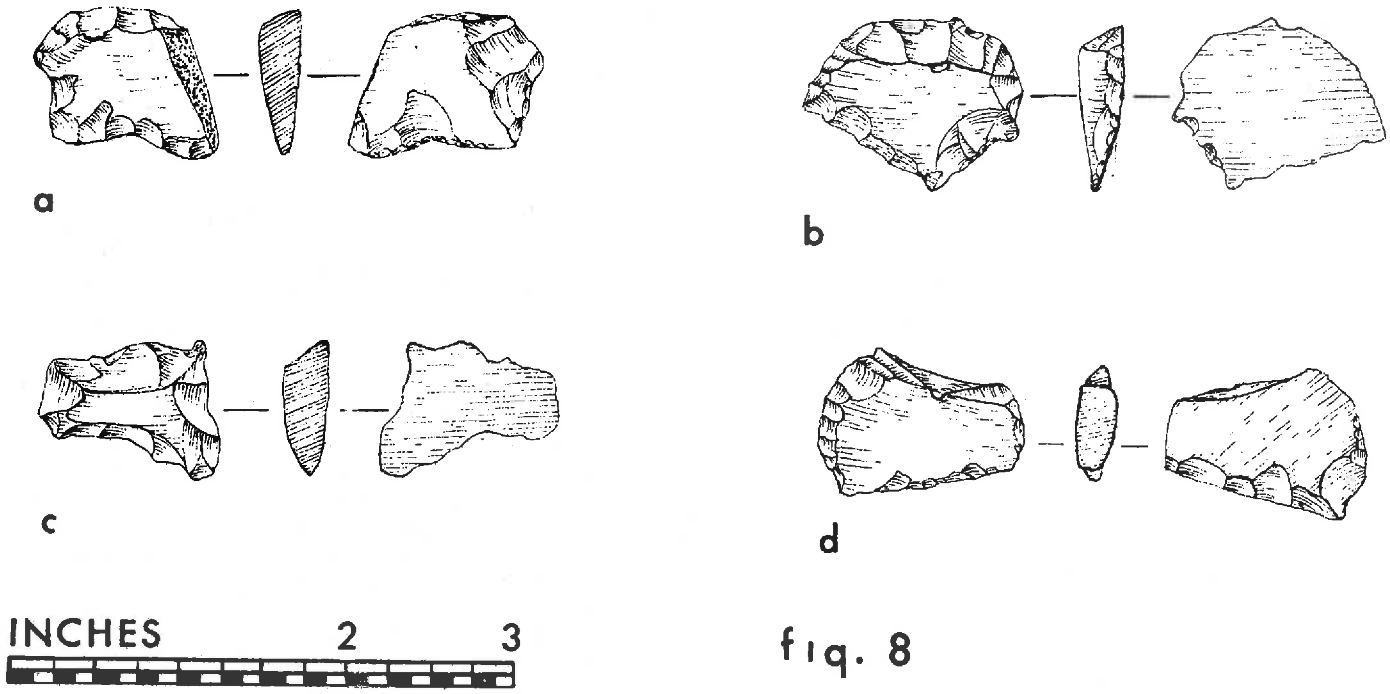


FIGURE 8

Wedge-shaped flints from French Fort Michilimackinac, drawn by Margaret Day Dilks. The first (a) shows a pebble rind on its right edge. The fourth (d) has had a cone of percussion driven out of it by too severe a flaking blow. The other three show extensive use against a fire-steel rather than in a gunlock.

a-MS3 1941; b-MS2 1962; c-MS2 1912; d-MS2 1937.

Continued study and research has made it possible for us to be able to identify with considerable certainty the source of lithic materials used as flints. In my own early attempts to differentiate flints, the variable wedge-shaped examples led me far astray. I at first interpreted the blackish flints as British pebbles, the yellowish flints as French pebbles, and others as pebbles from different strata in France and England. I had not suspected the existence of undocumented gunflint industries in other areas. Since that time, checking wedge-shaped flints against European samples has demonstrated their true origin. Wedge-shaped flints include scarcely any examples of the distinct phases of French or British flint. A little of it would surely be present if these drift pebbles had come from any area that held debris within southeastern England or the Paris or Loire basins. The range of material in wedge-shaped flints does, however, correspond precisely with the pebble content of a specific drift; this drift is found only in the Low Countries. Therefore regardless of what nondescript flint may be found on exposures and in the country-till of these areas, we can eliminate France and England from any consideration as early sources for gunflints.

French flints are yellow in color, have a waxy lustre, and are quite translucent. The very finest grades, which we rarely see, are light in color and nearly transparent on thin edges. The stone often includes little burrow-like spaces that are lined with a thin layer of chalky crust, but real chalky zones in this flint (the "chalkheels" of the British knapper) are not usual. Smith and others doubt the validity of these identifications of European gunflint materials; they claim that other flints were available and other sources show evidence of exploitation in each area (Hamilton 1960: 49). This does not fit old statements which describe the workmen of both France and England as mining one particular stratum out of many flint-bearing levels for gunflints, and as mining other different strata to obtain mason's stone and flint for other purposes. French workmen could have made gunflints from other kinds of chalk-flint, but that they did this is most unlikely because the evidence indicates that they were turning out a standardized product from a homogeneous source of material. The same was true in England at a later date.

The specific flint varieties used in England can be distingushed from those of France, Belgium, Albania, and Poland by their color, texture, and the form of their chalky voids. Our efforts to find more fundamental differences between the various chalk-flints of Europe have met with little success and attempts to find chemical and petrographic differences which might further serve to distinguish them have been fruitless. All the flints come from equivalent horizons within the Upper Cretaceous, and consequently have nearly identical mineralogical characteristics. As has long been suspected (Wallich 1880), only such gross features as color and texture really serve to distinguish the flint varieties.

One set of criteria might be promising that has not yet been studied. If the flints from the separate areas were formed at different temperatures, perhaps they could

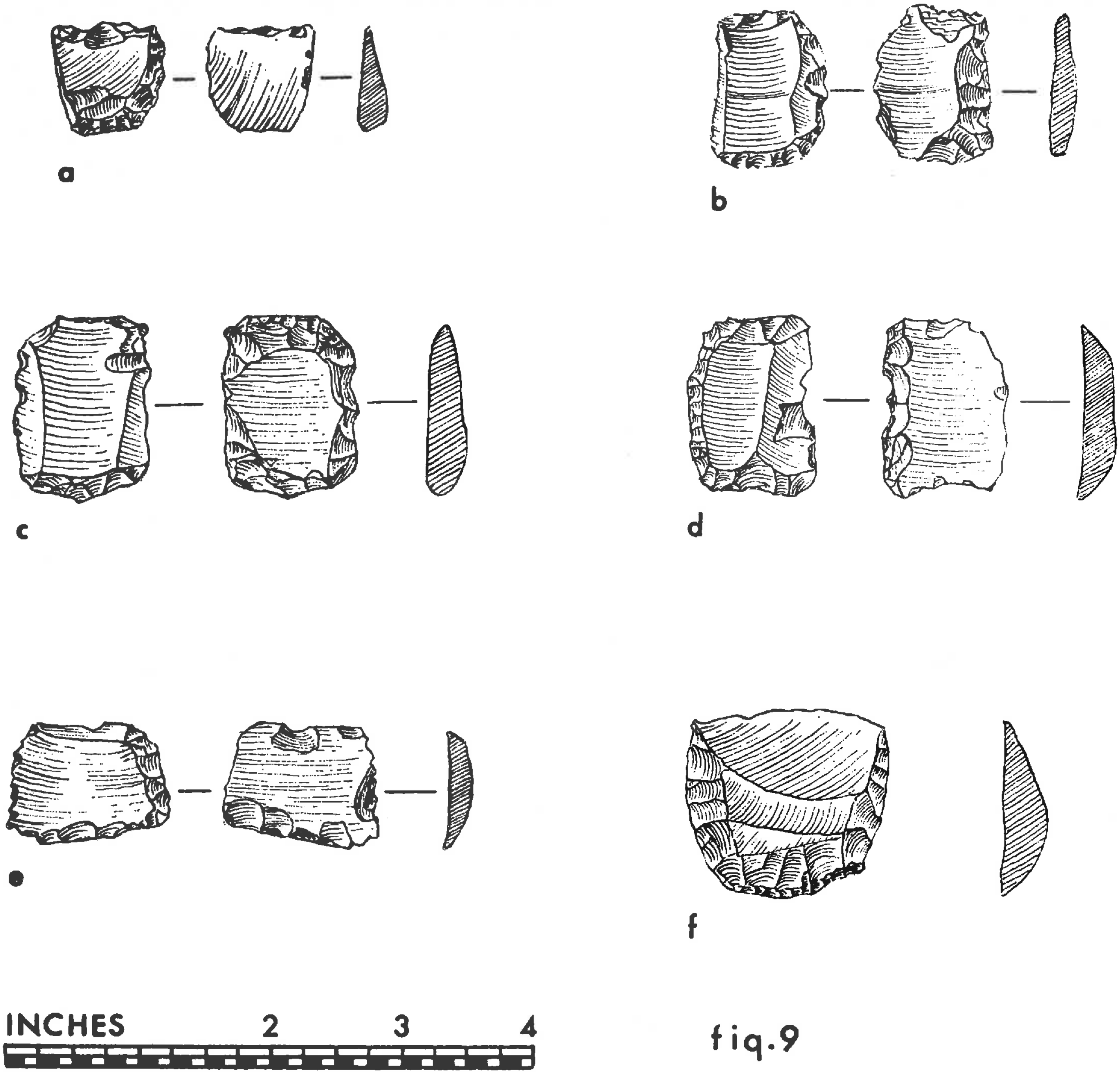


FIGURE 9

Gunflints from Valley Forge. This sample, from our excavation of June, 1962, came from the floors of a group of five isolated huts near the eastern end of the encampment of the New Jersey Line, between fortifications of the Inner Line. This particular site is believed to represent a field hospital. a, is a small French blade flint, sized to a pocket pistol. b-d, are French blade flints for the musket, but they have all been used against a fire-steel rather than on a gunlock. e, is a Clactonian flint of north Germanic drift-pebble material, the only flint of this older type that we have so far seen from a site of the American Revolution. We believe that some veteran of the French and Indian War brought it in the cock of an old musket when he enlisted in the Continental Army. f, is an unused French blade flint for the musket. Specimens in the Valley Forge Museum at Washington's Headquarters. Drawings by Margaret Day Dilks.

be distinguished through reconstruction of the termperature gradients that existed at different stations. This would require very refined measurements of trace-element proportions correlated with determinations of oxygenisotope proportions. Costs are prohibitive, especially for a problem of so limited interest.

THE LATE HISTORY OF FRENCH FLINTS

From the Revolution until the 1840's, the small calibre rifle and the fowling piece were standard hunting implements in Pennsylvania. Most of them had small locks and delicate vises; they took a somewhat diminutive flint, much like that made for a pocket pistol. In the vicinity of older houses small flints characteristic of this period can often be found on the surface. At least three-fourths of them are French blade-flints with blunted backs and edges, the remainder being equally small sized British flints. Edges and backs of the earlier British flints are also dulled by backing, but their sides retain a distinctive scar that was caused by a micro-burin blow, a feature which I will describe later. As late as 1840, French flint held sway over other kinds. It was preferred then, as it is today, because it is superior material.

During the War of 1812, both French and British flints were used by British and Federal troops. At Sackett's Harbor, New York, French flints predominate, but the British flints found there are of exceptional quality and had apparently been highly selected. They can also be distinguished from one another on the basis of lithic material. A few of the French flints, however, have micro-burin blow scars in the British manner. These are a hybrid product, made in France and finished in England.

Prior to the Napoleonic Wars, the British government bought gunflints in France, and accumulated large stores (Hamilton 1960: 31). In the early 1800's, preferring French flint but desiring gunflints shaped in the British manner, it began to buy unfinished blades from French shops. These were sent to Brandon to be broken into finished flints by English workmen. All the detailed procedures used by flintmakers were kept as trade secrets, and the British had no intention of allowing a British method to go to France. These are the reasons why we do sometimes find French flints finished with British technique.

In 1963 a stock of unfinished French blades was found in London. This stock was quickly dispersed through the American antique firearms trade, where they were sold as "cannon flints," a spurious name which we frequently hear applied to large Victorian flints designed for the fire-steel (Hamilton 1960: 33). These blades are two to five inches long, thin and narrow, and were sized for military pistols of the 1810 period.

Flintlock guns were last used by the American Army in the Mexican War, at a time when such firearms were thoroughly obsolete. The last American flintlock musket was made in 1848 at the Mill Creek Arsenal near Valley Forge. Military purchasing agents being what they are, in the years prior to 1848, there accumulated arsenal stocks so huge as to be sufficient for a century of normal use.

In my own youth, dealers in military surplus goods held enormous stocks of flints which they had bought at government auctions. Those which David Bannerman showed me were musket, carbine, and pistol flints of French stone; he also had a few kegs and packages of British flint. They could be purchased by the barrel, keg or gross package, and were widely retailed at a dollar a dozen. Bannerman's stock was exhausted before 1955. Colonial Williamsburg (a presentday Virginia tourist reconstruction) was the largest customer, dispersing barrels of flints as souvenirs. Army surplus French flints now retail at fifty cents to a dollar each in the antique firearms trade, and there are no large stocks left.

With the obsolescence of flintlock guns in the 1820's, French shops nearly ceased their production of gunflints. Ordinance purchasing agents already had unusable surpluses which they were dumping on the world's markets, and the African trade market was closed because sale to and possession of firearms by natives was illegal in many French colonies. Other trade gun markets were controlled by Great Britain. As gunflint manufacture terminated, flints for the fire-steel became the specialty of French shops. The French peasant, always strongly opposed to taxation, still bought flints because matches were taxed. A small but stable market for fire-steels and flints also continued in other parts of the world. French flints later than 1850 are very large, unlike earlier flints for firemaking. I have twice found large flints on Pennsylvania fields, the central part of the edge cut back deeply into an irregular concavity by blows from a thin steel. The University Museum collections in Philadelphia include a sample of newly-made flints purchased by Henry Mercer (Mason 1956) in France in 1893 (Fig. 10 k, 1). This lot is a gross, packed with sawdust in a small dovetailed wooden box, apparently just as they were prepared for the wholesale market. They are fragments of massive blades, a quarter of them with bulbs of percussion, indicating that the original blades were more than eight inches long and were snapped into four flints. In its last period, French flint-making demonstrates remarkable ability in the drawing of large blades.

HISTORY OF THE FRENCH FLINT INDUSTRY

The great French encyclopedia of the eighteenth century barely mentions the gunflint industry. According to this authority, the best flints were made in parishes of Meusne and Couffy in Berry (Diderot and D'Alembert 1751-80: XII-583). They believe that French flintmaking started long before the invention of firearms, and was a survival from earlier technology. Their chapter on guns is one of the least detailed among their statements on the crafts; trade secrecy was still effective (Ibid: VII-395-98). Mineralogical essays on flint, silica, pyrite, and marcasite provide no further information about fire-making tools (Ibid: X-82-83, XIII-603, XV-193-95). A slightly later author noted that the best flints were produced in the neighborhoods of St. Agnau and Meusne (Beckmann 1846: II-538).

James Wyatt later drew upon a source not familiar to me, the reports of the French archives of the Depot Central de l'Artillerie (Stevens 1870: 580). According to his notes, Meusne had been the central collecting point for flints by the French ordnance. Gunflints originated at Meusne, Noyers, Couffy, Pouille, Ange, Chatillon, Langon, Lyes, Paulmay, Lucion, Valencay, Moyesse, St. Vincent in Ardeche, Cerilly, and La Roche Guyon in Oise. But the only shops still in operation in 1870 were at Meusne (Ibid: 586).

Ludwig Pfeiffer, the German pioneer in the study of stone-age technology, visited shops at Meusne (Pfeiffer 1912: 11-13). He described and illustrated the French method of reducing a blade-core; it differed in pattern and sequence from the British method. The French core started at one end of a long, cylindrical nodule and was exhausted at the other end. The British core started as a block of flint split from a sub-spherical core, blades were removed around its circumference, and the core was exhausted as a sub-conical nucleus.

Carlyle Smith, during recent field studies of gunflint sites in France, found evidence for the persistence of the French industry after 1910 (Smith 1961). He collected workshop debris and visited quarry-sites at several locations in the Chere Valley. A quarry site at Vitray yielded a grey-black flint which seems identical with the chalk flint of the Belgium coal-fields; debris in this stone was found at a nearby workshop. Smith notes that it must have been little used, since dark flints made in the French manner have not been recorded. The most recent study of French gunflints mentions an archival record of the mining and working of flint nodules at Meusne in 1643 (Emy and de Tinguy 1964).

BRITISH GUNFLINTS OF THE NINETEENTH CENTURY

Many contradictory dates have been placed in the record as a result of efforts to mark the beginnings of gunflint industries. Of the dates given for the origins of the French industry, 1719 seems to fit the archaeological evidence best (Stevens 1870: 579), 1643 the least (Smith 1961: 420). Most authors have favored the early seventeenth century for the beginnings of the British works at Brandon, with 1686 being one of the latest specific suggestions (Hamilton 1960: 29). The archaeological evidence is overwhelmingly against the existence of any British gunflint industry prior to 1780.

One of the recurrent traditions of Brandon states that the art of gunflint making was introduced by French prisoners-of-war who had been flint-makers in France and who were settled at Brandon by the British army. In this connection 1709

FIGURE 10

Prismatic flints from England and France. a-i, were made at Brandon in 1893 by Fred Snare, and are typical examples from a sizable sample purchased by Henry Mercer and now in the collections of the University Museum, Philadelphia. k-l, are samples of the flints for the fire-steel that Mercer bought in one of the French shops at Le Grande Pressigny, during the same tour. j, is a large French flint for the fire-steel of the 1750's from Fort LeBoeuf (Pa. State Museum No. Z109).

The samples which Mercer bought were graded by size and quality. I have drawn a median example from each group. The terms for each which follow were the terms used by Fred Snare at the date; some later terms, such as "Long Dane" for a specific Turkish trade size, are missing. Two samples from this groups are also illustrated in Figure 3, i and j, representing a "double-edged musket flint" and a "double-edged carbine flint."

Specimens in Figure 10 are as follows: a, No. 12089, "rifle flint;" b, No. 12089, a rifle flint with three demi-cones of percussion, which was trimmed on three edges with the cutting hammer. c, 12099, "spindle flint". This term and this tool are completely unknown to me. This lot of flints was carefully selected for flat and parallel tops and bottom surfaces, and all edges have been very carefully trimmed and dulled with the circular retouching hammer (the "roulette"). I imagine that they were either ground and drilled to make them into "jeweled" bearings, or that they were used to line a bearing-box that carried wooden shafting.

d, No. 12105, "common horse-pistol;" e, No. 12107, "double-edged horse pistol;" f, No. 12063, "chalk-heel carbine;" g, No. 12106, "common musket;" h, 12103, "tinder box;" i, the same, but this one is a pseudo-clactonian flake cleaved across the base of a nucleus, it shows no burin blows, and was entirely finished with the roulette. k and l were not catalogued, and the box is labeled merely with the date and place name in pencil.

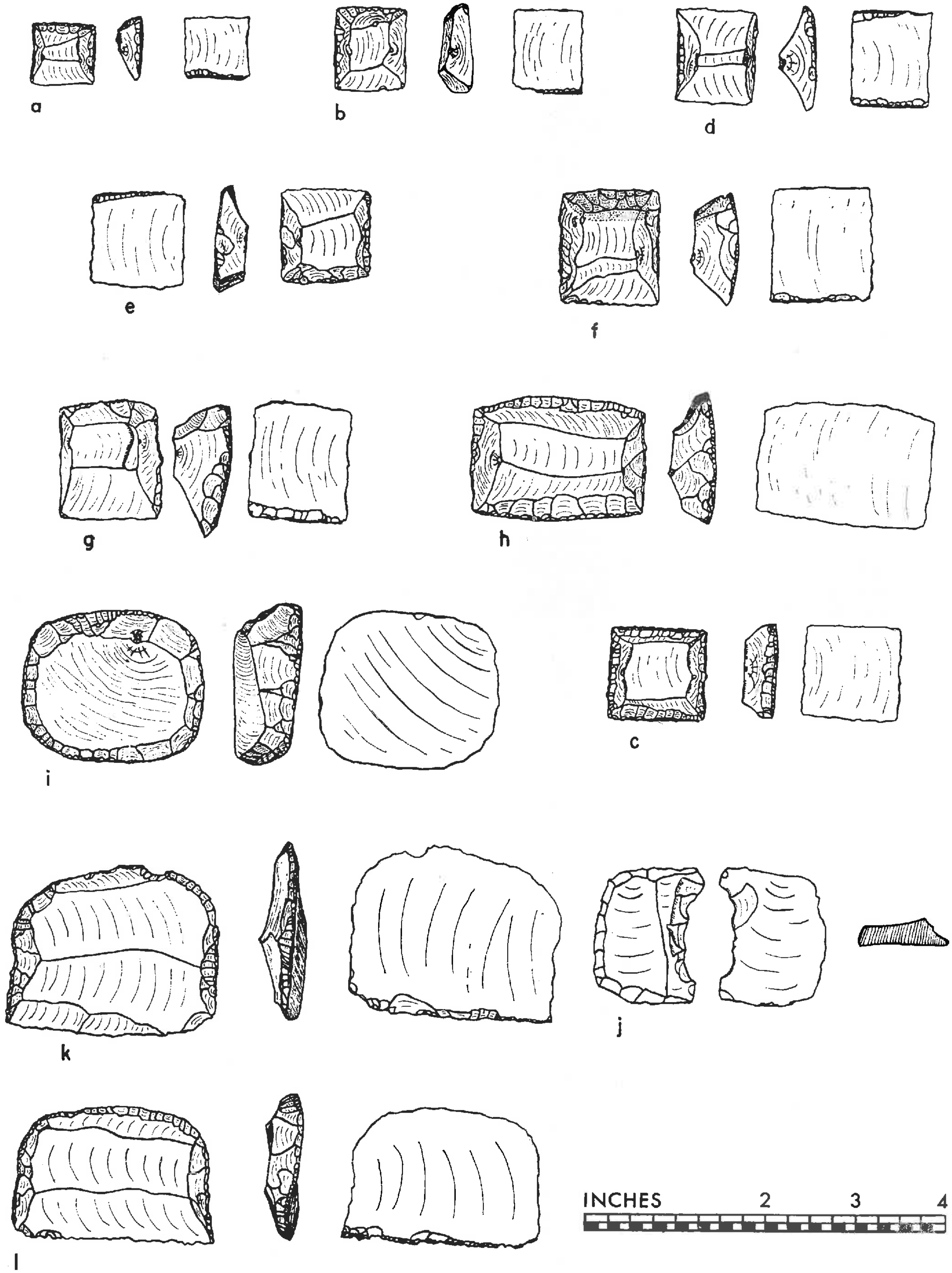


Fig. 10

has been suggested as the date (Emy and de Tinguy 1964: 37). The British technique is so like the French one that this must have been its source. Dates for the earliest British flints indicate that French mentors were from actions having to do with the American Revolution, but it is not possible to tell whether these flint-makers were taken prisoner in North America or seized from French ships.

The British industry used a glassy black flint. The miners obtained all gunflint material from one stratum, but they mined other flint strata for mason's building stone and for ceramic material. Flints were also worked at Icklingham and at King Manor in Clarendon near Salisbury (Stevens 1870: 588). Rejected gunflint material and the debris from the shop also went into the mason's stone pile. As in many other areas on the European chalk, mining for flints and for chalk has been carried on at numerous different times for a variety of purposes, and specific gunflint mines represent but a very tiny proportion of the shafts dug into the chalk. While flint mining has had a long history, Brandon gunflints are objects produced during the nineteenth century.

Brandon knappers also themselves made a technological advance in the production of gunflints. This was the discovery of a micro-burin technique for separating blades into segments, a technique which eliminated the necessity for retouching a flint to shape. The blade was placed top down upon a "stake" (a chisel-edge set upright into a wooden anvil) and was struck with a light chisel-edged hammer, the two edges approaching one another somewhat like the blades of a shears. This removed a flint from the blade, and in the process produced a sloping end on the flint and a projecting end on the blade. The flint-end bore a partial positive cone of percussion; the blade-end bore a partial negative cone of percussion. The blade was advanced a trifle on the stake, and a tiny section was struck from its tip in the same manner, shaping the end of the next flint and throwing off a piece formed between two partial negative cones of percussion. This tiny reject piece is the micro-burin. The rapidity and efficiency of this operation, and its adaptation to making double-edged flints, mark it as a significant innovation. The technique was known only in England; when found on French flint, it marks a French blade cut into flints at Brandon. Early British flints often have their back edges dulled by backing, however. The demi-cone on the scar of the micro-burin blow, not the outline or the kind of retouch, characterizes the British gunflint.

Brandon is the only place where gunflint technology has been fully studied, and is the only aspect of the British gunflint industry for which we have full samples of tools, in-process work, dated and graded samples from shops, and debetage (Stevens 1870: 578-90; Evans 1872: 15-20; Skertchly 1879; Wilson 1899: 861-64; Pfeiffer 1912: 5-17; Clark 1935; Knowles and Barnes 1937). Since these authors give full accounts of the precise sequence involved in shaping the core, removing the blade, and severing and finishing the flint, I will not summarize the complete operation.

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The British industry used a glassy black flint. The miners obtained all gunflint material from one stratum, but they mined other flint strata for mason's building stone and for ceramic material. Flints were also worked at Icklingham and at King Manor in Clarendon near Salisbury (Stevens 1870: 588). Rejected gunflint material and the debris from the shop also went into the mason's stone pile. As in many other areas on the European chalk, mining for flints and for chalk has been carried on at numerous different times for a variety of purposes, and specific gunflint mines represent but a very tiny proportion of the shafts dug into the chalk. While flint mining has had a long history, Brandon gunflints are objects produced during the nineteenth century.

Brandon knappers also themselves made a technological advance in the production of gunflints. This was the discovery of a micro-burin technique for separating blades into segments, a technique which eliminated the necessity for retouching a flint to shape. The blade was placed top down upon a "stake" (a chisel-edge set upright into a wooden anvil) and was struck with a light chisel-edged hammer, the two edges approaching one another somewhat like the blades of a shears. This removed a flint from the blade, and in the process produced a sloping end on the flint and a projecting end on the blade. The flint-end bore a partial positive cone of percussion; the blade-end bore a partial negative cone of percussion. The blade was advanced a trifle on the stake, and a tiny section was struck from its tip in the same manner, shaping the end of the next flint and throwing off a piece formed between two partial negative cones of percussion. This tiny reject piece is the micro-burin. The rapidity and efficiency of this operation, and its adaptation to making double-edged flints, mark it as a significant innovation. The technique was known only in England; when found on French flint, it marks a French blade cut into flints at Brandon. Early British flints often have their back edges dulled by backing, however. The demi-cone on the scar of the micro-burin blow, not the outline or the kind of retouch, characterizes the British gunflint.

Brandon is the only place where gunflint technology has been fully studied, and is the only aspect of the British gunflint industry for which we have full samples of tools, in-process work, dated and graded samples from shops, and debetage (Stevens 1870: 578-90; Evans 1872: 15-20; Skertchly 1879; Wilson 1899: 861-64; Pfeiffer 1912: 5-17; Clark 1935; Knowles and Barnes 1937). Since these authors give full accounts of the precise sequence involved in shaping the core, removing the blade, and severing and finishing the flint, I will not summarize the complete operation.

Henry Mercer visited Fred Snare's shop at Brandon in 1893 and collected labeled samples of flints, tools, and in-process material. The unpublished series, now in the University Museum, Philadelphia, includes several previously unnoted items (Mercer n.d.). The most interesting of these are flints for the firesteel that were made from an exhausted nucleus, from what was left after all blades had been removed. Such a nucleus was laid on its side on a wooden anvil, and struck a hard blow with the hammer to split off a tapered slice across the base of the nucleus. The removed piece resembles a core-rejuvenation flake. These wedges were then trimmed into a more even circular shape. Smaller flakes of this sort, which came from the apex of the core, were sometimes trimmed into gunflints. They show a high platform angle and a wedge-shaped form, and are pseudo-Clactonian flakes. Flints of this kind have been found at Sackett's Harbor and other American sites and have been confused with Dutch wedge-shaped gunflints. They represent salvage of usable pieces from flint waste of exceptional quality. They are not the result of a standardized primary industrial technique.

During early stages of the Brandon industry, part of its output went into military stores; it does not appear, however, that Brandon ever approached the importance of the French shops as a source for military flints. Brandon flints figures most heavily as an export, shipped in British bottoms to English-dominated lands where flints were retailed by British merchants. The Brandon gunflint industry was closely associated with the production of trade guns in Britain. In the age during which the flintlock declined, Brandon became the source of flints for Turk, African, American Indian, and other markets in areas where people still clung to old-fashioned guns and where main trade and political alliances were with the British.

British shops made eight kinds of flints in 1870: common gun, double barreled sporter, single barreled sporter, pocket pistol, horse pistol, carbine, musket, and tinder box, each in three or four grades (Stevens 1870: 583-84). In 1893, they made nine kinds, with some changes in terminology: pocket pistol, horse pistol, double-edged horse pistol, carbine, common musket, double-edged musket, rifle, spindle flint, and tinder box flint (Mercer n.d.). The Brandon industry has been revived in recent years for the gun collector's market. Herbert and V. R. Edwards of Brandon now use the following names for eight types: single barreled sporter, pocket pistol, horse pistol, carbine, musket, rifle, Long Dane, and cannon flint (Hamilton 1960: 33). These terms indicate how the markets have shifted and that types are common to a given period. Only recently have flints ceased to be a standard item of commerce; the 1905 Sears Roebuck general catalog still offered Brandon gunflints at fifty cents a dozen because they were then still used in Kentucky rifles of the Appalachians and in the trade guns of western Indian hunters.

Flintlock trade guns remained in use long after the appearance of percussion caps in 1820. There were various reasons for their popularity. They were not only cheap guns, but economical to use. Even today, many people, turned by the complexity and gadgetry of modern high-powered sporting guns, and the brutal slaughter which they produce, have returned to more rudimentary hunter's tackle: the bow, the flintlock Kentucky rifle, the simple fowler. These require honest hunting skill in their use; they kill humanely and there is little chance of maiming the object of the hunt. They are conservative, efficient tools which emphasize handling ability.

Flintlock Indian trade guns were light fowlers; they remained long in use in our Northwest. The North West gun, with its cast-brass dragon sideplate, huge iron trigger guard, and other distinctive features, was a sixteen gauge smoothbore (Hanson 1955; Russell 1957: 103-41). The dragon plate is an anachronism; it was a feature adapted from the sporting arms of the early 1600's. Its first appearance on a trade gun was probably in 1775, on guns by Joseph Heylin of London. Some North West guns were made in America, but most came from London and Birmingham. Many guns for the African trade were also mass-produced in the same shops and some of them were essentially North West guns in most of their details.

Many North West trade guns were purchased by the United States Government for War Department distribution. The Indian Office, a section of the Department of War, included firearms among the goods used in payment for land cessions by treaty.

H. E. Lemon of Lancaster, Pa., was a major producer of North West guns from 1834 to 1860, but his barrels and most of his locks were mass-produced in Birmingham. Often pronounced "Layman" by gun collectors, his family name is still Lemon (pronounced like the sour fruit) in Lancaster. Mr. Vincent W. Nolt of Lancaster kindly supplied me with the following note, which documents the importance of Lemon trade guns at a late date:

> "I have a photostat of a contract between the U. S. and H. E. Lemon dated November 10, 1860, and signed November 14, 1860, by Lemon. Contract to be filled April 1, 1861, for 1,000 flintlock Northwest guns at $7.00 each - $7,000.00, for 100 percussion lock guns for $675.00, and for 100 dozen powder horns at $350.00, $.291 each."

I am not certain what the terminal date for manufacture of flintlock North West guns might be. Parker Field and Company of London was probably making them after 1875. The latest dated lock marked for Hudson Bay that I have seen is 1873. This gun (a specimen in the collections of the University Museum, Philadelphia) was in Blackfoot possession, but I believe later dates are known for Parker Field locks from the Rocky Mountain states. Tyrone of Philadelphia still made flintlock North West guns in 1887.

Flintlock guns remained desirable in the Northwest because they were the most efficient hunting tools for a frontier territory. Spencers, Remingtons, and Henrys were the great rapid-fire weapons used by Plains Indians after the Civil War, but their ammunition was costly, difficult to obtain, bulky and heavy for quantity transport. An inexpensive gun with simple parts and little to go wrong, a few flints, a small quantity of powder, ball, and shot; with these a man was lightly burdened but well equipped for a long period away from stores. The North West gun could provide a maximum of meat for a minimum of cost and burden, hence its long popularity and the late survival of an American market for Brandon flints.

Flintlock trade guns remained in use in the tropical rain forests even longer, and for more fundamental reasons. Mercury fulminate primers, used on the caplock guns of Victorian times, were worthless in the wet tropics. The priming mixture quickly deteriorated and could not function and the native hunter rarely had access to fresh caps. Thus flintlock trade guns, mostly made in England, Belgium, and Turkey, remained standard in the African trade until more stable primers had been invented for cartridge guns. The invention of non-corrosive primers just before the first World War was the decisive event that practically put the last gunflint makers out of business.

GUNFLINTS OF POLAND

Several writers refer to the making of gunflints in Austria (Hamilton 1960: 61; Pfeiffer 1912: 17). They give town names: Nizniow, Podhajce, Podorca, Podgorze, Brzeczam, Brzezany. These place-names cluster near one of the ancient out-corners of the Austro-Hungarian Empire that is located on the upper Dniester River in Galicia; later it became a part of southeastern Poland and now it is a part of the U. S.S.R. These centers were about 100 kilometers southeast of Lemberg, the ancient capital of Galicia. This industry was apparently described by a geologist who may have been its founder, but I have not yet been able to find a copy of his rare publication (Von Hacquet 1792, my citation is from an auction catalog).

Gunflints from Galicia have not been defined and none have been recognized. However, T. M. Hamilton sent me two flints from the Russian post of St. Michael on Norton Sound in Alaska. They are thick, massive flints designed for the military musket, made from coarse blades, their backs and sides chipped to a semi-circular outline after the French manner. They are thicker than any French musket flint. I had not seen the flint material before. It is a porous, mat-surfaced, non-glossy chalk flint, light grey to grey-black in color, with many tiny spherical whitish blotches and dots. I believe that these specimens represent the nineteenth century flints from that section of Galicia in Russian Poland, and that the Russian armies were supplied from the shops that made them.

THE EVOLUTION OF GUNFLINTS

Firearms are significant in the history of technology because new developments in weapons can be of utmost social import. Weaponry is always at the forefront of human invention and archaeology can provide abundant evidence for the antiquity and omnipresence of death-dealing machines. Men have devoted more time, resources, and ingenuity to matters having to do with the perfection of weapons than they have spent upon all the altruistic hopes of recorded history. Hunting arms are useful, but they are a by-product; guns were created and improved as tools of warfare, conquest, and exploitation. The great markets for gunflints were in armies and police, not with Indian hunters.

Because the improvement of gunflints was a fundamental effort on the part of European society, their evolution provides good examples of cultural process. These objects have survived in context in abundance. Hence our four stages in gunflint-making are not only useful for dating, they they are one of the chapters in the history of technology.

The most striking feature involved is that there was a change in area of manufacture with each advance in the art. When Dutch centers began production in the mid-1600's, they did so with a new technique, and they started somewhat outside the area of previous production. They quickly put the makers of Nordic flints out of business. The next advance was a new invention in flint-knapping that was not made in the Netherlands, but on its periphery, in France. French shops in turn gradually put the Dutch shops out of work. The shift to an English center after 1780 was also coincident with an invention, and when the markets shrank the English put the French out of competition.

Gunflints were the concern of the total society rather than of individual nations because they were an item of international commerce. It made little difference where the flints came from, as long as they were the best available. An army in the field often used flints made by the nation it opposed. The Thirty Years' War, the Seven Years' War, and the Napoleonic Wars saw the same flints used on both sides; these wars were all equally contrived within Europe's ruling circles and of this the lowly gunflint is a clear, if minor, bit of evidence.

However, in the south of Europe a distinct regional culture developed after the Renaissance; but for its fringes, all of it was isolated from the North. From Spain to Turkey, including these two power centers, there stood one of the great stagnant pools of civilization. The Mediterranean upper classes maintained it and in it along with other realms of technology, the gun patterns that had been introduced by the Moor during the early 1600's persisted with but little change.

Guns of the Spanish and Turkish varieties were made in great numbers, and they probably slaughtered many more people than did the weapons of north Europe, but they were noted for their archaisms. Even their gunflints were apparently fossil types that had persisted from the seventeenth century. It would be no surprise to learn that all the early gunflints of Spain actually came from Albania, and were but one small item in a prosperous commerce. These peoples may have been implacable enemies before the world, but we suspect they were blood-brothers in the privacy of the counting-house.

THE SOCIAL HISTORY OF FLINT-KNAPPING

Gunflints can be looked at in other contexts, however. They are part of a social history of European technology. The men who made them gained some slight prosperity. Gunflint towns were among those craft-centers that rose like islands slightly above the sea of European poverty. Miners and workers of flint paid for their economic survival through a bitter coin, but in the manner of many other craftsmen; silicosis was the industrial disease of the flint-worker. Although they were skilled workmen, often harried by speed-ups and other economic pressures, they seem to have followed but one sequence of motions and to have made few innovations.

Because critical poverty prevailed over most of Europe, the mechanic guarded all knowledge of his trade as a close secret, called a "mystery". Less fortunate peoples and communities would hope to establish competitive industries, but could not do this without their own "mystery". The rural worlds of eighteenth century France and Germany were harsh. Twenty-year intervals separated periodic famines during which the "haves" survived and the "have-nots" perished. "Have-not" communities sought any new resource.

It is surprising that guild and craft secrecy worked as well as it did against this background. When a community succeeded in establishing a new craft, it did so by stealing the secret techniques of another community and improving upon them. In so doing, it was innovating; also through invention, it discovered the technological improvements that insured its continued competition with established craft centers. As it was in other crafts, this seems to have been the situation through the evolution of gunflints. The industrial spy has always been an important agent in such a medium. One of our earliest records of French flint-knapping makes known the fact that the King of Hannover sent a spy to the French gunflint shops in 1727 (Beckmann 1846: II-538).

Eric de Jonge has called my attention to a major source (Jacobsson 1781: I-750) which includes the earliest discussion of the gunflint industry. He writes that the French provinces of Picardie and Champagne supplied the armies of Europe with flints. However, all of the flints were actually made in the province of Berry. The Prussian king Friedrich Wilhelm sent a spy to France to ferret out the "mystery" ofgunflint making. For this assignment he selected Matthias Close, a gunsmith at the Potsdam Arsenal who had been born in Belgium in 1722 and therefore spoke French as his native tongue. Close found employment at St. Ange (province of Berry, department of Cher), and after several years there was able to learn the methods of flint-knapping. He proceeded slowly by subterfuge, since he found that a foreigner would forfeit his life if found spying out the techniques. Close returned to Prussia, bringing with him samples of French flint, tools, and work. He readily duplicated the French gunflints from local chalk flints, but these shattered when used. Simply for the lack of suitable material, Close's project was cut off and abandoned.

Jacobsson noted that gunflints were made from agate in Nurnberg. The foreman of the Potsdam Arsenal, Mader, had seen them made. They were cleaved and cut like diamonds. Apparently they were sawed to shape, and were one of many items in the esoteric agate industry of southern Germany (Hamilton 1960: 52). I think it is extremely important that Jacobsson had not learned of any other sources for gunflints, and that the only ones familiar to him were the *cailloux a fusil* from France.

INDEPENDENT INVENTION IN BASIC FLINT TECHNOLOGY

The evolution of gunflint technology shows significant parallels to the ancient stone age developmental sequence of flint technology. The first gunflints were bifacially flaked by coarse percussion, and in my opinion are comparable to Lower Paleolithic handaxes. Second-stage gunflints represent a Clactonian industry, I believe to be precisely parallel to Clacton I of Great Britain. The third stage in gunflints was the reinvention of blade-making which had been one of the key advances during the Upper Paleolithic. In the fourth stage, British workers developed a micro-burin technique for severing blades into segments and in accomplishing this stumbled upon one of the inventions of Mesolithic times. The sequence, from core-tool to efficiently-produced flake tool to blade to microlith made from a blade, is analogous to the overall trend seen in the evolution of prehistoric flint tools during the first half million years of prehistory. The gunflint series was compressed into two centuries, but seems to recapitulate prehistoric technological trends in a much-simplified outline.

Parallels indicate that many independent centers of prehistoric technology may well have gone through comparable stages without any contact with one another. The data suggests that underlying laws may direct the evolution of flint technology which might be visualized from the study of these and other unrelated series. Techniques of blade-making have been independently invented by different peoples at different times in the prehistoric past. Gunflint sequences merit the same study as do prehistoric flint traditions, and are especially instructive as to the nature of independent developments.

THE WHEEL LOCK GUN AND SULFIDE MECHANISMS

Literature concerning firearms and the literature of archaeology are filled with references to iron pyrite as a fire-stone used against flint or steel. As with many beliefs, these statements have been so long repeated that they have become ingrained and now represent errors almost impossible to eradicate. I had never thought about these fire-stone using mechanisms in any doubting manner, nor had I seen the obvious reasons for questioning them, until attempts to use a wheel lock gun brought me sharply to face with facts.

In 1962 we acquired a plain Austrian wheel lock military fusil of the late seventeenth century; a sturdy, unadorned, simple workaday firearm. Its mechanical train had none of the fragility or refinement often seen on elaborate sporting wheel locks of the continental nobility. Corrosion on internal parts of the lock included some sulfides in limonitic rust, indicating that the vise had once held a slab of iron sulfide against which the steel wheel had spun. We put the gun into good working order, got the mechanical train to function perfectly, and tried to bring the gun into use. Our attempts were sorry failures.

Our first fire-stones were sawed from large single crystals of the purest pyrite we could obtain. They simply shattered against the wheel, producing no sparks. After a few attempts, we had to disassemble and clean the lock because it was becoming choked with pyrite debris. We tried good pure pyrite from other locations and in other mineralogical forms, with no success whatever. We finally hit upon a piece of pyrite that was finely-granular and poorly consolidated, a sort of "sandstone" made up of tiny cuboid crystals. This sparked beautifully, but was rapidly cut down by the wheel, so that the lock mechanism became choked with grit. We began to wonder if it might not be necessary to make up a synthetic stone by cementing a pyrite frit with waterglass or some other cement. Not a single sulfide block for a wheel lock gun is known to exist, and since there is no contemporary literature on the wheel lock and its use, we felt completely at sea.

When we cleaned the lock, it was found to be choked with unaltered pyrite crystals and cleavages, mixed with small amounts of a sour, soluble white dust: iron (ferrous) sulfate. Our fire-stone was examined more carefully, and we found that the weak but original cement between the pyrites crystal was marcasite, a paramorph of pyrite. Marcasite is of the same chemical composition as pyrite, but has a different crystal form, specific gravity, and chemical properties because its molecular structure differs from that of pyrite. We set a slab of marcasite, part of a ball of radiating needle-like crystals, in the vise. It worked perfectly, with slight erosion from the wheel but with spectacular production of fire. Oxidation products which collected in the pan were ferrous sulfate, with sulfuric acid traces. The problem seemed to be solved, but an even more difficult puzzle appeared later.

Marcasite is usually a perishable mineral, surviving only when protected from moist air. Unless they have been protectively coated, many specimens in mineral cabinets vanish in a few years, leaving only a pile of white ferrous sulfate powder. This explains why sulfide slabs for wheel lock guns have not survived. Neither can we expect any evidence for sulfide fire-stones to survive in most archaeological sites, since they would have oxidized readily and their oxidation products are soluble. Numerous references in the archaeological literature to earthy limonitic masses discovered in prehistoric graves as being chemically-altered sulfide fire-stones, cannot be correct, since normal pyrites is stable and would still be pyrites and marcasite fire-stones would have disappeared without leaving a trace. Neither could possibly give rise to hydrated iron oxide through weathering except under extreme conditions of heat and pressure, such as could come about only through deep burial within the earth's crust.

Only Neolithic and Bronze Age firemaking sets of stone have been recognized in Europe. Certain types of flint tools have been identified as having been used with iron sulfide. The type specimen, often mentioned and illustrated, is a set (half a sphere of sulfide with a crest-blade of flint) found by Rev. W. Greenwell with the central burial in a long barrow at Rudston, Yorkshire, in 1872 (Evans 1872: 281-86). The first identification of such a set had been made in 1844, however. Like other specimens from Bronze Age tumuli, the sulfide is a split half-sphere of radiating hair-like marcasite crystals; these originate in the base of the Chalk. Other Bronze Age fire-flints are described as massive blades with beveled ends much like end-scrapers. I have found little data on later specimens, and cannot trace the history of this technique through the interval between the Bronze Age and the date (about A.D. 1480) when the wheel lock was invented.

After our experiements with the wheel lock, I began to look at Eskimo fire-making sets in various museum collections. They are everywhere published as being made up of pyrite and flint. Thus far, every specimen appears to be either marcasite or iron sulfate dust. Not a single specimen shows any of the crystal forms of pyrite. Archaeological specimens described as pyrite, for similar reasons, in reality appear to be marcasite. Throughout the Eskimo area, judging by actual specimens, pyrite apparently was not used as one of the elements in fire-making. There are doubts about exactly what kind of strikers were used and about the precise nature of the marcasite, however.

Eskimo ethnographic collections present knotty problems of authenticity because they contain many reconstructed archaeological specimens. The Eskimo have long collected on top of and dug archaeological sites in search of carving ivory. As soon as a sailor's and tourist's market developed, Eskimo sought stained archaeological ivory as a carving material, and they sought archaeological specimens for sale. Many of these were faked into ethnographic specimens. Beveled flint tools placed in scraper handles, archaeological knife blades hafted as arrowheads, adze-blades mated to strange handles, and other spurious reconstructions abound, even in old collections. Eskimo series must be used with critical caution. Parts of fire-making sets may have been taken from frozen sites and mated with unrelated archaeological pieces.

At any rate, marcasite in Eskimo sets occurs with marcasite, with fire-steels, with files, with Brandon gunflints, with archaeological flint tools, and with battered quartzite pebbles (of which more will be said). Some kits contain three or four of these objects or materials in multiple combinations. Very likely all of these combinations are usable and were used, but one feels uneasy about accepting certain ethnographic pairs as authentic. It is most significant, however, that no pyrite crystal forms occur.

Some sets from Alaska, the Coppermine River, and Cockburn Land included a curious tool that is new to me. It is a quartzite pebble, battered to shatter its surface into coarse irregular teeth. It was used as a coarse stone rasp to stroke a sulfide fire-stone. Figure 11 illustrates the most refined example. This crude tool has doubtless been discarded from many an archaeological collection at the excavations, and is a good example of a simple but important kind of implement that we failed to recognize as such. Coarse-textured hammerstones apparently had a similar use among Eskimo. A somewhat comparable coarse-grained quartzite striker, allegedly used against steel, is known from Viking times in Scandinavia and Ireland (Christy 1926: 10, 88-89, 231). Eskimo specimens are usually coarsely toothed, shattered rather than pecked; the Viking type is grooved with a finely battered depression.

Fire-making with sulfide is documented among the Eskimo from Greenland and Labrador to Kotzebue Sound, for the Aleutian Islands, and at Yakatat Bay. It has been noted for Kutchin and some other Athabascan tribes of the Northwest. It has also been documented for Terra del Fuego. It was probably unknown throughout most of the rest of the Americas. The last essay published on these distributions is now inadequate (Hough 1899: 571-77). It is demonstrated for Bronze Age England by several grave-finds that include fire-making sets from water-logged graves where the sulfide has been preserved, and for the Neolithic Swiss lake dwellings by the presence of sulfide fire-stones. It has been falsely claimed for many parts of North America on the basis of archaeological evidence incorrectly assessed in that the presence of limonitic paint masses have been misinterpreted as hydrated pyrite. It has been inferred for prehistoric Greece and Italy, and has been suspected for other cultures because of symbolic remarks about fire in mythological texts. Its geographic distribution and culture history are not known, even for the Alaskan Eskimo, but some curious discontinuities in time and space are nevertheless obvious. Most conspicuous are the European gaps: for Iron Age cultures, for classical antiquity, and for the Middle Ages. It has been accepted as a technique present in the Upper Paleolithic of Europe (Forbes 1958: 5).

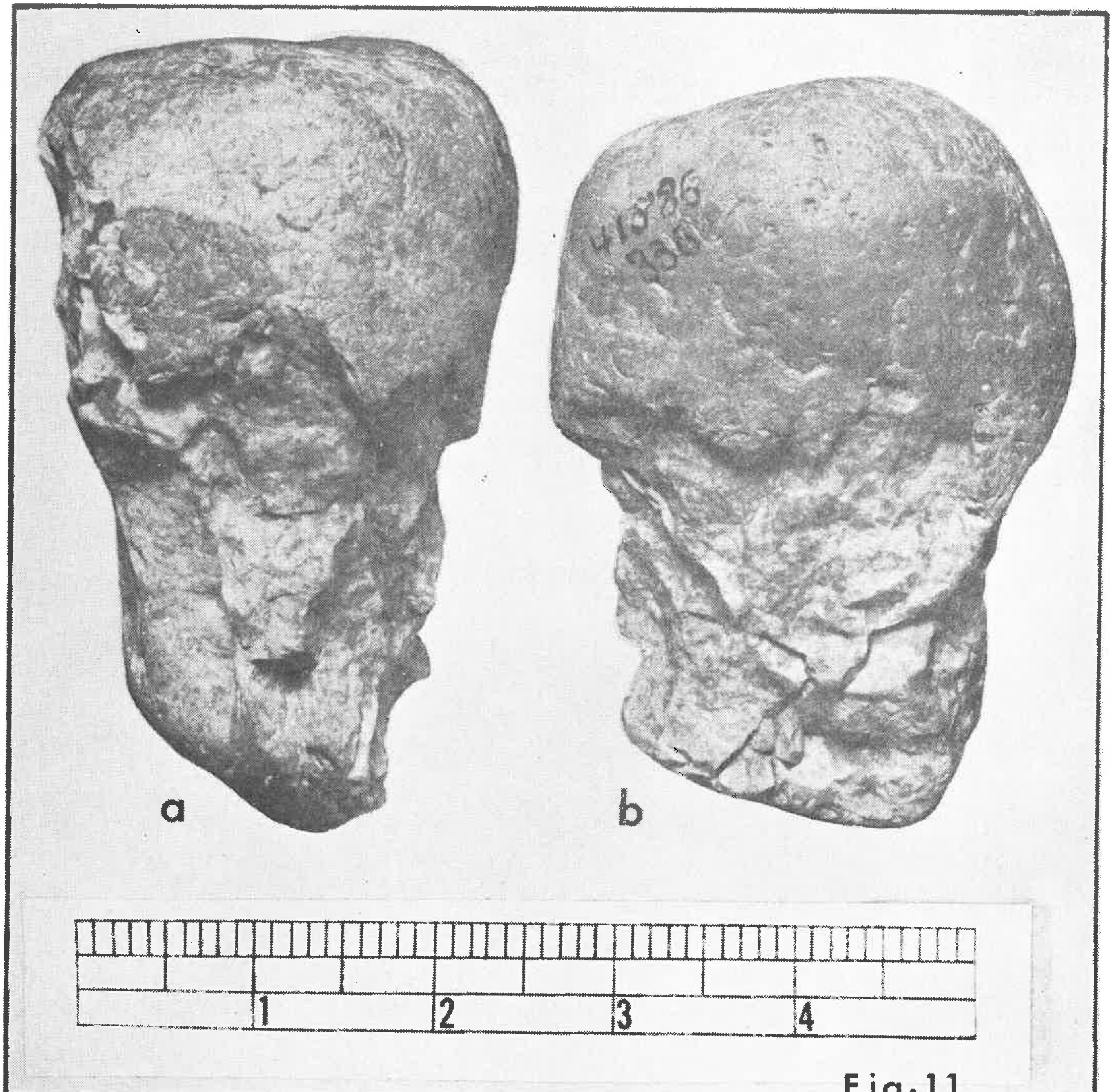

FIGURE 11

Eskimo fire-stone of quartzite from Point Barrow, Alaska, forms a set with marcasite located in the University Museum, Philadelphia (cat. No. 41586, weight 12-1/8 ounces). Working surfaces have been formed into a very coarse rasp by battering and shattering the surfaces of the pebble. High points on the rasping surface have been worn smooth by the stroke of marcasite; since this mineral is softer and weaker than flint or quartzite, it abrades and fuses the surface of the firestone rather than shattering it.

Kindling of fire is one of the oldest and most fundamental techniques. It is also a neglected field of inquiry in world archaeology. It is a matter that we think we understand, when in fact we know little of it, and have never throught about it in a technological way. To comprehend any problem in primitive technology, the investigator must strive for a full understanding of the mechanics, physics, and chemistry that underlie the processes. When this is gained, it usually also becomes obvious that the primitive technology involved some expert and scientific, if empirical, knowledge of a phenomenon which we did not ourselves understand. Short of this, those interested fall into a category with the explorers who tell us that the curious natives make fire by striking two stones together, or that they make their tools from stone by some esoteric use of fire and water. To many it comes as a surprise to find that recent everyday techniques (such as the ignition of gunpowder by simple kindling machines) are not technologically understood. In fact, the chemistry of sulfide ignition is still a mystery, and its study has only begun. Many precise determinations on mineral specimens will be necessary before a definitive explanation can be offered.

THE MINERALOGY OF SULFIDE IGNITION SETS

The sulfide ignition problem is indeed more difficult than the mere distinction between pyrite and marcasite. We now have some evidence that a special unstable variety of iron sulfide, properly not marcasite, is required.

Twenty-four sulfide fire-stones from Alaska and northern Canada have been studied in the collections of the University Museum (Philadelphia). Most are parts of ethnographic fire-sets; four are prehistoric Eskimo. These and additional specimens are being subjected to further analysis, and more complete details will be published at a later date.

The series which I have studied includes four natural groups of sulfides. 1) Massive blocks from sulfide veins, showing radiating internal structure. 2) Spheres of radiating needle-like crystals. The Alaskan Eskimo believe that these are meteorites; they are found on the coast in the Point Barrow area, whereas the other kinds were brought from the interior. 3) Masses of hair-like crystals, in parallel felt-like groups of crystals. 4) Botryoidal crusts of parallel needles. Dr. Davis M. Lapham, mineralogist of the Pennsylvania Geological Survey, has been especially helpful in aiding and checking my determinations. All specimens seemed to represent classic forms of marcasite.

Lapham selected a specimen from each of the four groups for X-ray diffraction study. These four specimens showed no trace of the molecular structure of marcasite, but revealed only the lattice pattern of pyrites. One also showed traces of silica, another of calcite, but no other minerals were indicated. These specimens are something new to me, pseudomorphs of pyrite after marcasite.

This surprising result makes similar determinations necessary on a larger series of fire-stones and on marcasite specimens from many sources. The fact that inversion of marcasite to pyrite can occur with pressure and heating is so recent a discovery that the frequency of this cannot be estimated. Most of our knowledge of the relationship between pyrite and marcasite was derived long before this pseudomorphism was detected. Total relationships among iron sulfides must now be restudied. The following summarize our current knowledge (Mellor 1922-37: XIII-885-94, XIV-199-230; Berry and Mason 1959: 176, 179, 230-35).

Marcasite is formed in soils and in near-surface rocks at normal temperatures, usually from acid solutions. Its origins come about through biological processes, in and upon soils. Crystals are prismatic with pyramidal tips, but they generally occur in hair-like forms or as multiple twins with projecting non-symmetrical groups of saw-edged terminations ("cockscomb crystals"). Marcasite is slightly less dense than pyrite, with a specific gravity of 4.89. It is not at all magnetic. Its color is light, often tin-like, and not yellow as compared to pyrite. Marcasite will decompose in hot nitric acid, releasing sulfur as a precipitate. Many specimens are quickly oxidized in moist air, forming ferrous sulfate and sulfuric acid. However, some marcasite specimens are quite stable, and the perishable examples may actually be pyrite pseudomorphs after marcasite. Other accepted chemical tests may actually be only relevant to certain pseudomorphisms and therefore may not really serve to distinguish two mineral species.

Pyrite is formed in deeper rocks at higher temperatures, from alkaline or slightly acid solutions. Crystals are cubical, octahedral, or related shapes. Pyrite is slightly more dense than marcasite, with a specific gravity of 5.01. It is paramagnetic. Its color is yellow and brassy, darker than that displayed by any marcasite. It completely dissolves in hot nitric acid, leaving no residue. Pyrite is stable under normal conditions. Limonite pseudomorphs after pyrite are formed under pressure, in an alkaline evnironment, by hydration, and by normal near-surface weathering. Limonite pseudomorphs come about at temperatures higher than those necessary to the formation of pyrite.

Pseudomorphs in pyrite have been formed from marcasite by subterranean heating. Conditions of temperature, pressure, and acidity are as yet poorly known. Although the molecular structure of these pseudomorphs is that of pyrite, other characteristics are those of marcasite. Since pyrite is more dense than marcasite, with closer packing of molecules in the lattice, a space-saving must be involved, and consequently we might expect a reduction in volume with inversion to pyrite and a later expansion with reduction of pressure and heat. A failure of the marcasite crystal to shift its density and dimensions to that required by altered lattice-structure might be the reason for the perishable condition of the pseudomorphs. They may contain innumerable stresses and dislocations which make sulfur radicles available to oxidation. The features long recognized as distinctive to marcasite may only apply to the pesudomorphs. Pseudomorphs of limonite after marcasite have doubtless gone through an earlier shift from marcasite to pyrite; if so, they will have passed through two temperature thresholds.

I now suspect that sulfide fire-stones were pseudomorphs of pyrite after marcasite. Many specimens that we call marcasite may be marcasite but only X-ray diffraction study can reveal their history. The fire-stones, which show exothermic oxidation upon shearing, with production of ferrous sulfate and sulfur dioxide, may owe their fire-making potential to pseudomorphism. Their very instability (of great value to fire-making) may have been created by pseudomorphic molecular shifts in the lattice. It will be necessary to study many more specimens before we can test this suggestion.

CONCLUSION

Men who designed wheel lock guns had some commonplace knowledge of fire-making with sulfide. An elementary study of their mechanisms leads us immediately to the ignition-systems of preliterate peoples; we find that even the simple mechanics of their process are a lost art.

It is no wonder that we know so little of the technology of flint tools: we still think in the sterotyped image of ancient man knocking two stones together. The world literature in ethnology and archaeology thus far would seem to have based its ideas of sulfide fire-making materials upon what amount to errors in mineral identification. In view of this, I suggest that every fire-set in museum collections, every flint, sulfide or steel tool which anyone has ever identified in the past as part of an ignition set, needs to be reviewed and reidentified, before study of this subject can continue with accuracy. In a similar way the early usage of steel against flint in fire-making is under a dark cloud of suspect information. It was probably a relatively recent discovery, however, following upon the invention of the steeling of iron by pack-carburization in the late Middle Ages.

This is only one small segment of a much larger problem. The tool-kits of mankind as a whole throughout time and space are also involved, for our understanding of them is childish. Detailed studies of this particular kind of subject matter are not pedantic; they are prerequisite to the most elementary insight into the fundamental world of social history. A critical study of the history of gunflints, like such a study of any other industry, leads us back to unrecognized puzzles in the history of earlier basic technology.

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