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HISTORY

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UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Hopewell Village NHS NATIONAL PARK

FILE NO.

REPORT ON THE FURNISHINGS AND EQUIPMENT AND METHODS USED IN THE BLACKSMITH SHOP HOPEWELL VILLAGE NATIONAL HISTORIC SITE

by

Howard Gale
Research Assistant

[February, 1941?]

1510R.4

Hopewell Village National Historic Site
Birdsboro, Pennsylvania

August 21, 1952

Memorandum

To: Regional Director, Region One

From: Superintendent, Hopewell Village N.H.S.

Subject: Report on Furnishings and Equipment of Blacksmith Shop

Reference was made in Historian Hugins' narrative report for July, 1952, to the finding of a report on the furnishings and equipment of the Hopewell Village Blacksmith Shop in a little-used storeroom. This report was prepared by former Research Assistant Howard Gale early in 1941, but was apparently never submitted to your office after Mr. Gale left Hopewell in March, 1941.

We are attaching the original and one copy of this report, complete with drawings of early blacksmithing tools and equipment. We have bound with this report as a preface a 12-page preliminary report on the same subject prepared by Mr. Gale in 1940. The 51-page report which follows it is essentially a more detailed discussion of the material in the preliminary report.

As is readily apparent, these reports and their accompanying drawings constitute a valuable discovery. Not only do they embody research which Mr. Hugins intended to undertake this year in order to complete the restoration of the Blacksmith Shop, but they contain information, acquired from old smiths, which is not easily available today. We feel that little or no further research needs to be done on this project, so Mr. Hugins is now preparing a brief report which will summarize the known data, correlate it with the available tools and artifacts, and make recommendations regarding the restoration of the interior of this interesting historic structure.

James Cass
James Cass
Superintendent

Attachments 2

UNITED STATES

DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

Hopewell Village NHS

Blacksmith Shop

Introduction:

The blacksmith shop at Hopewell Furnace, aside from being a vital necessity to maintenance and operation, was also a financial asset. Its social status, it is believed, was above that of the furnace, or company store. The versatility of the blacksmiths of the "old school," and the freedom of discussion prevalent in the blacksmith shop, is the basis of this conclusion.

While the Hopewell Furnace was built in 1770[1] by Mark Bird, the exact date of the erection of the blacksmith shop is not definitely known. Our most authentic informants on Hopewell history do not care to even hazard a guess as to the date of its erection. As many of them have stated "As far back as I can remember, or have heard others speak, the blacksmith shop has been where it is now, and it looks the same."

However, the archaeological examinations made in and around the blacksmith shop by Mr. Motz, have been instrumental, by means of identifiable objects recovered and contents of strata, in establishing the period of erection as being between 1775-1780[2].

The existence of various floor and roof levels, window and door placements, forges built one upon another[3], may have been questioned heretofore, but their discovery and also the possible reasons for these changes, flood conditions in 1807, as verified by old Hopewell records of that date[4], which state that on two occasions the dam broke and later, during the same year, "lightning struck the dam wall and it fell to the bottom," accumulation of slag piled outside the blacksmith shop[5] seem to clarify the reasons for these conditions, and materially assist in establishing an approximate date of erection.

Mention is also made here of some of the identifiable objects recovered through the archaeological examinations and their places in industrial history: the "pointless wood screw," used 1700-1846[6]; hand made clay roof tile, recovered in lower levels, ca. 1775-1860[7]; hand made wrought iron nails, ca. prior to 1825 when they were superceded by the cut nail with hand wrought head[8]. Such findings are definitely invaluable in assisting to determine the conclusion arrived at, relative to the date of erection.

United States Department of the Interior

NATIONAL PARK SERVICE
HARPERS FERRY CENTER
HARPERS FERRY, WEST VIRGINIA 25425

IN REPLY REFER TO:

MH-RS

OCT 1 1974

MID ATLANTIC REGION
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Initial and Date
Director
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Park Management
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Prof Services
Lands
Administration
EEO

Memorandum

To: Regional Director, Mid-Atlantic Region

From: Manager, Harpers Ferry Center

Subject: Blacksmith Shop, Hopewell Village

John Albright, historian at the Denver Service Center, has called to our attention the existence of a study of the Hopewell Village Blacksmith Shop done by Howard Gale about 1939. We would appreciate it if Hopewell could send us a copy of this report for our permanent files.

Marc Sagan

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
REGION ONE
RICHMOND, VIRGINIA

File reference:
H 14 HOVI

September 3, 1952

Memorandum

To: Superintendent, Hopewell Village National Historic Site

From: Regional Historian, Region One

Subject: Report on furnishings and equipment of Blacksmith Shop

We hereby acknowledge receipt of your memorandum of August 21 transmitting two copies of the "lost" reports on the furnishings and equipment which were prepared by former Research Assistant Howard Gale early in 1940-41.

We agree that it is indeed fortunate that this study has been discovered. As you say, it will obviate the necessity for Historian Hugins to undertake an investigation of the same subject and so will release him for other important research activity.

JWHolland:rnp

Regional Historian

Copy to: Director

General
Daybook

UNITED STATES

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NATIONAL PARK SERVICE

Blacksmith Shop

Furnishings and Equipment:

While it is not definitely known exactly how the blacksmith shop at Hopewell was furnished, it would have contained beyond reasonable doubt, the following: forge without hood, hand bellows, iron anvil on a wooden block base, quenching tub, crane, drill press, work bench, mandrel, grindstone, stock and tool racks, racks for horse and mule shoes, and a box, or locker, in which the blacksmith kept his more valued tools and instruments, and the 101 tools which he used daily.

It is quite probable that the smith possessed farrier's tools and also such veterinary instruments as the occasions required, tire blocks and small casting ladles, beside an ax, hand saws, wood chisels, and other hand tools.

The forge, usually built of native stone was of the size most adaptable to the smith and from two (2) to two and one half ($2\frac{1}{2}$) feet in height, with a hearth usually built at the left end of the platform. A chimney erected at the same end with the opening at the hearth provided the means for escape of the greater portion of the smoke and gases from the fire. The early balcksmith's forges, such as this one at Hopewell, were not equipped with hoods. Informants have definitely stated that hoods were non-existent[9]. Ventilation was provided, in addition to the chimney, by the opened doors and windows, with possibly a crudely louvered ventilator in the roof. One of our informants stated that "a little smoke was good for the skin." Boards or planks found in front of forges are no definite indication of a wooden floor, especially in the old shops. Boards and planks were placed in front of the forge to provide a dry surface for the blacksmith to stand upon. Wet and cold feet were two of the tribulations of a blacksmith's life.

The hand bellows provided the real draft for the fire. The bellows found in the blacksmith shop are of the double type, which was, and is the type used in the average shop. The single bellows was used where steel was handled to a greater extent. With a single bellows the draft would cease when the smith stopped the bellows, thereby preventing an excessive heat which might burn the steel, whereas, the double bellows would reduce the draft gradually, and not permit a rapid decrease of temperature in the fire which was a condition not always desired by the smith when handling iron.

Blacksmith Shop

Furnishings and Equipment-con't.

The bellows found in the shop at Hopewell (see measured drawings of Blacksmith Shop) while in a good state of preservation to be used as a museum piece, should not be put into service. During a conversation with Mr. Straley, of Morristown, New Jersey, and Mr. Motz on August 16, 1940, relative to blacksmith shops and their furnishings, Mr. Straley advised using a good saddle soap on the old bellows to prevent them from deteriorating any further. The bellows were operated by hand by the smith himself or his helper. They were located to the left of the chimney with the nozzle inserted into a pipe which was connected to the hearth. The handle of the bellows would have been anything from a piece of shaped scantling to a thin limb of a tree. Often a weight of some sort, piece of iron or a stone would be placed upon the bellows to increase the rapidity of the double action of the double bellows.

The anvils used during the period of the active existence of Hopewell Furnace were of two types, a cast wrought iron anvil or a cast wrought iron anvil with a steel face. The former would have been made in two parts and the latter in three parts. One informant has exhibited to the writer an anvil that has been in service for more than 70 years[10]. It is of the steel faced type. The three part divisions were distinctly discernible (see sketch A), the lower part, or base, the upper portion or face and horn, and applied steel face. These parts were welded together. The informant definitely stated that prior to 1880, solid steel anvils were very rare and also very expensive. Anvils were usually located two (2) or three (3) feet from the forge at a spot most convenient to the smith. They were mounted upon a wooden block, usually a portion of the trunk of a large tree and fastened by means of spikes driven into the block and bent around the base of the anvil or by iron bands holding the anvil to the block. The hole through the base of the anvil, as seen in the older types, was made while casting the base and used for convenience in moving the anvil, a bar being placed through this hole, permitted two persons to easily handle the anvil.

The quenching tub, a receptacle to contain water to chill metal, consisted of one half of a barrel. This piece of equipment was located near the anvil at a place suitable to the smith. However, special quenches for hardening or tempering, such as oil quenches, brine quenches were kept in other receptacles, buckets, etc.,[11] and located in readily accessible spots in the shop near the forge.

Blacksmith Shop

Furnishings and Equipment -con't.

The crane was made by hand of seasoned wood, usually of scantling 6 inches square or larger. The mast or upright post resting upon a block of wood and having a pivoting pin driven into or attached to the bottom. At a point where the upright passed one of the beams, a supporting band attached to the beam of the shop permitted the movement of the crane from a center point to a full sweep of a circle. The jib or projecting arm, also of wood, was usually mortised to the mast and securely anchored and supported by an iron rod or chain attached to the top or to the upper part of the upright post or mast and to the outer end of the arm. This arm was at a 90° angle to the upright post. From the end of the arm extended the carrying chain or connected rods of a suitable length to which the smith attached heavy work being handled. (See measured drawings of Blacksmith Shop). The crane was generally located at the left end of the forge.

The existing crane in the Hopewell Furnace blacksmith shop is quite efficient and in excellent usable condition.

During the early life of the shop, the drill press used was of an entirely different type than that being used during the past 60 years. The existing pressure beam of the old drill press, that is still existent in the shop, is in excellent condition. The remainder of the equipment necessary to complete an assembly of this type of drill press can be easily made by a competent blacksmith. Mr. L. Kaczor, now employed in that capacity, is quite capable to do this work. The accompanying sketch "D" illustrates[12] the shape necessary. The size can be varied to suit existing conditions. Sketch showing raw hide drill press, illustrates another type of drill press used. It is doubtful, however, if this latter type was ever used at Hopewell Furnace.

The work bench, as many other pieces of equipment, was hand made, usually of heavy planks of various widths, lengths and thicknesses, to suit the smith. General dimensions would probably be from 6 to 12 feet long, 18 to 24 inches wide and of from 2 to 3 inches in thickness, strongly supported by heavy legs and would be located along the wall of the shop opposite the forge and beneath a window or near a door, in order to secure the maximum amount of natural illumination.

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Furnishings and Equipment -con't.

Mandrels were made of cast iron and were used to true up articles having circular shapes, i, e., hub rings, chain links, etc. The mandrels varied in sizes from 15" in base diameter and 5 feet in length to 8 inches base diameter and 3 feet in length. Some were made in two sections[13] (se sketch "B".) The groove shown is to accomodate portions of the object being worked that protruded inward from the circumference. They were hollow and conical shaped.

Grindstones were vital necessities in the blacksmith shop. While they varied in sizes, our informants have stated that they were from 3½ inches thick and 30 inches in diameter to 5 inches thick and 40 inches in diameter. They were mounted upon wooden frames and turned by a handle attached to the axel which was of wrought iron or low carbon steel, set in spelter (an impure zinc) which was generally poured by the smith[14] from cast iron dippers or ladles.

Stock and tool racks were usually large nails or spikes, or pieces of iron rod driven into the wall by the smith at convenient places. However, wooden racks were also constructed for this purpose. Often, rod and bar stock would be stood in a corner of the shop. Racks for horse and mule shoes were of a similar type, arranged to hold the various partially sized shoes. The smith always had a box or locker in which to keep his lunch, more valuable tools or other personal belongings. This was of a size and shape to suit his fancy.

The tire block was made of hard wood and used to shape wheel tires upon (see sketch "C")[15].

The regular tools used by the blacksmith were many and varied as to size and shape. The smiths, of the period during which Hopewell Furnace operated, made their own tools. While Fig.1-24 illustrate a few of the standard shapes of tongs, etc., whenever a particular job required a different shaped or sized tool than those which the smith had, he made the new tool to fit the job in question. Generally speaking, the blacksmith's tools universally used were flatters, set hammers, swages, swage blocks, fullers, hand hammers and sledges, punches, bolt headers, hot and cold cutters (handled and anvil tools,)cutting blocks, tongs of many sizes and shapes, bending tools, breakers, bucking bars, vee blocks, surface plates, cold and

Furnishings and Equipment - con't.

cape chisels, taps and dies, small cast iron dippers or ladles, to cast small pieces; wood saws, planes, chisels, screw drivers and ax, fire tools, calipers and rule and files[16].

Farrier's tools included driving hammers, pincers, clinch cutters, horse rasps, foot hooks, farrier's knives of various sizes, hand hammers, 10 oz. to 24 oz.; creasers, both light and heavy bitted, stamps or punches, pricks, hoof cutting nippers, 3 square files, froat (to rasp teeth), double rasp, 1/2 round bastard hot filing rasp, steel or iron rule[17].

It has not been definitely learned whether the blacksmiths at Hopewell Furnace did veterinary work, but with the number of animals, horses, mules, cows, used and kept on the Furnace property, it can be reasonably presumed that the blacksmith here[18], as in many other localities, took care of sick and injured animals or assisted in such duties and possessed the necessary instruments for this work.

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Blacksmith Shop

Personnel.

Beside the smith, there was always a helper or an apprentice, or both to assist the blacksmith in the work to be accomplished in the shop. Apprentice boys, in the early years, were almost sold to their masters; but, the parents had to pay the master annual sums of money, as stipulated in the indenture contract, and provide the necessary clothing for the boy; while the master provided the instruction, meals, lodging, washing, and the oftimes uncontrollable incentive to work. During the earlier periods of operations, blacksmiths were usually paid $1.25 per week, board, lodging and laundry; $1.90 per week when they provided their own board, etc. Helpers received 75 cents to 90 cents per week. During later years, ca. 1865, the smith received $1.35 per day, house, fire-wood, a cow and hay for the same[19].

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Blacksmith Shop

Types of Work:

It would be quite a problem to enumerate the kinds of work performed by the blacksmith; but it can be stated that in the blacksmith shop the work of manufacturing and repairing metallic equipment of the furnace, and also some of the equipment used at the mines from which Hopewell Furnace secured ore, was accomplished. The blacksmith not only made his own tools, but he made most of those of other workers at the furnace and kept them in repair. Horse and mule shoes were made and fitted by the blacksmith. Building hardware, hinges, latches, bolts, locks and lock plates, etc., as well as some agricultural equipment, plow shares, cutters, hoes, mattocks, spades, etc., were the results of his handiwork. The making of steel edged ax heads was often a usual occupation.

The "old school" blacksmith made his own horseshoe nails; at first from old shoes and scrap iron; later from a special nail iron known to the trade as "Norway Iron." Whether commercially made horseshoe nails were used in the old shop cannot be definitely stated; but records show that mule shoes were purchased[20] from hardware dealers, during the later years of the Furnace's operation.

Additional work by the blacksmith for individuals and outside interests, as indicated by old Hopewell records[21], show definitely that the operation of the blacksmith shop was a genuine financial asset. Often, the old blacksmiths, being very ingenious craftemen, would cast small pewter and lead ornamental objects and make many decorative wrought iron pieces, many of which, today, are almost priceless.

It has been stated by informants that soft (bituminous) coal was used in the blacksmith's forge. However, other fuel, wood charcoal or peat, may have been used for special welding or hardening jobs.

Peat has been found in the vicinity and its properties as a fuel for the blacksmith's forge are indicative of its possible use.

"Turf, or peat, when properly pressed, dried and charred is an excellent fuel for the blacksmith's forge. When properly prepared

Blacksmith Shop

Types of Work - con't.

yields a charcoal as hard again as the best sugar maple, or hickory coal. However, it should never be used in its raw form, but only when charred.

The component parts of turf differ from those of wood. The difference is owing to the fact of its being decomposed woody fibre. It has been found that it contains less oxygen and more combustible matter than wood. An analysis of several specimens of good turf contained, beside ashes, in 100 parts:

	Carbon	Hydrogen	Oxygen
No. 1	57.03	5.63	31.76
No. 2	58.09	6.93	31.37
No. 3	57.79	6.11	30.77

and analysis of the following kinds of wood shows, in 100 parts:

	Carbon	Hydrogen	Oxygen
Sugar Maple	52.65	5.25	42.10
Oak	49.43	6.07	44.50
Poplar, Black	49.70	6.31	43.99
Pine	50.11	6.31	43.58

Though the elements of turf ashes are beneficial to the working of bar iron and steel, it does not follow that they are equally beneficial in reducing iron ore; for in the blast furnace phosphates of any kind are injurious, and produce a cold-short iron."[22]

(While the abundance of wood and stone coal indicates that wood charcoal and stone coal were the fuels generally used, those conditions are no definite indications that turf or peat fuel was not used in the blacksmith's forge for special welding and hardening jobs, since peat is existent in the locality.)

It is believed by the writer, that if the peat deposit recently located can be properly prepared for use in the blacksmith's forge, its use will provide a definite attraction for visitors, if sufficient publicity is given.

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NATIONAL PARK SERVICE

Blacksmith Shop

Conclusion:

Now that Hopewell Village is a National Historic Site and that the old Blacksmith Shop will be restored to its existing condition during the last days of its operation, it may be recommended to have "old style" equipment procured or manufactured that would correspond with that period. The styles of tools have changed but little, with the exception of drill presses and draft producing equipment. The attached sketches of the more important tools and furnishings provide a basis from which to start at this time.

Howard Gale.

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NATIONAL PARK SERVICE

Hopewell Village National Historic Site.

1940.

Blacksmith Shop

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Blacksmith Shop

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Howard Gale.

MM:HG

UNITED STATES

DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

HOPEWELL VILLAGE NATIONAL HISTORIC SITE

Report

on the

Furnishings and Equipment

and

Methods Used

in the

Blacksmith Shop

UNITED STATES

DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

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UNITED STATES

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HOPEWELL VILLAGE NATIONAL HISTORIC SITE

INTRODUCTION

This report is subsequent to that which has previously been submitted by Mr. J. C. F. Motz upon the blacksmith shop at Hopewell Village National Historic Site., and treats of the equipment, furnishings, and methods apparently used.

The activities of the life of the shop have been separated into four periods[1], namely:

1.	First Period	1775-80 to 1800
2.	Second Period	1800 to 1849
3.	Third Period	1849 to 1883
4.	Fourth Period	1883 to 1940

Due to the definite lack of authentic data relative to particular and specific equipment and methods used in the Hopewell shop during the first three periods, it is necessary to depend upon other sources for information that will be valuable in restoring the shop to the state existent during the third period in respect to furnishings, equipment, and methods used during that period.

Each period shall be treated respectively, as far as is possible, from the facts known at this time.

Other information has been secured from blacksmiths of excellent reputation and from others who were familiar with the equipment and methods used in blacksmith shops during the latter part of the third period and since. Sketches made from verbal descriptions have been approved by the informants.

FIRST PERIOD, 1775-80 to 1800.

Very little can be stated relative to the first period. The forge discovered[2] and associated with this period, is apparently of a type similar to those erected above it. The artifacts discovered, indicative of this period, portion of a bolt[3], hand made iron staple[4], show that such items were quite probably made in the shop.

Other items have been discovered, that cannot be assigned to but the first period and therefore should be included in an era inclusive of the latter portion of the first period and the early part of the second period. These items include a gate hook[5], handled hot cutter head[6], section of wagon tongue[7], and iron bar[8]. The handled hot cutter head is hand made of fibrous iron, indicating that the smith made some of his tools and also other small items or tools.

Second Period, 1800-1849

The following objects, which have been discovered and by archaeological determination, can be assigned to the second period of the life of the Blacksmith Shop are : hand anvil[9], rectangular punch[10], flattening hammer (flatter)[11], section of an iron rasp[12], small forge hoe (fire tool)[13], small hardy[14], half of a die[15], head of a handled punch[16], portion of a bit[17], harness buckle[18], cold chisel[19], half round file[20], section of a scythe blade[21], fragment of a curry comb[22], head of a handled cutter[23], and an oval hand punch[24], two cutters or coulters, for a wooden plow [25-26], and a decorated flask cast stove plate[27].

With the exceptions of the portion of iron rasp, and the half round file, the artifacts mentioned are hand made, and indicate that the smith not only made tools for his own use, but also made items for agricultural purposes. The different types of work accomplished, as indicated by the tools and coulters are definitely not typical of a particular period, inasmuch as the same activities were also engaged in during later periods.

The forge level[28] discovered in archaeological examinations and assigned to the second period is of a type similar to its successor, which is being used in the shop at this time and which is built above the forge indicating the second period.

However, nothing has been discovered as yet, to indicate specific equipment, furnishings or methods used in the Hopewell shop during this period that would materially differ from a subsequent period. The decorated flask cast stove plate was probably used as a platform upon which the smith stood and although it is believed that it was made about 1800, there is no evidence that that particular date is correct.

Informants have been unable to supply information relative to the first two periods; and examination of old records, thus far, has resulted negatively upon these subjects.

Here, again, are findings of a nature that cannot be definitely associated solely with the second period; a head of a handled cold cutter[29], and a hand made drill[30]; both are indicative of the second and third periods, due to their specific locations when discovered. However, dates of their manufacture or use cannot be definitely stated. Their nature and purpose are similar to those used during later periods.

Third Period, 1849-1883

Of this period, several pieces of equipment of the Blacksmith Shop remain. The forge, crane, work bench, bellows and part of a hand operated drill press[31] are in good condition. The forge has been repaired and put into service, but the bellows are not serviceable. One informant, Mr. Straley of Morristown, New Jersey, has stated that old forges did not have hoods. A hood has been added to the forge. Another informant[32] has described a portable hood used by the last blacksmith at the Hopewell Shop in 1883 (see sketch "E"). Mr. Straley also suggested treatment of saddle soap to the bellows to prevent further deterioration.

The crane is in excellent condition and very serviceable. The portion of the hand operated drill (pressure beam) now in the shop, was not the drill press operated during the last years of operation. However, the missing portion of the press can easily be constructed. Specific information has been secured [33] describing that portion (see sketch "D") in detail. The drills were hand made of the sizes desired. (see sketch "K") -. Many specimens have been secured as donations. The last drill press used in the Hopewell shop was a post drill made of iron with screw feed, similar to that in use at the present time (see sketch "J"), in the shop.

Artifacts discovered which have been designated as belonging to the 3rd period are a hand made ax head, farrier's shoeing hammer, horseshoe, heel of a scythe blade, eye pin for a gate hinge, an unfinished hand made hoe, large flask cast stove plate in 5 pieces (date of manufacture undeterminable)(probably used as a platform for the smith). --

On the surface were located a wood chisel, mower plate, hand made tap, rivet or nail header, cleavis, trace end, whip socket, buggy thimble ferule, and a wagon step.

Inasmuch as there was possibly activity in the shop during the fourth Period, the latter named items could have belonged to either the latter part of the third period or to a portion of the fourth period.

The activities indicated are horse and mule shoeing, manufacturing or repairing of agricultural tools, probable wagon repairs and some items of builder's hardware.

The following information has been secured from sources other than the sources available at Hopewell Village. Inasmuch as one or even a number of shops cannot be stated to be typical of the period, the information is given as it was secured.

Third Period, 1849-1883 con't.

The quenching tub was a receptacle, usually one half of a barrel or cask, containing water, was used to chill hot metal. There is one in use at the present time.

The work bench found in the shop has been removed and replaced by a more substantial one, which was placed in the same location.

Mandrels were of various sizes, made of cast iron, some being hollow, others solid, and were conical in shape (see sketch "B"). The style varied. Some were made in two sections[34]. They were used to true up articles having circular shapes, i. e., hub rings, chain links, etc. They varied in size from 15 inches base diameter and 5 feet in height to 8 inches base diameter and 3 feet or less in height. Many smaller sizes were made as the occasion required. The groove shown is to accomodate portions of the object being worked that protruded inward from the circumference of the piece.

The tire block usually found in old shops is illustrated by sketch "C". Our informant[35] stated that they were made of a hard wood and used to shape wagon wheel tires on, the metal being cold. A large swage block has been viewed in another old shop which had one side shaped for this purpose. The proprietor[36] stated that it was a rare type, but could give no history of the block. It could be used for hot or cold metal.

It is quite possible that individual blacksmiths often made equipment quite different from that in general usage; however, such specialized furnishings, etc., will not be dealt with here.

Grindstones were of different sizes, varying in thickness from 3 to 5 inches and in diameter from 30 inches to 40 inches. They were mounted on wooden frames and turned by hand by a handle attached to the axel. The axel was of wrought iron or low carbon steel, set in spelter (an impure zinc) which was generally poured by the blacksmith from cast iron dippers or ladles[37].

Stock and tool racks were usually large nails or spikes driven into the wall at places convenient to the smith. However, wooden racks were also constructed for this purpose[38].

The regular hand tools used by the blacksmith were many and varied as to shapes and sizes. During the third period and the early portion of the fourth period of the history of the Hopewell Village shop, these tools were made by hand by the smith. While Figs. 1-24 illustrate a few of the standard shapes of tongs, etc., whenever a particular job required a different shaped or sized tool from those possessed by the smith, he made the tool to fit the need.

Third Period, 1849-1883, con't.

Generally, the tools universally used were known as flatters, set hammers, swages, swage blocks, fullers, hand hammers, sledges, punches, bolt headers, hot and cold cutters (handled and anvil tools), cutting blocks, tongs, bending tools, breakers, bucking bars, vee blocks, surface plates, cold and cape chisels, taps and dies, small cast iron dippers or ladles to cast small articles, wood saws, planes, chisels, screw drivers, ax, fire tools, calipers, iron or steel rules and files[39].

Farrier's tools for horse and mule shoeing included driving or shoeing hammers (the type discovered as indicative of the third period is similar to that used during the fourth period by the average horseshoer), pincers, clinch cutters, horse rasps, foot hooks, farrier's knives of various sizes, hand hammers, 10 oz. to 24 oz.; creasers, light and heavy bitted; stamps or punches, pricks, hoof cutting nippers, 3 square files, froat (to rasp teeth), double rasp, 1/2 round bastard hot filing rasps, steel or iron rule[40].

Whether the blacksmith at Hopewell Village shop performed any veterinary duties is not known. However, in shops where horses and mules were shod, the blacksmith, especially in isolated locations was able to do this type of work to a limited extent[41].

Information gathered from the many informants indicates that the methods of operation pursued during the first part of the fourth period, 1883-1903, were very similar to those used during the greater portion of the third period 1860-1883, especially in shops similar to that of Hopewell. Hand tools did not change. Machinery, drill presses, forge draft equipment and heavy shearing and punching equipment were greatly improved during the latter part of the third period and during the fourth period.

The methods hereinafter described were those used by informants and secured from other reliable sources that would be applicable to the third period of the life of Hopewell Village Blacksmith Shop.

METHODS

Fuels:

"A coal known as smithing coal was the common fuel burned in the smith's forge. Coke and charcoal are sometimes used for special fires, or in the working of tool steel.---- It should coke readily and be free from sulphur, slate and dirt. Smithing coal is coked by banking a quantity of green or fresh coal over the fire and partially burning out the gases. The coke formed should be firm and clean.[42]" In the absence or unprocureability of smithing coal, regular bituminous coal was used, being well coked before being used in the working fire.

"Coke is mostly used in ---- when heavy pieces of metal are to be heated. ---- Charcoal is the best fuel for heating carbon steel, because it has a tendency to impart carbon instead of withdrawing it as the other fuels due to a small extent[43]."

Fire:

"The fire is kindled on the hearth over the tuyere iron. This iron, the terminal of the blast pipe that leads from the bellows, is made in various forms and of cast iron; sometimes it has a large opening at the bottom, but often it has none[44]." "When the tuyere is clean, shavings were lighted in the bottom, and when well burned, coke is raked back on the fire. A little wind or draft is turned on. Wet coal is banked around the sides and back of the fire. When the fire is well started and loosened up in front with the poker and most of the smoke burned, it is then ready for heating[45]".

"A good depth of fire is always necessary. If the fire is too shallow, a cold blast will blow through the fire and cause the metal that is being heated to scale or oxidize rapidly. It is also impossible to heat metals properly for welding purposes in a shallow fire[46]."

In order to secure the necessary temperatures to heat iron and steel, a draft was necessary. This was obtained by use of the bellows, which was usually operated by the blacksmith himself. The bellows, operated by a lever which expands the sides and forces air through the tuyere iron, causes the fire to burn freely and creates a temperature sufficient for heating the metals. Bellows were of various sizes and of single action and double action type. (The double action type was found in the blacksmith shop in Hopewell Village).

Methods, con't.

In manufacturing the many metal items and in the repairing of equipment by the blacksmith, welding played an extremely important part. There were but few fixed rules in welding during the early days, and even up until the 20th century, the rural blacksmiths followed the "rule of thumb". All work being performed in the methods of the "old school", nearly every job presenting its own difficulties, and the smith had to adapt the method to be used to the job. The following was the usual method pursued:

"1 - Prepare a fire properly adapted to the heating of a weld.
(a) The fire must be well coked, clean, deep, free from clinkers.
(b) Proper control of the blast is necessary.
2 - Prepare the pieces to be welded.
(a) Upset the ends to provide sufficient metal to allow for burning during the heating process and for hammering down to normal size during the welding operation.
(b) Scarf the ends to be joined; these differ greatly, with some of the type shown (see sketch "G")[47].
3 - Heat the weld.
(a) Place the scarf ends in the fire.
(b) Heat slowly to a full yellow; then force draft for a few moments[48]" Care must be taken at this point, not to permit cold air from the blast to reach the heated metal[49].
(c) Flux the welds by sprinkling suitable fusion agent on the scarfs without removing from the fire.[50] The flux could have been powdered yellow clay[51], fine grained white sand, borax, mixtures of clay and borax or clay and fine iron scale[52]. (The commercial fluxes or fusion agents used in shops of today were unknown to the blacksmiths[53] of 1770-1883, although some of them had their own compounds, the formulae of which they closely guarded[54].)
4. - "Place hammer on anvil where same can be quickly caught up to strike necessary blows [54]"
5. - Allow flux to melt and spread over scarfs and remove from fire quickly[55].
(a) Lift pieces clear of fire, do not drag through fresh coal on hearth.
6. - Place pieces together on anvil.
(a) Strike pieces together or on anvil lightly to remove any dirt or scale.
(b) Place scarfs together and rapidly set weld with light blows. When weld is set increase force of the blows gradually until the weld is sufficiently firm, the work is turned on the side and the edges hammered to close the seam. If the weld does not take from the first heat, it was necessary to repeat the heating.

Methods, con't.

7. - Finish

(a) After the weld is complete, the enlarged diameter created is hammered to the desired size or shape, working the metal as thoroughly as possible. In some instances the joint was finished by filing, to improve the appearance.

In heating metal in the fire, the method really successful was to have ample hot coke under and over the metal and the whole covered with "green" coal (see sketch "H" 56), thus not only properly heating the metal, but expelling some of the impurities, namely sulphur, from the green coal.

Horseshoe nails were made from scrap iron which was heated, drawn out, cut to size, head, shank and point then formed. These were made by hand for many years. A special Norway or Swedish iron was a brand of excellent pure iron free from slag and other impurities was universally used for horseshoe nails[57].

Metals:

The blacksmith of the 19th century had but little choice of metals in the rural districts. Wrought iron was commonly used. It was of fibrous structure with black slag seams lengthwise of the bar. It was not a good metal to use if very much forming is to be done. It had very little, if any, carbon content. It could not be tempered. It welded easily. It must be forged at a high yellow or at a mellow welding heat, if it showed an inclination to split.

(Note: The use of wrought iron in the blacksmith-shops of today is practically obsolete, mild steel having taken its place[58].)

The many tools used by the smith were hand made by him. The position of the smith and his helper can be illustrated by accompanying sketch (see sketch "I" 59).

In handling long pieces of metal that were to be heated in or near the center, one end was extended through an opening in the rear wall at forge height and the portion to be heated placed in the fire and supported at the other end by a block or the crane alongside the forge[50]. Heavy work was supported and moved by means of the crane. (See measured drawings of Blacksmith Shop.)

Metals: con't.

Wagon wheel tires were generally made from scrap iron that was worked over in a bloomery or forge into sizes and thicknesses desirable for the purpose. In making the tires, the smith would measure the perimeter of of the wheel and measure the iron accordingly. The holes were bored for the tire bolts. ---- "The whole tire is heated to a high temperature but not red hot ----This operation will cause the tire to expand the necessary amount" ----[61] to fit the rim. A punch is driven through a hole in the tire into a bolt hole in the felly of the wheel to hold the tire by means of a tire puller and a heavy hammer, the tire is driven onto the felly of the wheel by striking it around the edges and on the outside. The wheel is stood in a quench trough, drawing it through the water and at the same time striking down against the tire causing the tire to adjust itself, drawing the tire, felly and spoke ends tightly together. Then the bolts would be replaced and the felly pointed[62]. It would then be shaped to fit the wheel, sized slightly smaller than the wheel rim and welded.

Holes were drilled in metal by the blacksmith with hand made drills rotated in drill presses of various types (see sketches "D" and Rawhide Drill Press), The type described as being last seen in the blacksmith shop at Hopewell Village was apparently of the post drill type[63] (see sketch "J"). The drills were made of steel rod of the thickness desired. Of the majority of hand made drills made by the smith, the square taper shank was most popular. Actually the tip did the drilling. Many of these can be illustrated by the accompanying sketch (see sketch "K"). The drills were hardened and tempered in the shop. The accomplishment of this task was one of importance. The smith had to really know his materials and the various colors shown by the heated metals at different temperatures. The following are the colors and corresponding temperatures generally used and are only approximately correct[64]:

Color	Temp. Cent.	Temp. Fahr.
1. Faint Red	482°	900°
2. Blood Red	566°	1050°
3. Dark Cherry	635°	1175°
4. Medium Cherry	677°	1250°
5. Cherry or Full Red	746°	1375°
6. Bright Cherry Red	774°	1425°
7. Bright Red	843°	1550°
8. Salmon	899°	1650°
9. Orange	941°	1725°
10. Lemon	996°	1825°
11. Light Yellow	1079°	1975°
12. White	1204°	2200°

Methods - con't.

Metals: con't.

The blacksmith in the rural shop had no equipment to determine temperatures, but relied solely upon the colors shown by the metal.

In tempering, much depended upon the use of the tool as to the degree of hardness desired. The steel would be forged to the shape wanted and the point or edge to be hardened would be heated to a cherry red and then immersed in cold water. Immediately afterward, it was rubbed bright, usually with a piece of brick. The colors would then be watched and upon the showing of the correct, to the smith, color, the piece would be again immersed and cooled entirely. The informant[65] stated that a real blacksmith could readily determine the proper color of the metal for the desired degree of hardness.

Another authority[66] quotes the following method: "It is only possible to give general instructions for hardening, as every temper of carbon steel will require slightly different hardening temperatures and different treatments will be required according to the results desired.--- The operation is extremely simple but requires a great deal of care and close attention. ---- The tool should be slowly warmed through, and slowly heated to a dull red, 1375° - 1500° F., and allowed to cool in dry lime. The tool when cold, or slightly warm should be slowly re-heated, care having been taken that there is plenty of fuel between the tool to be heated and the blast nozzle. It is also essential that the blast should be very gentle and tool be turned over and over so that the heat will be conveyed across the steel in a uniform manner. Immediately the tool has been uniformly heated through, from a dull to a full cherry red, varying with the temper, that is, from 1375° to 1500° F., it should be quickly withdrawn from the fire and chilled in the cooling medium. The tool should be agitated, as this will prevent any hardening line occurring and will cool the steel more uniformly.

The quenching medium is preferably good clean water at about 65° F. If a tough center tool is required, water 80° F. will be found most satisfactory. A brine or acid solution can be used if extreme hardness is required, or desired. It is generally better to use a higher temper and quench in cold water rather than endeavor to get extreme hardness with a lower temper steel. For slender and irregular shapes it is preferable to quench in oil at about 70° to 85° F. The oils most suitable for this purpose are as in the order named:

Metals: con't.

New Fish oil
Lard oil, 75% plus 25% parafin
Boiled linseed oil
Raw linseed oil
Extra bleached fish oil
Cotton seed oil
Tempering oil - 65% cotton seed - 40% mineral oil
Mineral oil

"Either of the first three are excellent oils for all purposes of quenching."

Other informants have stated that a little powdered lead[67] would be placed on the hot tool before immersing in the quench; brine solutions were made by dissolvong a sufficient quantity of salt in water to procure a brine capable of supporting an uncooked egg[68].

"To harden wrought iron or low carbon steel, much depended upon how deeply the hardened surface was to extend. For a thin hardened surface, the piece would be heated red hot (bright cherry red), removed from the fire, cyanide of potassium applied, or sprinkled on the surface and then re-heated. After re-heating to a cherry red, the piece would be removed from the fire and immersed in cold water. To increase the depth of hardening, the above process was repeated until the desired results were obtained[69]."

The use of cyanide in hardening should be explained for clarification. "Cyanide is a deadly poison and must be handled with care. A violent explosion will result if moisture of any kind touches the melted cyanide. For this reason it is advisable to preheat the tongs or pieces to be cased in a clean fire or flame. A suitable hood should be provided over the melting pot to carry off the fumes, which are poisonous, and to protect the workman in case the metal should spatter about. The hands should be washed clean after handling cyanide.

Sprinkle method. The simplest method is to heat the piece in a clean flame or fire to a cherry red, then rub or sprinkle the heated part with potassium ferrocyanide, allow the cyanide to fuze on the heated surface, return the steel to the fire, reheat, and again apply the cyanide. Lastly, heat the steel to a cherry red and quench in a clear cold water. Plowshares, corn plow shovels, screw driver bits, etc., can be treated by this process.

Metals: con't.

Cyanide bath. The cyanide is melted in a suitable cast iron pot or in a large ladle. The work to be cased is immersed in the liquid cyanide. The piece is left in the cyanide for about thirty minutes, and immediately quenched in clear cold water[70].

Cutting Metals. (See sketch "L")

The cutting edges of the tools should be kept properly dressed and ground.

1. - Cutting on a Hardy. The hardy is placed in position as shown, the cutting edge parallel with the side of the anvil. The piece to be cut is held on the hardy and struck with the hammer. The rod, or piece is turned one half and nicked opposite this cut. Continue the cut around the rod. Metal may be split by cutting it between the hardy and a hot-cutter. (See sketch "L", I.)

II - To Nick and Break Tool Steel. Tool steel may be nicked deeply with a cold cutter, the bar held through the swedge block or over the edge of the anvil, and the metal struck a sharp blow. Only an expert could successfully nick and break the larger sizes of steel. It was much safer to heat the steel, nick it deeply, and then quench at the nick, hardening the metal at that spot. The bar could then easily be broken. The metal could be completely severed while heated. (See sketch "L", II.)

III - Cutting with a Hot or Cold Cutter. These tools, see Fig. 18, are held in position by the smith and struck by a helper with a sledge. The metal may be deeply cut with the piece on the face of the anvil, and the cut finished by shearing at the edge of the anvil (see sketch "L", III.) Metals cut hot should be kept to near a full forging temperature (full yellow) for the best results. Heavy cutting is done on the cutting block, see Fig. 20.

IV - Chisel. This tool is made for splitting and cutting hot or cold metals. For hot work the shank should be considerably longer than the common cold chisel. The blade should be quite thin but not longer than necessary. Thin metals are frequently cut by shearing them in a vise as shown at Sketch "L", IV. Sheet metal is frequently cut through by placing it firmly on a bench block of steel or cast iron.

Cutting Metals: con't.

V - Removing Sickle Sections. The sections on a sickle-bar were removed by loosely clamping the section between the vise jaws with the sickle-bar firmly supported against one vise jaw. The section was then struck a sharp blow with the hammer (see sketch "L", V,) thus shearing the rivets.

VI - Removing Rivets. A sack or heavy cloth should be hung in such a position that it will stop the flying pieces, preventing injury to the workman or damage to finished pieces, breaking of windows, etc.

(a) Chipping off the head with a strong cold chisel and a heavy hammer. (See sketch "L", VI).

(b) Knocking the head off with a breaker and a sledge, see Fig. 21 and Fig. 8. This was a very satisfactory method when considerable heavy work was to be done.

(c) Drilling. A drill slightly smaller than the shank of the rivet should be used. Care had to be exercised not to drill into the metal about the rivet.

VII - Roughing Out with a Drill. This method was used when removing metal from a key-way or in the making of an opening in heavy sheet or bar iron or steel (see sketch "L", VII).

VIII - Ripping. The blade of the tool was shaped in such a manner as to shear out the metal. (see sketch "L", VIII).

VI - Hack Saw. This is a metal severing saw. The blade is held in a frame deep enough to allow the severing of any ordinary thickness of metal. It is possible to place the blade in a position as shown by Sketch "L", A. The blade cuts on the forward stroke. Pressure should be relieved on the return stroke. Special care must be exercised to avoid twisting or wrenching the blade or it will break. About fifty strokes per minute is a practical speed. For ordinary work, the 10 inch size, 18 or 24 tooth blade is used. The 18 tooth size is generally used for cutting steel, cast iron and slate in thickness of 3/16 inch and above. The finer blades are better for sheet metal, tubing and tool steels. The piece being cut must be firmly held. (See sketch "L", IX).

Bending and Straightening:

Bending: (Sketch M). "This is one of the most important of the smithing processes. Iron and steel can be bent to almost any angle while hot. Many metals or sizes can be bent when cold. Due consideration

Bending and Straightening: con't.

must be given to the kind of metal, the size of metal and the result desired in selecting the method to be used. Mild steel is the material best adapted to bending. Iron may split; cast iron can be bent but slightly, and it is a difficult operation."71

"Metal can be forced into desired shapes or forms by delivering the hammer blows in different ways. All hammer blows are not alike; some will have one effect and others will produce an entirely different result."72

Angle bends are generally made in the vise or over the edge of the anvil. Curves are made over the rounded edges of the anvil or over the horn. Pieces may be easily and accurately bent by fastening them in a vise and hammering or pulling them to shape. A hooked bending clamp bar (I, Sketch M) was found to be very useful. The sledge placed at II could assist in making short bends. The point at which a bend was to be made was marked with a center punch. A cold chisel should never be used for this purpose. Bending flat stock (III) was done by first marking metal plainly with center punch, heating to full forging temperature and bending in the vise or over the edge of the anvil. Blows should not be struck directly down on the corner metal. Work the blows as illustrated at A.

IV - Bending Eye. Two methods are illustrated.

A - Heat the end of the rod to forging temperature and bend as shown, maintaining forging temperature, feeding the stock forward and striking a glancing blow over the horn to avoid flattening or reducing the stock. Set the eye straight with the stock.

B - It is necessary to know the exact amount of stock for the eye. Begin as shown at 1. Bend rod as at 2. Continue as at 3. It is very necessary to bend the end of the bar as the first operation to prevent a common fault as at C.

V - Bending sheet metal was accomplished by placing it between bending bars made from heavy bars or angle iron, firmly bolted or clamped together. The hammer or mallet should be used with consideration to prevent denting or breaking the material.

VI - Bending Angle Iron. The metal should be heated to a full yellow. Grasp the piece in the vise. Pull or hammer the iron around into position. Keep the metal from bulging by hammering down.

Bending and Straightening: con't.

VII - Bending Flat Material Edgewise. The metal is kept at a high forging temperature. As the metal is fed over the horn the blows are struck with a glancing motion. The metal must be kept flat. If the ends of the ring are to be butted closely or to be welded, it will be necessary to cut the ends.

VII - Bending forks. (see also Fig. 21) Are used for bending brackets, cranks, etc.

VII - Bending Iron Pipe. Large sizes are bent by heating the end about 12 inches back to an even red heat (a coupling should be attached to the end of the pipe); strike the end of the pipe on the floor, reheat and repeat the operation. Lay the pipe on the floor and hammer any bulge or irregularity down. Plug the end of the pipe to prevent the flame from passing through the pipe and heating it. The seam should be on the inside of the bend, not on the quarter, but slightly between. A tool (made by the smith from a tee and a suitable length of pipe) is used to bend the smaller sizes.

IX - Twisting. This operation may be done as a necessary part of construction, or as frequently used, for ornamental purposes. A uniform temperature is maintained throughout the portion to be twisted. Spots at a higher temperature will bend more readily, causing the twist to be irregular. The metal may be fastened in the vise and twisted with a strong wrench or heavy tongs. To straighten twisted work, either hot or cold, and not damage it, a wooden mallet and wood block should be used.

Straightening.[73] (See sketch N).

"This process requires considerable good judgement. Special care should be exercised when working on finished parts not to mar or otherwise damage the piece.

Lead hammers, wood blocks and pry bars, with the ends suitably guarded with brass or copper shields may be used.----"

"I - Illustrates where a blow should be placed when straightening a bar or similar piece.

II - Peening is a method used in straightening thin flat pieces, such as saws, knives, etc. The metal is struck with the hammer as indicated at A. This action stretches the metal at this point, giving the desired results. A careful study of the job is usually necessary. To peen

Methods - con't.

Straightening: con't.

[redacted] out a bad dent ----hold a hand anvil behind the dent and carefully work around the dent and in toward the center, thus gradually returning the metal to its original position.

III - A piece similar to the hook may be brought to the proper form by placing a flat bar in position as shown and hammering the metal against it.

IV - A link or U shaped piece may be opened by placing it against a corner of the anvil over the hardy and striking as shown.

V - Many small bends and short kinks may be removed by clamping the piece with the vise jaws.

VI - A press may be used to advantage when straightening axels, shafts and similar pieces. Pressure should not be applied with an insecure support under the work. It is advisable to strike the piece that is being straightened several sharp, well placed blows while the piece is under the straightening tension applied by the press or pry bar. This will cause the metal to set, and tend to prevent it springing back toward the original bent position.

VII - Bending Bar. Engine connecting rods and similar pieces must be straight and not twisted. Where many rods are to be straightened a tool as illustrated may be used to advantage. A large monkey wrench is usually used. (In many cases, the blacksmith made the necessary tool to fit the particular job)[74].

VIII - Many special bending and twisting bars are essential around a general shop.

IX - Bending forks (see also Fig. 21) are of value in straightening processes.

Forging:

The work of forging metals constitutes the greater portion of the employment of the blacksmith. The hammer is the tool playing the important part in this process. The blows struck upon the metal have their various purposes. "The "upright blow" is delivered so that the hammer strikes the metal in an upright position and fully upon the anvil. Such blows force

Forging: con't.

the metal equally in all directions, providing the surrounding dimensions are equal. They will also reduce the thickness of the metal in the direction in which they are delivered ----They are used for drawing where the metal is supposed to spread evenly in all directions and for making smooth surfaces." ----

"The "edge to edge" blow is delivered so that the edge or side of the hammer face will be directly above the edge or side of the anvil. When blows are delivered in this manner the hammer forms a depression on the upper side of the metal and the anvil forms one on the bottom. When a piece of metal is to be drawn to a smaller dimension with shoulders opposite each other on either two or four sides, these blows will produce the desired results." ----

"The overhanging blow is delivered so that one half of the width of the hammer extends over the edge of the anvil. It is used for forming shoulders on one side of the metal and for drawing out points of scarfs. The leveling or angle blows are delivered at any angle that the form of the work may require. ---- The hammer should not come in contact with the face of the anvil." ----

"The leverage blows are used mostly for bending, as they will not leave marks where the bending occurs. The backing up blows are used to upset metal in the usual manner and in backing up the heel of a scarf. The metal should be extended over the anvil and thrust forward as the blow is being delivered, to get the best results. ---- The metal should be as hot as possible when being upset in this manner."

"The shearing blow is conveniently used for cutting off small portions of metal instead of employing the hardy. It is delivered so that the side or edge of the hammer will pass by and nearly against the side or edge of the anvil. A blow so delivered will have a shearing effect and cut the metal." ----

"Forging is the operation of hammering or compressing metals into a desired shape. Seven specific operations are used. Sometimes a piece of work of forging requires two, three, or even all of them to complete it. These operations are designated by the following names: drawing, bending, upsetting, straightening, twisting and welding.

Drawing, (see sketch 0)the process of spreading or extending metal in a desired direction is accomplished by hammering or pressing the metal between such tools as the swages (Fig. 3) and fullers (Fig.4), or by holding it on the anvil and using either of the set hammers, the flatter or the fuller. When using either of these pressing tools for drawing, a helper is supposed to use the sledge to deliver the blows upon them.

Methods - con't.

Drawing: con't.

It is best to draw round metal with the swages as it will be smoother when finished than if done with the hammer; it should be rolled in the swage a little after each blow of the sledge and after a complete revolution in one direction it should be turned in the opposite direction, and so alternately continued until finished. Especially if iron is drawn, this will prevent twisting of the fiber, which, if prolonged, would cause the metal to crack.

I. "When drawing any shape or size of metal to a smaller round diameter, it is best first to draw it square to about the required size, delivering the blows by turns on all four sides, then to make it octagonal, and finally round. The finishing should be done with the swages, if those of proper size are at hand; if not, light blows should be used, and the metal revolved constantly in alternate directions to make an acceptable shape. Drawing with the top and bottom fullers ---- ought to be done cautiously, as the metal decreases in size so rapidly that there is danger of its becoming too small at the fullered place before the operator is aware of it."[75]

II. "Drawing to a Short Taper. It is necessary that the metal be drawn at a high forging temperature. The bar should be held at an angle with the face of the anvil; this angle should be half of the whole taper required ---- The hammer blows should be delivered with the piece held very close to the edge of the anvil.

III. "Shoulder Work and Notching. It is very evident that only a careful treatment of this process will give satisfactory results.

A. Notches formed with a fuller.

B. Shoulders formed by the proper placing of the piece on the anvil edge, and the correct use of the hammer.

C. Forging made, employing an anvil and hammer only.

IV. "Cold Shuts and Flaws. These must be prevented. If the metal folds in or a small crack is started, it is necessary to cut out the offending part. This may be removed by the use of a chisel, or by grinding. In some cases the flaw may be welded in.

Failure to heat metals properly causes more poor results than any other smithing processes.

Large pieces should be heated slowly and with care to insure a uniform temperature.

It is preferred to cut metal from a forging rather than to weld to a forging.

In general do not quench a forging. Allow it to cool naturally.[76]

(See sketches "P" illustrating methods of drawing.)

Mthods - continued.

"Punching and Fastenings. Punching, the process of perforating metals by means of a tool known as a punch. The rectifying of a mistake during this process is of such a difficult nature that the operation of punching requires special attention. It is essential that the punches used be in good condition and that they be accurately placed to insure the best results. Punching is done while the metal is either hot or cold. (See sketch "Q" which illustrates some methods).

I. Cold Punching. The punch should be comparatively stiff with an abrupt taper, and its point portion should be of the same section for a short distance from the end as shown at A. The end should be flat and the edges short. Sheet metal up to 1/16 inch may be placed on the grain end of a wood block, or on a lead block as at B. The heavier sheet metal should be placed on a suitable punch block as at C. A machine punch is and was frequently a part of the shop equipment. However, it is not known whether there was such a type of equipment used in the Hopewell Village shop during the life of the establishment. Sketch "Q"#II illustrates one of the older styles of combination punch and shear used for working cold metals and was hand operated.

The location of each hole must be accurately made. Center punch marks, slate-pencil, soapstone or scriber marks may be used.

III. Broaching. When the shape or size of a hole is changed by means of a tool pressed or drawn through a hole and metal is removed, the operation is known as broaching. Socket wrenches and similar tools and items have broached openings. The operation is as follows:

A. Provides a broach of suitable size and shape. Machine, grind, forge or file the bit of the tool as illustrated at B. Clearance immediately back of the face of the tool must be provided to prevent its binding in the hole. The bit must be carefully hardened and tempered. Draw the temper of the bit to a brown.

B. Drill a hole slightly greater than across the flats of the broach as shown.

(a) Securely fasten the piece in a vise or hold it firmly on the face of the anvil.

(b) Place the broach accurately in position and strike it one fairly heavy blow. Remove the broach and closely inspect the mark left, to assure the proper starting of the cut.

A heavy hammer and well placed blows should be used in driving the broach. When the bit is well started, oil may be used on it. Broaching is usually done cold. ----.

<u>Methods- continued</u>

IV. Hot Punching. ---- It is advisable plainly to mark the spot to be punched. A center punch should be used for this purpose. The operation is as follows:

(1) Select and dress a punch to good working condition. The section of the point should be uniform and the end of the punch flat and the corners comparatively sharp.

(2) Heat the metal to a full forging temperature. This is generally a full yellow.

(3) Place the metal on the solid face of the anvil.

(4) Drive the punch into the metal as shown in sketch "Q".

IV A. If the metal is thick it may be necessary to cool the end of the punch during the operation to prevent its spreading and sticking in the hole. It may be necessary to reheat the piece several times. A forging temperature must be closely maintained, especially when heavy punching is being done.

(5) Continue to drive the punch until the metal under the end of the punch is firmly compressed as indicated at A.

(6) Turn the piece over and strike a blow or two directly on the spot that is being punched. This should cause a dark smooth mark to form.

(7) Place punch accurately on the center of this mark. With the metal still on the solid face of the anvil, drive the punch into this surface, driving the slug against the face of the anvil.

(8) Move the piece over the hardy or punch hole in the face of the anvil and drive out the slug as shown in sketch Q IV C.

(9) To finish a punched hole, heat the piece only to a red. Hammer down either side of the piece and drive the punch into the hole from either side.

QV illustrates very bad practice. It is not right to drive the punch through from one side when hot punching.

Punch a Deep Hole. The punch must be especially dressed as shown at A, Sketch Q, to insure a hole of a uniform section. The punch must be kept straight and must be prevented from sticking. Forge ash or hammer scale placed in the hole will tend to prevent the punch from sticking. A high forging temperature must be maintained while punching. The piece must be firmly supported.

VI. Drifting. When a hole or opening is changed as to size and shape by forcing the metal about rather than removing metal, the operation is known as drifting. Hammer eyes are usually punched approximately to shape, but are finished accurately to size by means of a drift. Sketch Q-VI illustrates a simple drifting job. A slotted hole was first made in the piece, and the piece again brought to a forging temperature and driven at one end, causing

Drifting, continued:

the slot to open as shown by the dotted lines. A pointed drift punch was used to finish the hole to a round. Where the opening is at the end of a bar, it is worked over the horn of the anvil to the desired size and shape.

VII. Pin Punch. A special punch shaped as illustrated is used for removing keys and pins. If the pin is very solid a solid punch similar to IA, Sketch Q, should be used to start the pin.

Fastenings[78]. (Sketch R)

Fastenings of a wide variety are used on the many kinds of work done by the smith. Common fastenings are rivets, bolts, cap screws and studs. These are all of such importance that the smith should fully appreciate the responsibility of selecting and using them properly.

I.- Riveting. Shapes of the different heads as shown in Sketch RI. Approximately the right amount of point to form the head of a rivet is $1\frac{1}{2}$ times the diameter. Large rivets and special jobs are headed hot. Working room and plenty of it is absolutely necessary to do a hot rivet job right. A bucking bar (Fig. 21) of sufficient heft should be provided to insure a firm backing to the rivet.

Joints to be riveted must be closely fitted and the holes accurately located. In case the job cannot be properly riveted, it is much preferred to ream the holes and drive fit cap screws, held securely in place by means of lock washers and a nut.

Holes may be provided by punching or drilling, the latter method being preferred where accuracy and strength are required.

When it is desired to give the riveting job a uniform quality of finish, rivet sets and bucking tools are provided with cavities in their working faces to conform to the shape and size of the head to be finished.

A finished riveting job should be carefully inspected and tested to insure that all rivets are sound. To test a rivet, strike it a sharp blow with a hammer and listen closely to the sound. The sound should be solid and as though the rivet were part of the solid piece. A loose rivet will be readily noticed by the dull loose thud.

II. - Bolt. A bolt is a rod with a head on one end and a thread on the other. The threaded end is fitted with a nut. ----. The head and nut may be either square or octagon.

III. - Carriage Bolt. Used for fastening wood to metal. A plain washer should always be used under the nut when the bolt is used to hold together two wood parts.

IV. - Plow Bolt.
(1) Key or tit head
(2) Round head, square neck.

V. - Tire Bolt. The hole should be properly counter-board to receive the tapered head.

VI. - Bolt End. Short threaded piece of rod fitted with a nut. This may be welded on to rods and bolts as required.

VII. - Cut Washer. Used under the head of a bolt or under the nut, when it is necessary to draw it up against wood.

VIII. - Lock Washer. A spring washer used under the head of a cap-screw, under a nut, and between a plain washer and a nut when locking a nut against wood surfaces.

IX. - Cotter Pin. Used to securely fasten slotted or castellated nuts ---. The end should be well spread. ----.

X. - Taper Pin. Used to fasten the hub and shaft together. Taper pins are fitted by means of a taper reamer, which corresponds in size --- to the pin that is being fitted. Care should be taken to fit the pin as illustrated. Do not ream too far in without trying the fit of the pin. ----.

XI. - Nuts. These may be secured in a wide variety of materials, shapes, and sizes. ----. They are made in either square or hexagon shape.

XII. - Cap Screws. Cap screws are not fitted with a nut, though a nut may be used on them. Cap screws generally hold two parts together by passing through an unthreaded and into a threaded hole in the other part. ----. The shapes of the different heads are shown in the sketch. ----.

XIII. - Stud. Usually a rod threaded on both ends. One end is turned into a threaded hole; the other receives the nut.

XIV. - Set Screws. Set screws are made of case hardened steel. A set screw is passed through a threaded hole in the hub, and the point is forced against the shaft. ----. When tightening up, draw the screw up tight against the shaft and tap the head of the screw with a hammer. Types of points are: A-flat; B - round; C - hanger; D - cup point; E - flat pivot; F - round pivot point. Hollow head set screws (safety screws) have a square or hexagon hole. The screw is turned with a special wrench. The head may be slotted and turned with a screw-driver.

XV. - Machine screws are similar in form to cap screws, except they are fitted with a slotted head for use with a screw-driver. ----. The included angle of the countersunk head is 82°.

XVI. - Wood Screws. Fastenings are used in holding wood to wood, wood to metal, etc. The threaded end is usually forced into the wood without any holes being prepared to receive it. When working on hard wood or where special care is necessary, a small hole may be drilled to receive the screw. ----. The included angle of the countersunk head is 82°.

XVII. - Thumb Nuts

XVIII. - Thumb Bolts (not illustrated)

XIX. - Lag Screws. Heavy wood screws fitted with a head to be turned with a wrench.

XX. - Illustrates four common fastenings for wood. A cut washer should be used between the wood and nut, or between a lock washer and wood.

XXI. - Pins are frequently used, held in place with a cotter pin as illustrated. Yokes, turnbuckles, and similar construction may be held secure by means of a lock ((yam)) nut or a strong wire properly placed.

XXII. - Three types of fastenings commonly used in metal are shown: A - cap screw; B - stud; C - bolt.

XXIII. - Special locking washers are often necessary.

XXIV. - A saw cut and bolt point spread, center punch mark, or end of bolt slightly riveted will prevent the nut from loosening.

The shoeing of horses and mules which was one of the many duties of the blacksmith at Hopewell Village and the methods used here, undoubtedly were similar to those used by other blacksmiths elsewhere during the periods of Hopewell's Blacksmith Shop. We have been informed that horseshoe nails were made by hand and that the shoes were hand-made in many shops, during this period[79]; but entries in one of the Hopewell Furnace Day Books, Feb. 1, 1851 - Sept. 25, 1883 show entries that horse shoes and mule shoes were purchased 1877 and in 1880[80]. While there are no specific mentions of the purchase of horseshoe nails, in the records thus far examined, it is not possible, at this time, to definitely state that all the nails used for shoeing of mules and horses were hand made; a purchase of nail rods was made in 1880[81], along with a shoeing rasp. It may be possible that purchases of shoes and nails may have not been specifically noted in all entries for such supplies, but were included in the many bills for iron or in purchase of nails, type not mentioned, from 1865-83[82].

It is not known, at this time whether, during this or the prior periods, any attempts were made to manufacture ornamental items in the Blacksmith Shop. No evidence of such has appeared either as entries in the Hopewell books and documents thus far examined, or from personal contact with informants. Neither is there any evidence, thus far, to the contrary. It has been stated by informants[83] that the blacksmiths of this and prior periods were, as a general rule, quite capable of producing ornamental items of quite intricate and beautiful design. (The writer has seen several such pieces made by the blacksmith, Mr. L. Kaczor, employed at this time, in the blacksmith shop at Hopewell Village.)

With the exception of mechanical devices and power sources, there has been little change in the types of equipment used during the third and fourth periods. Some methods have changed in respect to welding, cutting, punching, hardening and tempering, forging, and bending, due to scientific developements during the latter portion of the third period. However, these improved methods were usually existent in the larger shops in industrial centers[84], and rarely used in shops similar to that at Hopewell Village, during the third period of its history.

Fourth Period - 1883 ---

During this, the fourth and last period of the history of Hopewell Village Blacksmith Shop, there were no activities in connection with the Furnace, operations having ceased late in 1883. However, the farm properties continued to be operated and the former furnace manager, Mr. Harker Long, became manager of the property. From these activities, it might be presumed that occasional use was made of the blacksmith shop by persons residing on the property for repair work to agricultural equipment and probably horse and mule shoeing. During 1937, some of the equipment belonging to the shop was removed, anvil, vise, sun dial and possibly other numerous articles. The first two named items are in the possession of Mr. Nathan Care, Jr., Hamburg, R. D. # 1, Pa. Mr. Care was the last manager of Hopewell Farms when the National Park Service of the United States Department of the Interior acquired the property. The sun dial has been donated by Mr. Care, along with other items, to the Historical Society of Berks County, Reading, Pa.

The chimney from the forge has been repaired in a modern manner, with bricks, and a hood installed over the hearth. A blower has replaced the old bellows. A modern anvil, an iron screw drill press and a forged leg vise have been set up and are being used by the present blacksmith, Mr. L. Kaczor, who is the owner of the drill press and who is using many of his own personal tools.

The items specifically mentioned as being in the possession of Mr. Care and those which have been donated by him to the Historical Society of Berks County, were given to him, Care, by Mrs. Brooke, last owner of Hopewell, before he left Hopewell Village in 1937.

It was during this period that the equipment, with the exception of the crane, work bench, old anvil block and bellows, was removed and the shop permitted to deteriorate.

Personnel

Very little is known, at this time, relative to individuals employed as blacksmithsat Hopewell. It has been stated[85] that the early superintendents did their own blacksmithing. However, during the third period, it has been learned, that blacksmiths were employed and that apprentices were taught the trade[86]. In about 1851, it has been stated[87] that one, Henry Henry, started to learn the trade in the Hopewell shop under a smith named "Maurer". (Reference was made by the informant that the blacksmith was an ancestor of the late James Maurer, noted Socialist of Reading, Pa.) There has been no entries of this name, or a similar name, in the Hopewell Furnace "Day Book" for commodities purchased and charged to employees from Jan. 1, 1851 to March 19, 1853 (last date of entry of this type of record). Mr. "Maurer" was said to have left the employ of Hopewell Furnace in 1854. Mr. Henry was paid $25.00 for the first year, $50.00 for the second year, and $75.00 for the third year.[88] Mr. Henry is said to have been the blacksmith at Hopewell from 1854 to 1861 when he enlisted in the Federal Army.

Examination of records of Hopewell Furnace, thus far, do not disclose indenture records of apprentices, neither has information been located which indicates that slave labor had been used in the Blacksmith Shop, nor services of prisoners of war during the Revolutionary War, nor records of indentured or redemptionist workers being employed in the shop. However, such types of workers may have been employed; there is no definite information to the contrary. Employees were hired under agreements whereby they received a certain sum of money with priveleges, wood, house rent free, or for a very nominal sum, fodder for cow, and other commodities. One G. M. Benner, known to be a blacksmith at Hopewell, did not have his duties specified in the agreement for one year, starting April 1, 1879. He received $10.00 per month, house rent free, fire wood, specified quantities of meat and other commodities[89]. Agreements with employees, and memorandums relative to the same, that have been examined thus far, cover a period from January 17, 1866 to September 25, 1883[90], and fail to show specific duties as blacksmithing at the Furnace. It is possible, however, that blacksmiths employed in the shop had additional duties and the agreement or contract under which they worked was of a blanket or general nature. Prior records of this nature have not been examined, thus far.

Wages paid blacksmiths during the third period averaged about $1.25 per week, board, lodging, and laundry; helpers received from $.75 to $.90 per week and board.[91] However, an entry, one of the last, in a Hopewell record book, shows the above referred to G. M. Benner as being credited with 3 days blacksmithing @ $1.50 per day, during June 1883(?). While previous entries on the same page show 1883, this particular entry does not indicate the year[92], merely the month. Many entries exist in this volume whereby employees were charged with blacksmithing costs by the superintendent, Mr. H. A. Long, usually in a monthly summary of accounts due[93].

Conclusion

The restoration of the blacksmith shop to its probable condition during the third period, 1840-83, as has been planned, can be accomplished at a minimum cost.

The forge can be restored by replacing the bricks, used in repairing the chimney, with stone. The hood can be retained, as it has been stated, a portable hood was used, and also as a safety precaution against burns to the body or clothing of the smith, and hoods were used in many shops during the third period[94].

The present blower can be replaced by a set of double action bellows which can be constructed from working drawings made from the old bellows found in the shop.

The drill press described by one Thomas Hoffman as being in use when operation at the furnace ceased was similar to that in use at the present time and owned by Mr. L. Kaczor, the blacksmith.

The anvil and vise, possessed by Mr. Nathan Care, Jr., Hamburg R. D. # 1, Pa., and said to have been in use during the third period, can possibly be secured from Mr. Care and set up in the shop. The writer has seen these items and they are in good serviceable condition.

A duplicate of the old work bench, it is stated, is now in use. A quenching tub has also been put into service.

The crane used during the third period is in very good condition and will be usable for many years for its original purpose. The present blacksmith has, however, installed a supporting stand of his own, in preference to using the crane.

It may be suggested that the blacksmith make hand tools from stock materials to replace those of his own. Also, small ornamental items can be manufactured in the shop and their sale, as souveniers, at such times as may be deemed appropriate, will add a definite source of maintenance income. The present blacksmith is quite capable of this work.

The methods described were general methods in use during the third and fourth periods. However, as has been previously stated, each individual job presented its own problem. Methods varied, dependent upon the experience and skill of the blacksmith. Often, similar results would be obtained by apparently different methods.

The tools described and illustrated are but few of the many used by a blacksmith and which, during the third period, were made by the smith.

The restoration of the structural features of the shop is incorporated in Mr. J. C. F. Motz's "Report on Archaeological Investigations of the Blacksmith Shop", previously submitted.

Howard Gale.

Howard Gale.

HG:MM

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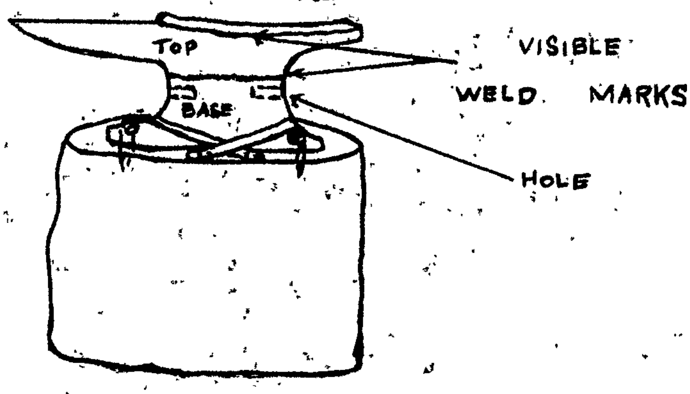
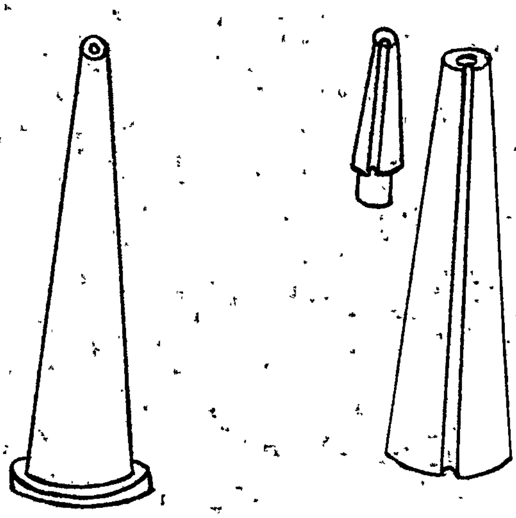
NATIONAL PARK SERVICE



ANVIL

SKETCH A.



MANDRELS

SKETCH B.

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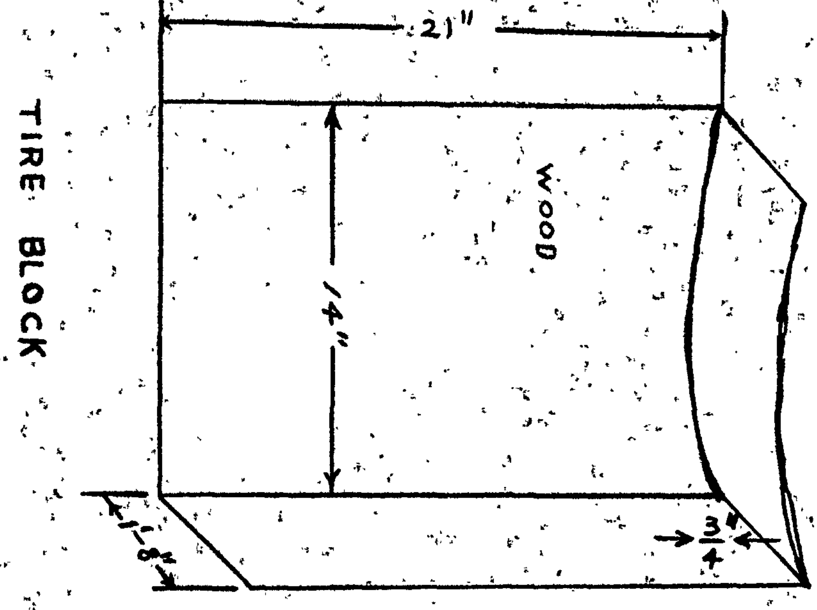
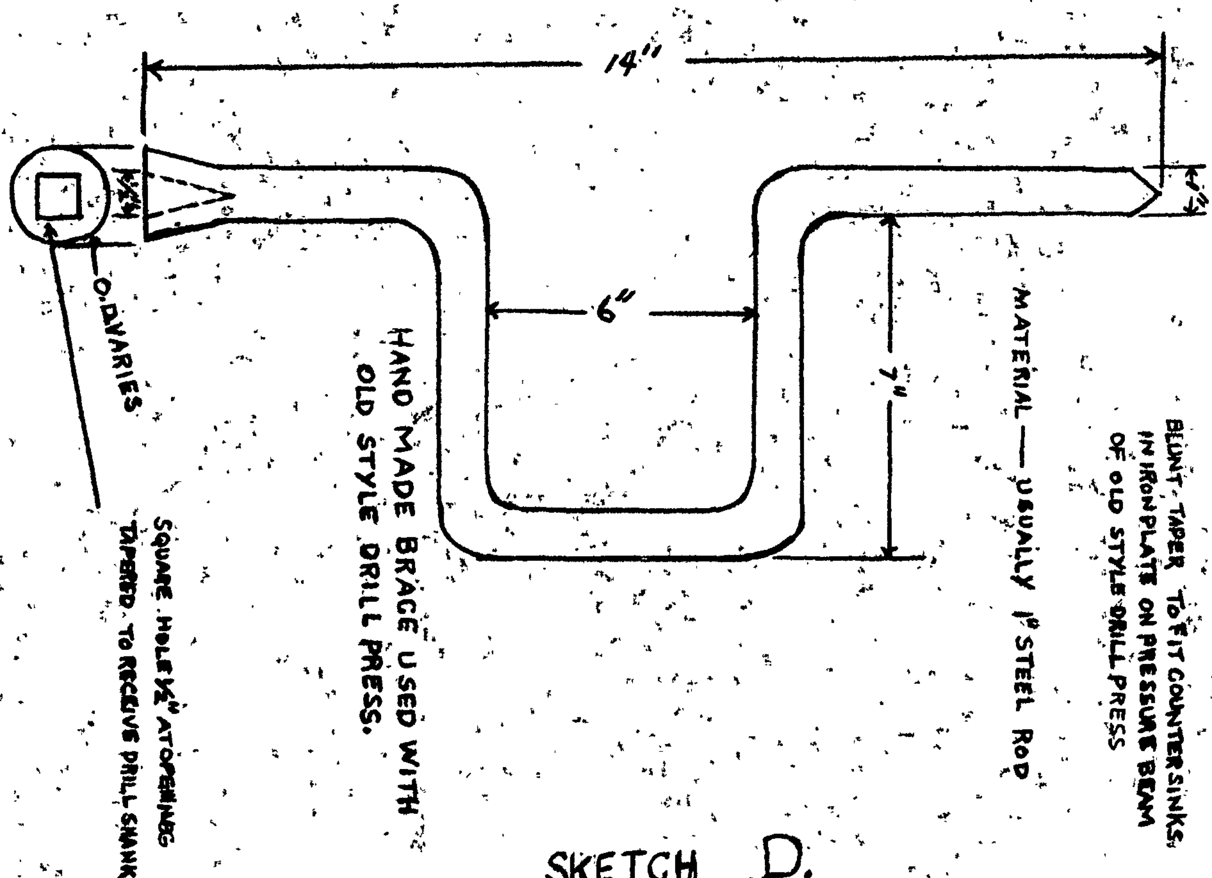


SKETCH C.



SKETCH D.

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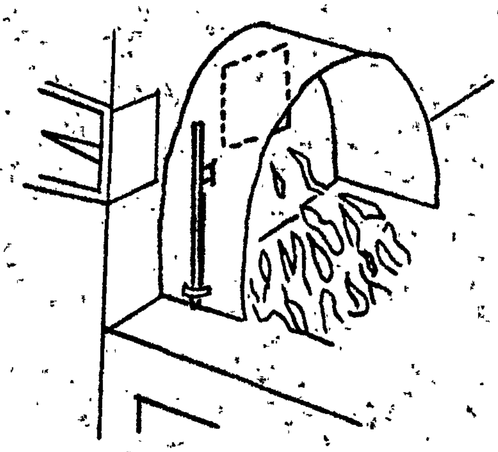
PORTABLE FORGE HOOD
(DESCRIBED BY THOMAS HOFFMAN)



SKETCH E

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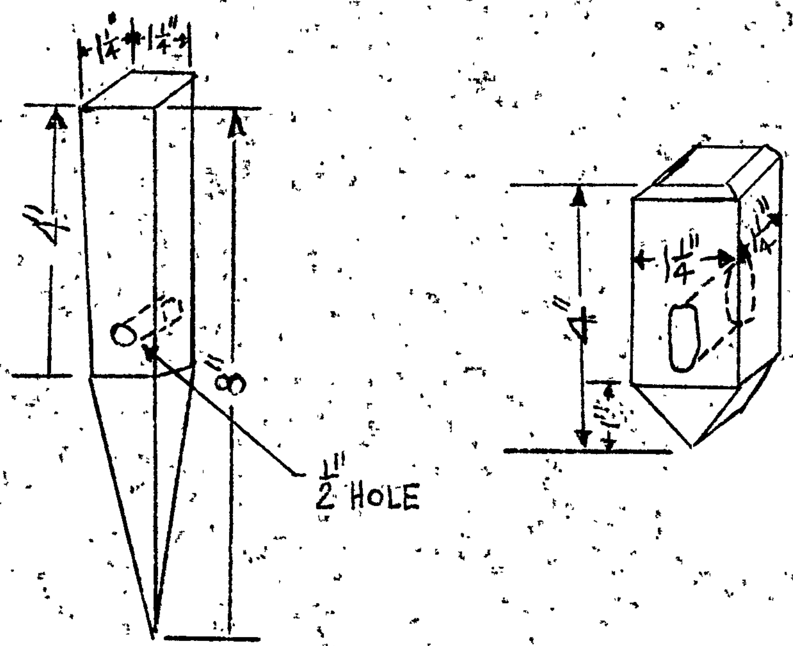
SHARPENING SET FOR GERMAN SCYTHES.



ANVIL (LOW CARBON STEEL)

HAMMER – (SHORT HANDLED) (WROUGHT IRON)

AS DESCRIBED BY
MR. IRA HINNERSHITZ
TO H. GALE.

SKETCH F.

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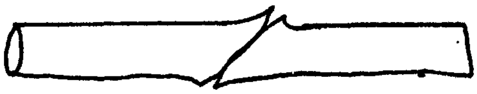
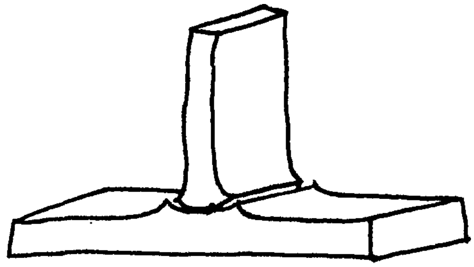
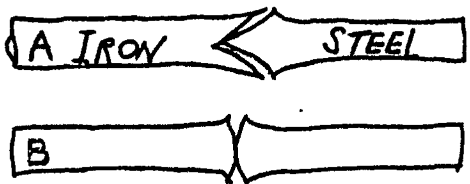


LAP WELD SCARF

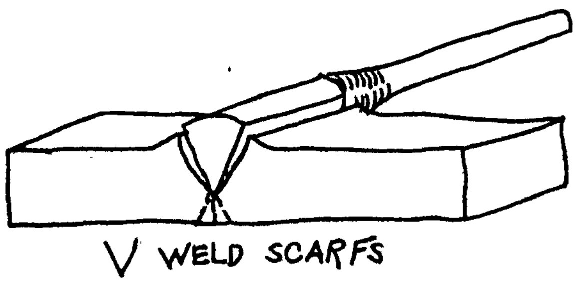


JUMP WELD SCARFS



A-CLEFT WELD SCARFS

B-BUTT WELD SCARFS



V WELD SCARFS

SKETCH G.

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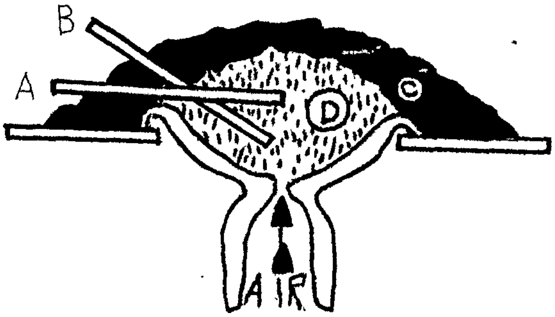
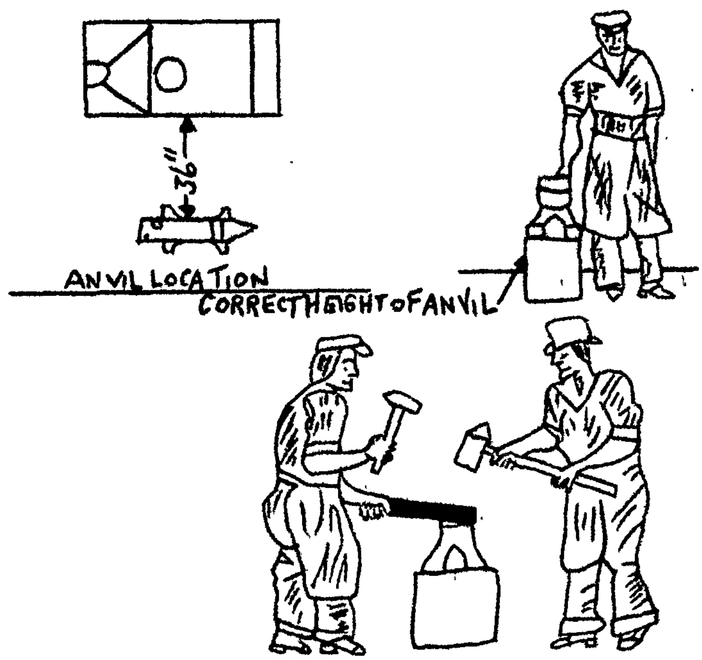


D-BED OF HOT COKE
C-DAMPENED GREEN COAL
A-PROPER WAY OF PLACING METAL IN FIRE
B-IMPROPER WAY OF PLACING METAL IN FIRE

SKETCH H.



POSITION OF THE SMITH AND HELPER

SKETCH I

POST DRILL PRESS

SKETCH J.

HAND MADE DRILL

SKETCH K.

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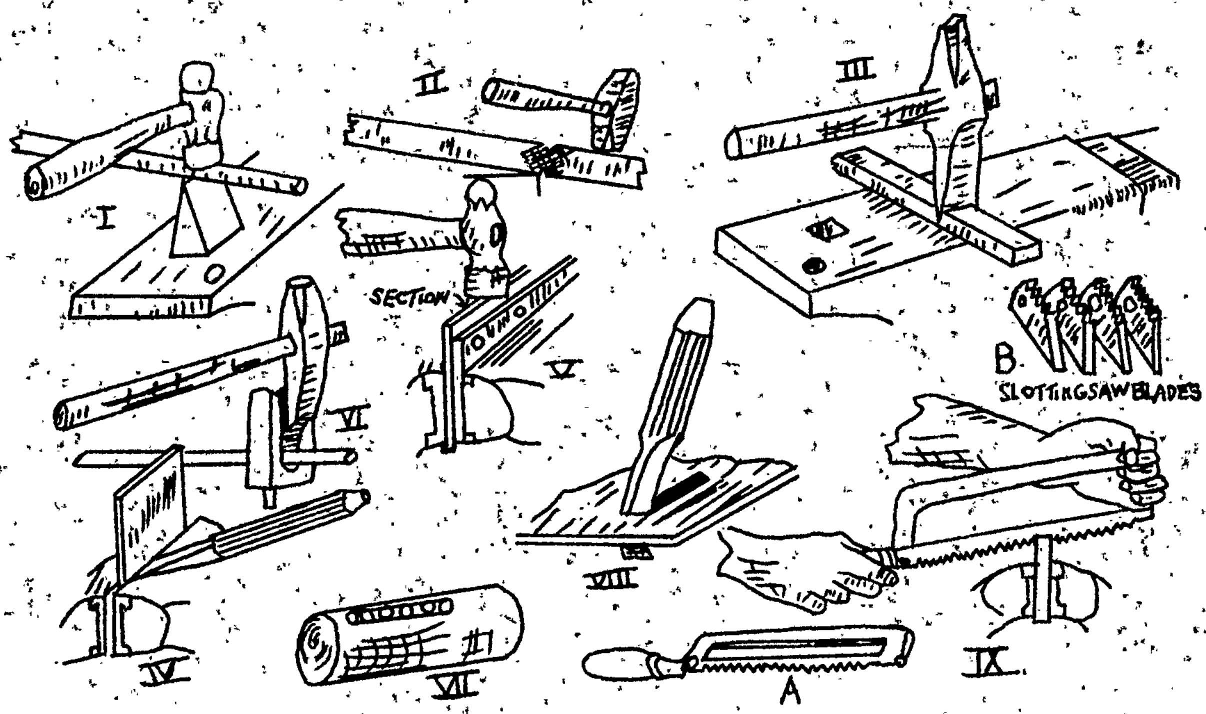

METHODS OF CUTTING METALS

SKETCH L.

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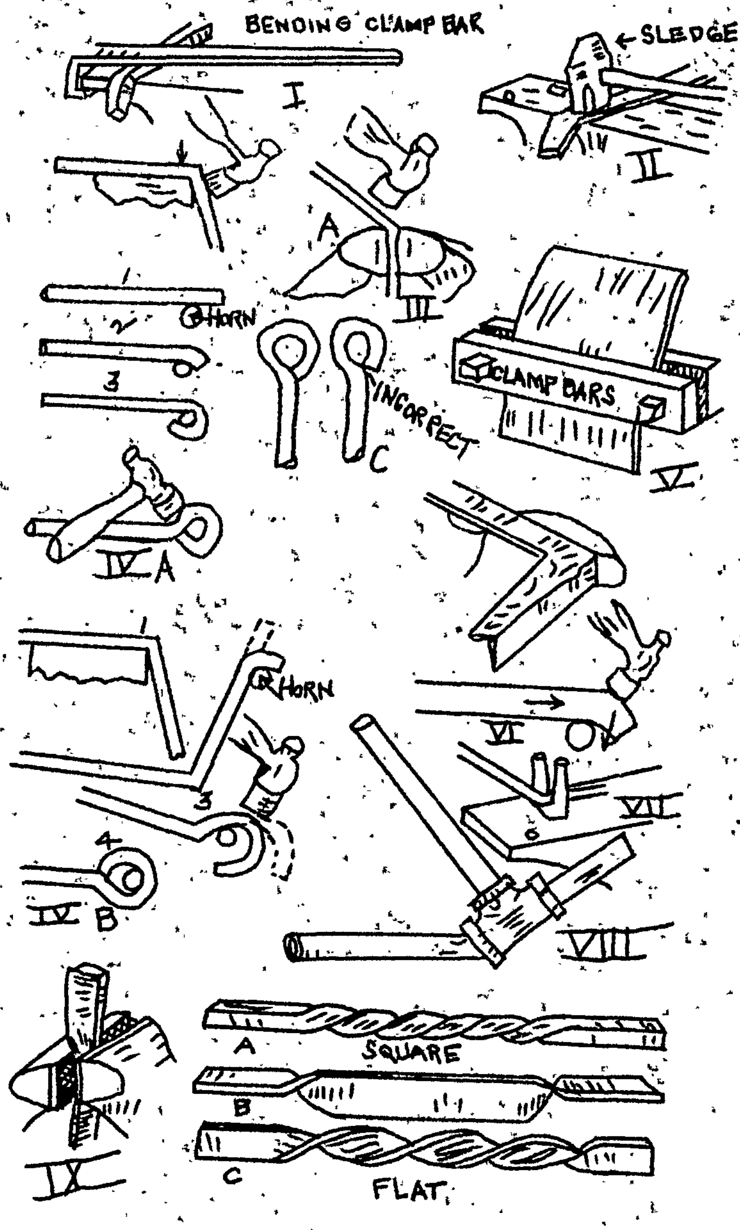

METHODS OF BENDING & TWISTING

SKETCH M.

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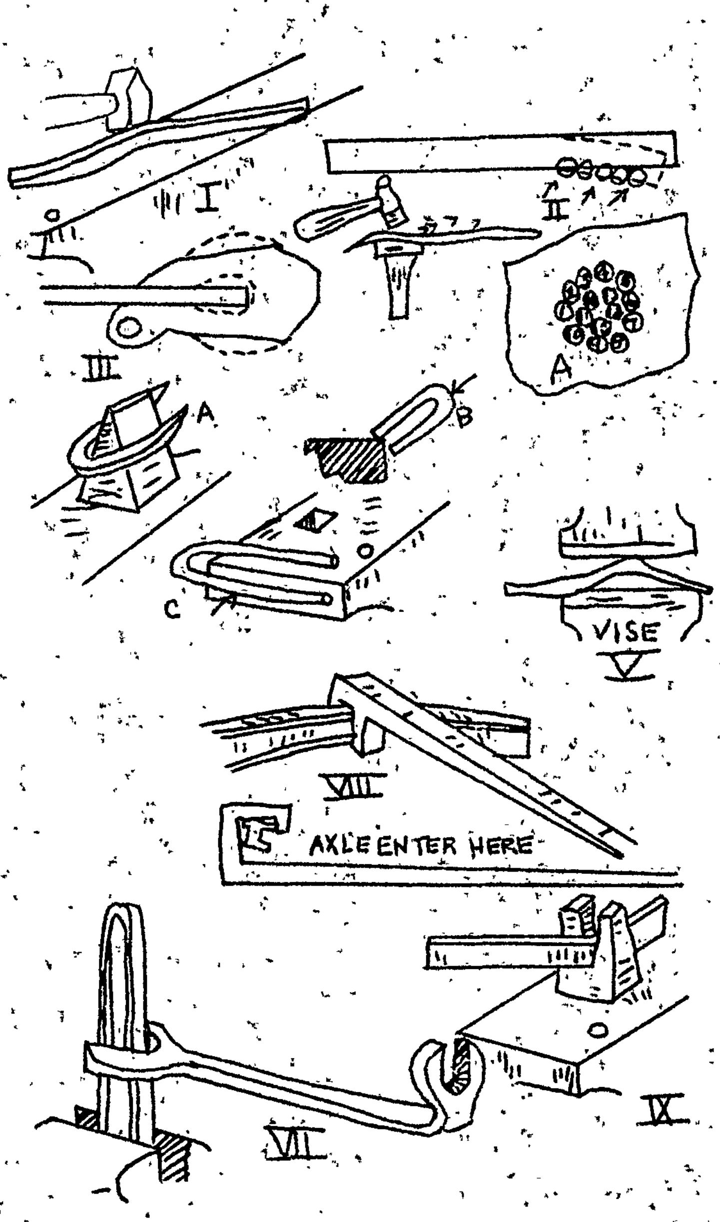

METHODS OF STRAIGHTENING.

SKETCH N.

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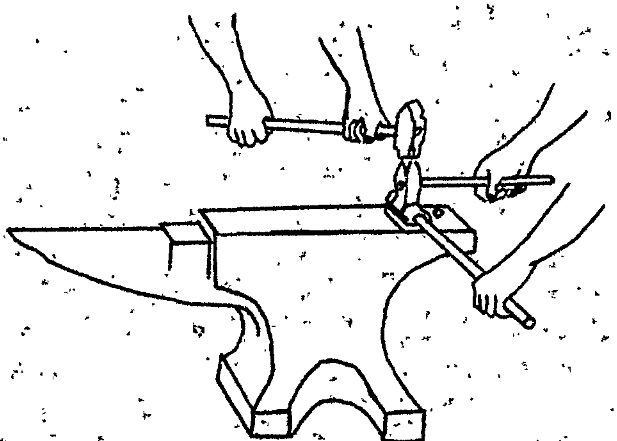
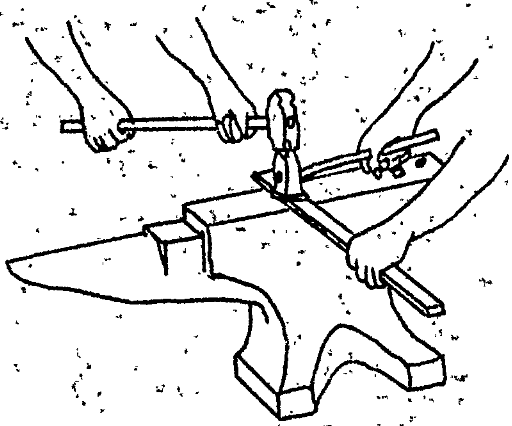
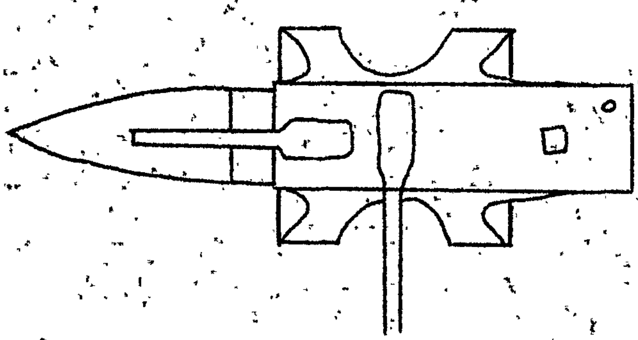


DRAWING WITH SWAGES.



DRAWING WITH FLATTER.



DRAWING WITH HAND HAMMER.

METHODS OF DRAWING METAL

SKETCH O.

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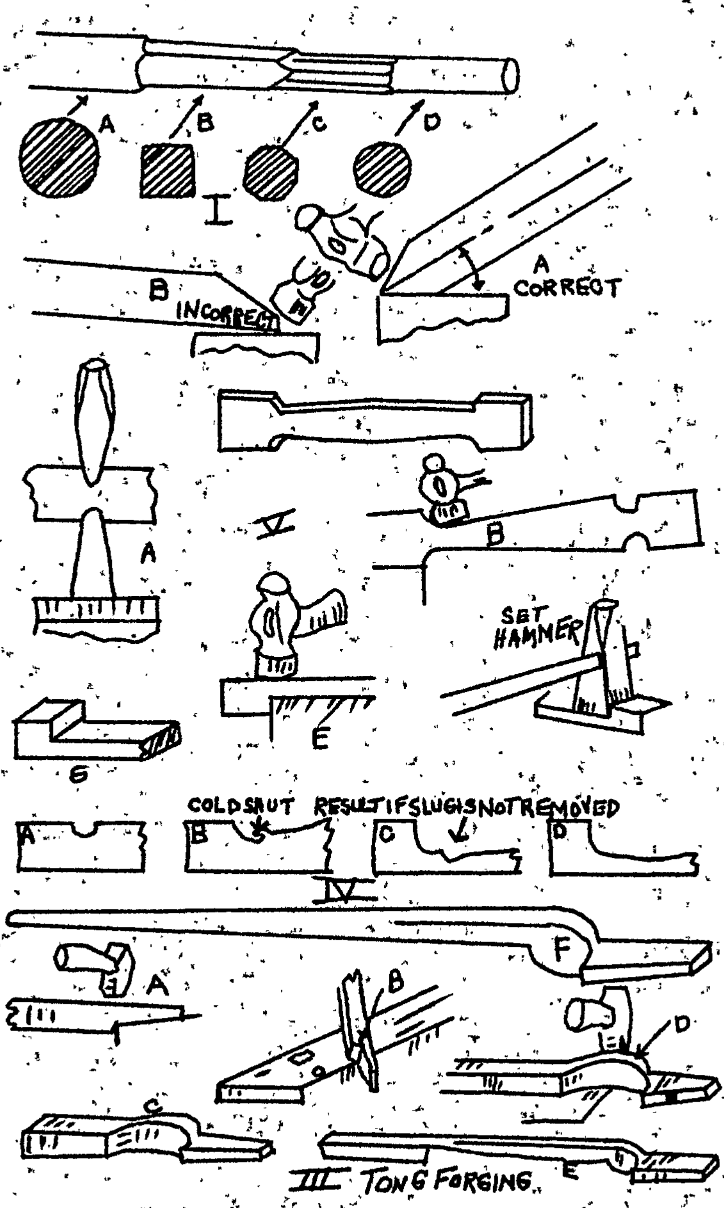

METHODS OF DRAWING AND FORGING

SKETCH P

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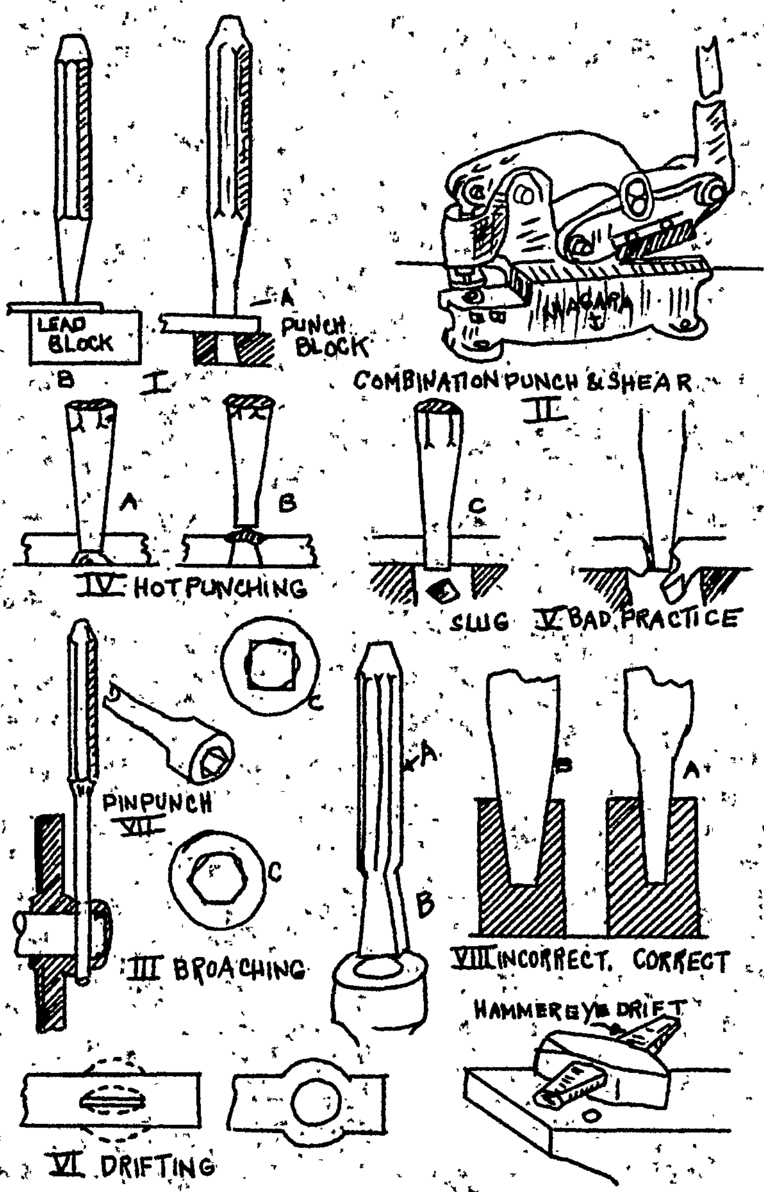

METHODS OF PUNCHING

SKETCH Q

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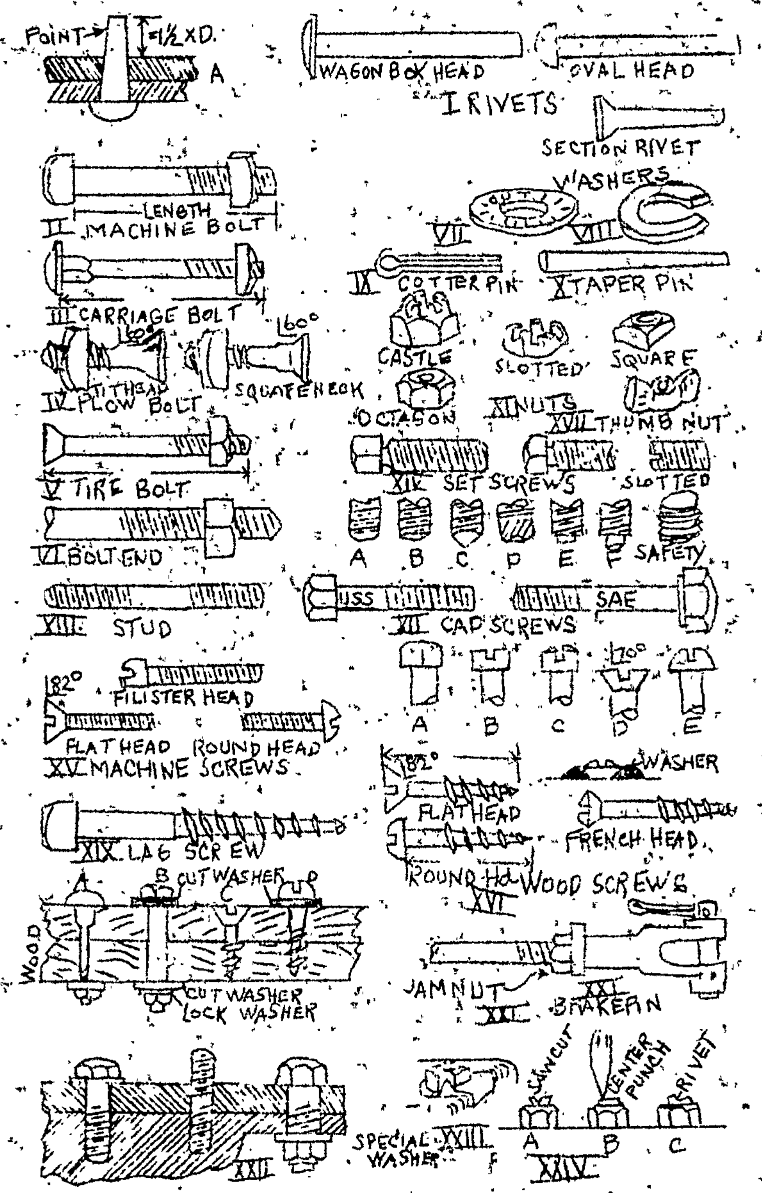

TYPES OF FASTENINGS

SKETCH R

J GALE.

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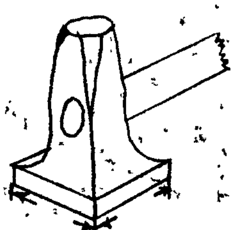
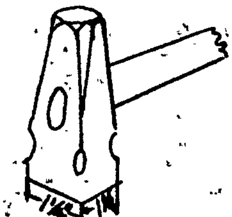
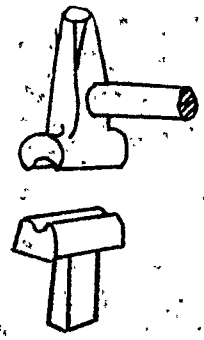


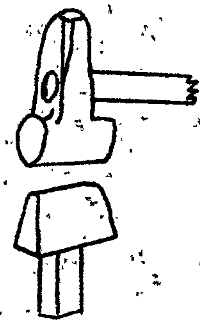
FLATTER
FIG. 1.



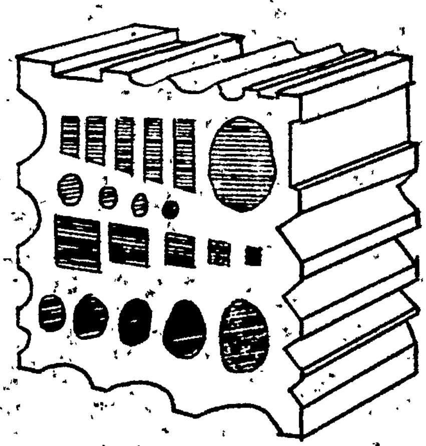
SET HAMMER
FIG. 2.



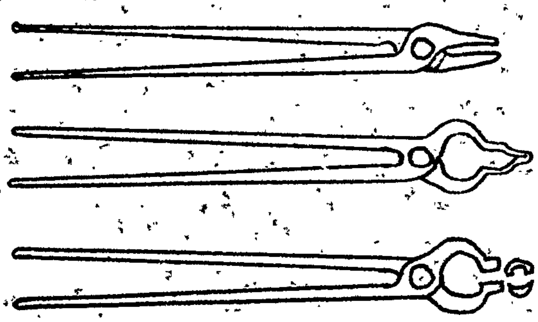
SWAGES FOR ROUND WORK
FIG. 3.



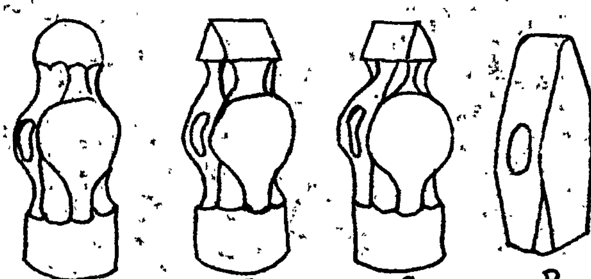
FULLERS
FIG. 4.



SWAGE BLOCK
FIG. 5.

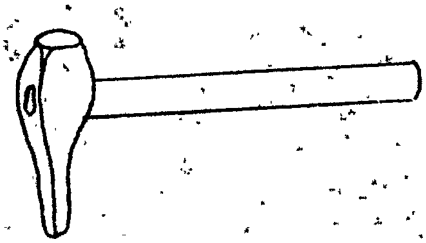


TYPES OF TONGS.
FIG. 6.



A B C D
COMMON TYPES OF HAMMERS
FIG. 7.

A B C
COMMON TYPES OF SLEDGES
FIG. 8.



PUNCH FOR HEAVY WORK
FIG. 9

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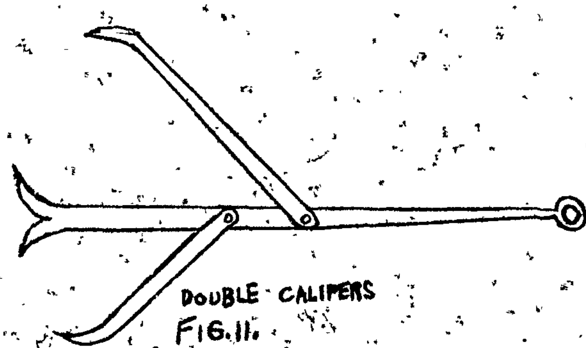
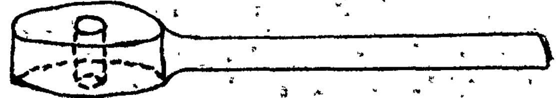
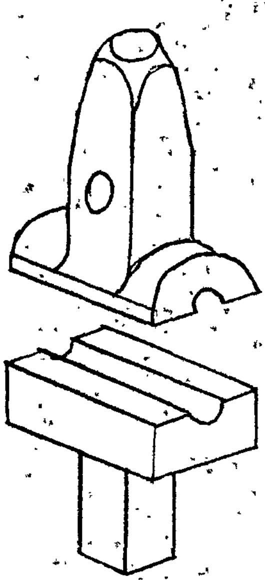
PUNCH FOR ROUND HOLES
FIG. 10



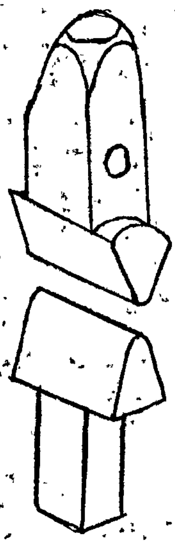
DOUBLE CALIPERS
FIG. 11.



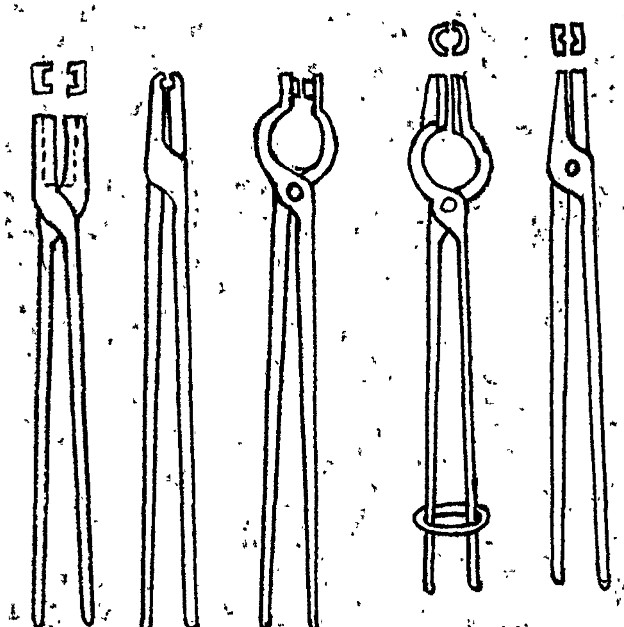
BOLT HEADER
FIG. 12.



SWAGE
FIG. 13



FULLER
FIG. 14



A B C D E

FIG. 15. TONGS.

A, TOOL OR BOX TONG; B, LINK TONGS; C, CHISEL TONG; D, HOLLOW BIT TONGS; E, GROOVED FLATJAW TONG.

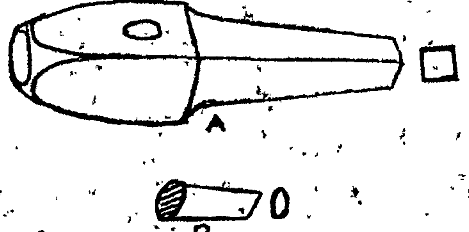


FIG. 16 HANDLED PUNCHES
A_SQUARE PUNCH B_EYE PUNCH

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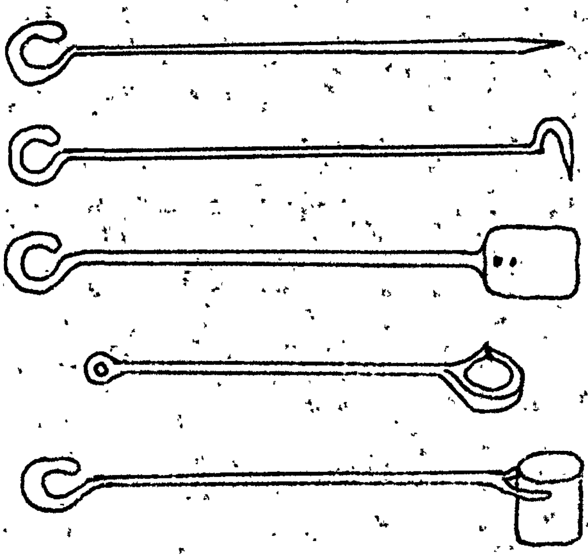


FIG. 17 FIRE TOOLS
A, POKER; B, RAKE; C, SHOVEL; D, DIPPER; E, SPRINKLER (PERFORATED BOTTOM)

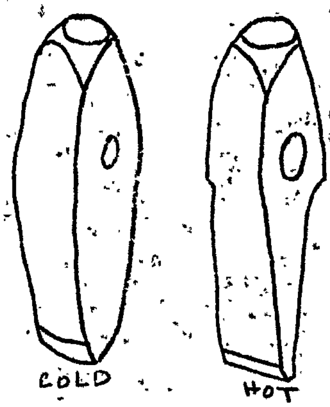


FIG. 18 HANDLED CUTTERS

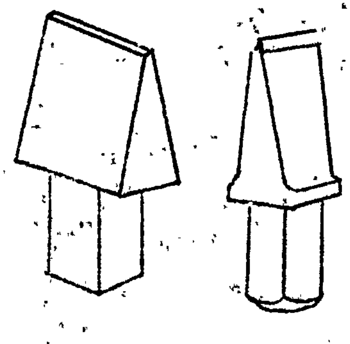


FIG. 19 ANVIL CUTTERS

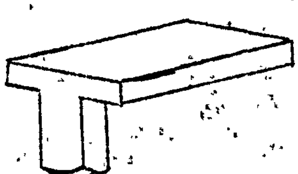


FIG. 20, CUTTING BLOCK

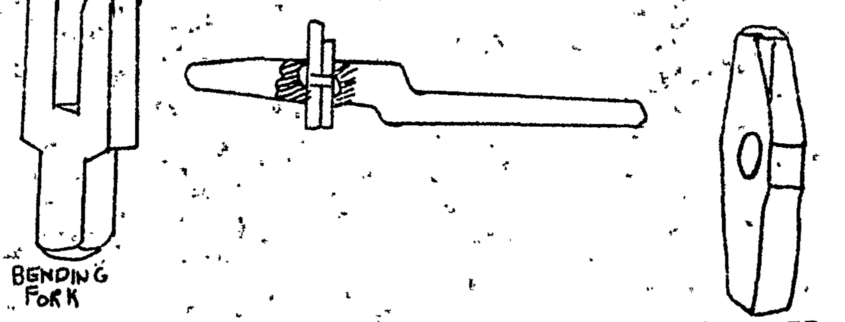


FIG. 21 SPECIAL PURPOSE TOOLS

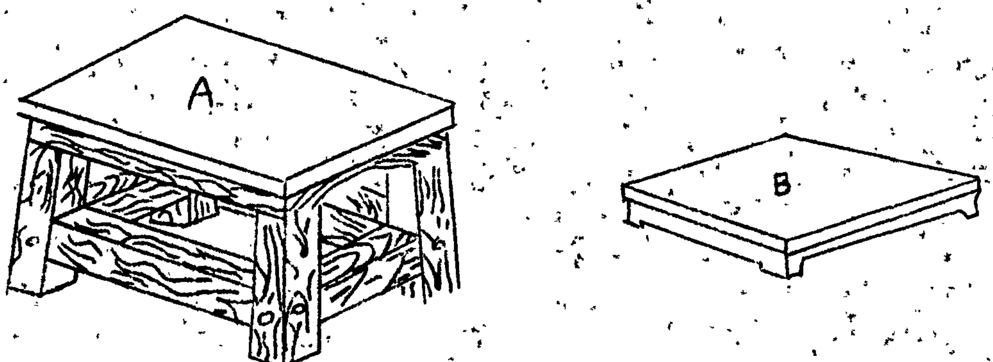


FIG. 22 SURFACE PLATES

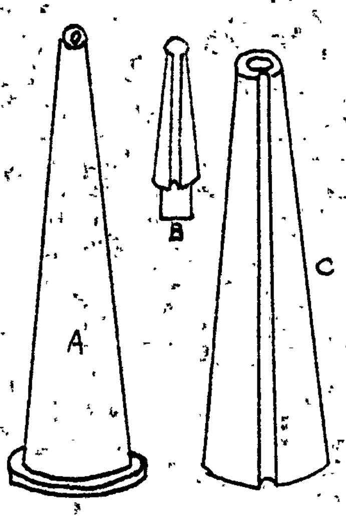


FIG.23 TAPERED MANDRELS

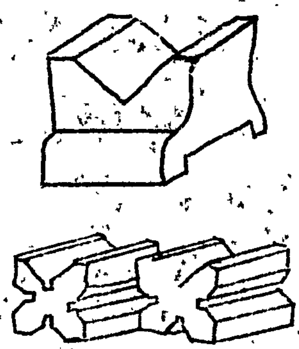
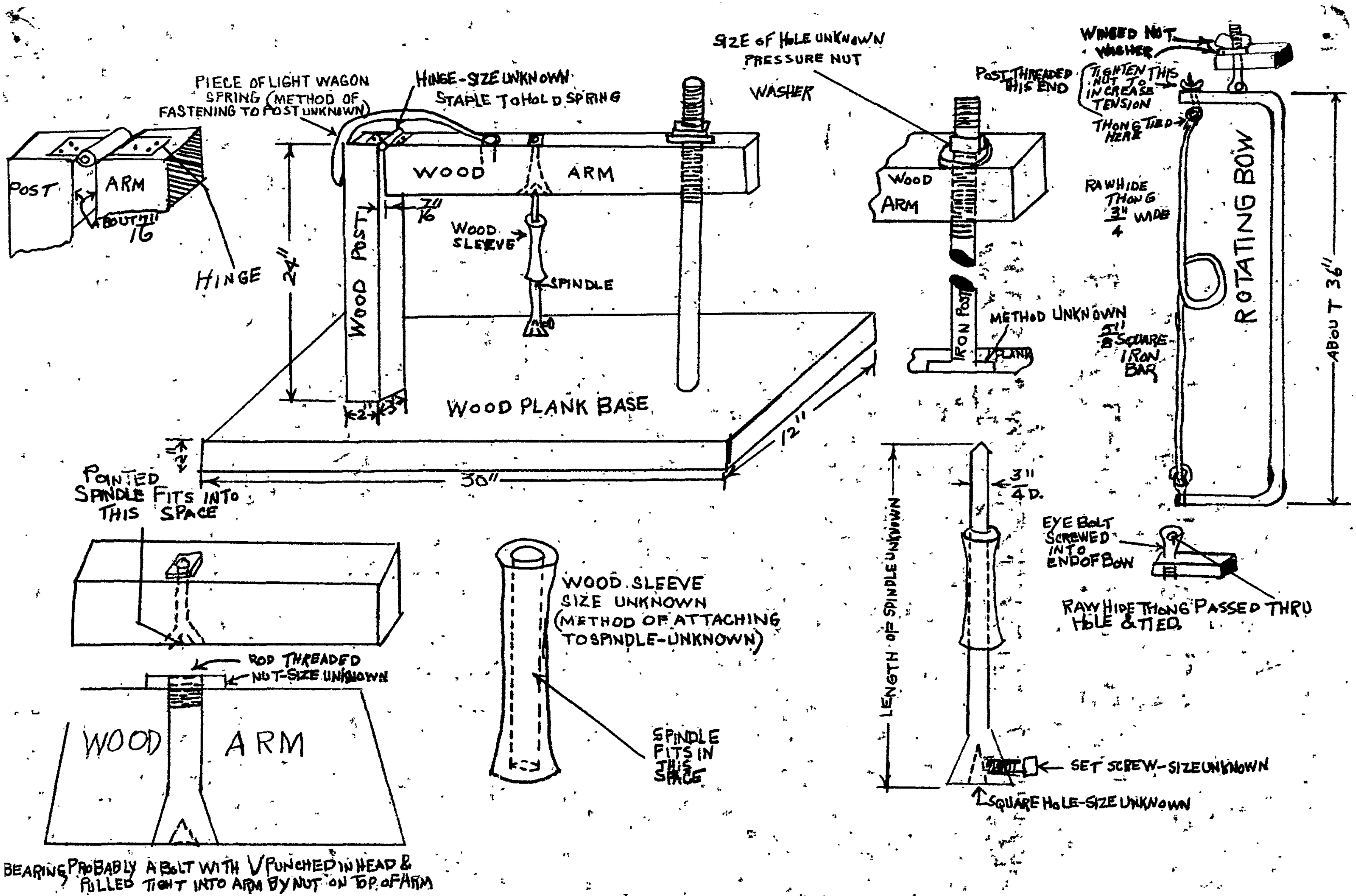


FIG.24 _ TYPES OF VEE BLOCKS



RAW HIDE DRILL PRESS

AS DESCRIBED BY SYLVESTER SQUIBB TO H. GALE AND AS SEEN BY MR. SQUIBB IN A BLACKSMITH SHOP AT HAUS' STORE, NEAR ELVERSON, PA.

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