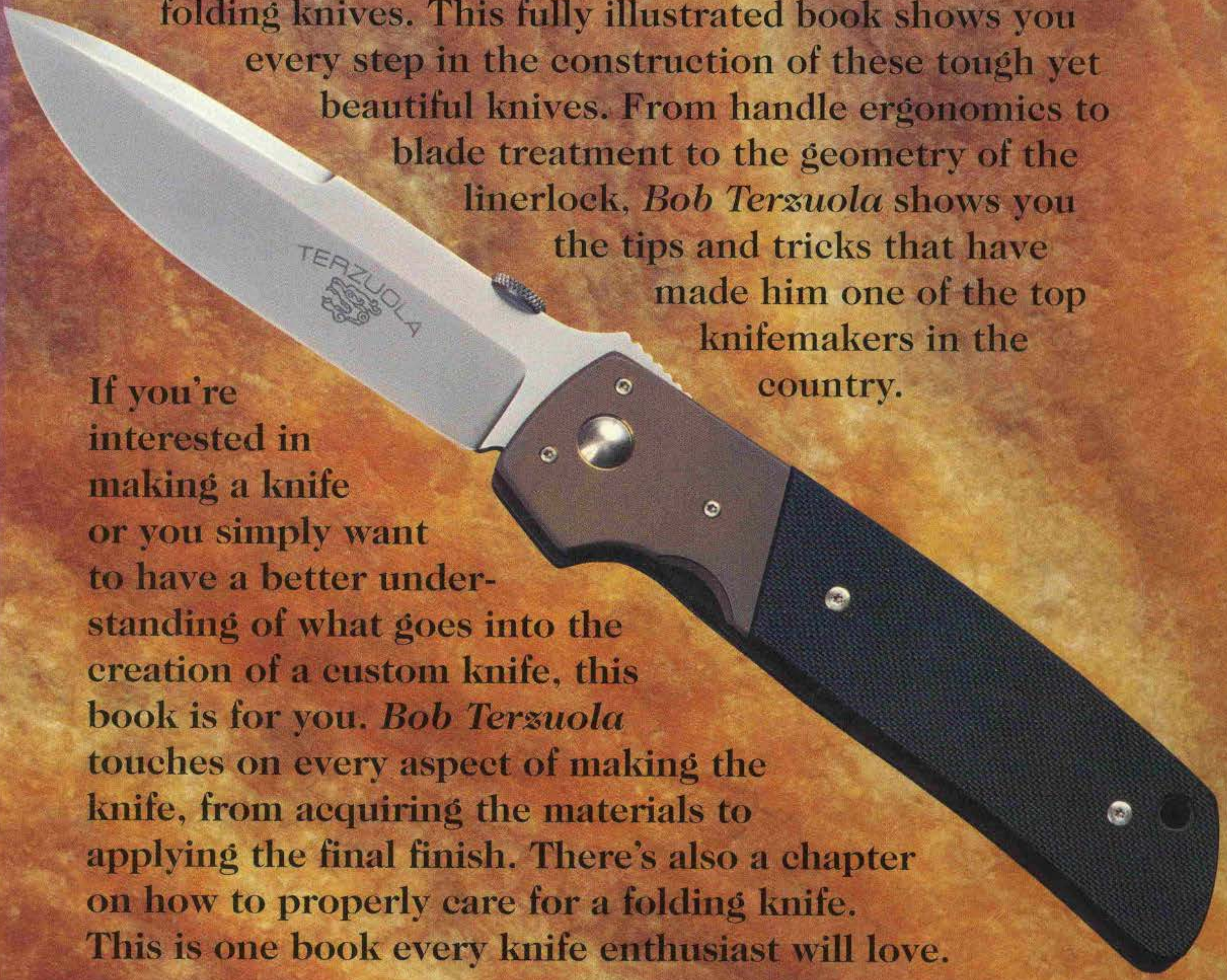
The Tactical Folding Knife

A Study Of The Anatomy And Construction Of The Liner-Locked Folder

BOB TERZUOLA

Watch the creation of a great knife!



Let noted custom knifemaker *Bob Terzuola* take you step-by-step through the creation of one of his tactical folding knives. This fully illustrated book shows you every step in the construction of these tough yet beautiful knives. From handle ergonomics to blade treatment to the geometry of the linerlock, *Bob Terzuola* shows you the tips and tricks that have made him one of the top knifemakers in the country.

If you're interested in making a knife or you simply want to have a better understanding of what goes into the creation of a custom knife, this book is for you. *Bob Terzuola* touches on every aspect of making the knife, from acquiring the materials to applying the final finish. There's also a chapter on how to properly care for a folding knife. This is one book every knife enthusiast will love.

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DEDICATION

FOR MY CHILDREN, MATTHEW AND DANIEL:
MY BLESSING AND MY HOPE THAT THEIR CHOSEN PATHS
WILL BRING THEM AS MUCH JOY AS KNIFE MAKING HAS
BROUGHT TO ME

AND

FOR MY MOTHER AND FATHER:
WHOSE STRENGTH, LOVE AND FORBEARANCE ALLOWED ME
TO FIND MY OWN WAY

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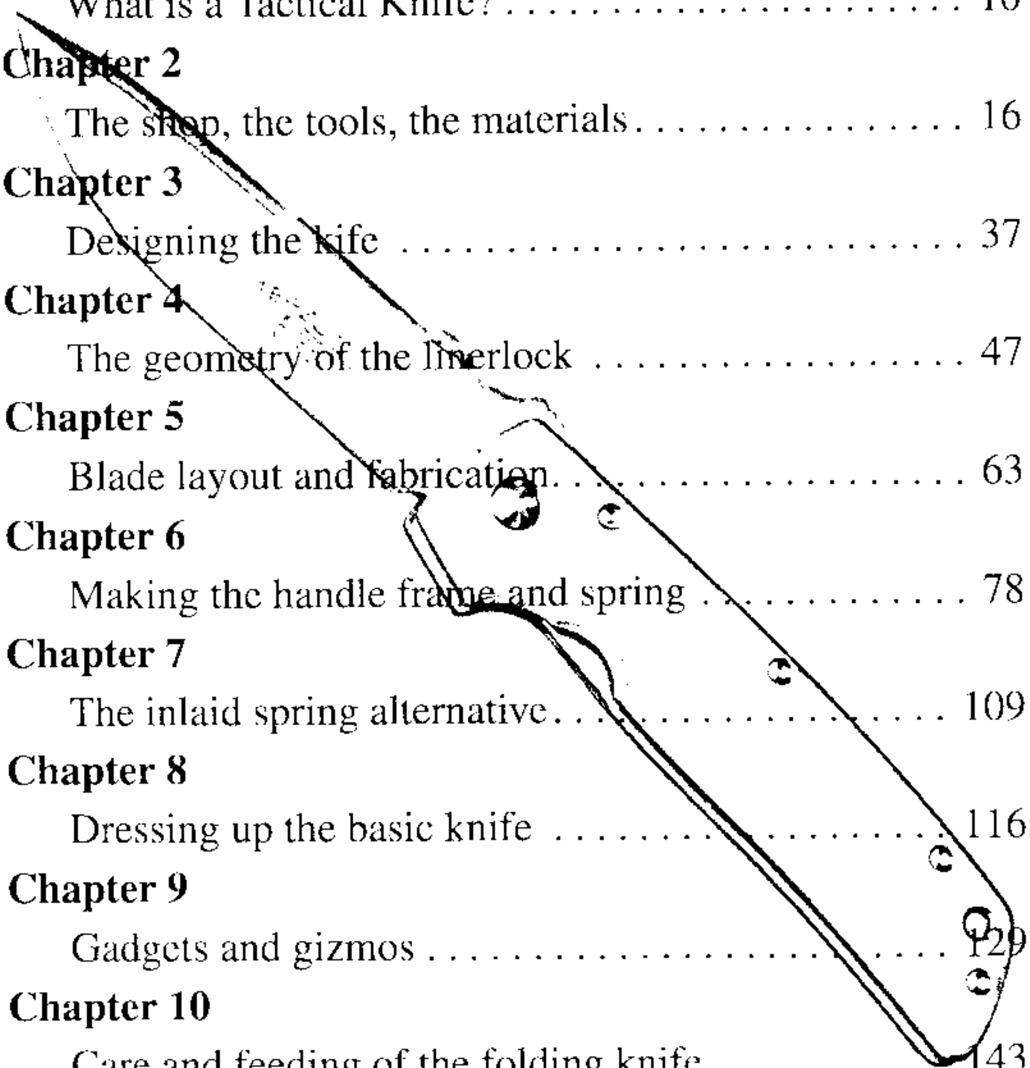


ACKNOWLEDGEMENTS

When I was asked to write this book, I had no idea of the complex nature of such an undertaking. Craftsmen, like myself, do hundreds of little things to produce their wares which are second nature to them but may be meaningless to one not in the trade. An example of this is blade grinding, which is far more involved than meets the eye since we do things with our bodies which are not controlled by conscious thought, sort of like a computer in a fly-by-wire aircraft.

The very vocabulary that we knife makers use on a daily basis may be confusing to one who is not confronted with the common (to us) procedure of creating knives from raw materials which, my friend Jurgen Steinau refers to as "little miracles".

As such, it was a challenge to write a book that would be meaningful to the experienced knife maker, yet understandable and interesting to the casual reader. I received a great deal of help from many friends who read all or portions of the book in progress and who contributed freely of their time and expertise to make this project possible. Any errors or omissions are mine, not theirs.

I give my sincere thanks and gratitude to:

Michael Walker, for allowing me to use his trade marked "linerlock" name and for reviewing the "geometry" chapter which helps set straight the historical record of his work; Ron Lake who read the whole first draft and taught me never to use the word "perfect"; Paul Bos who kept me on track with heat treating; Les Robertson and Bob Neal who helped me to define "tactical folding knife"; Al Pendray, Frank Centofante, Sal Glesser, Steve Shackleford and Marjorie Hartman who reviewed the work and made valuable contributions throughout; Pat Romero, my friend and workmate, and finally, Vince Ford who created the computer illustrations and helped me clarify my sometimes muddled thoughts.

A special thank you is due to Tony Vinella and Jody Blagden, world-class photographers who, through many days of long-suffering patience with hot lights and a frazzled knife maker, created the photographs that make this book understandable.

Finally, my deep gratitude goes to Bob Loveless, my first knifemaker guru who taught me hollow grinding and the relentless pursuit of excellence.

PREFACE

"What brings you Joy will bring you Abundance"
Hindu proverb

Problems and Solutions

The craft of knife making, like any other craft, consists of a series of mechanical problems which must be solved, organized into a logical continuum of solutions and then executed in an orderly manner. The problems presented for the construction of knives are similar for similar types of knives. That is, families or types of knives will pose related problems (e.g. folders are related to other types of folders, fixed blades are related to other types of fixed blades). Both families share some solutions and techniques (blade grinding, material finishing) but each poses its own set of parameters which are unique. Likewise, sub-sets of the families such as lock-back folders as opposed to linerlock folders present their own individual problems which must be addressed.

Many books have been written concerning the fabrication of knives, including a few on folding knives. Numerous authors have endeavored to instruct the reader on various techniques of knife making, some more successfully than others. The primary lesson to be learned from this body of work, as well as from conversations with other knife makers, is that there are often many different (and sometimes radically different) solutions to the same problem.

What I offer in this book are my solutions to the problems encountered in knife making, specifically the making of a tactical folding knife using the linerlock design for securing the blade in the open position. The following chapters will detail the construction of my Advanced Technology Combat Folder (ATCF). This knife remains virtually unchanged in design since I introduced it in 1986 and has proven itself in the field countless times. The original prototypes were mercilessly tested by a retired captain of the Special Forces (SOG) who runs his own Special Operations training facility, members of the Explosive Ordnance Disposal (EOD) team at Kirtland Air Force Base, Officers of the Albuquerque Police Department, an officer of the U.S. Border Patrol and several Soldiers of Fortune working in Central and South America, Africa, and Asia.

The techniques used in making folders are myriad and often as different as the knife makers themselves. I have sometimes adopted (with profuse gratitude) the advice of others in constructing my knives but more often than not I have sought my own counsel in using what works best for me in my shop and have developed my own techniques and tooling to that end. I encourage the new knife maker (as well as the seasoned veteran) to seek an individual path whenever possible and to experiment with what they feel is best for them, thus adding to the body of knowledge for the betterment of all.

Anatomy of a Terzuola Folding Knife

Generally speaking, my knives consist of a blade made from staubkess tiik steel, hardened to Rc 60-61; a handle made from titanium, carbon fiber or G-10 glass fiber laminate and the Michael Walker linerlock made from titanium. The rationale for my use of these materials and design will be found later in their corresponding chapters. The locking spring of my folders may be of the integral (full liner) design or of the more lightweight and compact inlaid design which I use for my smaller pocket knives.

All of my folding knives are assembled with screws rather than the more unforgiving peened pins. Early in my present incarnation as a knife maker, it became abundantly clear to me that I had neither the patience nor the requisite sense of finality and permanence that pinning the handle parts together demands. I have the greatest admiration for those makers who lovingly but permanently hammer their handles together with metal pins and then labor to make those pins become invisible thereby making the assembly inseparable for all eternity! While I stand dumbfounded by their skill, courage and faith in their own creation (how do they know the thing will work after smashing it together?) I have often considered them to be just a bit compulsive, though I love them for their dedication and stand in awe of their beautiful creations.

Knife Making as a Business

People often ask me, "Is it hard making knives?" My reply is always, "making knives is the easy part, it's hard making a living out of making knives." I am one of but a handful of makers who earn their entire living from making knives without a second income from another job, working spouse, investments or pension plan to supplement them. I truly enjoy what I do and at this time would not trade it for a "real" job of any sort (this is my fifth career so I know wherefrom I speak!). I treat this endeavor as a loving craft and work incessantly to improve and refine my knives and my techniques. Because I love it so much, I must treat it as a business in order to insure that I may continue doing it for as long as I desire.

I know that the majority of readers of this book will not be full-time knife makers. However, I also know that among the collectors and marginally curious people who read these words, there will be a percentage of dedicated craftsmen and women who, like me, love this work and are pursuing that elusive goal of making something with their own hands and wits and having some wonderful person admire it so much that they will actually give them money for it!

As a result I would like to share some random thoughts about the business end of knife making. These thoughts are not in any particular order of priority nor are they all-inclusive. They are simply some things I've learned over the years (often the hard way).

Shop Organization

I once had a professor at NYU who demanded that the machine shop be kept neat and clean enough to "eat a greasy baloney sandwich off the floor." I really don't keep my shop THAT clean but it is pretty well organized. I have a place for all my hand tools, materials, work in progress, drill bits etc. I try hard to put things back in place after I use them and keep my work benches clear of "stuff." Many people have told me that I waste a lot of energy doing this but my reply to them is that I simply don't have the time to keep the place messy. I would spend more time looking for that one special tool among a dozen others thrown around than I would by simply putting it back where it belonged. I have a terrible memory and often am distracted by phone calls or interruptions, such as the dogs bounding in and demanding their Milk Bones, so having things where they "live" is a definite advantage when I get back to work.

Orders

My two main points of sale are mail order and knife shows. Orders are all put on a 3x5 file card that I have specially printed. This same card is included, in fold-over, self-mailing style in my catalog which allows my customer to fill out his own card and mail it to me so I just trim it down and pop it in the order box. Phone, fax or e-mail orders are filled out by me on the same type of card. I find this system to be vitally important in remembering all of the special details a customer may want. I also jot down notes about the customer which help me personalize later conversations with them. Which reminds me.........

Customers

These are the people who really make this business of ours work! I always do my best to please my customers (and believe me that can sometimes be an ordeal!). I deeply appreciate those who would buy my handiwork because, after all, they are paying the bills and through their indulgence allow me to gain so much satisfaction by doing what I love best. I make an effort to be patient with them, especially at shows. They are taking their own time to visit me and see what I have to offer. I may not have what they are looking for at the moment but someday I might, and they will remember courtesy and civility just as well as an indifferent brush-off (this especially applies to the young'uns who will grow up and start buying knives sooner than you think!). I stand at my table rather than sit whenever possible and greet each person with a smile. I chat whenever I can but I keep in mind that a pushy, hard-sell will turn a customer off like lightening.

I always invite the folks to pick up the knives off the table and handle them. The sensual feel of a well-made handle will often close the deal. People won't buy what they can't feel, and rightly so. I also put my prices right on the back of the knife blade. I find it is easier than trying to remember them all when I have a bunch of special options on various knives or when I am engaged with a customer while others are browsing. Also, it makes the customer understand that I do not make up prices as I go along. That might make one think that I might be charging him more because he has the reputation of a wealthy, prolific collector or because he is wearing a business suit . Which brings us to.........

Your Word Is Your Bond

So much of this business of knife making relies on trust. Repeat customers are becoming more and more important in the market. One of the factors that keeps a buyer coming back is his trust in your work and his reliance on your word. I believe that trust is a sacred thing, only to be compromised at great peril, not only to the individual knife maker but to the craft as a whole. I personally know collectors who have left the field in disgust at having to deal with unscrupulous makers and some who have even liquidated their collections to remove the reminders of sour dealings.

When one gives his word on an agreement, whether it be pricing, delivery date or materials to be used, I believe that the agreement must be honored in order to maintain the maker's reputation. Sure, setbacks are sometimes encountered but communicating the problem to the customer usually eliminates ill feelings. Most people, I have found, are quite understanding and generous in the face of honesty and a genuine effort to fulfill a promise. A person's word is his bond and once that bond is broken, it is terribly difficult to repair.

Pricing

This is one of the more difficult aspects of the business. After all, how much is a knife worth? Well, it is worth what someone will pay for it assuming it has been honestly represented. I have seen truly fine craftsmanship sell for a pittance and genuine schlock go for a fortune. A large part has to do with the makers' name and reputation to be sure and this is right and just. Good reputations are earned over time, not granted by higher authority. It takes effort and will to build a good name and this makes a good name a valuable asset. My belief is that a knife maker must take the time and "pay his dues" in order to develop a good reputation, and then must guard that reputation with zealousness on a daily basis.

Another question commonly asked of me is "how long does it take to make a knife?" I answer (at this point in time) "about 10 hours and 20 years." I have paid my dues and built my reputation over this long period based on performance and customer satisfaction and new makers should expect to do likewise. As for base pricing, time and materials come into play but are by no means the only things that should be considered. The Mona Lisa was painted, after all, with only a few dollars worth of paint and wood. If it takes you a week to produce a batch knives, the price of those knives needs to reflect all of your expenses during that week. Assuming no other income, you must pay rent or mortgage on your shop, utilities, food, dog bones, insurance, braces for the kids etc. If you don't cover all your expenses you are losing money! Also you need to take into account tool and machinery replacement, grinding belts and the one hundred and one other things you are constantly buying.

Price within the market for what you are producing and keep in mind the price/customer pyramid. The lower the price, the broader the base of customer support you will have. The higher the price, the fewer people who will or can buy your product until you reach a point where only one person will be able to afford your knives. As some makers have learned to their regret, having only a few wealthy customers is a dangerous place to be.

Custom Tooling / Time-Savers

I have always been a gadget lover. As a kid, my father would call me "Rube Goldberg" because of all the weird things I'd put together to save time or effort (not always successfully, I might add). But I have found, over the years, that when a recurring problem presents itself, such as a special machine set-up or a repetitive operation on a particular knife part, it helps to speed things up or assure accurate repetition if I spend the time to create a jig, fixture or gizmo that will help me do that operation on subsequent knives. This is not time wasted, it is time invested in a long -term venture.

I have included in this tome a chapter devoted to such gadgets and although they are designed to help ME in MY shop with MY way of making knives, I hope they will in some small way help others along the path.

Factory Competition

The operative word here is competition. It helps us to improve our products and challenges us to be better at what we do. After all, everyone at a show is competing for the dollars which will be spent there, but then, rarely do we come away from a show without some new ideas we want to try out in our own shop.

In recent years, a good portion of the specialty knife market has been eaten up by the factories, both foreign and domestic. That is because custom, hand-made knives challenged the factories to make better, more innovative products than they had offered the public in the past. They sought out custom knife makers to help them design better products and scarfed up ideas and custom features at shows and exhibits. As a result, their products improved in both design and function and their increasing market share reflect these improvements.

Factories have the advantage of scale and production over individual makers and thus are able to offer their products at a lower price and in greater volume than we can. How can we compete with their prices and quantities? We can't. Not on those levels, so what are we to do?

The very fact that factories make knives in large volume is both their advantage as well as their disadvantage. Volume production allows for lower prices because of the economy of scale but also requires that the factory produce lots and lots of the same thing. This leads to their disadvantage in that all pieces are exactly the same and are impersonally made by machines cranking out huge batches. Factory knives lack individuality and soul. Enter the hand-made knife.

Many people today feel the need for some connection to the old ways when a knife, (or anything for that matter), was lovingly crafted by a master artisan who poured his soul and effort into a work of his own hands. Factory knives, by comparison are cold and lack the vibrant spirit and energy of a knife that is carefully and painstakingly hand-crafted by one who loves his work and displays that love in each of his creations.

Don't underestimate the connection of today's hand-made knives to a long and revered tradition of the armorer's craft. What we make today is truly a continuation of history and that connection is felt by most of us living in an increasingly modern, numerical and impersonal world. Play upon this facet of hand-made knives in your advertising and in your spiels to customers and let it show in the quality of your work.

Even if we, as knife makers, take advantage of modern technology in the employment of milling machines, ceramic abrasives, lasers for rough-cutting of parts and the use of exotic, 21st century materials such as G10 and carbon fiber, we are still producing a hand-made product and should take enormous pride in that fact.

Secondly, the hand-craftsman of knives can offer the public what no factory can, namely the ability to modify designs or dress up a knife with a bewildering variety of impressive options such as Damascus steel, mokume, bolsters, colored Micarta and composite laminates, woods, ivories, scrimshaw, engraving, etc., etc. This ability to cater to the individual customer's needs or fantasies is, I believe, the custom knife maker's greatest advantage over the big factories and precisely why our craft will live on as long as humans have a need to cut things.

Finally, I do believe that even as hand-craftsmen we should not turn away from some of the advantages of modern technology. Just as we are comfortable with the use of a drill press as opposed to the hand-cranked drill of yesteryear, we should also be comfortable with computer-assisted-designing and laser or water jet rough-cutting of parts for our knives. Laser cutting has helped me keep my costs down over the years by freeing me from standing behind a band saw for hours making titanium dust. There is no glory in this kind of drudge work especially when I can then turn my hand to more creative endeavors and satisfy more customers. I believe that when laser-cut parts still require 90 percent hand work to bring them to completion, that they are, essentially hand-made. I have always seen this business as an uneasy marriage of industrial technology and hand-craftsmanship, with a heavy priority on the latter. I believe that as long as we continue to emphasize personalized hand work and commitment to the craft, we will bring joy to a lot of knife enthusiasts, and, in turn, we will prosper.

Chapter 1

What is a tactical knife ?

Like most questions concerning the nature of things, this is not a simple one to answer. One could say that a tactical knife is one that is best suited for a combat role of some sort. While this may be true, it begs the question: Why is a tactical knife advantageous in combat or defense situations? What makes it so?

To begin with, let me state that we should probably be using the term "tactical / utility" knife because the vast majority of knife owners will never use a knife in a combat or defensive situation. Most people will perform only mundane but useful chores such as opening boxes, cutting twine and sharpening pencils. In this sense, all knives are utility knives, particularly if they are convenient to carry and comfortable to use. The corollary to this premise is that any knife can be used in a defensive mode if the person knows what to do with it. For the sake of simplicity in this book, however, I will simply try to define the term "tactical" knife as this is the term that is most open to confusion and which I feel requires the most explanation. The term "utility" is actually pretty self-explanatory.

I should also state the obvious caveat here that the following discussion, though based on many long conversations with countless knife makers, purveyors, customers and security professionals, reflects my own personal ideas and opinions. What follows is a collection of my thoughts on the definition of a tactical folding knife and. I am certain, will not be the last word on this subject.

Several years ago, I wrote some columns for the "Battle Blade" section of *Soldier of Fortune*

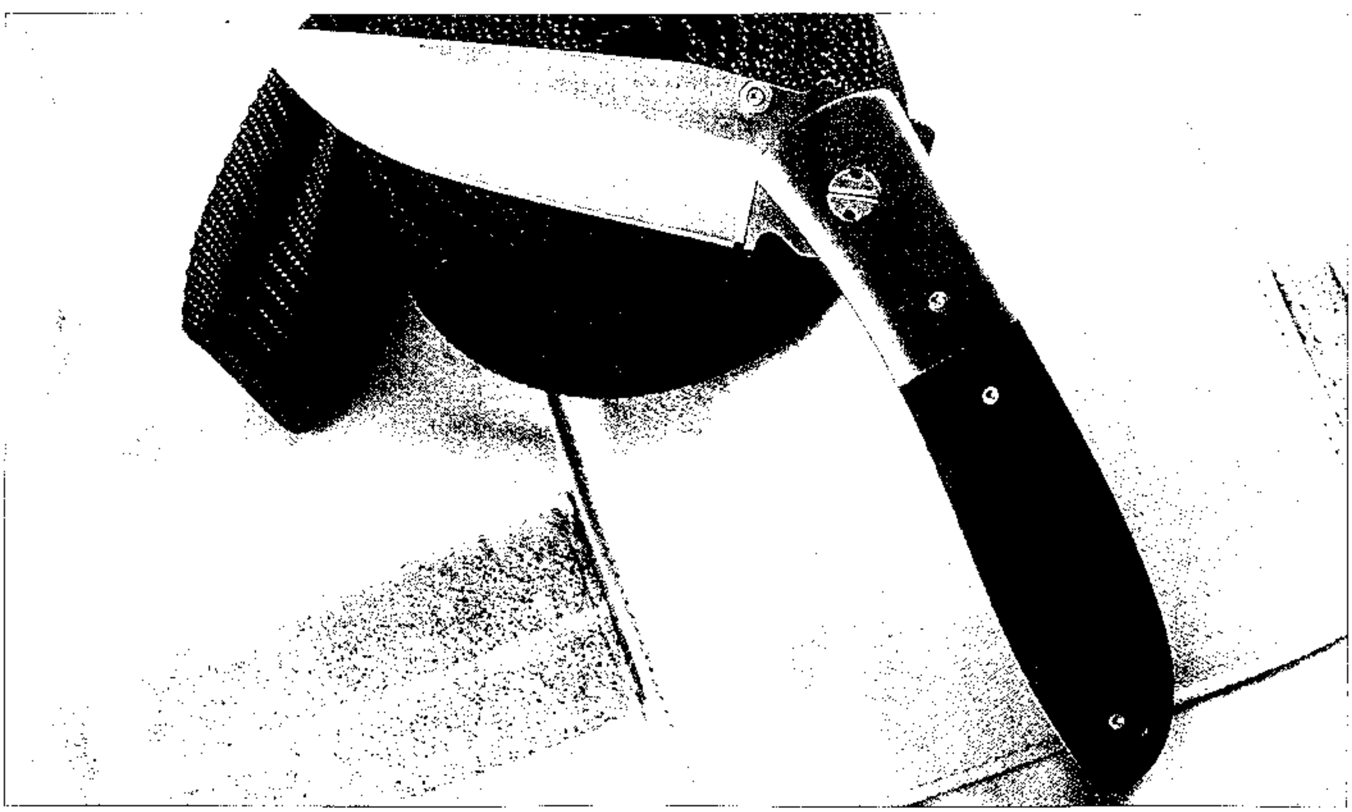


Fig. 1: "Kit" Carson's knife displays all of the elements which I consider to be essential in a tactical folder, including blade design, finger protection, blade lock-up and rapid deployment.

magazine. A previous author (also a knife maker), some weeks before, had answered a readers' question as to what constitutes the best combat / defense knife. The author, (who shall remain unidentified) stated the best knife for combat or self-defense was a 9-inch Bowie design of forged steel with a considerable cross guard; handle of stag, bone or ivory; and sheathed in quick-draw leather. I could not resist responding to this column and wrote words to the effect that no defense was effective against a well-trained, experienced and determined attacker, even if only armed with a razor blade, and no knife, no matter how big or of what design would turn an untrained schmuck into a deadly knife fighter. (Not those words exactly but you get the drift.)

The key elements, I reasoned, were training and determination, not the knife itself. Can a certain type of knife confer an advantage in a fight? Most assuredly. But when it comes down to the final crunch, the best knife to have in a fight is the one you have on you at the moment, not your 9-inch Bowie back home in a dresser drawer because it was too big to carry. What will save you is your mind, the most powerful weapon yet devised, not your knife.

Having said all this, let's assume that the user does possess some minimal degree of skill, perhaps even some training and experience in the fine art of self-defense with a knife. There are definitely some elements of design which can give the user an advantage during a confrontation. Following, we will therefore explore some of the design features which make a tactical knife, well, tactical.

First off, the term tactical implies a defensive or threatening situation of an immediate and local nature which is often, though not necessarily, unanticipated. We try to reduce threats to ourselves through the use of strategy which implies a broader picture of a potential danger zone and preplanning before entering said zone. We park our car under a light at the mall; as near to the entrance as possible; lock the doors and upon leaving the mall, perform a visual check of possible threats. This is strategy.

As we near the car, however, an uneducated and vile-smelling thug leaps at us from behind a truck and we are immediately faced with a tactical situation. Here, training and wits are your best allies but the knife you draw can give you some definite advantages which will help you get home in one piece. Let's look at some of them.

THE BLADE

Blade Length

Yes Virginia, there is a definite advantage to a longer blade. This is obvious and needs no elaboration. Most professionals that I know personally, and have made knives for, prefer a blade of 5 to 7 inches in length for combat use. There are, however, for us mere mortals, two insurmountable problems with a knife of this size.

A. It is very difficult to carry such a large knife, be it fixed blade or folder, without a sheath or pouch, which makes it visible and sometimes awkward on the body. A folding knife with a blade longer than 5 inches, is very cumbersome to carry and to wield because a folding knife's handle must be longer than the blade, thereby making for terrible balance. Also, most trouser pockets are about 5 to 6 inches deep, which makes a long knife uncomfortable to carry around, and a belt sheath of that size tends to jam into car or theater seats.

B. Our elected legislators, in their infinite wisdom and in a deep desire to show us that they are worth what we pay them, have decreed that we really don't need longer knives (I thought it was the Bill of Rights not the Bill of Needs) and that self-defense would be tolerated only so far (4 inches) and no further! Most knife restriction laws, therefore, allow a blade up to 4 inches in length but there are some places which may only allow 3 1/2 inches or less.

A tactical folder therefore, in order to be on your person when you need it most, should be comfortable and legal to carry. This means a blade length of about 3 1/2 to 4 inches.

Blade Design

This feature will be explored in the following chapters but the definition of tactical knife requires a few words at this point. A tactical knife must be capable of dealing a cutting blow as well as a penetrating blow (or puncture) with equal ease.

Cutting is pretty basic to a knife and depends both on the sharpness of the blade and the curve of the tip (or belly) of the blade. Some curvature towards the point helps in the slashing action of a knife because our arms and hands always move in a circular motion around pivot points (our joints), thereby describing large circles in the air. Curvature helps by reducing resistance as the material being cut nears the point of the blade.

Penetration is aided by two factors: sharpness and the geometry of the point. While it is true that a sharpened top edge will facilitate penetration, I feel that its disadvantages outweigh its advantages. First, sharpening the top edge means reducing the thickness of the steel at the very place where it is weakest, the point. Relieving the top of the blade with a clip point or false edge is quite effective for assistance in penetration and compromises the tip only marginally. Secondly, sharpening the top edge, (aside from being illegal in most places), requires that the handle shroud the whole top of the blade in order to protect the user when the blade is closed and carried in the pocket. This makes for either a wider handle, a narrower blade, or a handle design which may not be comfortable in the hand.

There are many blade styles being used today for tactical folding knives including the chisel-ground tanto, double-ground spear point (dagger), reverse curve hook style or bird's beak and some other truly creative patterns that defy simple description. All have advantages and disadvantages and most work pretty well in the tactical mode. I prefer blades that can also be useful in the utility mode for reasons I have already stated above. Therefore, I tend to be more conservative in my choices of blade patterns. The customer, of course is the ultimate arbiter in the debate over style and I encourage knife makers to seek their own path in the constant struggle to satisfy them. Study the existing designs, create your own and determine what works best for the product you wish to represent your craft.

Blade finish is not a major factor in defining a tactical knife. One of my friends, a retired Special Forces captain of Vietnam / SOG experience, (code name "Ronin",) always demands that his blades be black, dull, sandblasted and invisible at night while another friend and collector who runs his own security and anti-terrorist business wants a shiny blade so "..the sonofabitch can see clearly that I'm armed and dangerous."

Rapid blade deployment is, of course a necessity for a tactical folding knife and this can be achieved in a variety of ways including the patented Spyderco hole in the blade spine, a simple thumb stud protruding from the side or the Terzuola thumb disc, first introduced on the Advanced Technology Combat Folder (ATCF).

To summarize blade design factors: A tactical knife should be on you when you need it most. An overly long blade may end up being left at home (either for comfort or legal reasons) and, in the end, be of no use to you whatsoever. Therefore, I believe that a tactical folding knife should have a blade long enough to be useful (over 3 inches) yet short enough to allow a comfortable (thereby constant) and legal carry. My ideal would be 3-1/2 inches to 4 inches of blade length, with a spear point strong enough to resist breakage, relieved at the top edge (sharpened if you must, but not necessarily so) and with either a matte or polished finish.

Fig. 2: Alan Elishewitz adds style and uniqueness to his knife with some simple but effective touches. Note how finger protection is incorporated into the handle, both top and bottom.

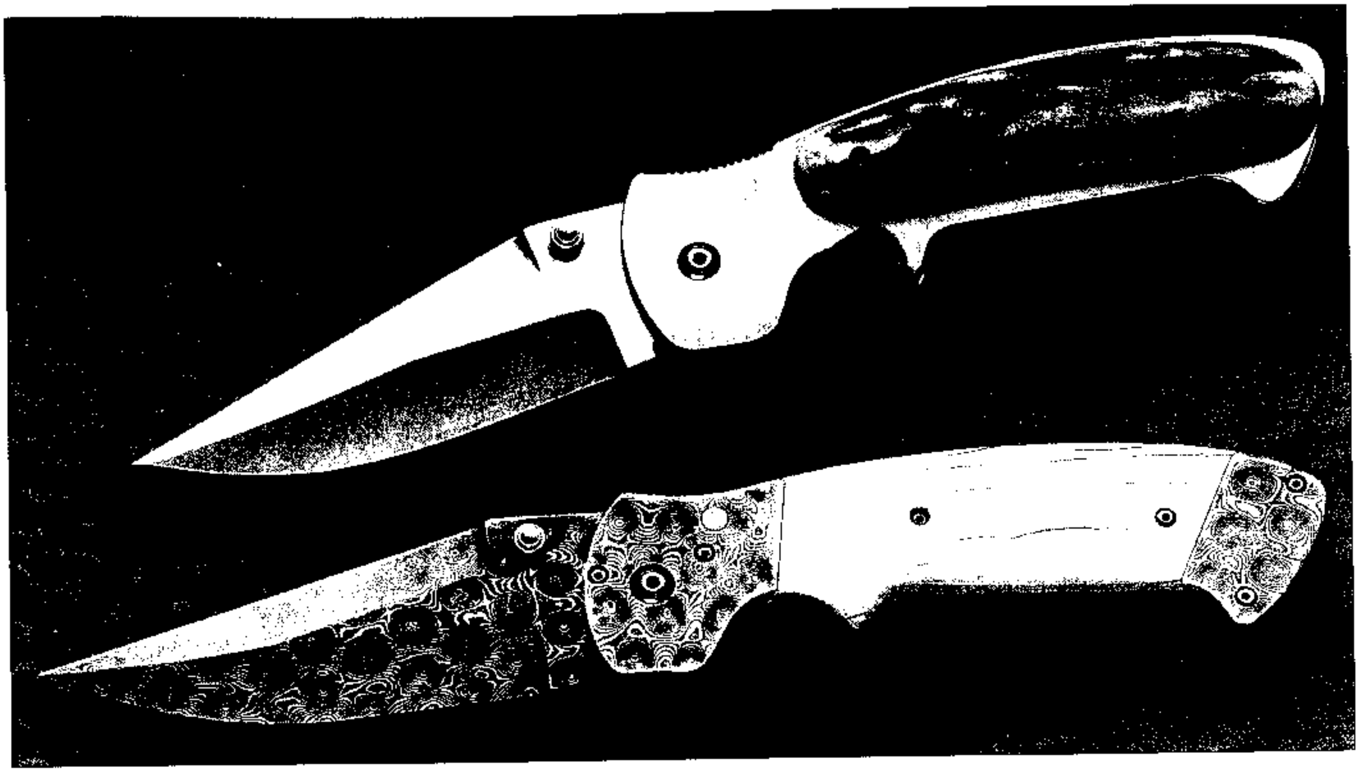


Fig. 3: I have admired Pat Crawford's knives since I started in this business in 1980. His designs are graceful yet practical and his workmanship is rugged and dependable.

THE HANDLE

Any knife handle must be comfortable in the users' hand in a number of holding positions. This is basic logic and needs no further elaboration. A tactical knife, however, must also provide some minimal protection to the fingers as well as a secure, easily accessible carry and a swift, positive deployment of the blade.

At this point, a few words about "automatics" are in order. More commonly called "switch blades" by the un-annointed, these are pocket knives which deploy the blade by means of an internal spring. There is a small but highly talented community of knife makers who produce very fine and often ingenious examples of this genre and I wish them only the best in their endeavors. I personally do not like automatics for a variety of reasons and I do not make them, although I have been asked many times to do so. I do not believe that an automatic provides the degree of safety to the user that a non-spring-loaded knife does. While an automatic does deploy its blade quickly, a well-made non-automatic is virtually as quick and safer in the pocket. Enough said about automatics.

The handle of a tactical knife should provide finger protection as noted above and this can usually be achieved with a flare at the bottom of the handle and a ramp at the top, usually checkered for a better grip with the thumb. This top ramp can also be located on the blade itself and, in fact, the ATCF, which I will describe in detail in later chapters, uses this blade-ramp feature.

A tactical knife must be convenient in the carry position and be capable of a fast draw and rapid blade deployment. For this reason, I favor the pocket clip feature rather than a belt pouch. Some particularly well dressed models are better off without a clip, being carried in a protective pouch. Many thanks are due to Sal Glesser of Spyderco for popularizing the pocket clip concept which I have used these many years and which has become de rigeur on most modern, tactical folders.

Maneuverability of the blade is a vital factor in knife play and is sometimes overlooked in a maker's desire to create a different "look" to his work. I have seen all manner of strange shapes in blade and handle design, some of which were positively alien in nature. I prefer a straight, in-line

Fig. 4: J.W. Smith makes tactical folders of unsurpassed quality and grace. While the design of this knife's blade is superb for cutting actions, it would need more of a point for penetration in a defensive mode.

relationship between blade and handle which, while not unique or glamorous, is a reliable design for making the blade a true extension of the hand and affords maximum maneuverability and control.

I try to incorporate a thong hole in my knife handles where possible because I know they will get a lot of hard use, often in very rugged territory. In such use, a thong or lanyard can be of vital service if the knife should be accidentally dropped over a ravine or deep water. The thong or lanyard hole, however, is probably not a defining element to a tactical knife.

Finally, the handle of a tactical folding knife must lock up or in some way secure the blade in the open position. A slip-joint folder could, of course, be used for defense but I would, in no way, consider such a system for a tactical folding knife. There is a good variety of dependable locking systems available to the custom knife maker and it seems that every week brings a new system to the market and, of course, right to the patent office. Most of these systems work pretty well, though some employ tiny parts, springs and other features which can become problematic in dusty, muddy and otherwise unfavorable environments.

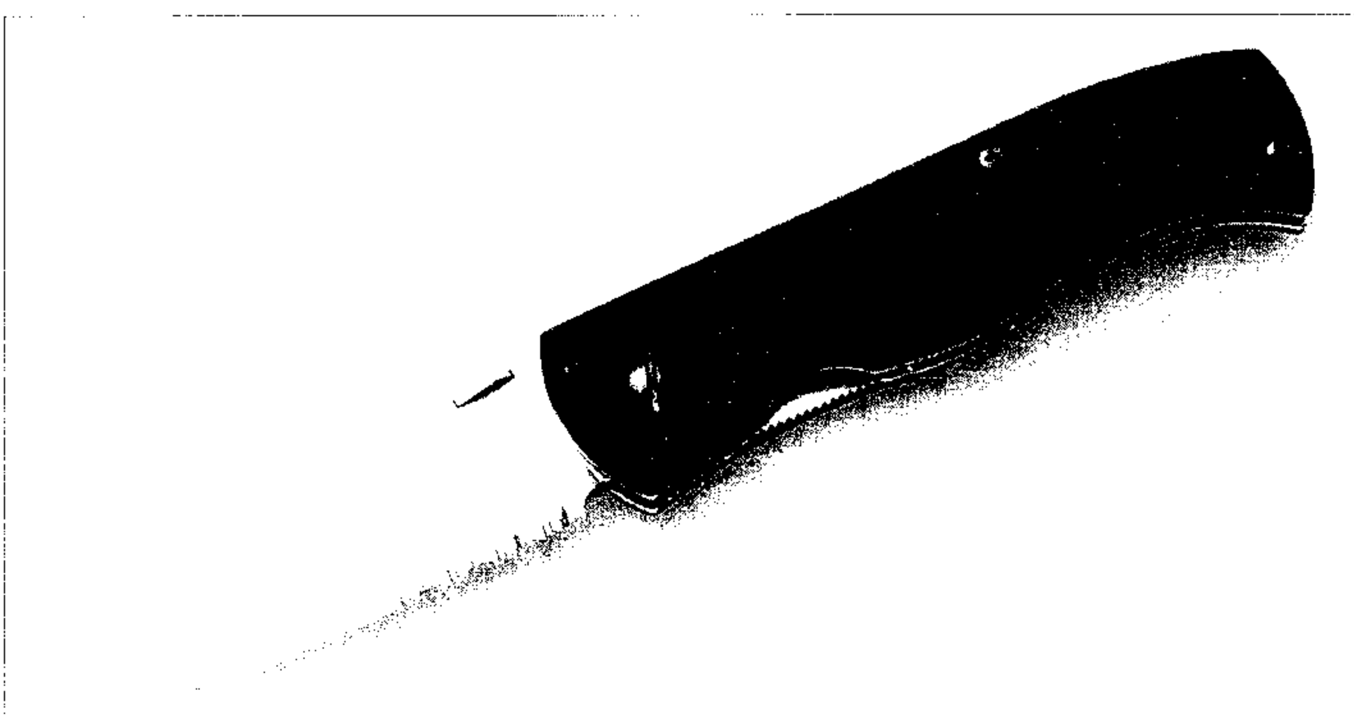


Fig. 6: Ernie Emerson's knives are always comfortable in the hand and display the ideal form of the tactical folder.

My personal preference for a folding knife is the linerlock as described in detail in later chapters. It is simple, (no moving parts), reliable, (if properly made) and exceedingly strong. The linerlock also lends itself nicely to easy cleaning and field maintenance.

SUMMARY

A tactical knife is one which can constantly be carried in a legal, comfortable, easily accessible manner and which becomes a natural part of the user and a controllable extension of his hand. It has a blade of between 3 inches and 4 inches, with a point, (spear type or otherwise) which allows for both cutting and penetration. A clip point, false edge or sharpened top helps improve the penetration. Blade grind (hollow or flat, chisel or double-bevel) is inconsequential and depends purely on the preference of the user. The blade must have a provision for rapid deployment such as a hole, stud or disc which can be engaged by the thumb quickly and without effort. Automatic blade deployment is acceptable for this definition.

The tactical knife should have a handle which safely shrouds the blade in the carry position, is comfortable to hold in any grip and has no sharp protrusions or edges which could injure the user. The handle should afford some protection to the fingers on the bottom of the handle as well as the top, and must lock or secure the blade, at the very least, in the open position.

Carry systems must allow for a quick draw and should offer some concealment.

Finishes to the blade and handle, materials from which they are made and decorative embellishments, I believe are of no real consequence to the definition of a tactical folder and these features are left to the good judgment of my fellow knife makers.

While this summary is probably incomplete, it does reflect accurately my concept of the tactical folding knife and does describe the majority of knives being sold as such today.

Chapter 2

The shop, the tools, the materials

This book is not intended as a comprehensive primer in the fundamentals of hand-made craft. It is understood that the interested reader will posses some basic skills in the use of hand tools, some knowledge of common materials and at least a rudimentary understanding of certain machine tools and processes. There are a number of excellent books which cover beginning steps, some of which may be found in the "sources" section at the back of this book.

For our purposes here, I assume that the reader knows something about drilling and tapping holes, grinding a knife blade with a belt grinder, polishing metal, cutting on the band saw, basic lathe and milling machine skills, etc. What we will explore below is the application of those basic skills and materials to the fabrication of a modern hand-made knife.

THE SHOP

Every craftsman sets his shop up in a way which is most comfortable for him. I regard my shop as a haven and my own private little cave. I look forward to being in there and am most happy when working and surrounded by my tools and machines. Those who have had the luxury of building their shop from scratch rather than converting a garage or basement give a lot of thought to machine and workbench placement, electrical outlets, lighting, etc. I personally like lots of open space to move around in and I tried to keep most

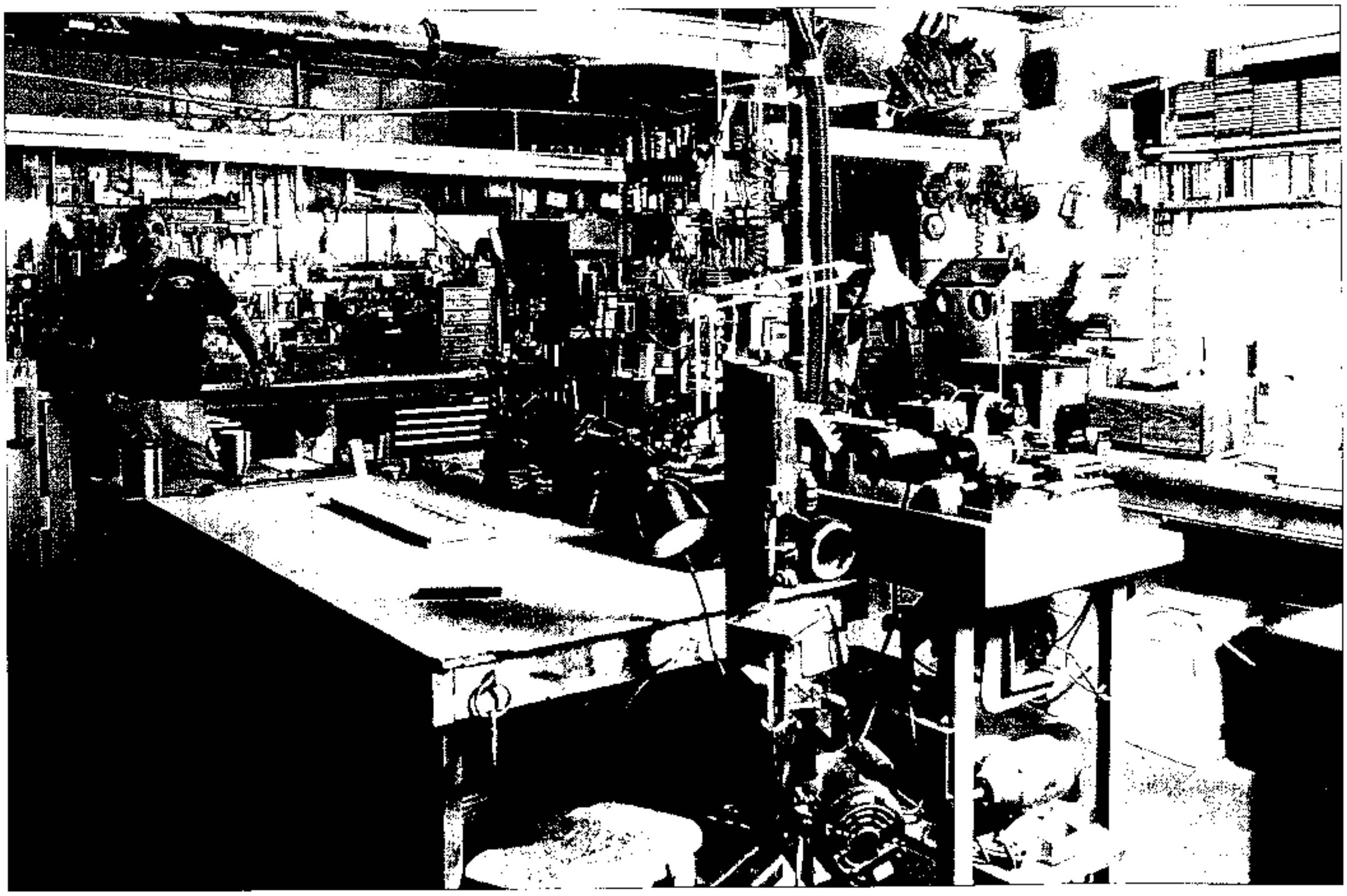


Fig. 6: A view of the shop, where the author feels most at home.

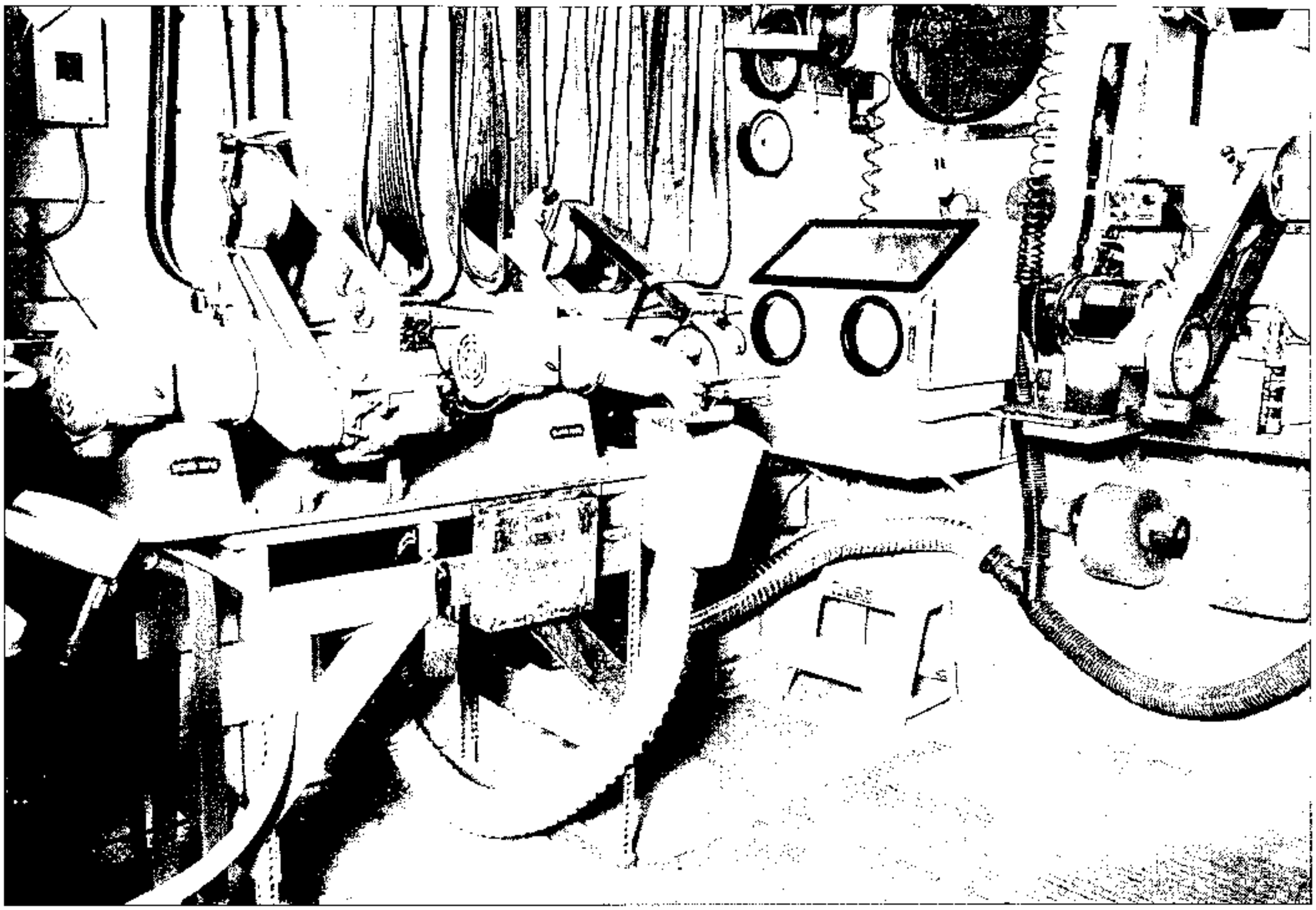


Fig. 7: Grinding and sandblasting are kept separate from the assembly workbench to avoid contamination from dust and grit.

of my big stuff against the walls. I also like islands around a large workbench for related operations, such as keeping the grinders together, drill presses together etc.

It's a good idea, when possible to keep the dusty operations such as grinding, polishing and sandblasting separated from the assembly and finishing workbench (Fig. 7).

This workbench is the heart of the shop and where I spend most of my time. I keep my most often-used hand tools within arm's reach and each has a place to live near the bench. I hate clutter and take the time to put things back where they belong after use. That, I guess, is the Virgo in me (Fig. 9).

Lighting is really important and I use high output fluorescent lights all over the shop with task spotlights at every point where I do concentrated work. A white ceiling greatly improved my shop light and I put in some extra windows so I could watch our beautiful Santa Fe sunsets while I work.

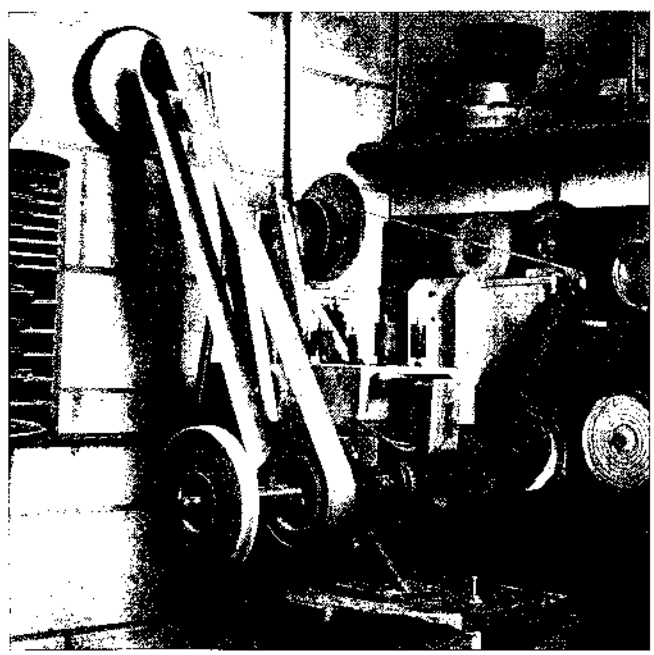


Fig. 8: A homemade grinder with small wheel attachment, Scotchbrite wheel and touch-up belt.

Fig. 9: The assembly workbench with grinding stations (far right) separated by a wall.

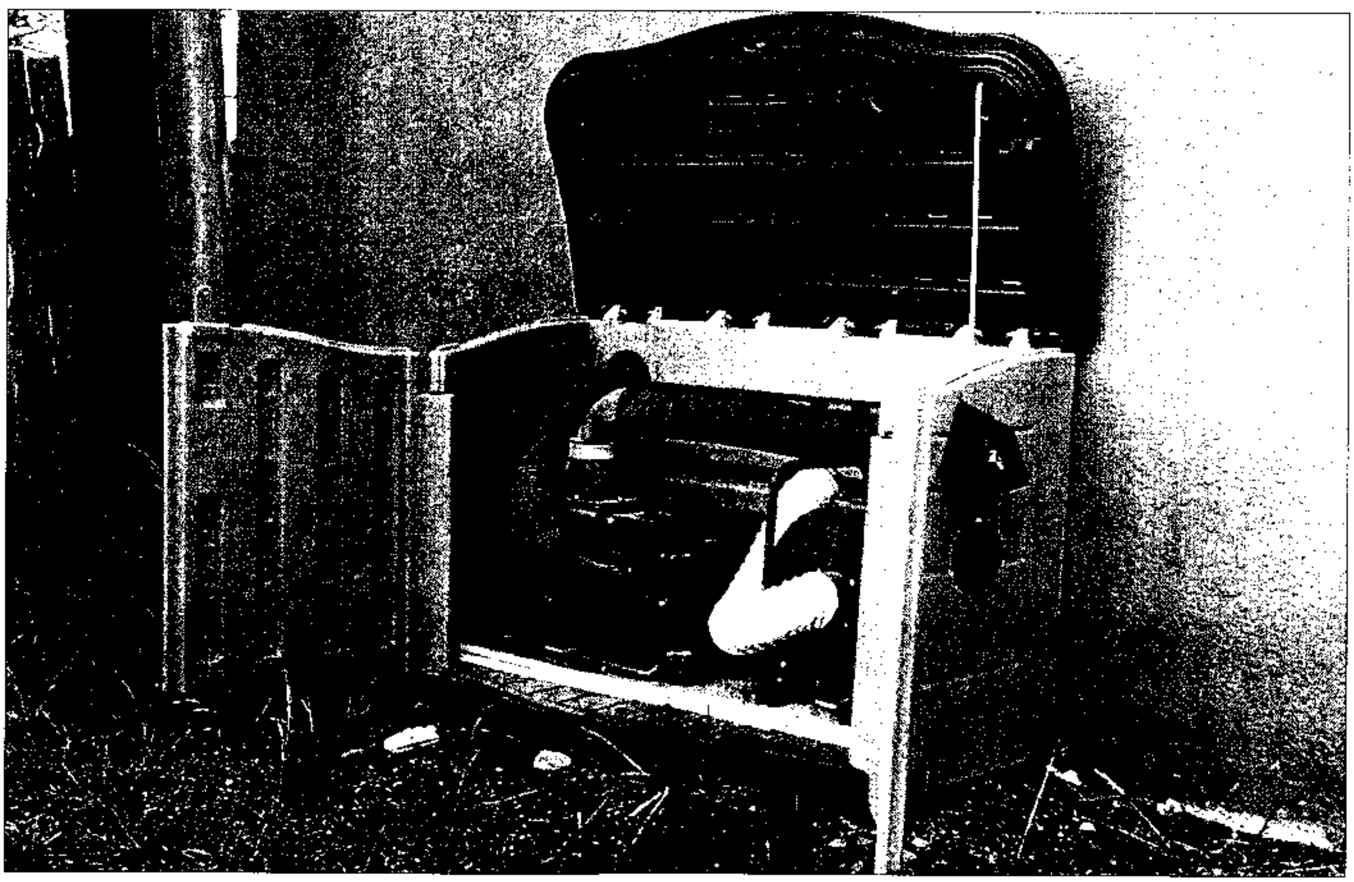


Fig. 10: Dust blowers are located outside of the shop in a weatherproof housing.

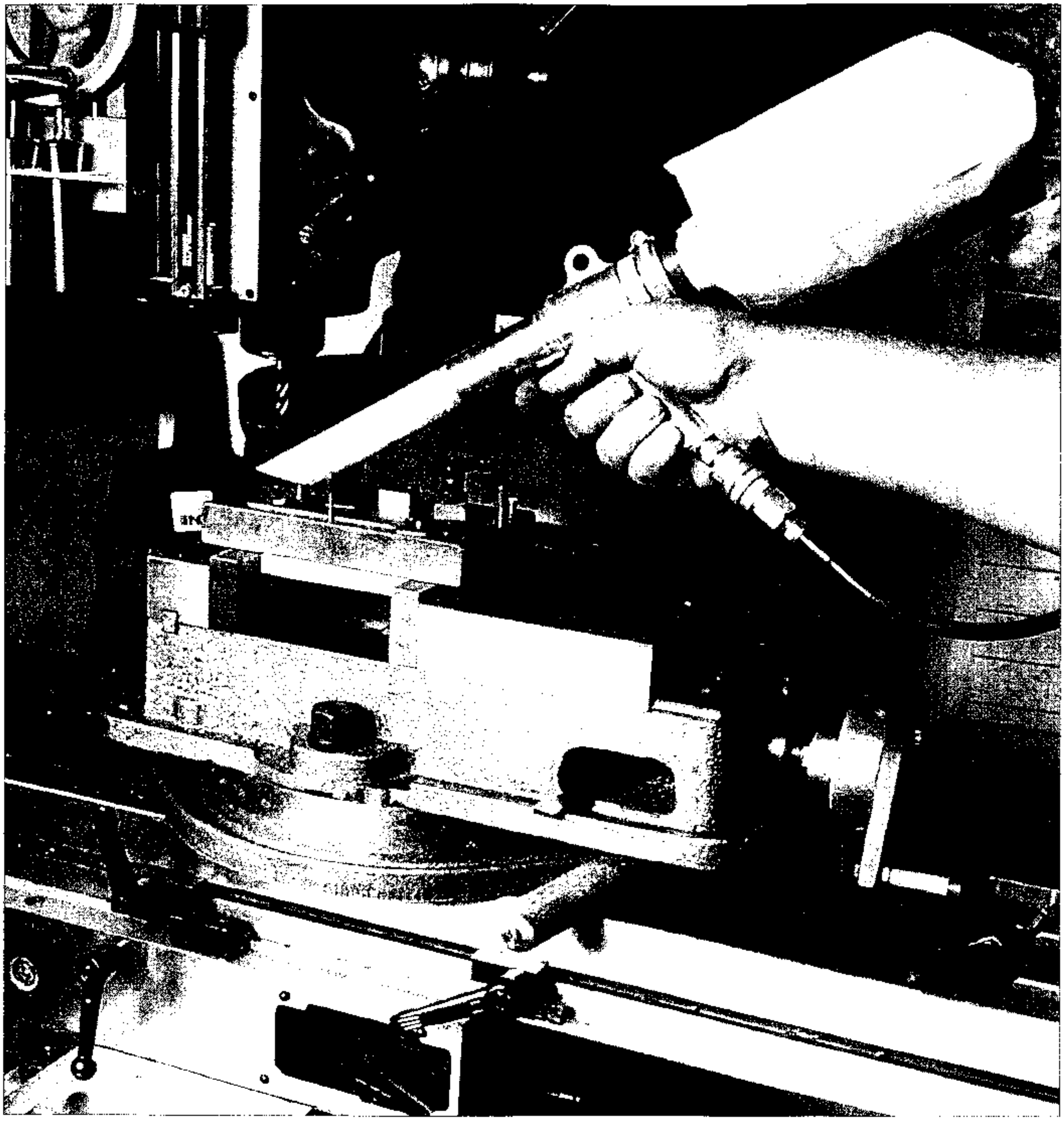


Fig. 11: Siphon type vacuums, connected to the air supply, help keep the machines free of chips.

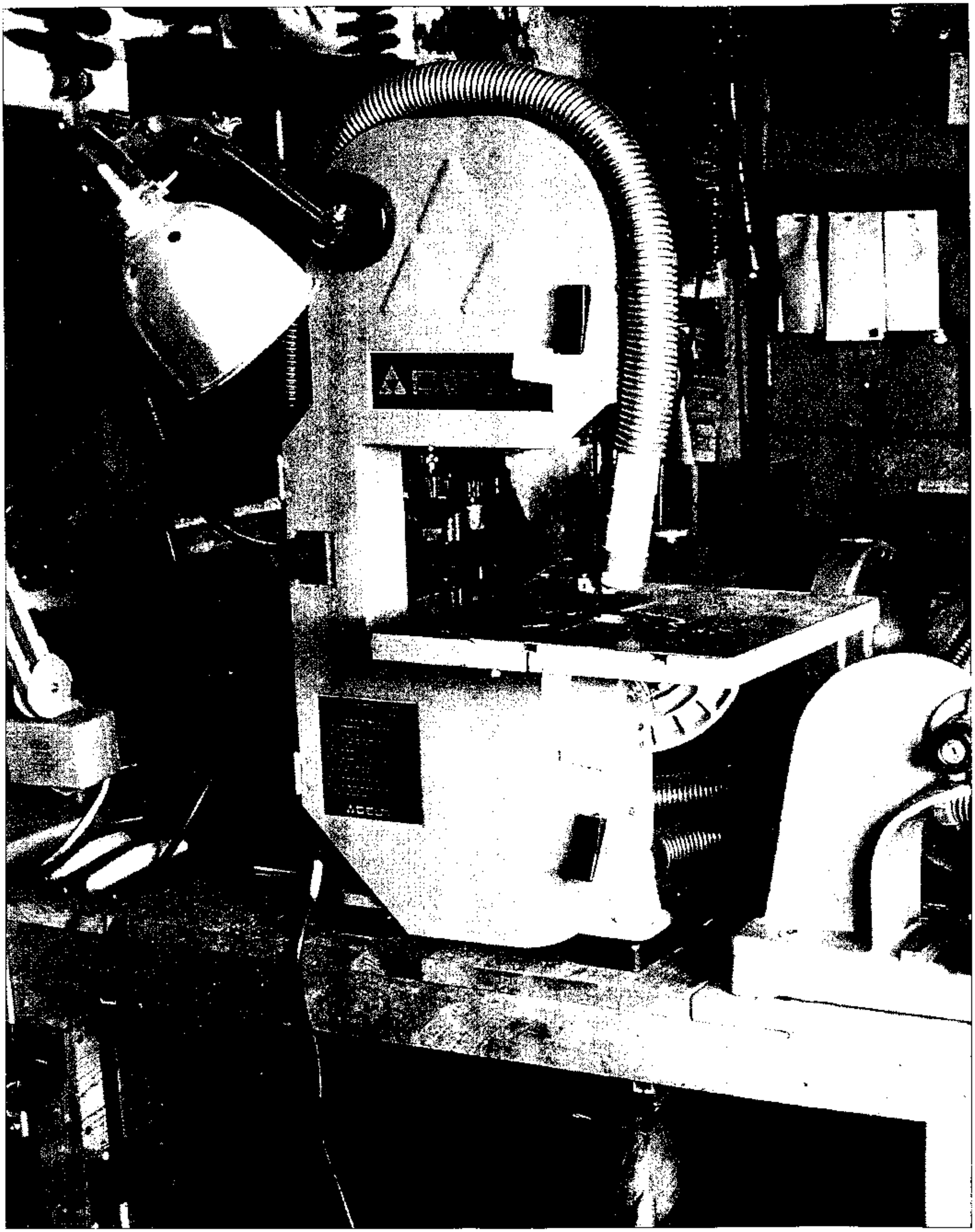


Fig. 12: The small band saw is used to cut materials such as Micarta, ivory and G-10 so it has its own high-filtration vacuum system. (not shown but located under the bench).

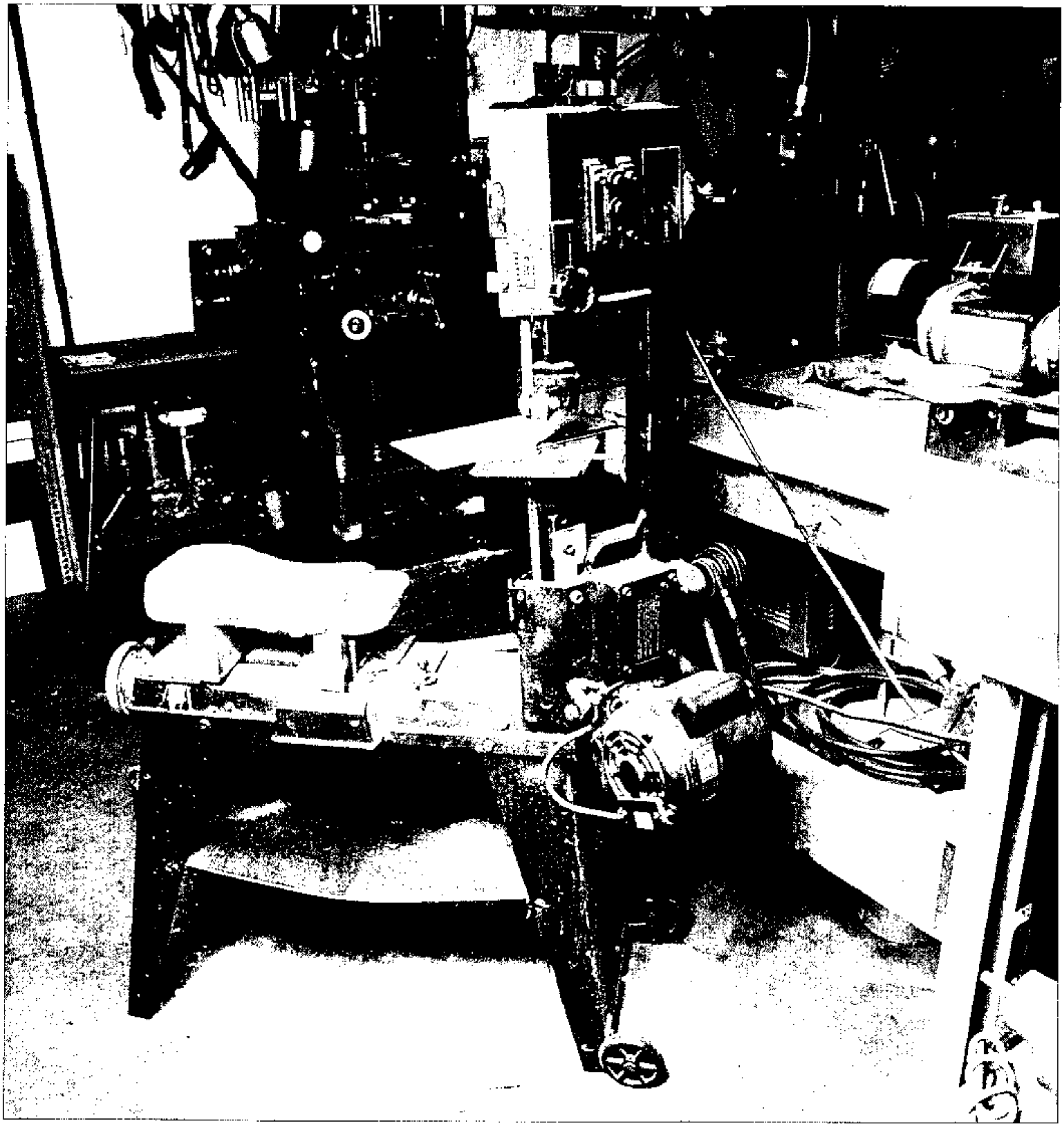


Fig. 13: The larger band saw. Not very big, but adequate. Note the padded saddle locked in the vise.

I set up a pretty powerful dust collection system for my grinders and sandblaster and exhaust them outside. The blowers are in a shed behind the shop because I don't like the noise, and I ducted each of the machines separately. (Fig. 10) As I mention below, I don't use the dust collector while grinding titanium because of the fire hazard but I use it for everything else. I have air guns with siphon vacuums on them near the drill presses and milling machine and this helps control the build up of chips around those machines and keeps them clean. (Fig. 11) For my small bandsaw, where I cut G10, carbon fiber, mastodon ivory and Micarta, I use a separate vacuum with a double hepa filter which really eliminates all the dust down to sub-micron level. (Fig. 12)

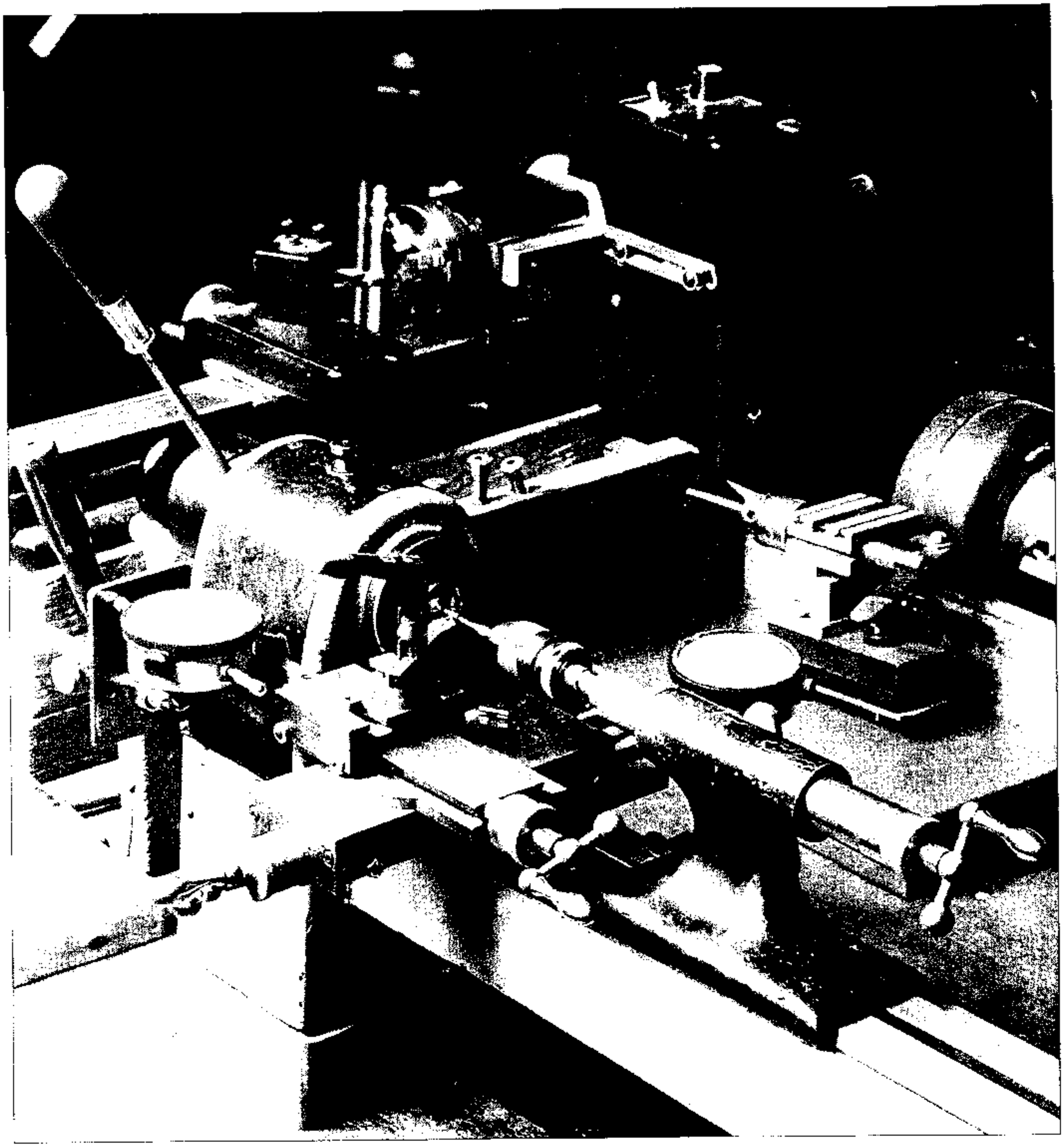


Fig. 14: Two small, precision lathes for making stop pins, thumb discs, etc.

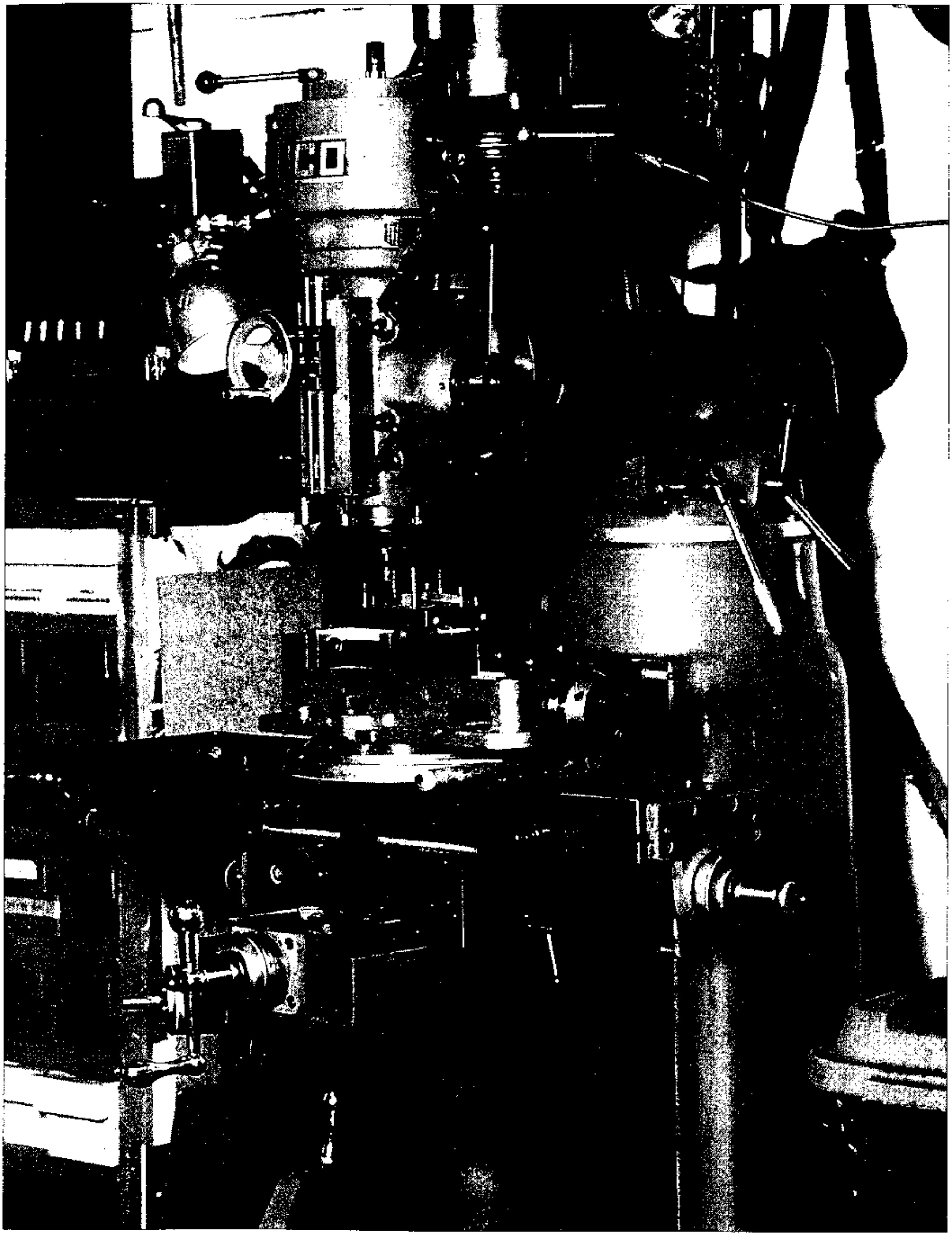


Fig. 15: The Enco 8-inch by 36-inch milling machine.

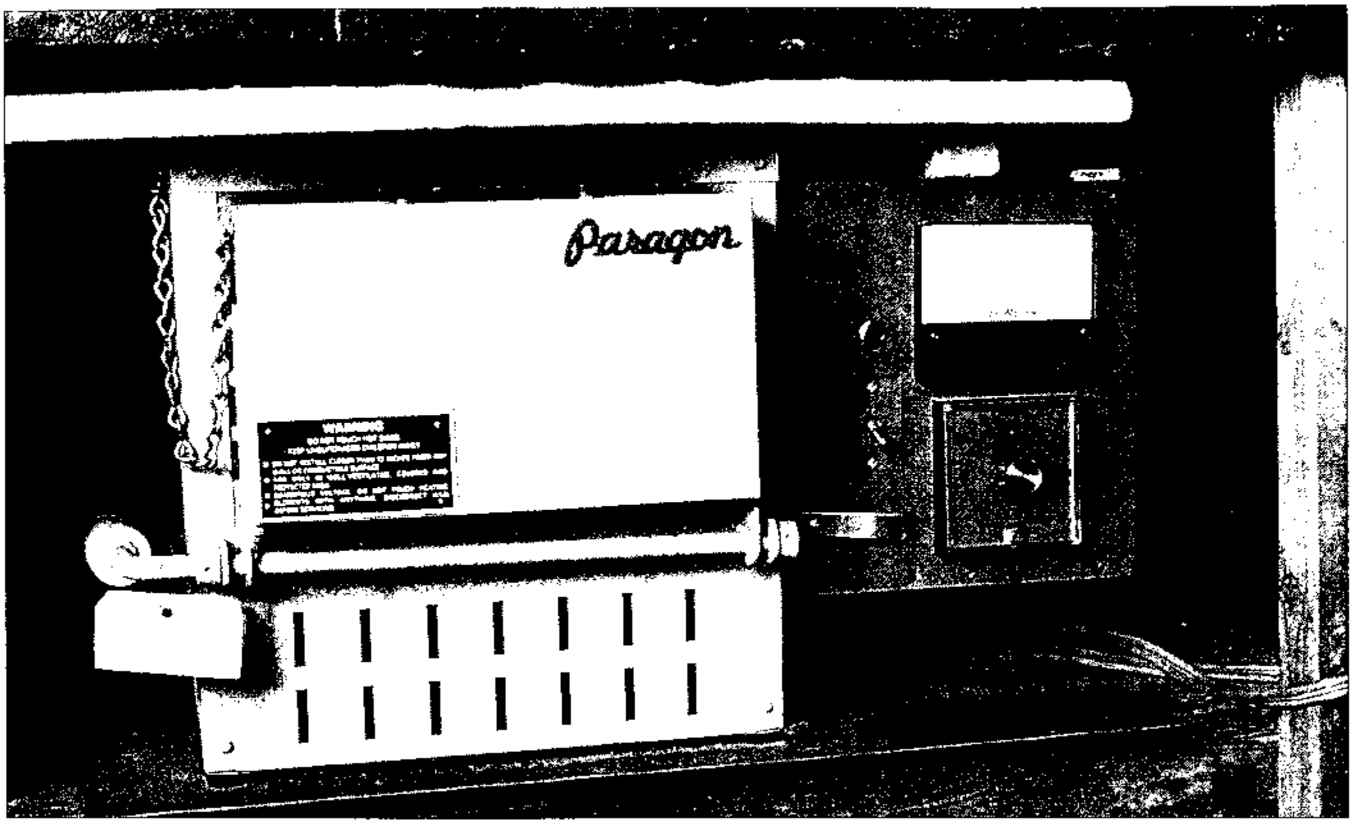


Fig. 16: Paragon furnace with manual controls.

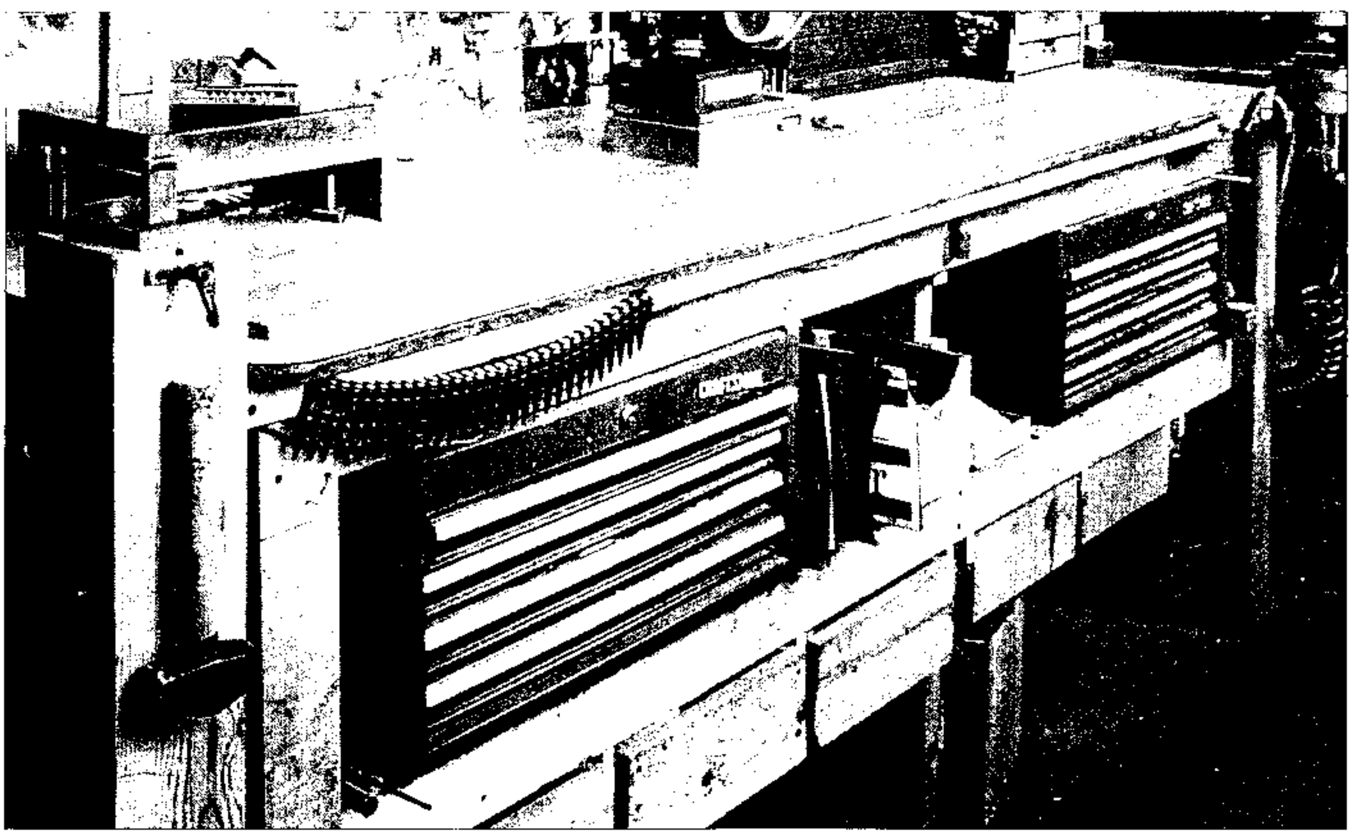


Fig. 17: Craftsman tool drawers, tucked under the workbench, help keep small parts and finished knives close at hand.

The grinders are really the heart of my shop as most of the work is done on them. I have three Burr Kings, one dedicated to the flat platen, one dedicated to the 8-inch contact wheel and one variable-speed which I use for a variety of jobs. I also have a homemade belt grinder with small contact wheels, a 6-inch belt contact wheel and a 10-inch Scotch-brite wheel. (Fig. 8) Additionally I use an 8-inch disc grinder and various small buffers.

My shop is equipped with three drill presses, two band saws, two small lathes and an Enco 8-inch x 36-inch Bridgeport-style milling machine. (Fig. 13, 14, 15) Aside from my lapidary equipment and electric furnace, (Fig. 16) that's about it as far as machinery goes.

I have many sets of Craftsman tool drawers all over the place. I find they are an inexpensive and neat way of storing tools, parts and finished knives while at the same time having them readily at hand. (Fig. 17).

Finally, my sound system! I don't work well in silence and I love to listen to opera, country, talk radio (conservative!) and old-time radio mystery tapes. I have speakers all over the place and they fill my shop with joyful sounds all day long.

THE TOOLS

Like most craftsmen, I have a myriad of tools all over my shop, some general tools, some more specialized. Many of these tools I have made myself to deal with specific, repetitive operations. Some I have bought. I won't go into all of the tools that most shops should have but I do want to mention some that I think are really helpful to the knife maker. I have included a GADGETS and GIZMOS section in this book to describe some of the more specialized jigs and fixtures that I have made so that chapter will really be a continuation of this one. Some of the more generally helpful items are described here.

I organize my work in wooden trays with 5 to 12 sections each for doing a batch of knives at a time. In this way I can carry the entire batch and all of the parts around with me from machine to machine and keep track of the processes I finish with each knife. Other handy helpers I use are wooden trays about 5 inches by 6 inches divided into two compartments. When I need to perform the same operation on a bunch of parts (like polishing screw heads or making stop pins), I carry the parts from place to place in one compartment and, as I work on each one, drop it into the other side so I know which parts are completed and which are not. (Virgo again!) (Fig. 18)

One of the best investments I have made for knife making is the Tapmatic 30x tapping head on a dedicated drill press. (Fig. 19) You can tap titanium by hand or with a power drill but when you

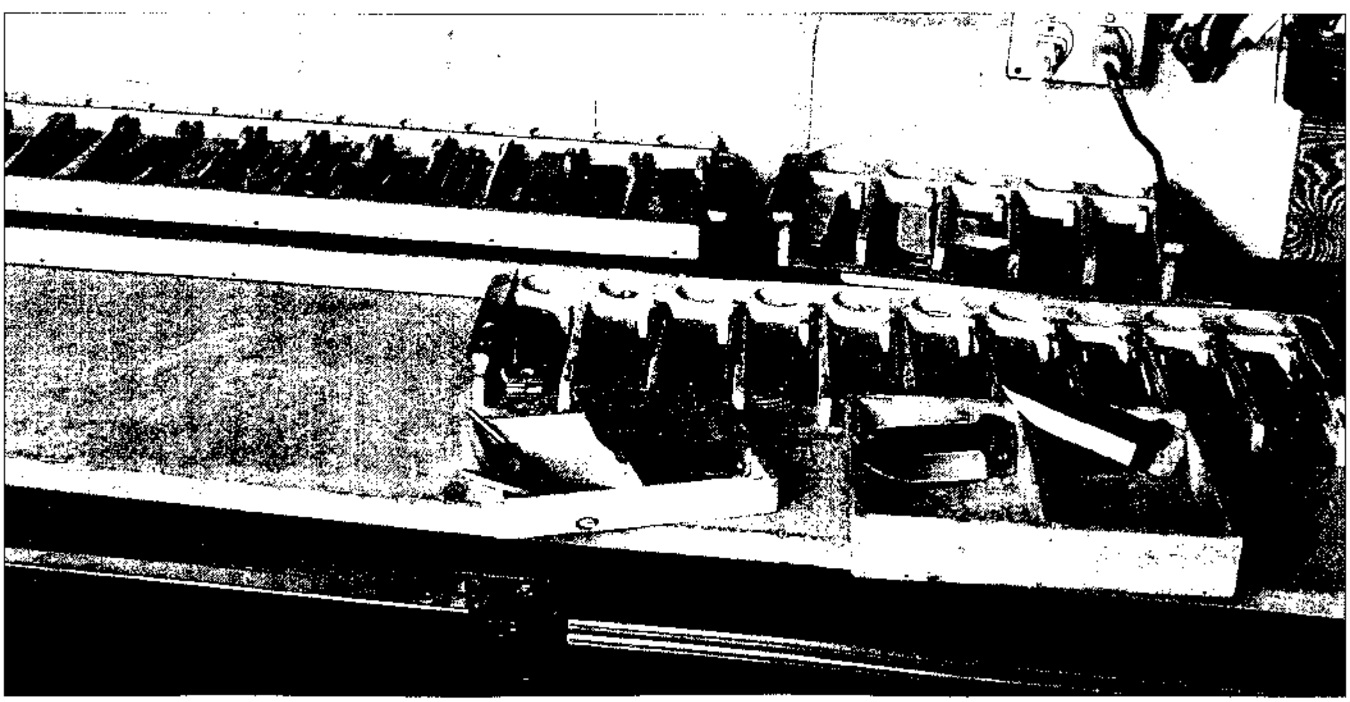


Fig. 18: Sectioned trays help keep track of all the parts on different batches of knives.

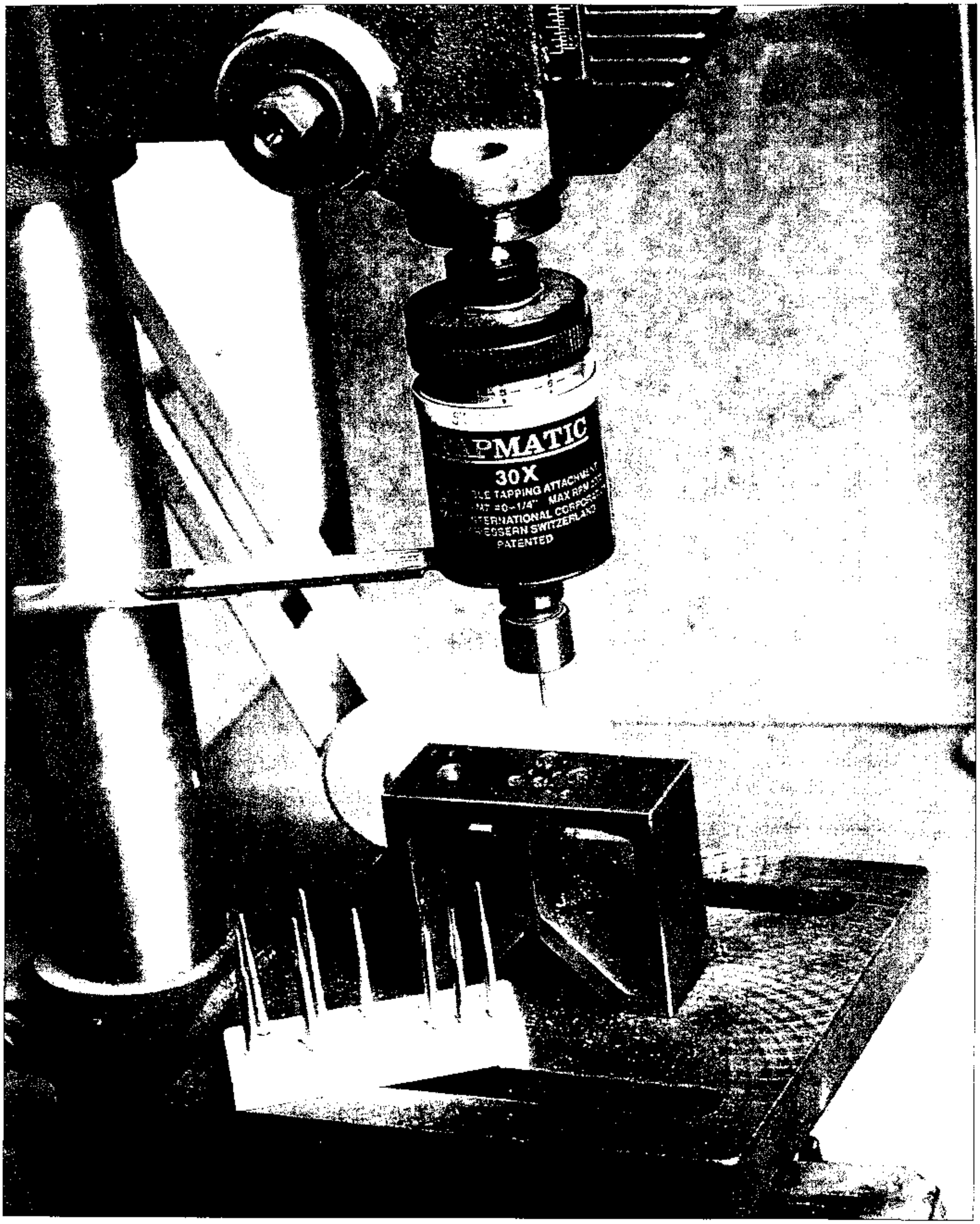


Fig. 19: The Tapmatic tapping head is a good investment for one who is more than just a hobbiest.

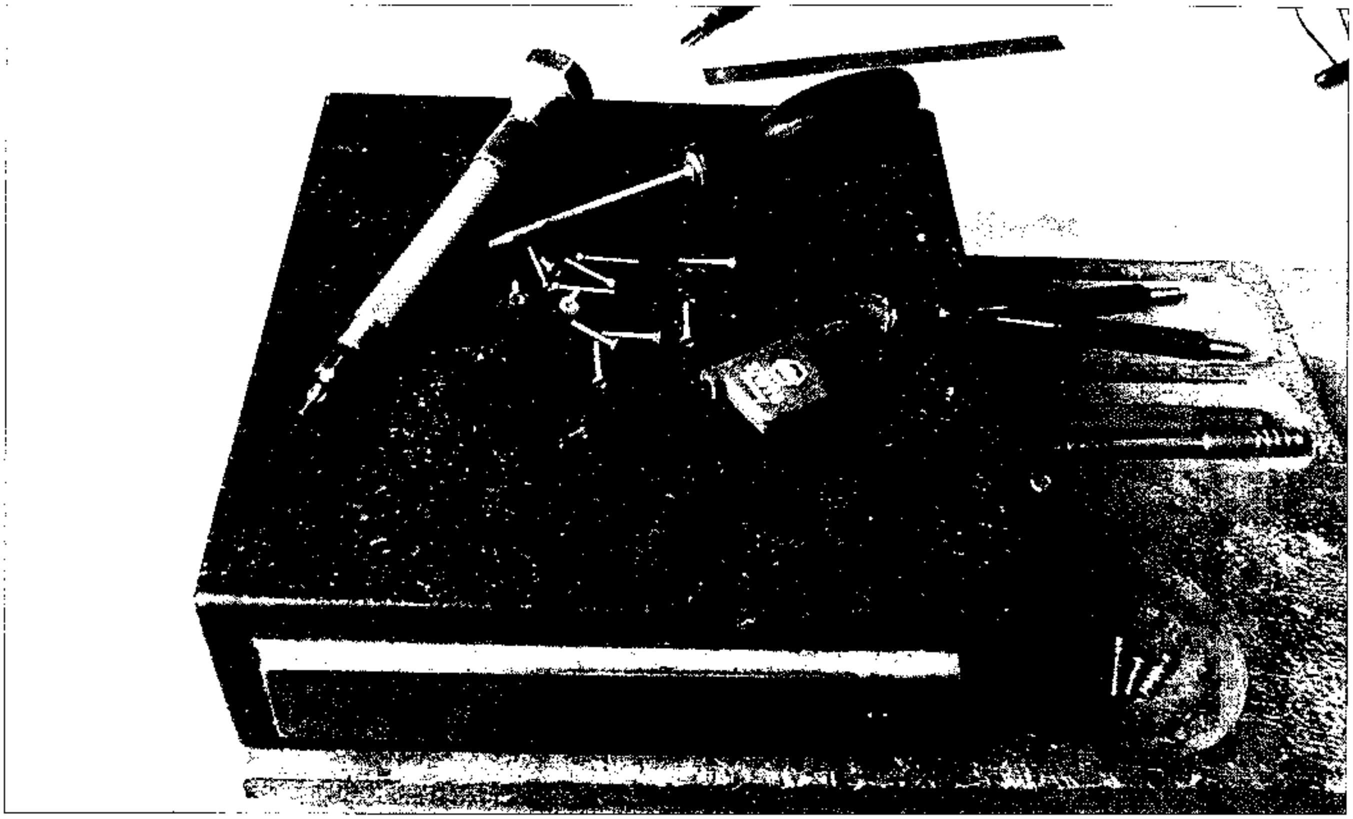


Fig. 20: Torx screws and drivers avoid stripped out screw heads during assembly

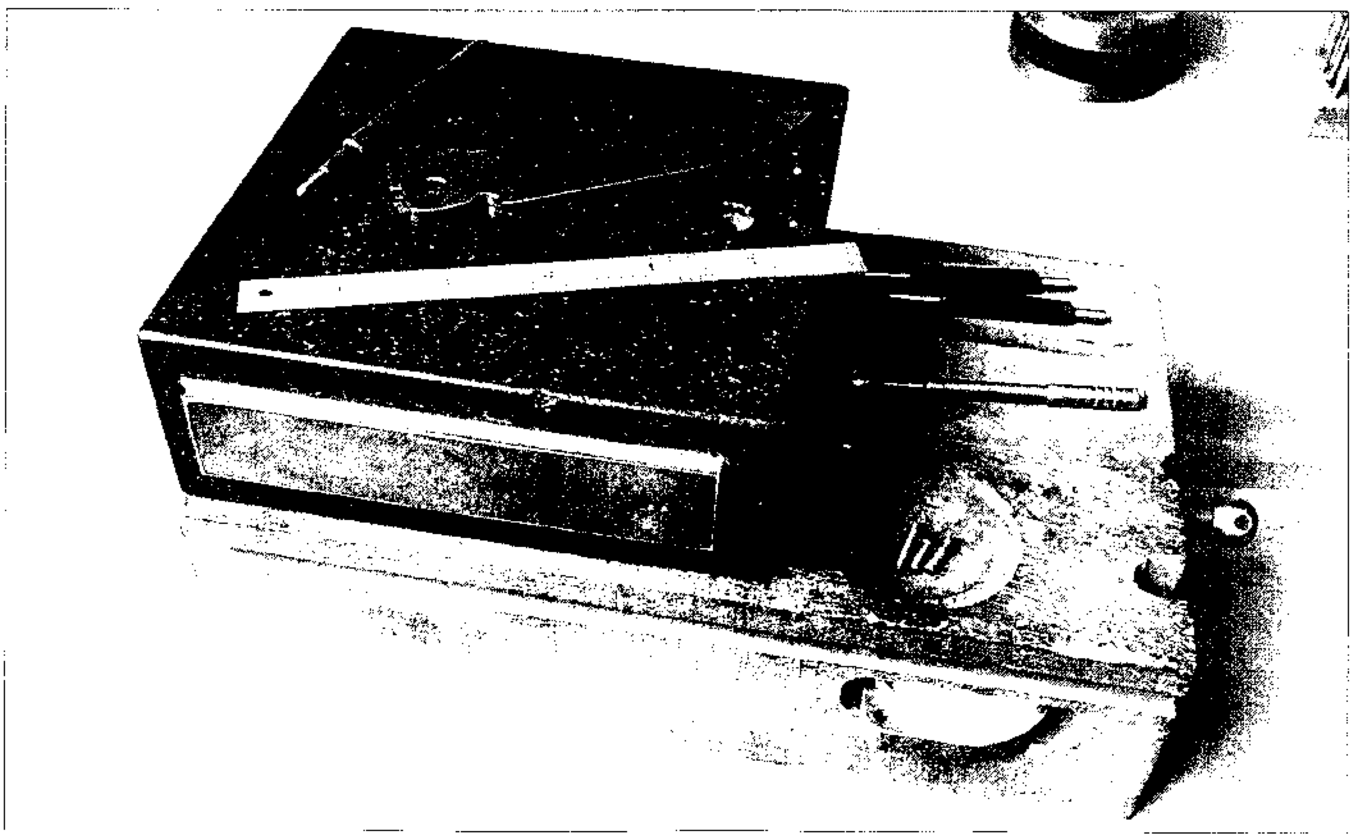


Fig. 21: My main work station. (See Chapter 9)

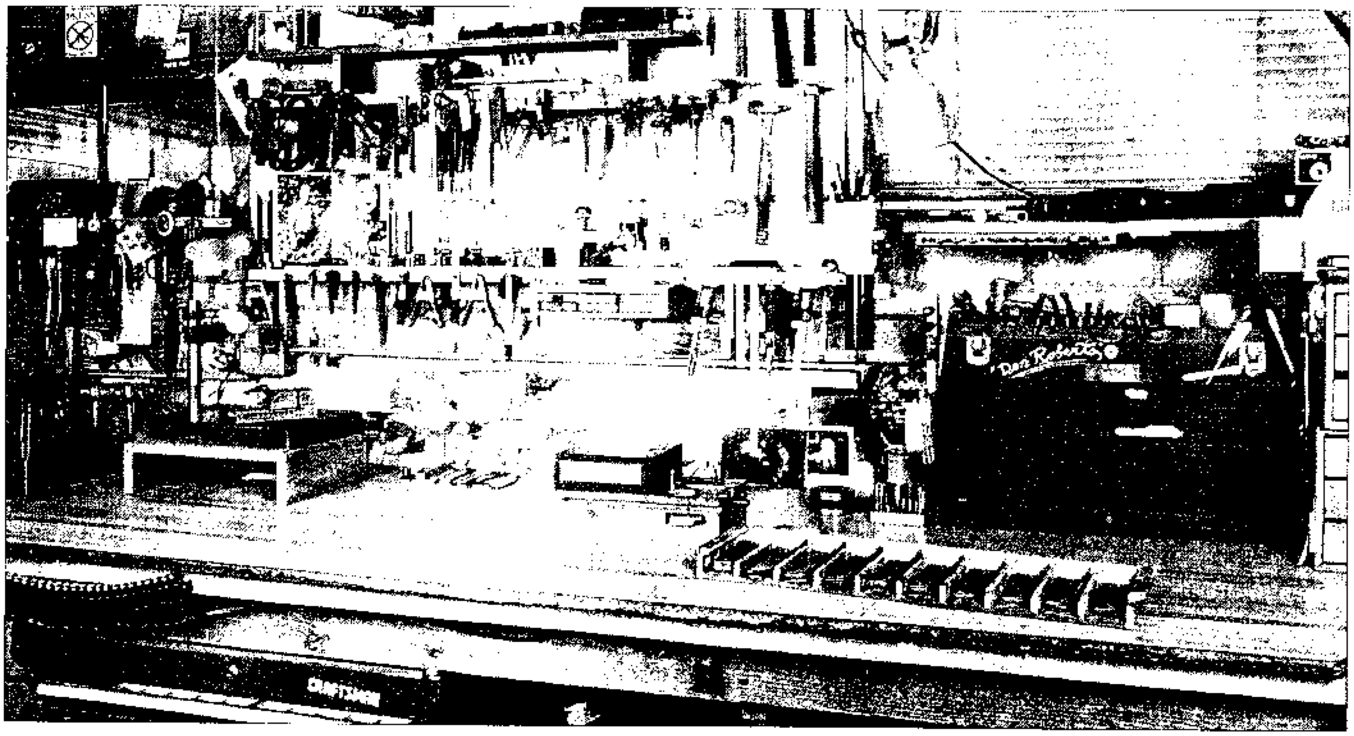


Fig. 22: The most frequently used tools and fixtures line the wall and shelves within hand's reach of the workbench.

get down to 1-72 or 0-80 threads, its quite easy to break those taps with frustrating regularity. The tapping head virtually eliminates broken taps, even in the very small sizes. Each hole is neatly tapped with amazing speed and a flick of the wrist reverses the tap and removes it from the hole. Don't ask me how the thing works. I've had it apart for cleaning and maintenance and I still don't understand it. But work it does and though expensive (about $350) it has paid for itself many times over. I can tap 300 to 400 holes with a single tap and only change it when it finally gets dull.

All of my assembly screws are Torx drive (with the exception of the pivot and clip) which I find to be perfect for knife work. (Fig. 20) I started with spline drives but found that the Torx drivers are stronger and better made. Hex drives on an 0-80 screw are just not solid enough and

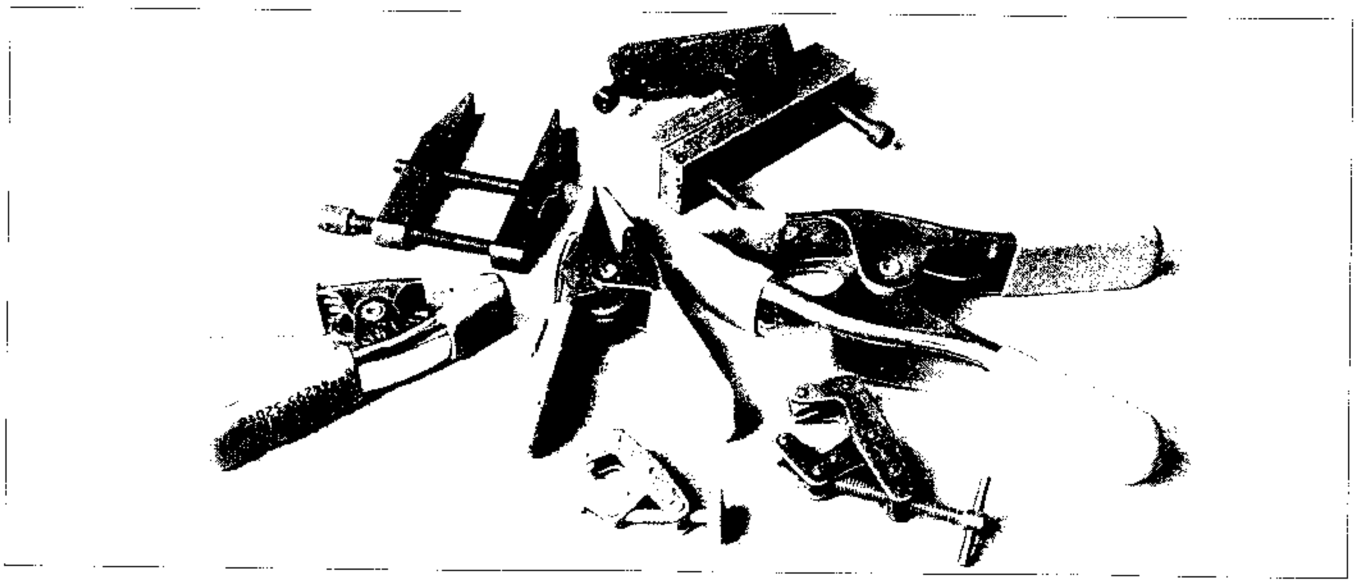


Fig. 23: Clamps and more clamps. They are indispensable in any shop.

are easily stripped. My hat is off to Mr. Torx for his invention!

On my workbench I have a large block of wood which I have milled out to hold my most frequently used small tools such as scriber, punches, thickness gage, try pins etc. (Fig. 21)

On this block of wood sits a 6-inch by 6-inch granite surface plate and it is on this base and plate that I do most of my work. Also within reach (so I can avoid exercise by not having to take an extra step) are the hand tools that I most frequently use such as Torx drivers, hammers, calipers, pliers, etc. (Fig. 22) I don't use up valuable workbench space by hanging patterns or knives in progress. They have their own, separate wall. Blade blanks, already heat treated, are hung in batches so I can readily tell when I am running low on a particular pattern.

One of the most important aspects of any craft is holding the work while you manipulate or cut it, and knife making is no exception. I use a wide variety of clamps such as spring-type pony clamps, wood Jorgensen-type parallel clamps and, of course, several vises. (Fig. 23) One of the most useful is a vise I made by taking a Wilton tilting-post base and attaching a modified parallel wood clamp to it. It revolves and swivels while holding the work quite securely. This is also described in Chapter 9.

I have two Scotchbrite wheel setups: One high-speed and one medium-speed. I find they are great for fast deburring and polishing small parts. I use the fine, gray deburring wheels from 3M.

MATERIALS

Today's knife maker is presented with a bewildering array of materials with which to craft his knives. We cannot possibly discuss all of them here, but suffice it to say that they range from the ultra hi-tech (titanium, G-10 and carbon fiber) to the ancient (mokume and Damascus). Keep in mind that materials, like anything else, come and go. Brass and nickel silver were once very common for guards and bolsters but are far less common today. In the early days of this American renaissance of hand-crafted knives, Damascus blades were very rare but have now become a staple of high-end, quality art knives as well as lower-priced utility knives. Listed below, by category, are some of the materials available today from which to make your tactical folder. (see SOURCES at the end of this book).

BLADE MATERIALS

ATS-34

This is a stainless tool steel which, for all practical purposes, is the Japanese equivalent of Crucible's 154-CM which Bob Loveless first started using during the 1970s. It was originally developed for the turbine blades on jet engines and has several characteristics which make it well suited for knife blades. It is virtually (though not completely) stainless, it is abrasion-resistant (for edge holding) and it is tough (resists breaking). ATS-34 requires specialized heat treating, best done in a controlled atmosphere. It also requires cryogenic quenching which imparts toughness and a few extra points of hardness to the blade. This is probably the most common steel in use today for handmade knives because it works so well. It has also gained favor in factory knives since its industry debut on the Spyderco C-15.

D-2

Less commonly used today in folders, D-2 is a die-making steel which has remarkable toughness and abrasion-resistance but, alas, is only classified as "stain-resistant," not "stainless" since it only has about 11 percent chromium in it. It is harder to grind than some other steels and wears out abrasive belts a lot faster. But that is the reason why it holds an edge so long, even in rugged use. I suggest not sandblasting this steel but rather polishing it to a fine hand -rubbed surface which will help it reject moisture and, therefore, staining.

440-C

This steel was the most common steel in knife making until ATS-34 came along. It is very stainless and relatively easy to grind but does not hold an edge quite as well as some of the other tool steels. It is still very common and overall it is an excellent material for blades, particularly some high-priced collector pieces which will see little use but must remain pristine over time.

CPM-440V / 420V/ BG-42 / Talonite / Other Powder Metallurgy Steels

Currently considered by some to be "the ultimate blade steels," Crucible Powder Metalurgy-440V and others are not easy to obtain in small quantities and are currently somewhat expensive. But they show extraordinary qualities which are dear to the knife maker, including stain-resistance, toughness and abrasion-resistance. They are harder to grind (similar to D-2) and hard to finish and the end user will find them more difficult to sharpen.

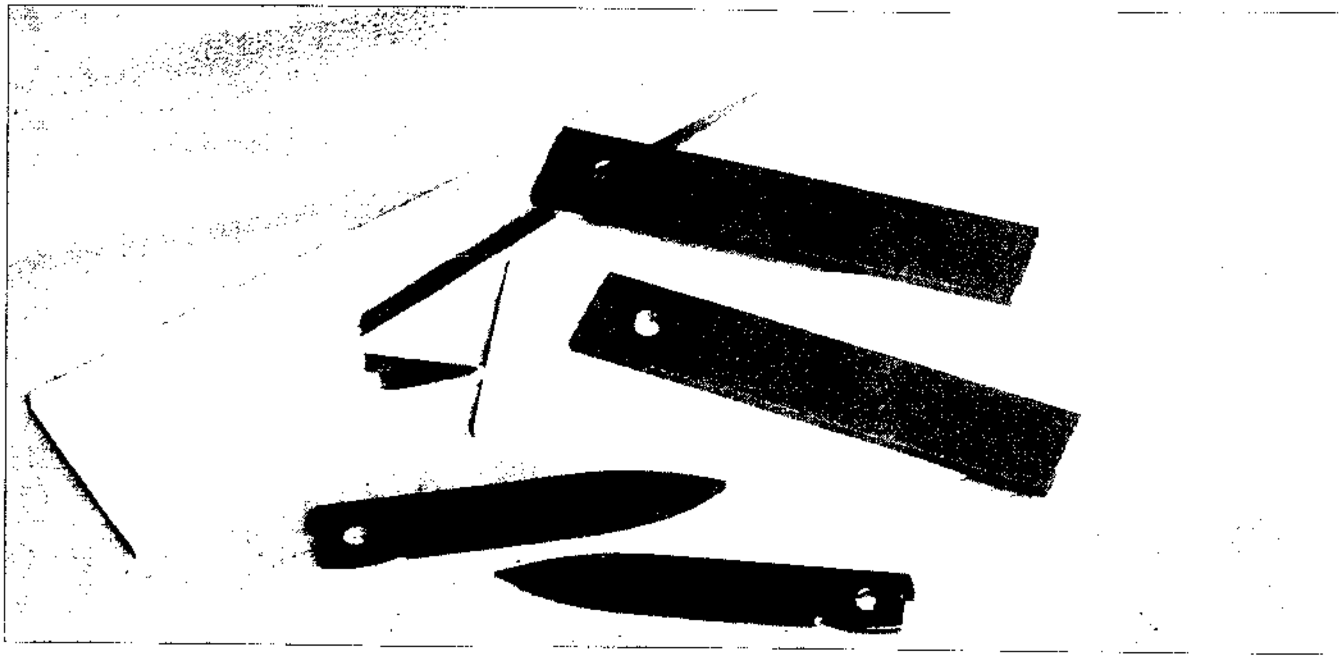


Fig. 24: Ceramic blade material. Not often used in the custom field but I think it has a future in knife making.

My own experience with these steels indicates that they tend to have coarse surfaces when they come from the mill so you may need to buy the material in oversized thickness and mill or grind off the factory surface. As of now, I am not sure that the bendfits of these steels out weigh their disadvantages.

A-2, W-2

These are tool steels which are also used in knife making today but have varying degrees of stain resistance. They hold their edges well, but are not very common in today's market.

Stellite

An interesting material for knife blades since it has no iron in it, therefore it is not, technically, a steel. Stellite is a cast super-alloy of cobalt with some chromium, tungsten and molybdenum thrown in for good measure. It is very difficult to cut and grind but it is totally stainless and holds an edge forever (not really, but close). It can be bent so a cutting edge can be turned, even against bone. Some intrepid knife makers do use stellite but it is rare because it is so hard to work. This stuff is not for the faint of heart!

Fig. 25: Damascus steel comes in a wide variety of patterns for blades and bolsters.

Ceramic

The current thinking on ceramic is that it is breakable and not easy for the user to sharpen. I make ceramic blades from time to time but it requires lapidary equipment, diamond tools and a fundamental knowledge of stone working. It is very hard and will hold an edge indefinitely but is not as tough as any of the steels, although the material I use, YTZAP (Yttrium Titanium Zirconia Alumina Polycrystaline) is far more flexible than one would commonly think. I believe there is a future for ceramic knife blades but probably not in the hand made market and not just yet. (Fig. 24)

Damascus

More properly named pattern-welded steel, Damascus is generally a hand made product, crafted by hammer forging different kinds of steel together and then repeatedly drawing out the bar and folding it over onto itself until a myriad of thin layers result. Modern technology is also producing some very interesting patterns using the particle or powder metallurgy process. Damascus may be patterned or made into mosaics in a truly bewildering variety of effects. (Fig. 25) After finishing to a finely rubbed surface, the steel is then etched, usually in ferric chloride, to differentiate the layers and display the built-in pattern. Damascus is usually pretty easy to grind and polish, not difficult to heat treat or etch and, in my opinion, is well worth the trouble and added expense to produce a dramatic and very usable or collectible knife. (See Chapter 8)

Wootz

Wootz steel, not very common today, is technically not a Damascus steel as we use the term because it is not pattern-welded. The pattern, later brought out by the etching process, is partially created in the crucible, and partially in the forging and heat treating. Ironically, wootz was the original steel of the Damascus region rather than pattern-welded steel.

FRAME MATERIALS

Folding knife handles or frames are generally made out of sheet metal for strength although some of the more hi-tech materials such as G-10, carbon fiber, etc. are well suited to a light-weight knife, particularly if the lock up is of the linerlock type with an inlaid spring or metal liner added. The imagination and creativity of knife makers tend to blur the line between frame materials and scale materials so for the sake of clarity, we will explore in this section only the metals used for frames and liners and visit the other materials below in the HANDLES and SCALES section.

Stainless Steels

There is a wide variety of stainless steels readily available in sheet form from which to make folding knives. The 300-series steels (303, 304, 310) are the most common and serve well, especially in the "half- or full-hard" state. These are not heat-treatable steels but are hardened in the rolling process and left without being annealed. These steels are the most corrosion-resistant of the stainless family, but tend to be "gummy" and generally do not machine easily unless they are alloyed with sulfur and so designated with an "s" after the number, such as 303s. I don't recommend 300-series steels for linerlocks as they tend to become slick on the lock face over time. The exception to this is when the liner's lock face is laser cut, which leaves a hardened edge where the lock meets the blade.

The 400-series stainless steels (410, 416, 440 A, B, C) are very popular as frame materials because they are stainless and very easy to machine, far more so than 303 or 304. They must be heat treated (usually to about Rc 46 or harder) in order to activate their stainless quality and to provide a sufficient degree of rigidity to the part. Type 416 steel is also a favorite for making small fittings such as stop pins, pivots, thumb studs etc.

Titanium

This is currently a very popular material from which to fabricate frames and springs for linerlock, tactical folders. It resists corrosion from just about anything you can throw at it, is lightweight and very strong and tough. Titanium, in the most common alloy of 6al4v (6%aluminum + 4%vanadium), has a phenomenal strength-to-weight ratio, exceeding those of steel or aluminum. It is a bear to work and does not take kindly to being cut, drilled or ground. Its sparks are fierce and emit dangerous UV light. its fumes are toxic, it quickly dulls cutting edges on tools and instantly kills grinding belts but, I believe, the final product is worth the extra work, expense and frustration. Titanium is available in a wide variety of sizes and thicknesses from several suppliers, some of whom are noted in the SOURCES section of this book.

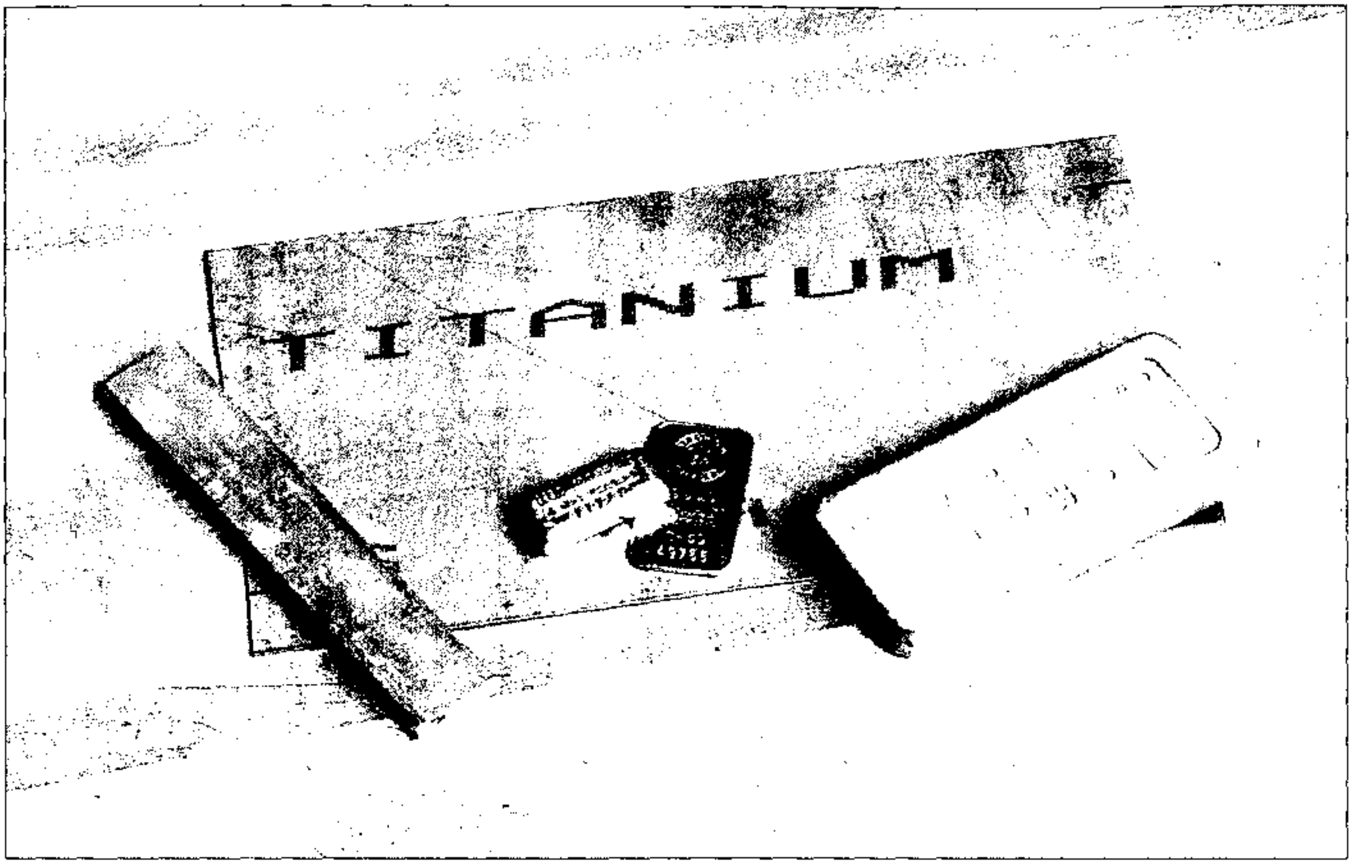


Fig. 26: Some of the metals I use for folder frames.

Titanium has the unique property of creating, under special conditions of chemistry and electricity, oxides which reflect color to the eye by a phenomena called interference refraction. This process, known as anodizing, was most beautifully and artistically exploited by Patricia Walker with her exquisite, multi-colored engravings on titanium knife frames. She pioneered the engraving of titanium and developed anodized color variations through surface texturing.

If you plan to use titanium, keep your cutting tools dead sharp. Use low speeds and slow feeds with a grease lubricant for drilling, reaming and milling. Use bi-metal blades on the band saw as they will last the longest. I use ceramic belts and find they work well but will still wear out quickly. Silicon carbide belts are probably better but seem to be hard to find in the coarser grits. Wet grinding with a sponge contacting the belt helps a lot. I prefer not to exhaust the dust into my vacuum system since a build up of titanium dust can be ignited by the intense sparks generated by grinding and can be nearly impossible to extinguish. I suspend a bucket of water below the spark stream instead of sending it through the exhaust ducts.

Aluminum

Aluminum is rarely used in the hand made genre of folder knives but it can be a good, serviceable material especially for the beginner or for building prototypes. It is relatively soft, lightweight, cheap and readily available everywhere.

Gold, Silver

I make quite a few knives out of gold and silver and find them to be excellent materials for small, higher priced, collectible folders. There is not much to be said about working them except to use very sharp cutting tools and keep your machines and workbench very clean so that the scrap can be retrieved and re-cycled. Both are "gummy" in their pure forms but many of their alloys are a pleasure to work with.

Mokume

This is a truly beautiful and exotic metal made from layers of non-ferrous materials, usually copper, brass and nickel silver. It is widely used for

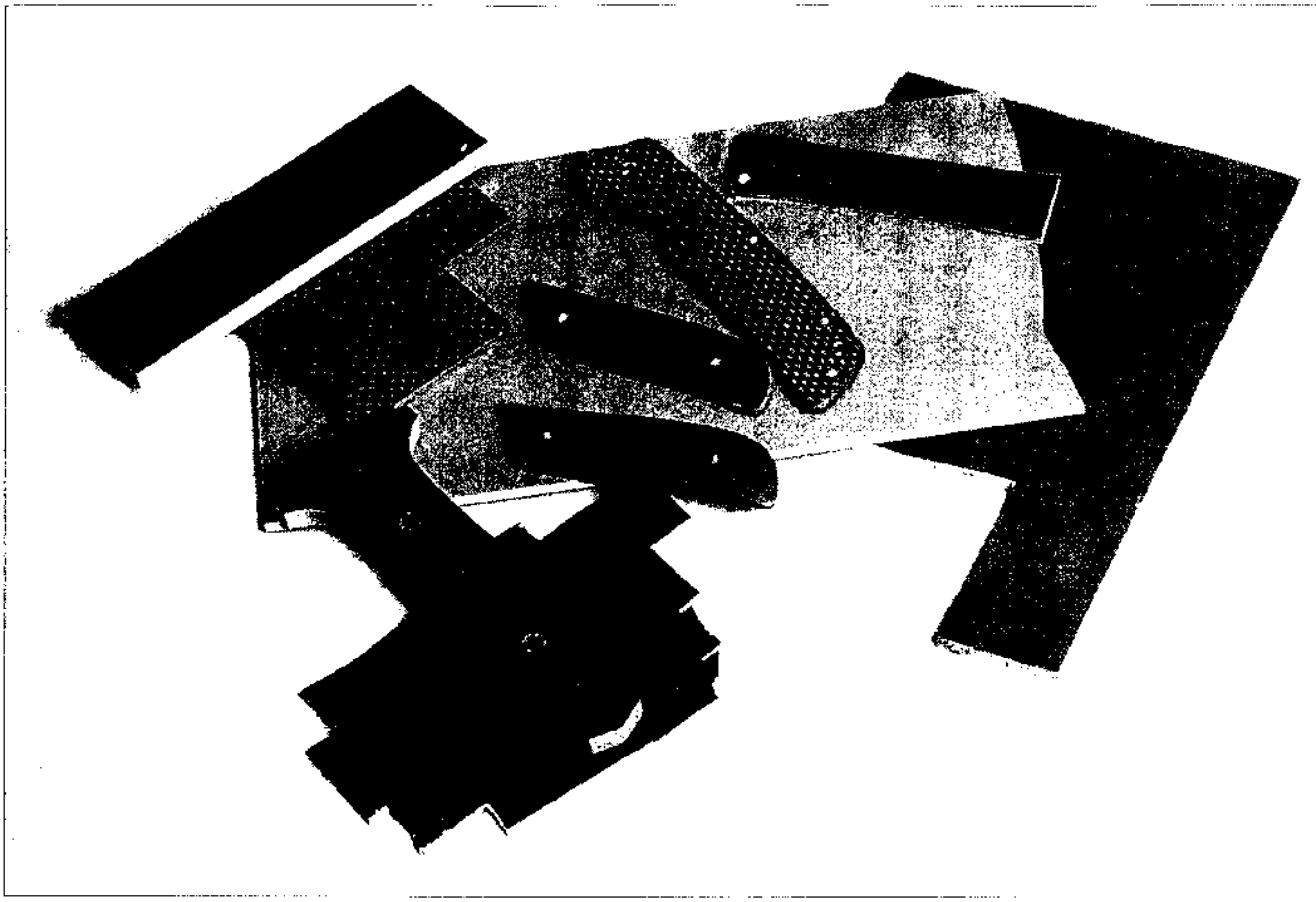


Fig. 27: Laminates such as Micarta, G-10 and carbon fiber are common in custom knife making.

bolsters but also makes excellent frames for smaller knives. Mokume is described in greater detail in Chapter 8.

HANDLE and SCALE MATERIALS

Micarta, G10 and Carbon Fiber

These all fall into the category of laminates. They are formed by compressing sheets of cloth or paper with a bonding agent and then curing them into a solid plate of very strong, lightweight material. The difference is in the type of materials and bonding agents used in the laminating process.

Micarta

There are four basic types of Micarta: paper, linen, canvas and rag. The most common forms used in knife making are the first three while the rag Micarta, made of random fragments of varied colored cloth scrap is sometimes used for a "camouflage" effect. The bonding agent used in Micarta is a phenolic resin and its dust can be toxic over time so breathing protection is recommended when cutting or grinding. The paper or cloth laminates come in a variety of colors and are quite strong and resistant to damage. The paper will give a more uniform finish and the white variety is often used as an ivory alternative. Linen and canvas Micarta are strongest and when ground and finished on the bias or in curved surfaces give an attractive wood-grain effect. Micartas are easily cut, drilled, sanded and polished but also lend themselves well to a matte, sandblasted finish.

G10

The difference between Micarta and G10 is that the latter is made from sheets of fiberglass cloth and the bonding agent is an epoxy resin. This makes G10 much stronger but a bit more difficult to work in that the glass tends to wear out cutting edges very quickly. Carbide tools are recommended. Breathing protection is mandatory with G10 because of the tiny glass fibers that are released during the cutting and sanding processes.

I recommend wet grinding and sanding of the material to eliminate dust and thereby itchy skin and serious lung problems.

The Advanced Technology Combat Folder (ATCF) was the first folding knife to use G10 as a handle material and I soon found that it was favored even over titanium by professionals because of its black, subdued color, its positive grip and its lighter weight (30% lighter than titanium) without compromising the knife's strength or rigidity.

Carbon Fiber

Sheets of carbon fiber cloth make this the strongest and most rigid of the laminates. Epoxy resin is the bonding agent, as in G10. This is the most difficult to work of the laminate family not because it is hard to cut but because it literally obliterates the cutting edges of tools instantly. Carbide cutting instruments work better but are still dulled very quickly, so be prepared to sharpen often and keep a good supply of cheap, fine-toothed band saw blades on hand. No reason to use the more expensive bi metal blades on carbon fiber because it is not a particularly hard material. Once again, breathing protection is required and, like G10, I prefer to wet grind and sand all my carbon fiber. I like a fine satin finish to the material, but some knife makers like a high polish. With both finishes, the material displays an attractive cross-hatch effect which changes as the piece is moved in the light, a phenomenon known as chatoyance which is also seen in certain gemstones such as tiger eye and star sapphire. I have worked with carbon fiber mixed with Kevlar but for the life of me I don't know why since it is terrible to work, frays easily and requires a truly masochistic streak to even contemplate.

Wood

There is a vast variety of beautiful hardwoods on the market today and all have their own unique

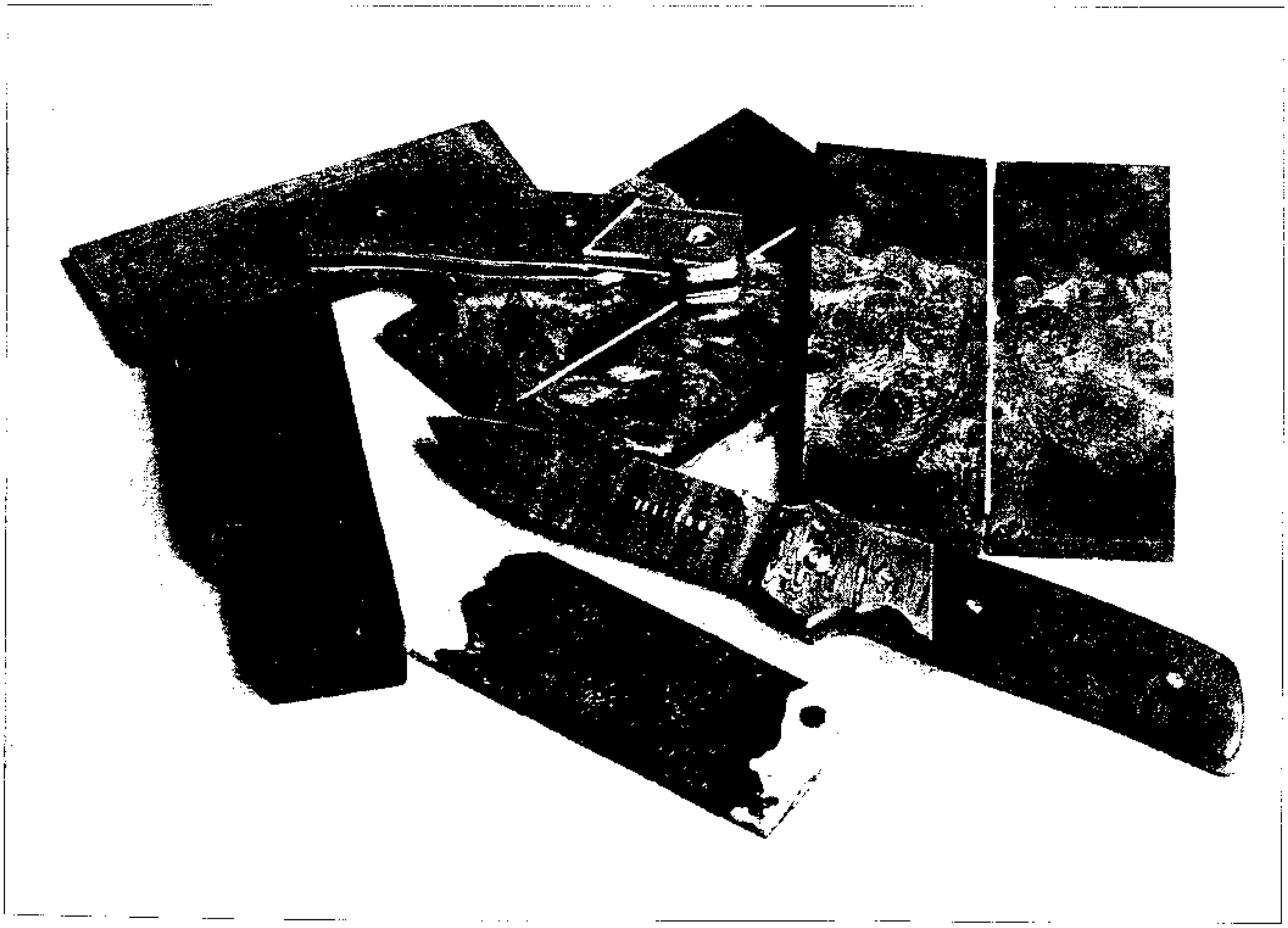


Fig. 28: A selection of woods which really help to dress up a knife.

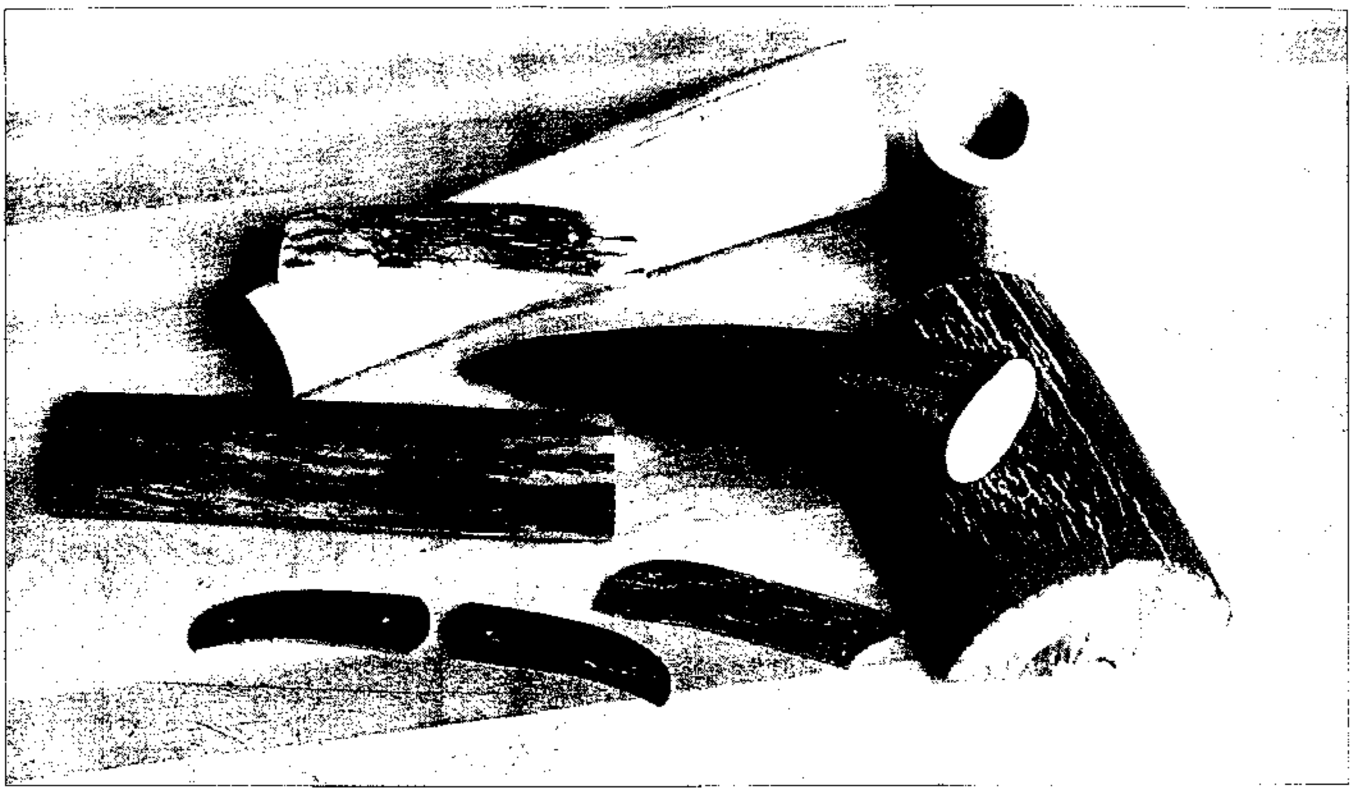


Fig. 29: Ivory such as mastodon, elephant and walrus can be expensive but well worth the expense for that "special" knife.

signature to them. In my opinion, nothing beats the warm lustrous feel of well finished wood on a knife handle. My favorites are desert ironwood, cocobola, ebony, rosewood and ziracote. I hand rub the wood to about an 800-grit finish and then soak it in Watco Danish oil finish for protection against shrinkage.

Ivory

This category comprises ivory of elephant, mastodon (mammoth) and walrus. All are beautiful and expensive, particularly the mastodon which comes with an aged, outer skin in a wide variety of textures and colors. The most highly prized is the blue color which is imparted to the ivory over the eons by a chemical compound called Vivianite. I prefer, when possible, to leave the natural texture of the ivory bark on the piece that may show scars and imperfections which, I believe, record the animal's life struggles more than 25,000 years ago. There is, to my mind a certain romance of survival and combat written in these scars which I think should be preserved.

Ivory has a nasty habit of shifting with changes in humidity and this is one of the prices we pay for using such a special and beautiful material. It can be somewhat stabilized by soaking it in mineral oil in a low-heat electric frying pan for a day or so but this does not completely eliminate the problem. I use only a bare minimum of grinding on my ivory, preferring instead to mill the back of the slab flat. If you must grind, use a new, sharp belt with a minimum of pressure as the heat generated will draw out the cellular water and warp the piece in a few hours. After grinding the back of the piece, let it sit for a day or two and then hand sand it on coarse abrasive paper on a sheet of glass to be sure it is flat. Cracks and checks can be filled with super glue and the ivory can be polished with normal buffing materials.

Pearl

Many knife makers use pearl scales and the results are often stunningly beautiful. Pearl (mother-of-pearl) comes in several colors including white, black lip and gold lip. It requires very sharp tools and a delicate touch as it flakes and chips easily, particularly on the edges of drilled holes. To minimize flaking, drill with the pearl supported on a flat, hard surface such as micarta and drill right through both materials. Do not drill over existing holes in the micarta. I find that diamond drills work very well in pearl and minimize the flaking, especially with a few drops of water at the drill point.

Fig. 30: Horn, stag and jigged bone make very tough handles with good grip and are also beautiful.

but standard drills work well if they are sharp. Pearl does not take kindly to heat so wet working it, when possible, is always a good idea. It can be carved or fluted with steel or carbide tools, but again, I find that diamond tools work the best.

Bone

Jigged bone comes from the shin bone of cows and is jigged or textured in several patterns. Jigged bone is dyed in a number of colors including red, green, brown and burgundy. It is cheap, easy to work, very forgiving, not easily affected by humidity, easily polished and provides a tough, attractive handle. But it really stinks when ground or cut so just plan on leaving a window open.

Horn

Another smelly material when cut, horn, particularly sheep horn, is a very attractive handle material which is often left in a near natural state by many knife makers to show off the patterns and convolutions of the original surface. like ivory, it should be worked with care to avoid heat build-up. It can be polished with standard equipment and provides a beautiful, unique knife handle.

Stag / Elk

These were probably the original knife handles used by Paleolithic craftsmen for their flint and chert blades. Stag is common and very popular. Elk less so because its spongy core is much bigger, leaving a thinner outer layer with which to work. The natural texture of stag provides a superior grip and its warm tones of brown, tan and honey are quite pleasing to the eye. It is very tough and durable even under harsh conditions and very easy to work and polish. Like bone and horn, it also smells awful when cut.

I'm sure that there are many other materials which knife makers have used for handles including plastics, rubber and... whatever else they feel will provide the needed qualities, but those mentioned above are the most common to be found in the field today.

Chapter 3

Designing the knife

Designing a knife is a very personal endeavor. There is no accounting for taste in the assemblage of design elements that make up a knife, (or anything else for that matter).

I will defer the matter of design criteria to the reader but will describe here, for the sake of clarity, some of the elements I deemed important while designing the Advanced Technology Combat Folder (ATCF) in 1985.

First, I determined that I wanted to make a folding pocket knife using Michael Walker's Linerlock mechanism which would be suitable for a number of uses, most particularly, self defense. Second, I wanted the knife to be rugged and as strong as possible while at the same time not being heavy or cumbersome to carry. Third, I wanted the handle to provide as much finger protection as possible; have it be graceful and pleasing to the eye and hand; and to be easily accessible in an emergency. Fourth, I wanted it to be completely usable with only one hand, unlike many of the popular folders of the day which required two hands to unlock and close the blade.

Because of two design elements stated above, light weight and ruggedness, I chose titanium as the handle and spring material. Titanium was virtually unknown in the knife making realm at the time (with very few exceptions). It possesses some unique physical characteristics and also some interesting problems in its fabrication. I decided that it was worth the learning curve time to be able to use titanium for what, I hoped would be, a groundbreaking knife. Time has borne out the validity of this decision as most custom tactical knives today use titanium in their handles and springs.

The steel I chose for the blade was my favorite, D-2. I had made a lot of fixed blades with this steel and felt it would serve me well in the folders. I was wrong. While I still believe that D-2 is one of the best blade steels, I soon learned that folders are not treated by their owners in the same way that fixed blades are. For instance, when opening a one-handed folder, the user's thumb invariably touches the blade leaving fingerprints. D-2 is stain-resistant but not stainless and many blades were returned for refinishing from corrosion problems especially if the user had cut fruit, gone fishing in the surf or was just plain sweating a lot through his jeans on a hot day. So, for my sanity and to be able to make more knives in my shop and not just refinish old ones, I changed the blade steel to ATS-34 after consulting with Bob Loveless and making several knives for his personal use out of the steel. It was a metal I had used from time to time and was well pleased with it. I consider it one of the best all-around steels for blade use and, for all practical purposes, it was pretty stainless as well.

Give careful thought and study to the materials you will use in your knife, several possibilities are discussed in Chapter 2. I would suggest the following procedure for designing your knife, pretty

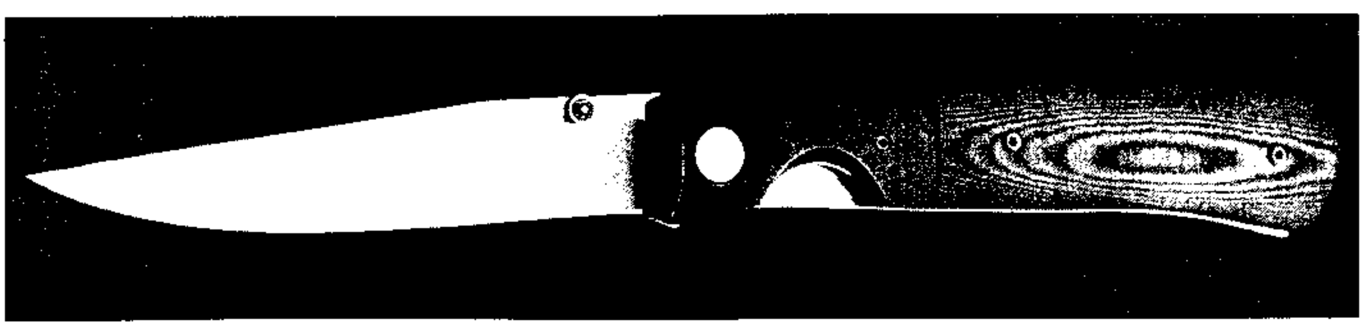


Fig. 31: The first tactical linerlock by Michael Walker of Taos, NM. Stephen Bradley photo.

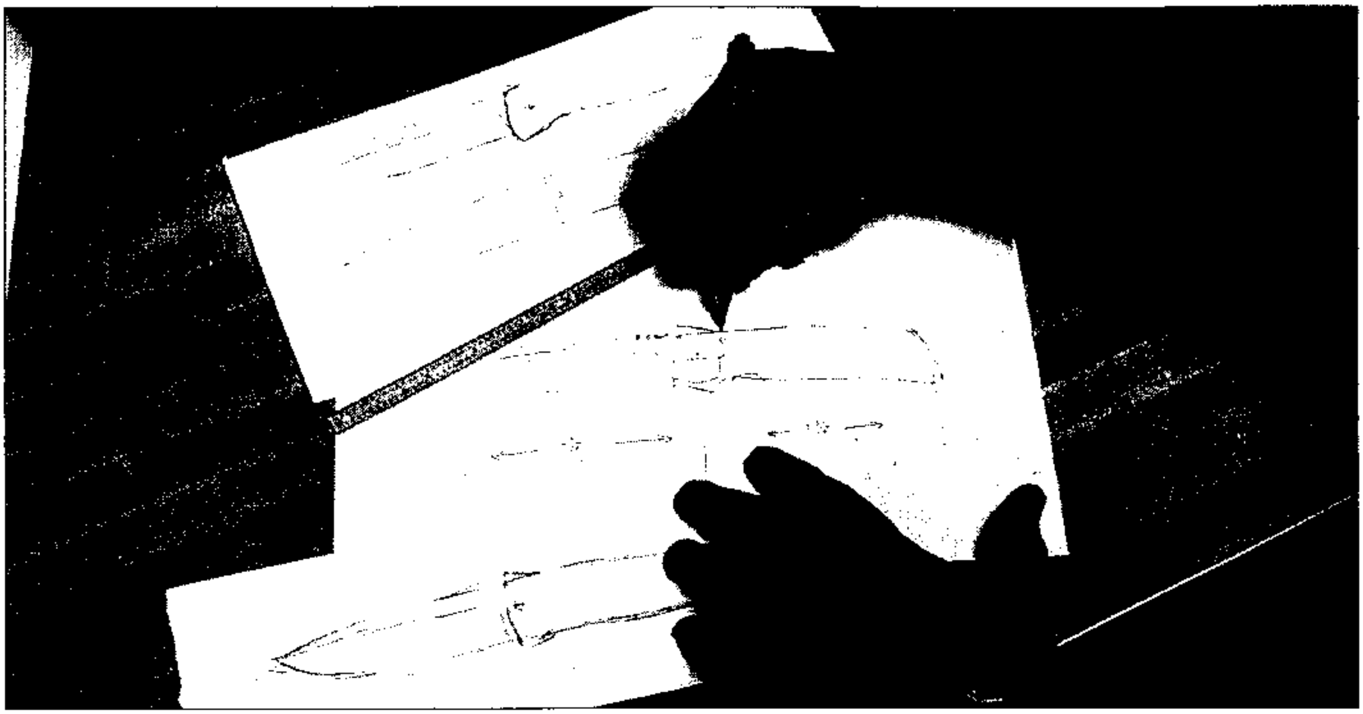


Fig. 32: Sketch free-hand a variety of profiles that represent your ideas for the knife.

much in the order stated below. While this is the procedure I use for designing a linerlock I made, it works well for other types of locks as well.

1. Having determined the best materials to use for your knife, the first step is to design the knife's actual profile and dimensions. Start with blank paper and free-hand sketches. (Fig. 32) Sketch several blade shapes and try to fit handles to them on paper. Rely on eyeball dimensioning at this point and don't try to be too precise about sizing.

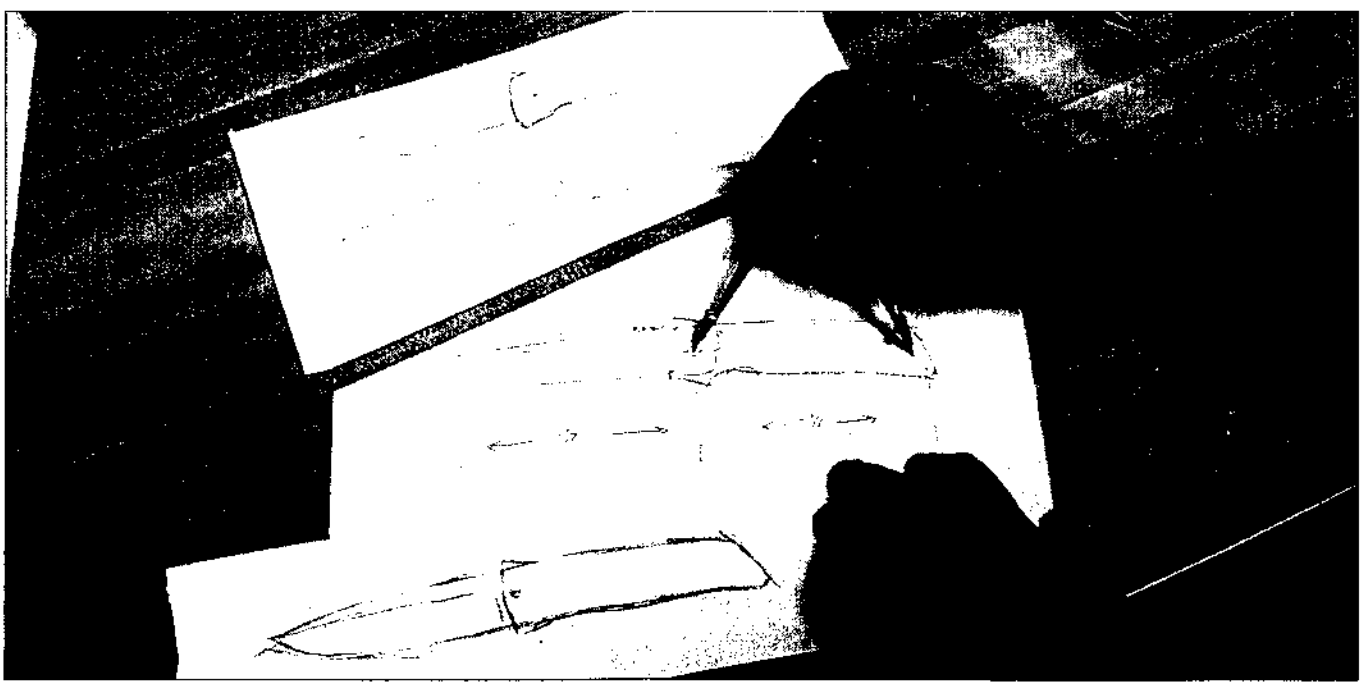


Fig. 33: Measure from the pivot center to the back of the handle to ensure that the blade will not be too long.

Here, you are only trying to develop a pleasing shape and overall identity to the knife. The one exception to this is the blade-to-handle ratio. Measure the blade length on the paper and make sure that it will fit into the handle. Over the years, I have received many sketches from customers who have wanted me to build their own special designs and often I have had to inform them that I could build the blade or build the handle but not put the two together and have the knife look like their drawing because they had drawn the blade too long. To deal with this problem while composing your own drawings, place the pivot point on the handle, about where you think it should be. (I place my pivots on the centerline of the major part of the handle and the same distance, half the handle width, in from the front edge). This will eventually be a vital point on the knife, because many measurements will originate from the pivot.

Measure from the pivot to the point of the blade (or to the end of the handle if you start with that first) and measure the same distance back

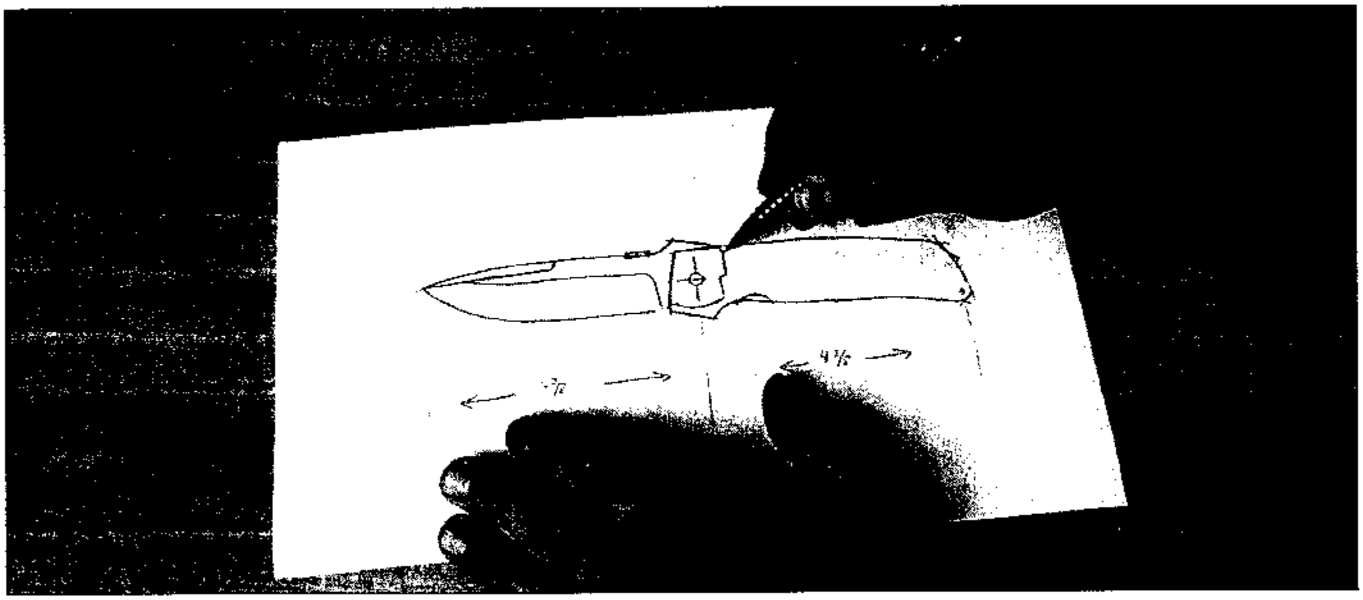


Fig. 34: Sketch in the blade tang area so your drawing looks like an X-ray. See chapter 4 for details on designing the tang.

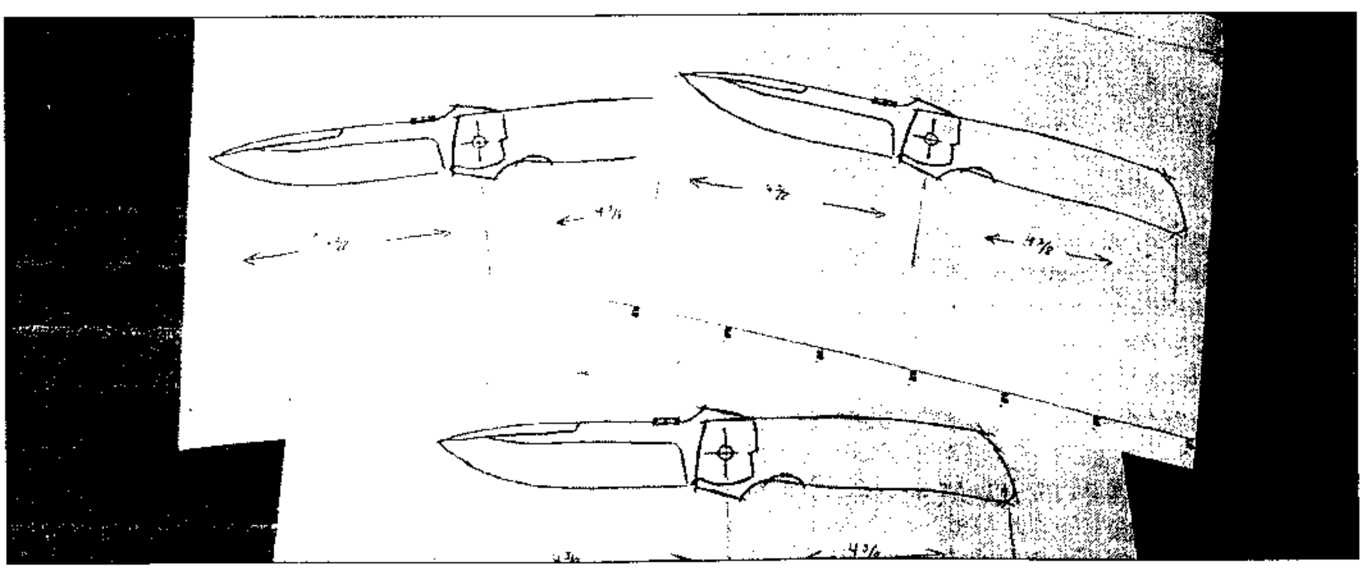


Fig. 35: Make two photocopies of the completed drawing so that you won't have to cut up your original.

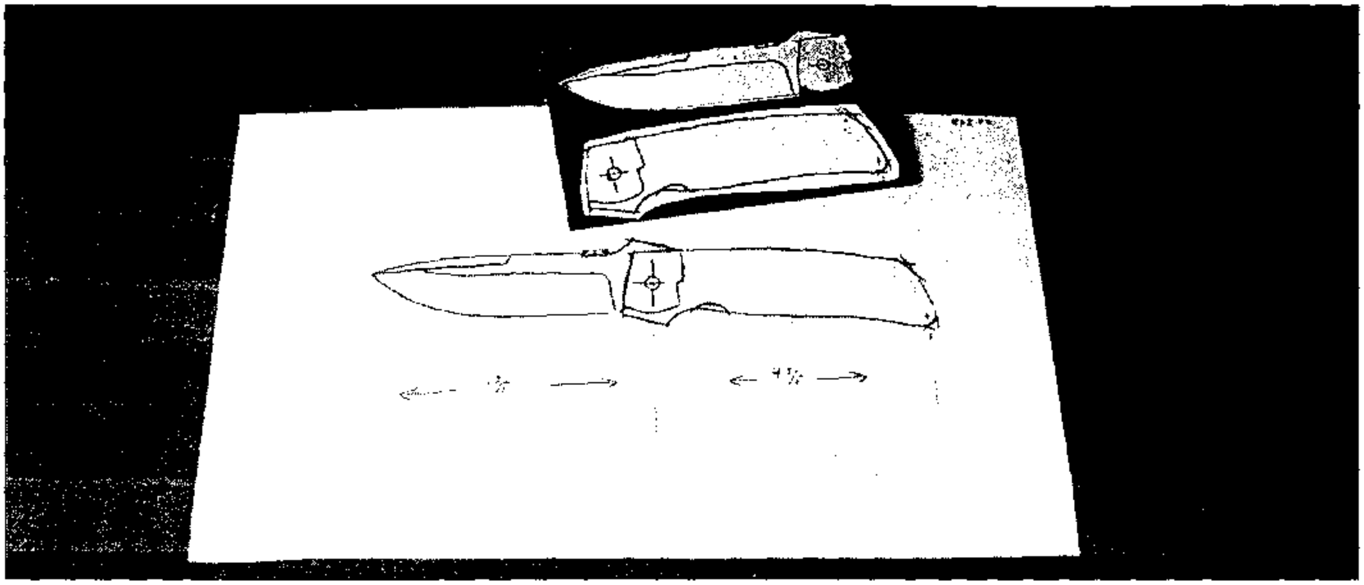


Fig. 36: Complete blade and handle profiles are glued to a piece of Kydex. Aluminum or other stiff, scrap material may be used.

from the pivot for the handle length (Fig. 33) (or forward from the pivot if the handle came first). Blade length needs to be a little shorter than the handle so that when closed, the blade will nest in the handle and its point will be shrouded, thereby protecting the user during closed carry. Handle length, therefore will be dictated by blade length (or vice-versa if you start with the handle first). I have found over the years that a handle of 4 to 4-1/2 inches will nicely fill most human hands.

A handle length less than 3 inches is fine for a more delicate knife which is not intended for heavy use. A handle of more than 5 inches in length tends to be a bit cumbersome unless one is building a heavy camp knife designed for chopping and rugged duty. The blade, of course, can be of any length provided it fits within the handle. But I always try to get the maximum blade for the handle size.

2. At this point, grind lines, false edge, etc. are sketched in. Design elements may be added such as finger guards on the blade and handle, refinements to the profile and approximate location of the lanyard hole, if any.

3. Sketch in the tang section of the blade so your drawing looks like an x-ray of the finished knife. (Fig. 34) This part of the blade is critical to the proper functioning of the knife and should be done with care. See Chapter 4: Linerlock Geometry for details on designing the lock area of the blade and proper placement of the stop pin and spring.

Fig. 37: Pivot holes are drilled out and a try pin inserted through both parts so the blade can swing freely.

4. When the sketch looks pretty much like you had in mind, it's time to transfer it from a two-dimensional representation to a three-dimensional object. For my test pattern, I like to use Kydex. It's cheap, easy to cut and therefore fast and simple to modify if the "feel " is not just right.

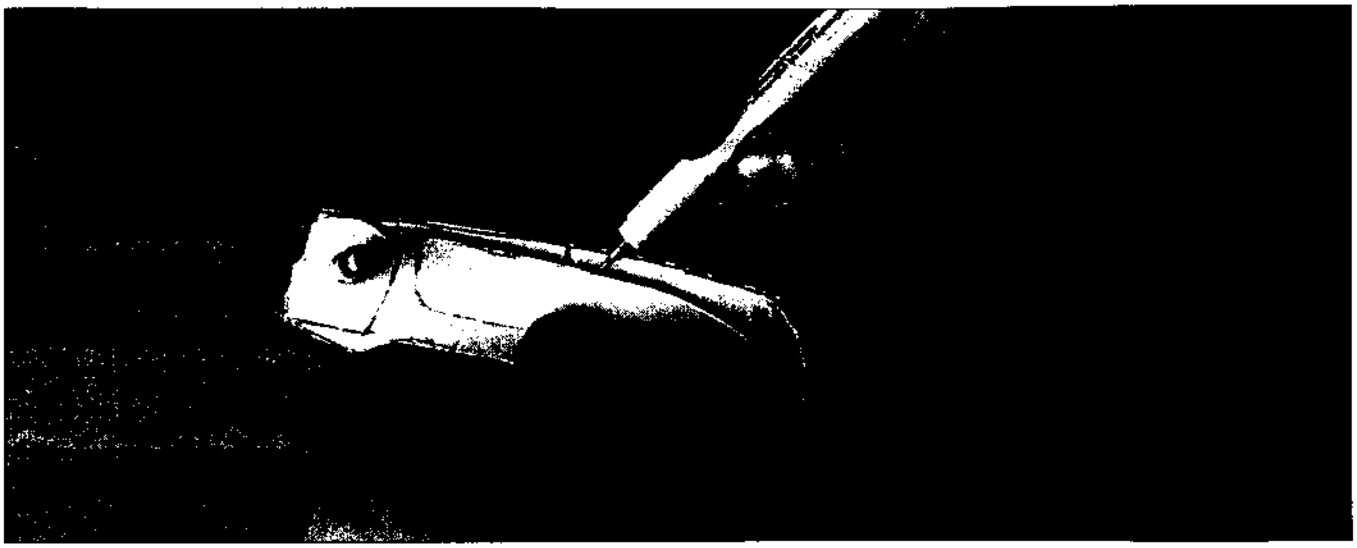


Fig. 38: Trace the blade profile on the handle pattern to describe where the spacer will go. Leave about .050 inches clearance between the cutting edge of the blade and the spacer.

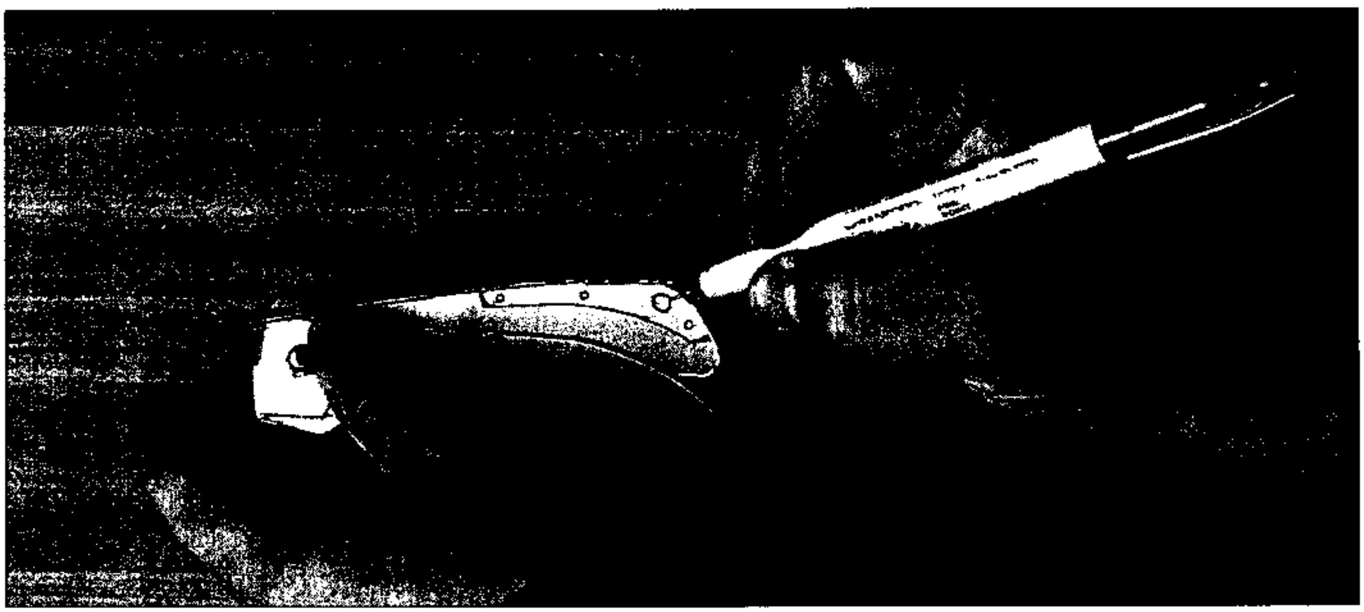


Fig. 39: The screw holes are located within the spacer outline.

5. Make a couple of photocopies so you will not have to cut up your original drawings. (Fig. 35) With a pair of scissors, cut out the complete blade section from one of the photocopies, and the complete handle section from the other. Spray the back of each with spray glue and affix them to a piece of Kydex. (Fig. 36) Then, cut out the profiles on a band saw or with a shears. There is no need to be too precise at this point as the next step is to carefully grind the profiles, leaving a little extra material on the back end of the blade pattern for fine tuning the blade in the open and closed positions against the stop pin.

You now have two pieces of Kydex in the rough shape of your handle and blade with your drawings still glued to them showing the location of the all-important pivot.

6. Drill out the pivot holes on both the blade pattern and the handle pattern and assemble them with a try pin. Close the blade against the handle and determine where it will sit when fully closed.

Fig. 40: Draw in the location of the stop pin on the handle pattern (See Chapter 4).

Fig. 41: Carefully remove material from the bottom of the tang until the blade sits correctly in the handle.

(Fig. 37) If the blade point is not well shrouded by the handle, modify the pattern until it is. Once the blade is properly fitted in the closed position, trace the inside edge (cutting edge) of the blade onto the handle sketch leaving about .050 inches between the blade and the spacer for clearance. (Fig. 38) This line will define where the handle spacer will reach in the handle and what shape it must be. Within the area of the handle spacer on the sketch, place the locations for the handle screws and lanyard hole. (Fig. 39) Remember to take into account the diameter of the screw heads you will use to

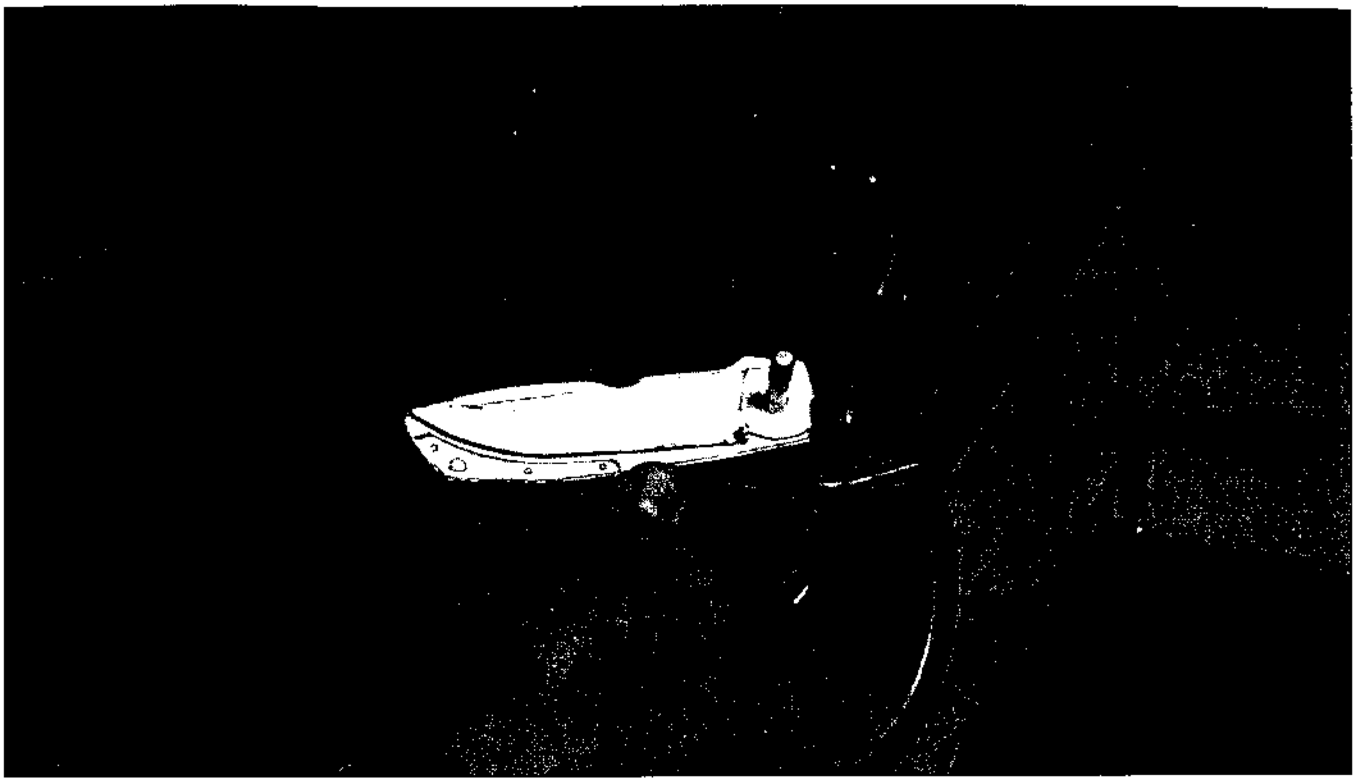


Fig. 42: Verify the placement of the blade in the handle (with the stop pin in place) to insure that the point is properly shrouded.

Fig. 43: Carefully remove material from the butt of the tang until the open blade shows the correct aspect, relative to the handle as it sits against the stop pin.

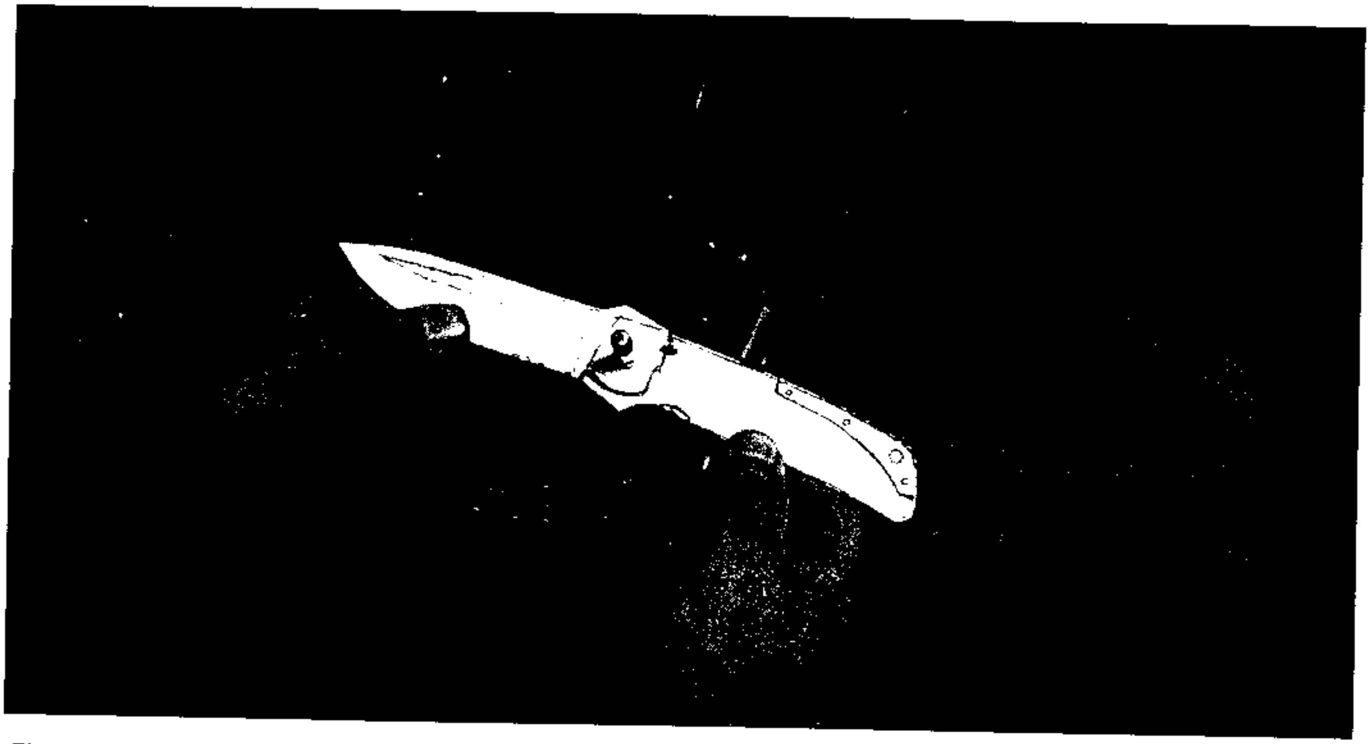


Fig. 44: Verify the aspect of the open blade against the stop pin.

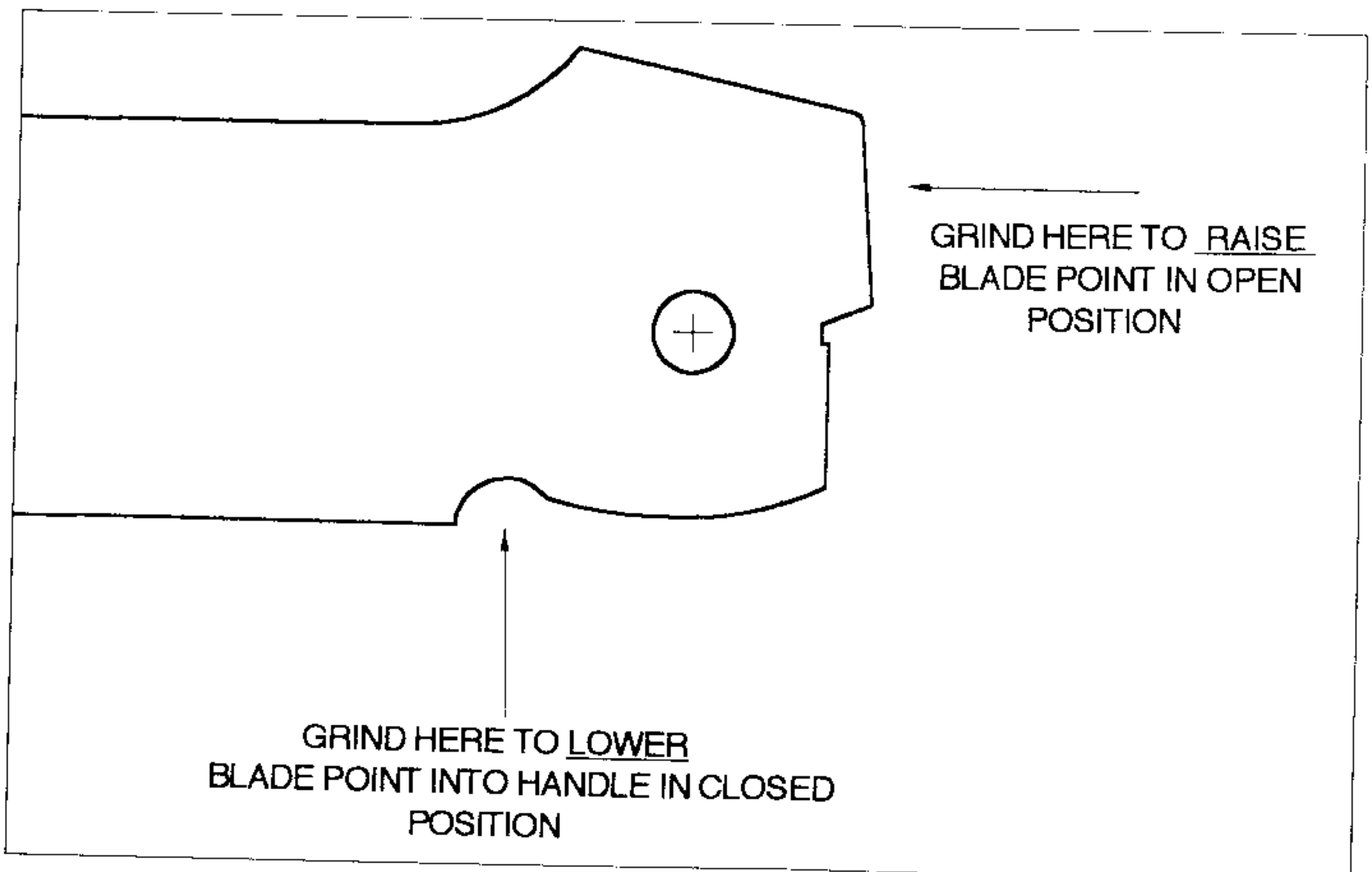


Fig. 45: This is where to remove material for fitting the blade to the handle.

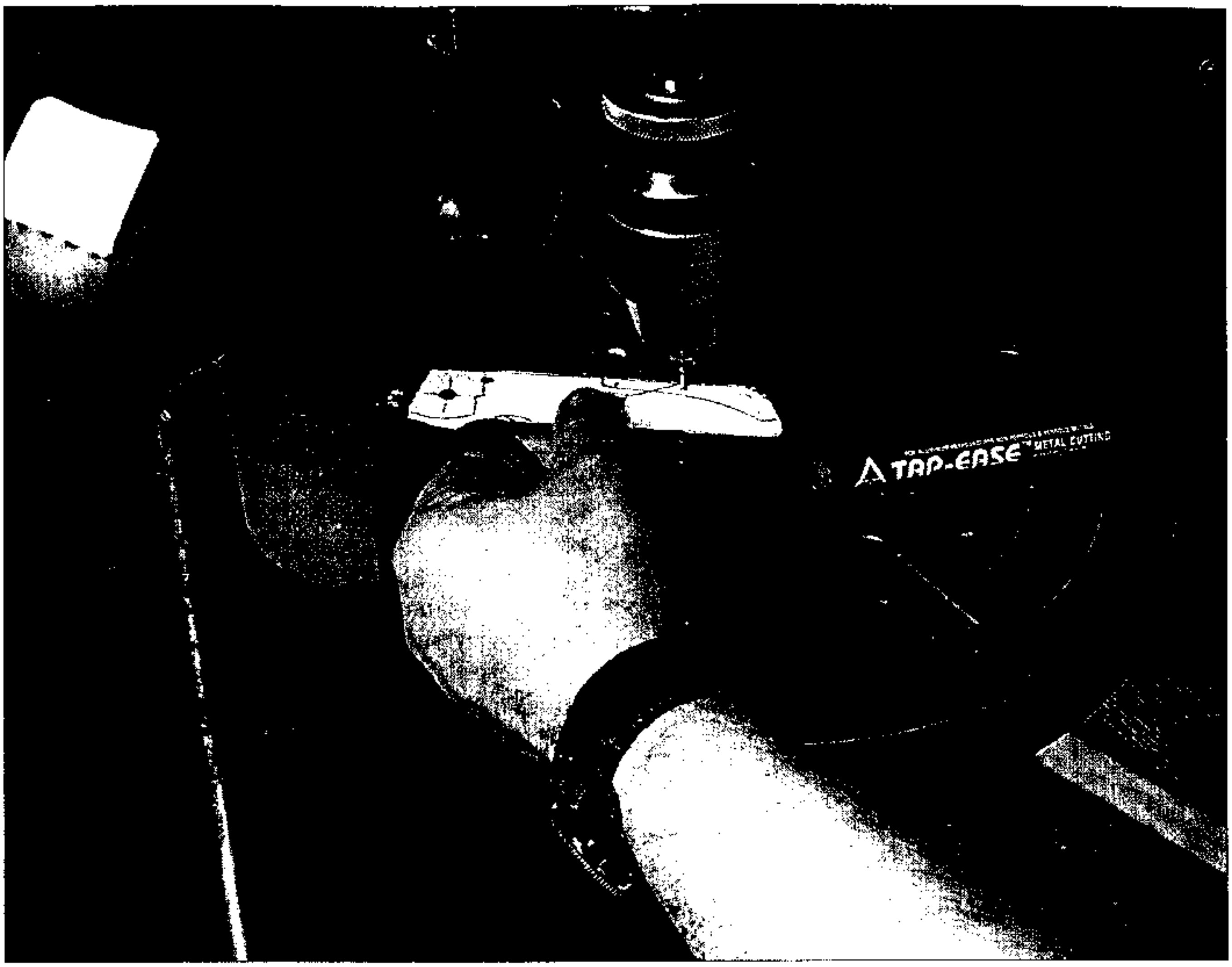


Fig. 46: Drill out the screw holes with the tap drill for the size screws you will use. On the ATCF I use 1-72 screws so the drill is a #53.

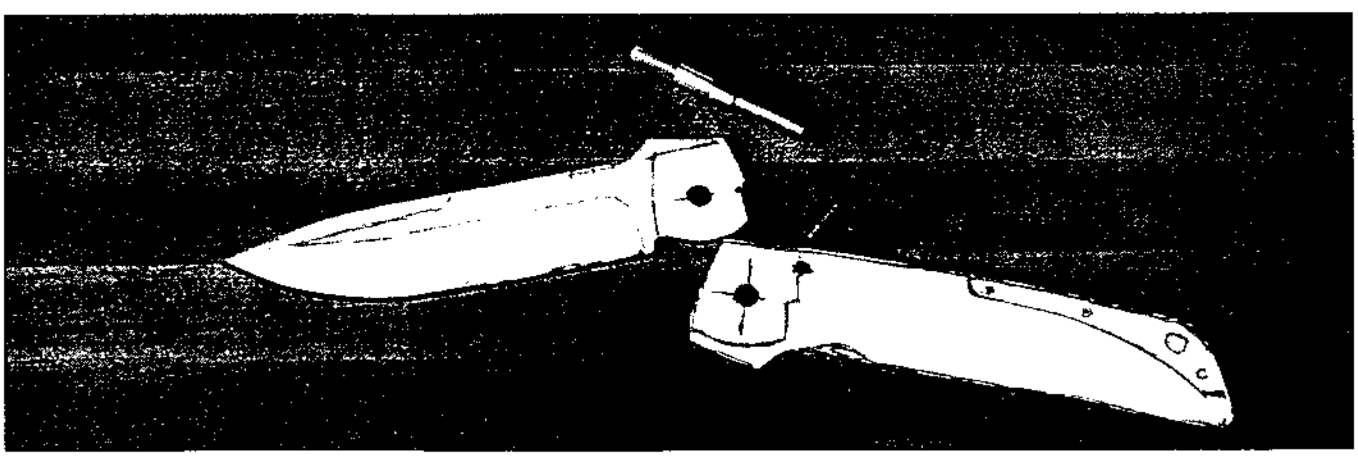


Fig. 47: Completed knife pattern with try pins.

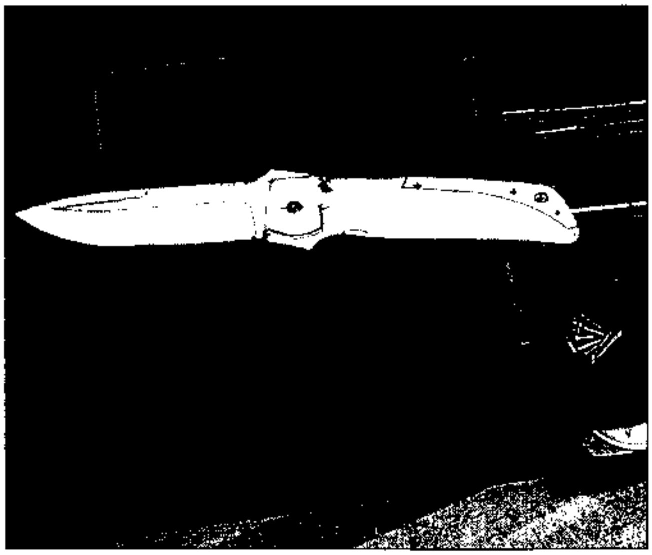


Fig. 48: The pattern assembled.

assemble the finished knife and don't place the holes too close to the edge of the handle as you will need to chamfer the finished handle and you don't want that chamfer to touch the screw holes.

7. Determine where on the handle the stop pin will be located (See Chapter 4) and drill a hole of the proper size (Fig. 40). Insert a try pin of the same size you will use for your stop pin** (see note, below) and close the blade against it. The blade will not close all the way to its proper position since a bit of extra material was left on the pattern. Carefully remove this extra material at the point where the stop pin hits the blade (Fig. 41), gradually lowering the blade to the proper closed position in the handle as determined by the line you drew for the spacer. (Fig. 42)

8. Open the blade and repeat the fitting process by removing material at the back of the blade tang where it hits the stop pin to gradually lift the blade into the proper open position as determined by your original drawing of the complete knife. (Fig. 43, 44)

The procedures described above in numbers 7 and 8 are the exact same procedures used to final fit the actual blade to the knife's handle as discussed in Chapter 6.

9. Drill out small holes for the screw and lanyard hole locations per your drawing (Fig. 46) and you now have patterns for the building of a complete knife (Fig. 47). Such patterns can also be made of sheet metal which will last longer if you are planning a long production run for this model knife. Kydex, however is sufficiently tough to last through several dozen applications.

*** For the ATCF I use a 5/32-inch diameter stop pin and step it down to 9/64 at the shoulders (Fig. 49). I drill a 9/64-inch hole in the Kydex test handle and use a pony clamp to hold it firmly in place so that the blade will not tilt the pin when pressure is applied thereby avoiding a false location of the blade when closed or open.*

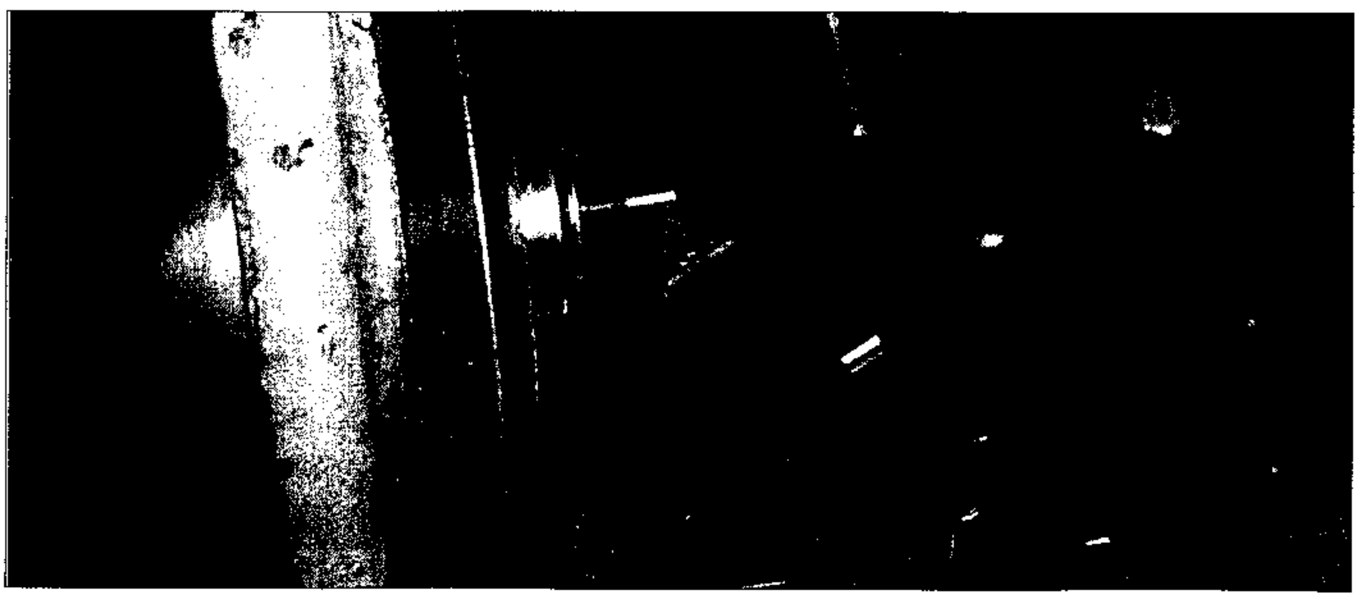


Fig. 49: Making the stop pin on the lathe. Each pin is held in place in the knife handle by machining a shoulder at each end.

Chapter 4

The geometry of the linerlock

The linerlock is a deceptively simple yet very efficient method of securing a folding blade in the open position of a knife. It has no moving parts and is very forgiving in that it does not require much precise machining or fitting of parts. The linerlock is easy to clean and works magnificently even in the most appalling conditions of dirt, mud, dust and abuse. It is, I believe, one of the strongest locking systems for a folding knife and the most trouble free for the user, particularly since it lends itself well to full operation with only one hand in both opening and closing.

Having said all that, it is important to note that for this (or any) type of lock to work properly, it must be made correctly. I believe the most common complaints about the linerlock have to do not with its basic design but with its construction by knife makers who may not be familiar with all of the elements which make up the system.

Contrary to popular myths, the linerlock as we know it today is not a simple improvement on the leaf spring safety used on the screwdriver blade of the old-fashioned electricians' knife which has been around for more than a century. Since the screwdriver blade was the only one designed to be used with forward pressure, something had to be devised to prevent that blade from closing back on the fingers. A portion of the brass liner was therefore split and bent so as to block the downward, closing motion of the blade should the back spring tension be overcome during use. The primary force, however which held the blade open was the back spring, just as on the main knife blade. This is a system known as a slip joint because there is no locking action to the blade and as a result, it can be closed with simple pressure on the spine.

The modern linerlock was invented and refined by Michael Walker in 1981 and aside from using a leaf spring, bears no resemblance to the electricians' knife. Basically what Michael did was to create a true locking system which did not need a back spring to hold the blade open. The leaf spring in the old design was nothing more than a safety device for the screwdriver blade. Michael's leaf spring actually locks and secures the blade in the open position without the need for a second spring. Also, the true linerlock allows the blade to be opened and closed with one hand, without changing the position of the knife. This invention has truly changed the face of modern pocket cutlery both in the hand-made and factory production arenas and full credit is due him for his contribution.

When Michael taught me the basics of the linerlock in 1985, I was amazed that no one else was using this very simple yet elegant system in their folding knives. I also saw that the design lent itself perfectly to the requirements I had devel-

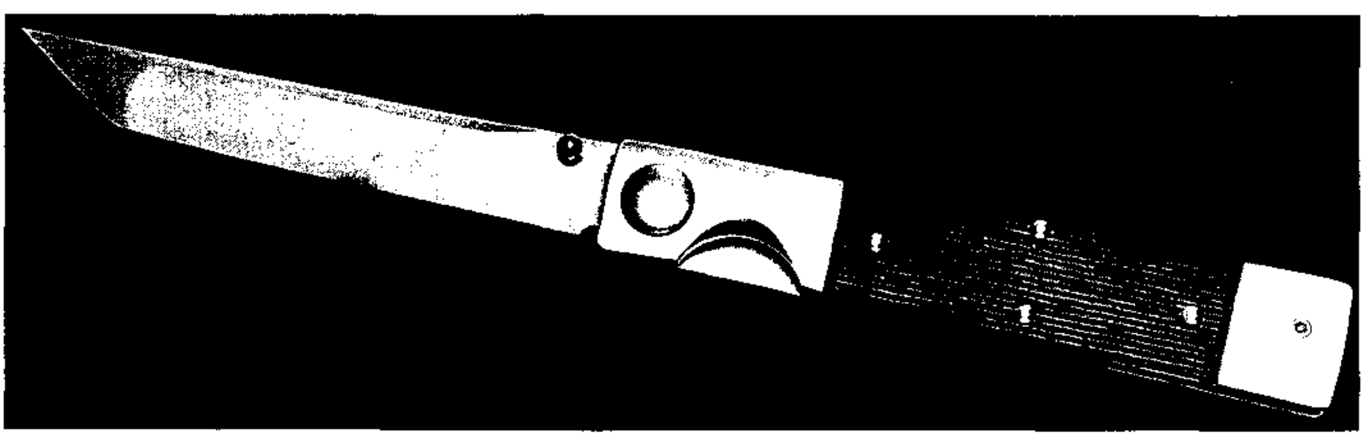


Fig. 50: The first folding Tanto by Michael Walker of Taos, NM. Pat Pollard photo.

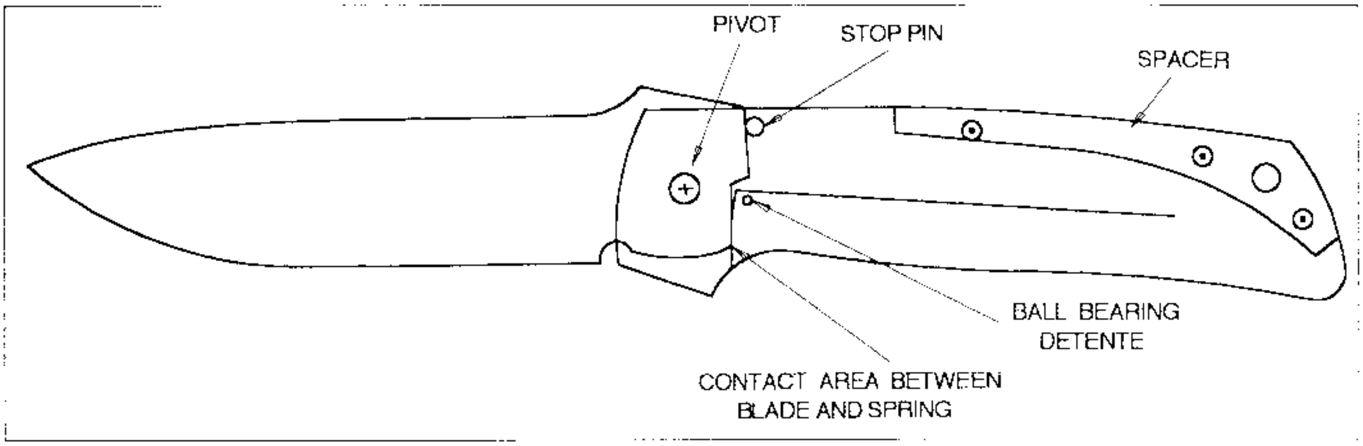


Fig. 51: Anatomy of a linerlock.

oped for my own folding knives (still on the drawing boards at that time), particularly those for one-handed operation and complete assembly and take down with screws rather than permanent pins.

While most of today's knife aficionados are familiar with the operation of the linerlock, many do not realize that there are several critical elements which must be executed correctly for the lock to work flawlessly. As I said, the system is a forgiving one and requires few precision fits, but certain rules must be observed for correct operation.

GEOMETRY

The reason why the linerlock works is because it is based on the triangle, the strongest shape in nature. The three apices of this triangle are the pivot, the stop pin and the contact point between the spring and the blade (Fig. 52). The spring places the entire system in compression rather than tension, (Fig. 53) (which is the way a lock-back folder works).

In order for a liner-locked blade to be forced closed from the open position, the flat spring must be bent double by excessive force exerted on its

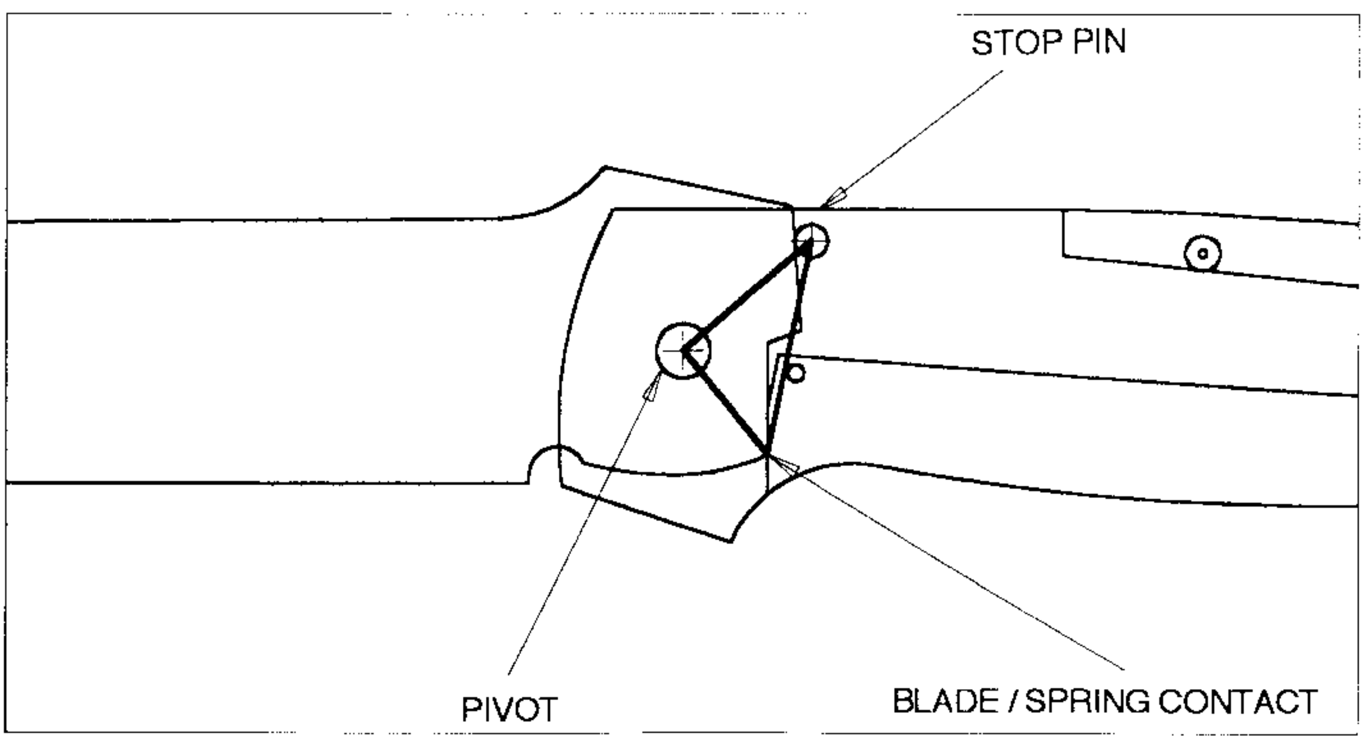


Fig. 52: The strength of the linerlock is derived from the triangle, the strongest geometric shape in nature.

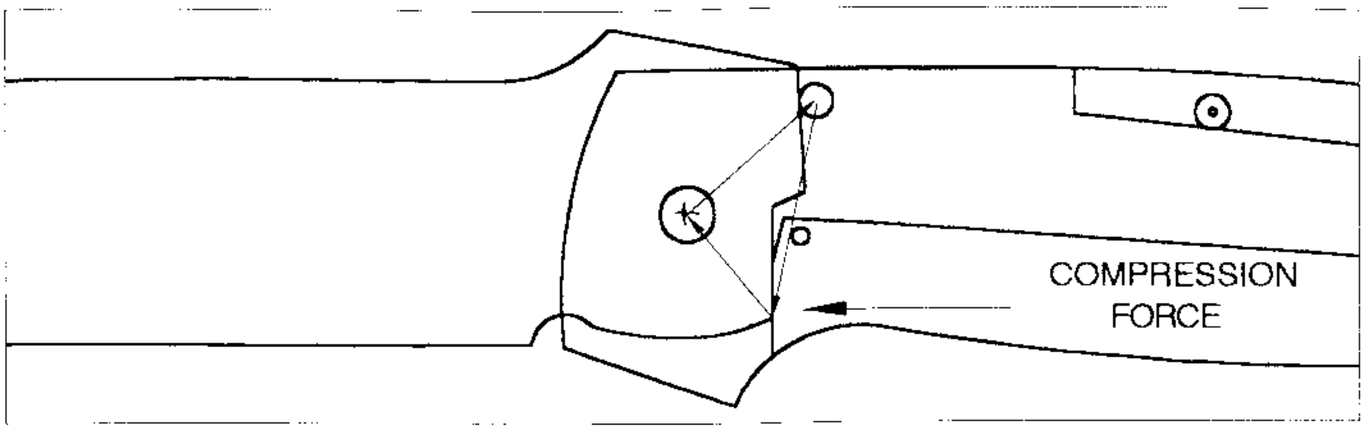


Fig. 53: Compression force from the spring is transmitted to the pivot, then to the stop pin and back to the spring/blade contact point.

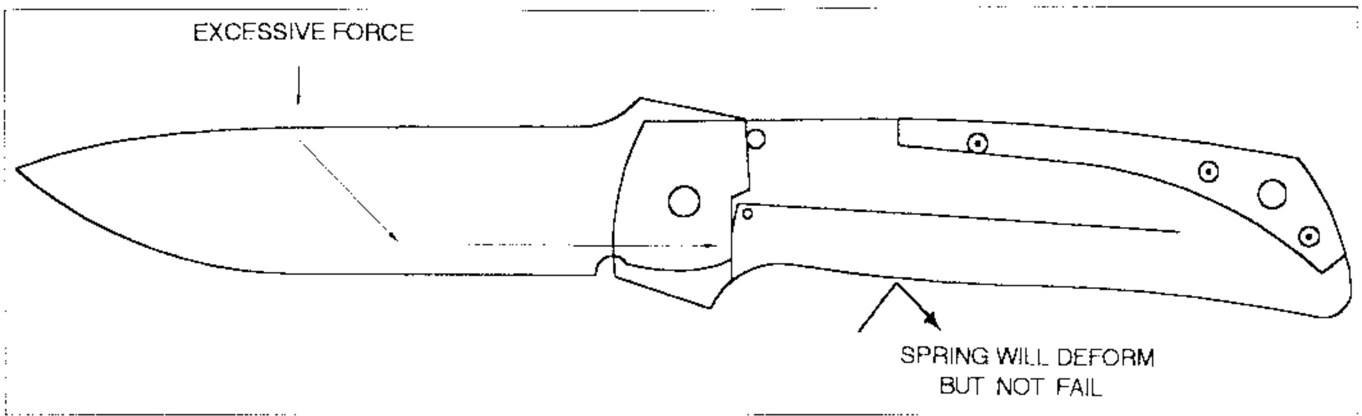


Fig. 54: Excessive force on the blade spine will not cause a properly made linerlock to fail but will, instead, deform the spring, thus avoiding a sudden, catastrophic collapse of the blade.

spine (assuming that the angles of contact were correctly made and the spring does not slip off the blade). If the liner is of sufficient thickness and of a material with great tensile strength, such as 440C stainless steel or titanium, the force required to bend it out of shape from the front edge (that is, attempting to close the blade), is enormous and not within the range of conduct of the human hand (Fig. 54).

Because the system is in compression, a substantial force must be applied to the top of the open blade in order for it to begin to fail. A force of about 35 foot pounds is required for this to happen with a titanium spring of about .063 inches thick. The linerlock, when enough force is applied to it, will degrade gradually as the spring is deformed by the compressive, downward force of the blade. On the other hand, when a conventional lock back fails, the failure is sudden, total and potentially catastrophic.

Aside from spring pressure, there is no inherent portion of the linerlock system which secures the blade in the closed position. For this reason, a hardened steel ball bearing is positioned in the spring to engage a detent drilled into the blade tang which, utilizing the force of the bent spring, holds the blade in the closed position. Locating this ball detent is an important part of the correct operation of the linerlock and is described below.

For maximum strength, the spring should engage the blade as far below the horizontal center line of the pivot as possible. The farther below this line, the stronger the lock up will be. Full contact between the blade and spring face is not necessary and is not recommended as this can cause the blade to rock up and down as will be explained later (Fig. 55).

The triangle created by the three apices described above should be as close to equilateral as possible as this is the strongest of the triangular shapes.

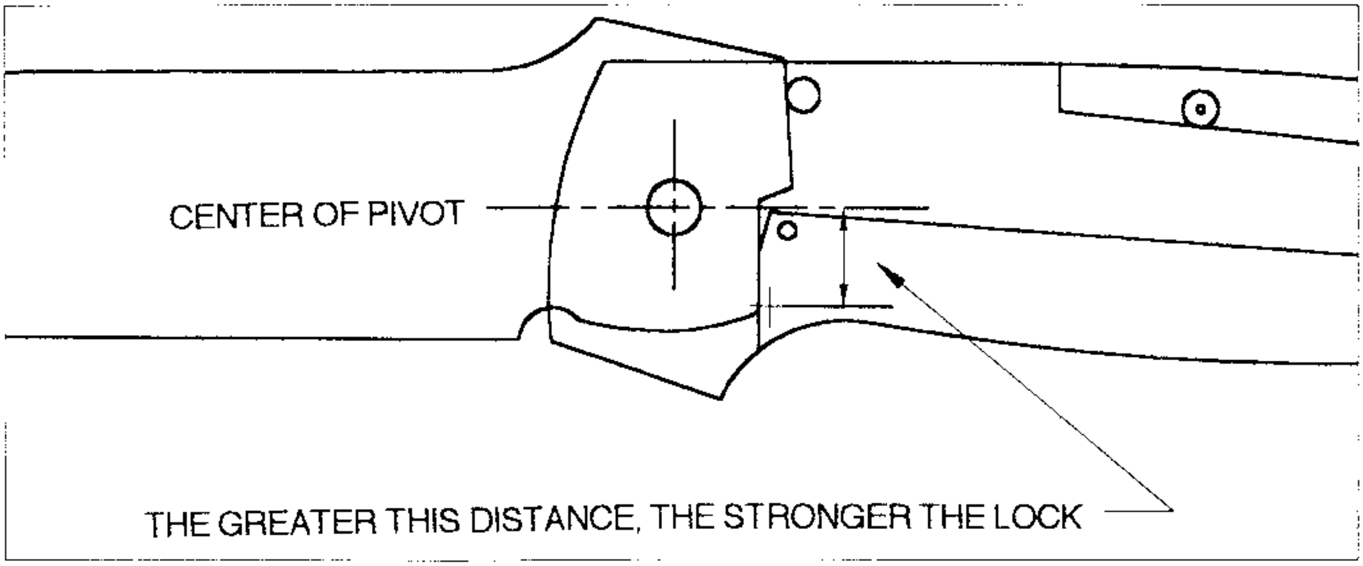


Fig. 55: The spread between the pivot and the blade/spring contact point is crucial to the lock.

Some design adjustments should be made on drawings and prototypes before starting the real knife to insure that the lower portion of the blade clears the stop pin as it travels from the closed to the open position and vice-versa. That is the reason why the bottom of the blades' tang is curved. This radius should be slightly shorter than the distance between the center of the pivot and the outer edge of the stop pin, in order to provide this clearance (Fig. 56).

Once this radius is established on the blade tang, it should be transfer scribed onto the spring with the blade held in place with a trial pivot and the blade in the half open position (Fig. 57). The locking edge of the blade must then be scribed onto the spring with the blade held in the full open position leaving a small triangular area with one curved leg. This will be the area into which the ball detent will be placed in order to avoid its run-

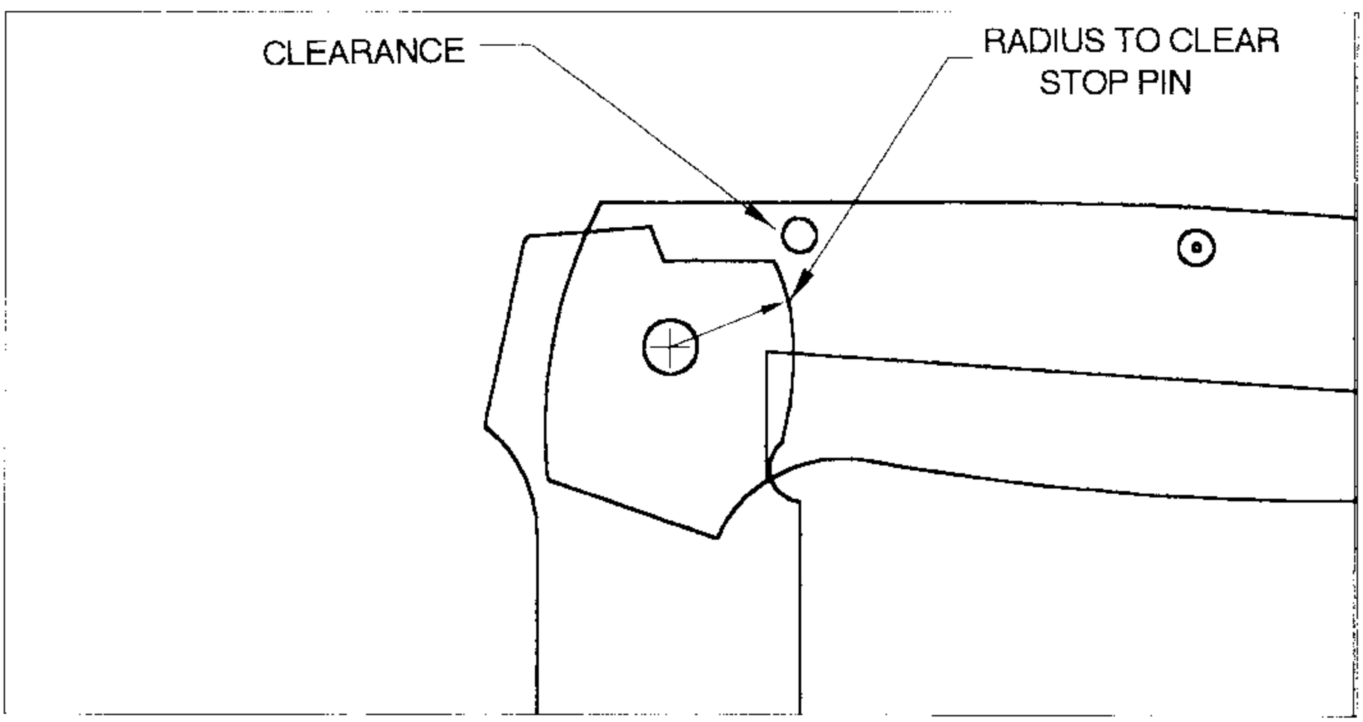


Fig. 56: The design of the blade must allow for clearance between the tang and the stop pin.

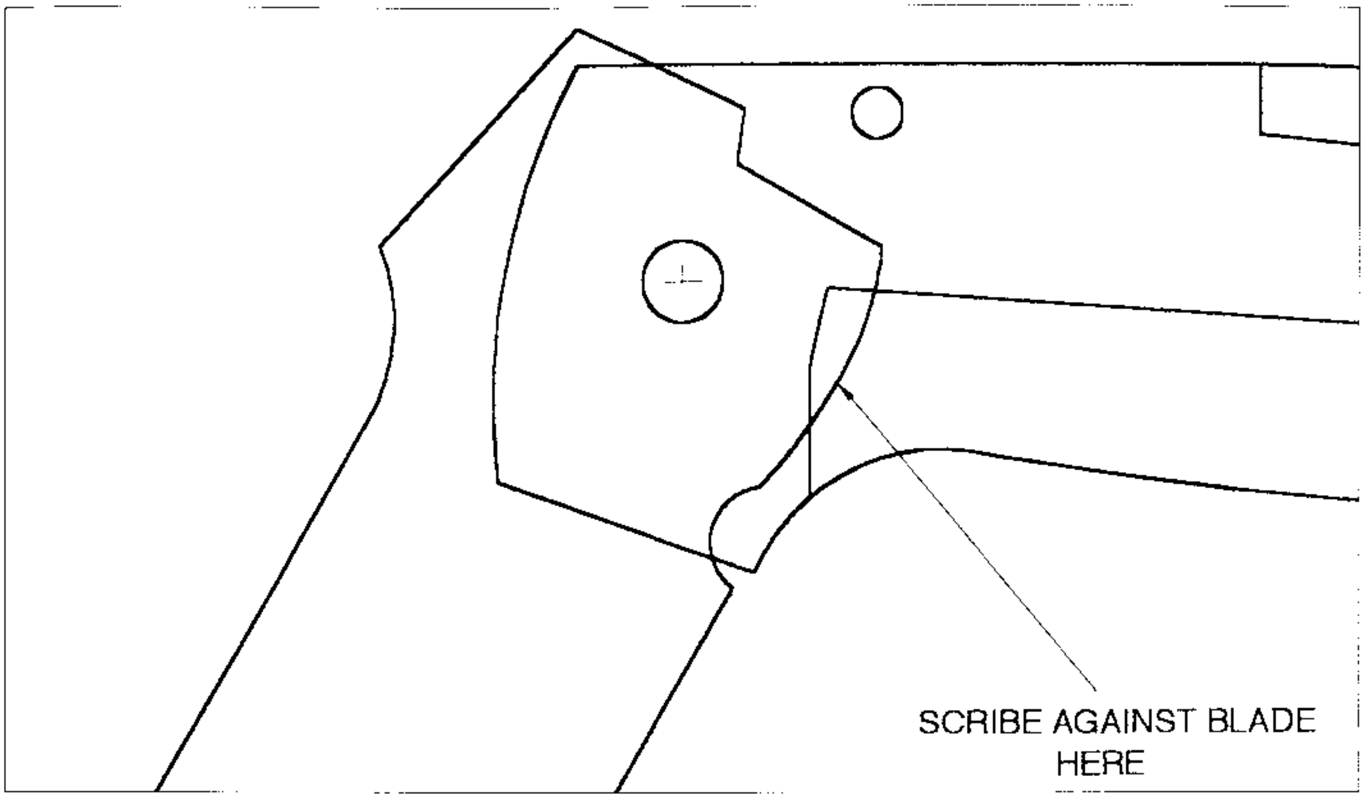


Fig. 57: The location of the ball bearing detent is determined by the dimensions of the lower radius of the blade's tang.

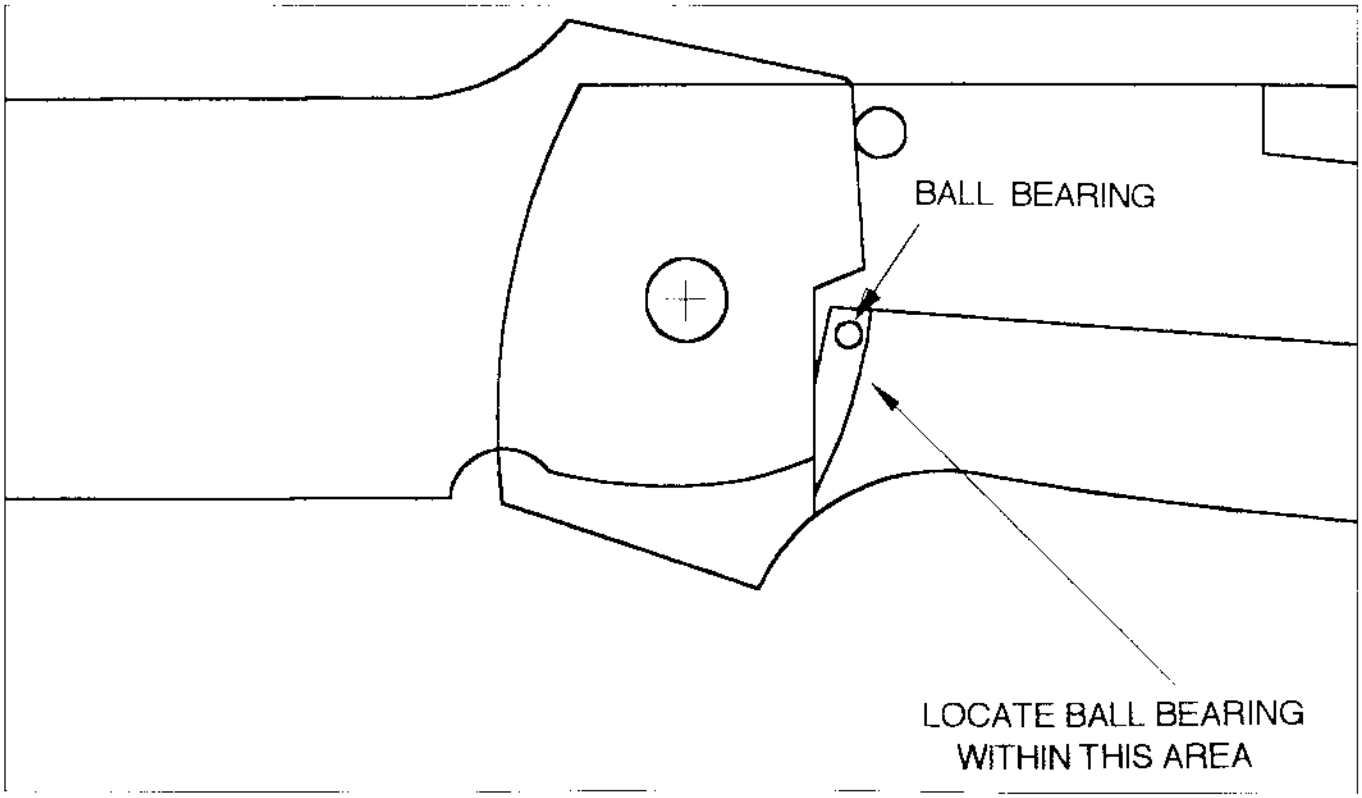


Fig. 58: Locating the ball bearing within the area described on the spring will prevent it from running off the blade when opening and closing the knife.

ning off the blade tang as the knife is opened and closed (Fig. 58). The ball should project about .015 to .020 inches above the spring. If the blade is to lay flush with the handle sides, the spring must be recessed into the handle plate enough to allow for the protrusion of the ball bearing.

Alternatively, washers may be used as bearings between the blade and the handle to provide this spacing. The washers must, therefore, be as thick as the height that the ball bearing protrudes from the spring. If the ball protrudes .020 inches above the spring then the washer on that side of the blade needs to be at least .020 inches thick (Fig. 59).

I prefer using washers between blade and handle for a number of reasons. First, the washers I use are self lubricating Nylatron and provide for a very smooth operation of the blade. Second, the washers stand the blade away from the handle plates and allow for easy cleaning of that joint. Third, I use titanium for my handles and steel and titanium do not go well together particularly when moving against each other under pressure. These materials tend to gall each other and should be separated (except, of course, for the lock faces).

The length of the spring is important but not critical to the functioning of the system. The shorter the spring, the greater the force applied to the lock but the greater the force required to unlock it and press it clear of the blade when disengaging. I have found by trial and error (lots of error), that for a 3-1/2 to 4-inch blade, a spring of about 2-3/4 to 3 inches long works well. Shorter blades in smaller knives can take a proportionally shorter spring.

The angle of the blade's lock bevel is critical within a very narrow range of tolerance. This angle

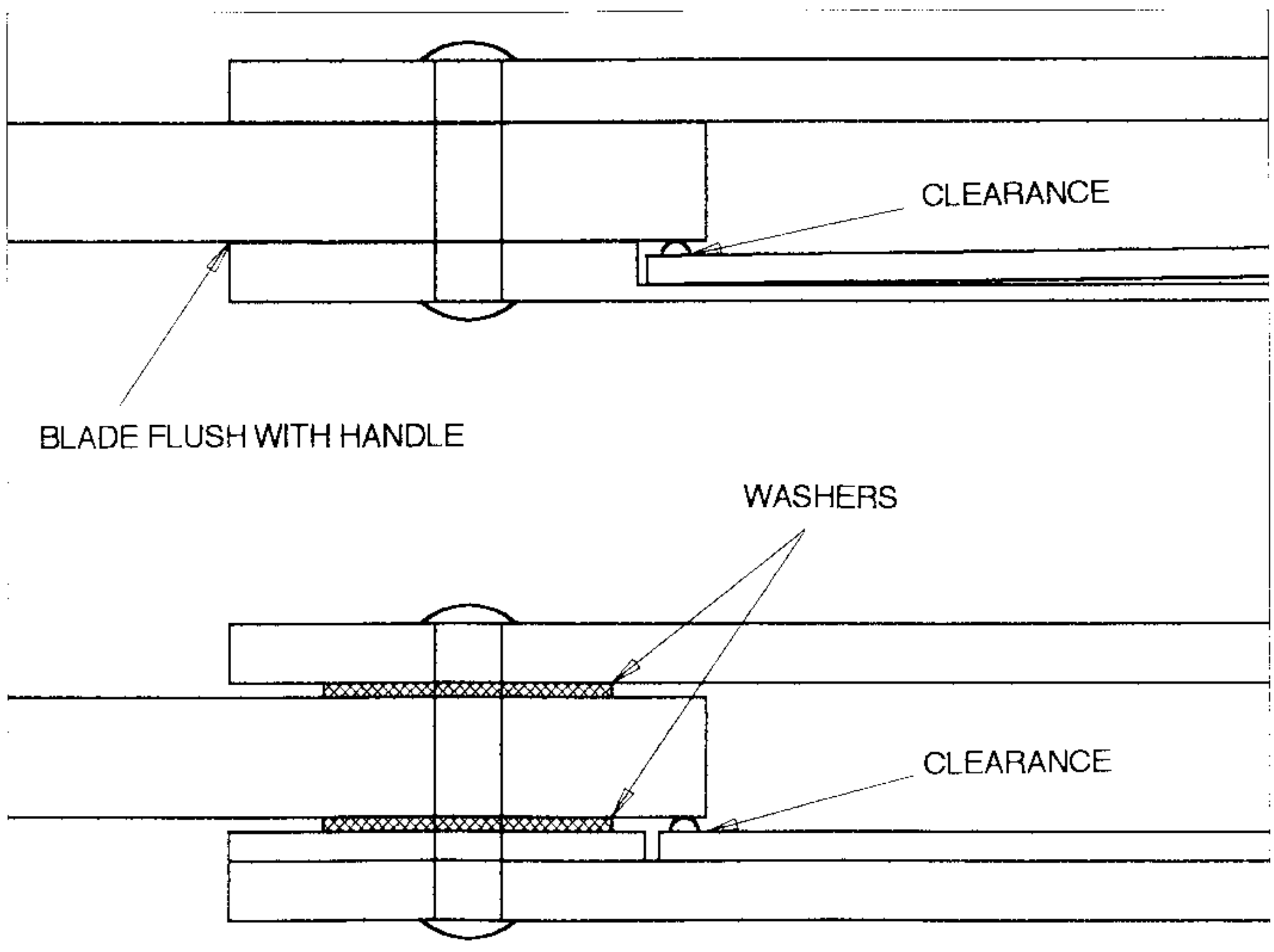


Fig. 59: Clearance between the ball bearing and the blade must be allowed for, whether or not washers are used in the design.

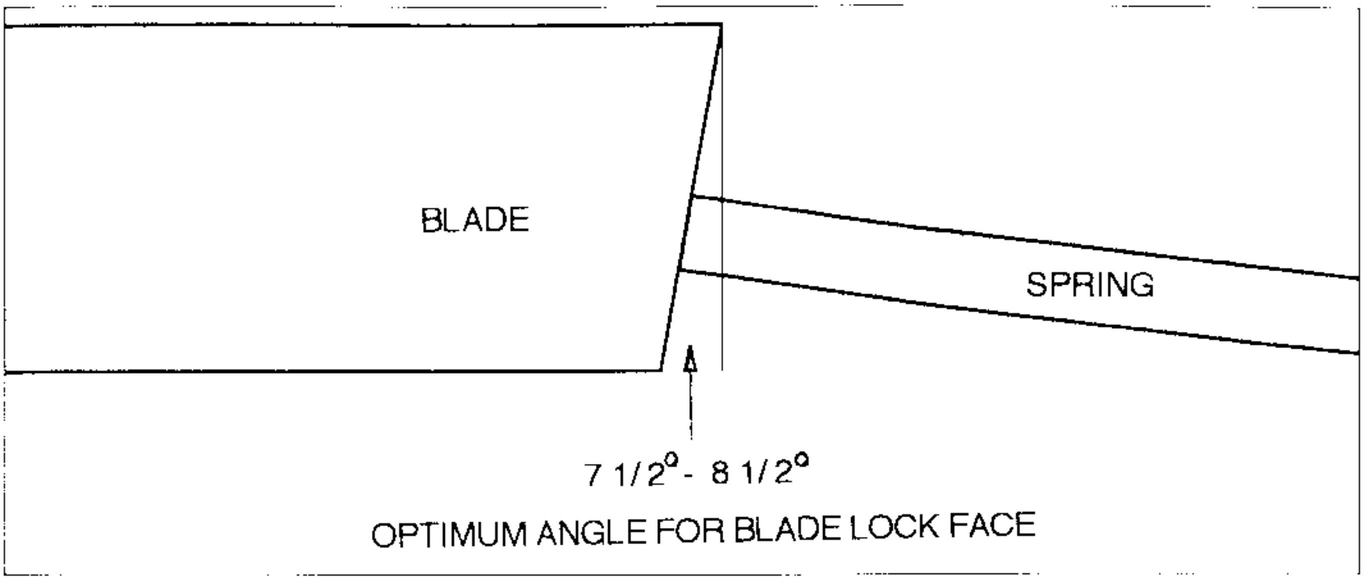


Fig. 60: The optimum angle for the blade's locking face is between 7-1/2 and 8-1/2 degrees.

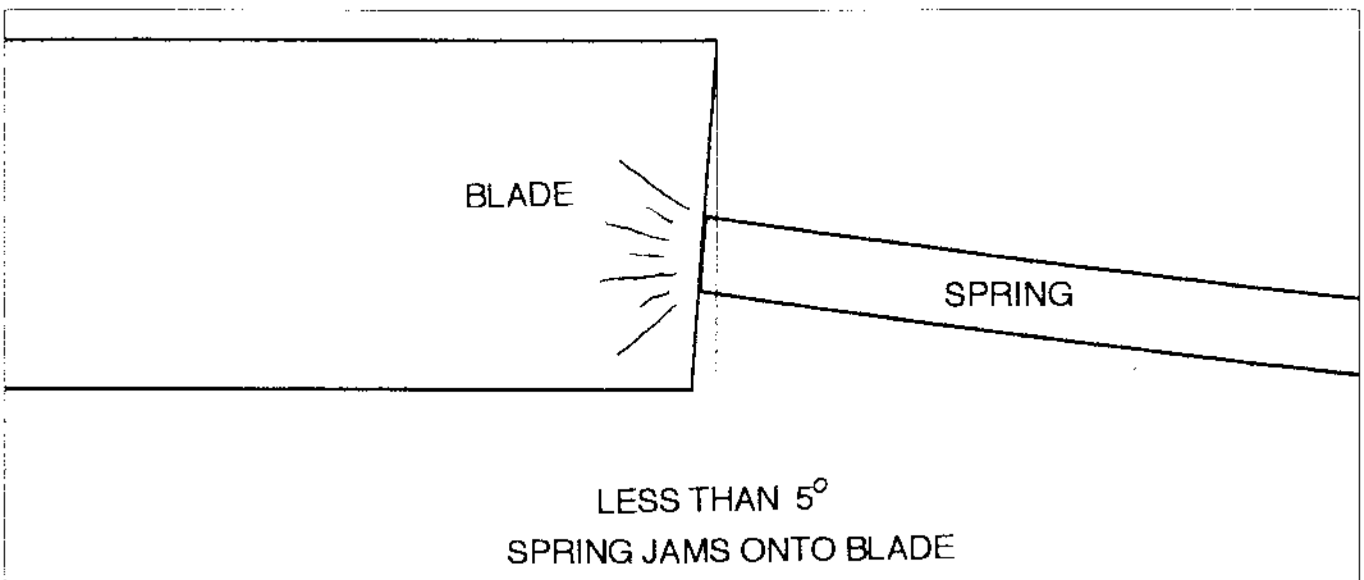


Fig. 61: Less than a 5-degree angle will cause the spring to jam tightly against the blade.

is determined by the arc described by the face of the spring as it opens and closes. A spring of between 2 inches and 3 inches in length works well with an angled bevel of 7-1/2 to 8-1/2 degrees. This seems to be the optimum angle for a linerlock (Fig. 60). In my opinion, the full range of this angle should only be between 7 and 9 degrees for these reasons: An angle of 5 degrees or less is considered to be a seizing taper and will cause the spring to be very difficult to disengage from the blade (Fig. 61). An angle of 10 degrees or more will not be secure in that it may tend to wedge the spring off the blade when closing pressure is applied to the blade's spine (Fig. 62). I grind my blade angles at 8-1/2 degrees and find that this works well in all sizes of knives.

I do not grind the locking bevel on the blade as a flat plane but rather I use a hard wood contact wheel with a 2-inch radius so that the bevel is actually a curve and will gradually increase its contact with the spring over time as the spring wears (Fig. 63). And, speaking of wear on the spring, I have found that the constant pounding against the hardened steel blade will, in effect, hammer forge the face of the spring and harden it so that after a

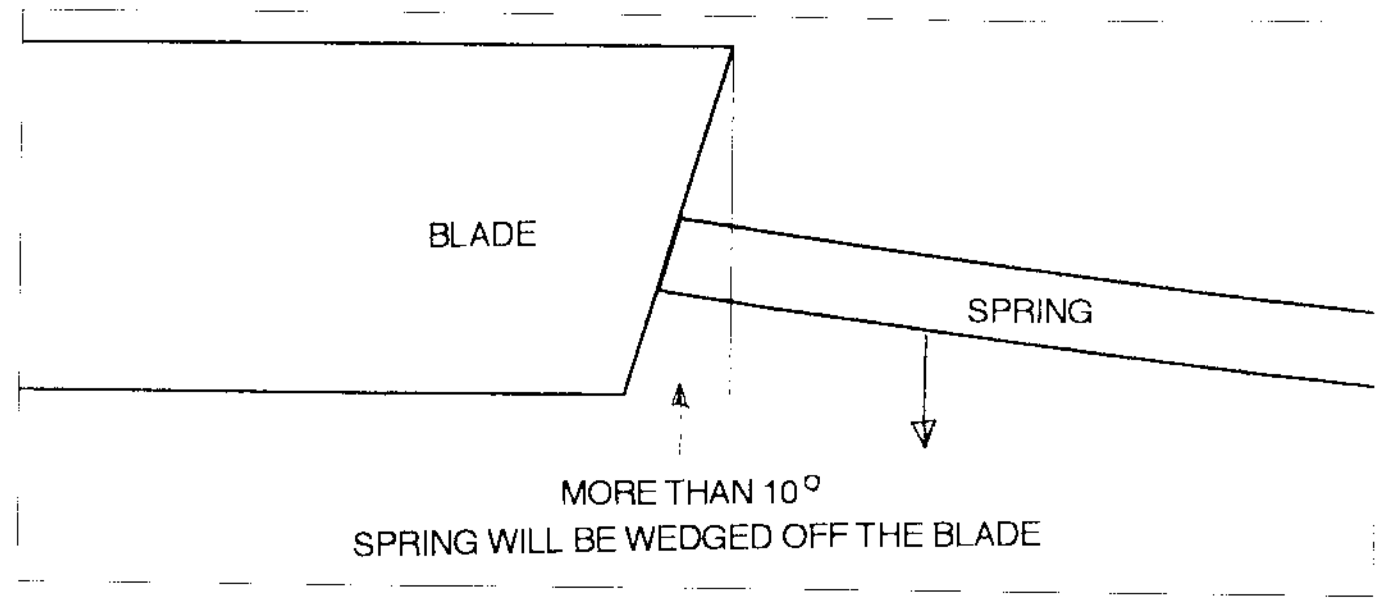


Fig. 62: More than a 10-degree angle may force the spring off the blade with a wedging effect.

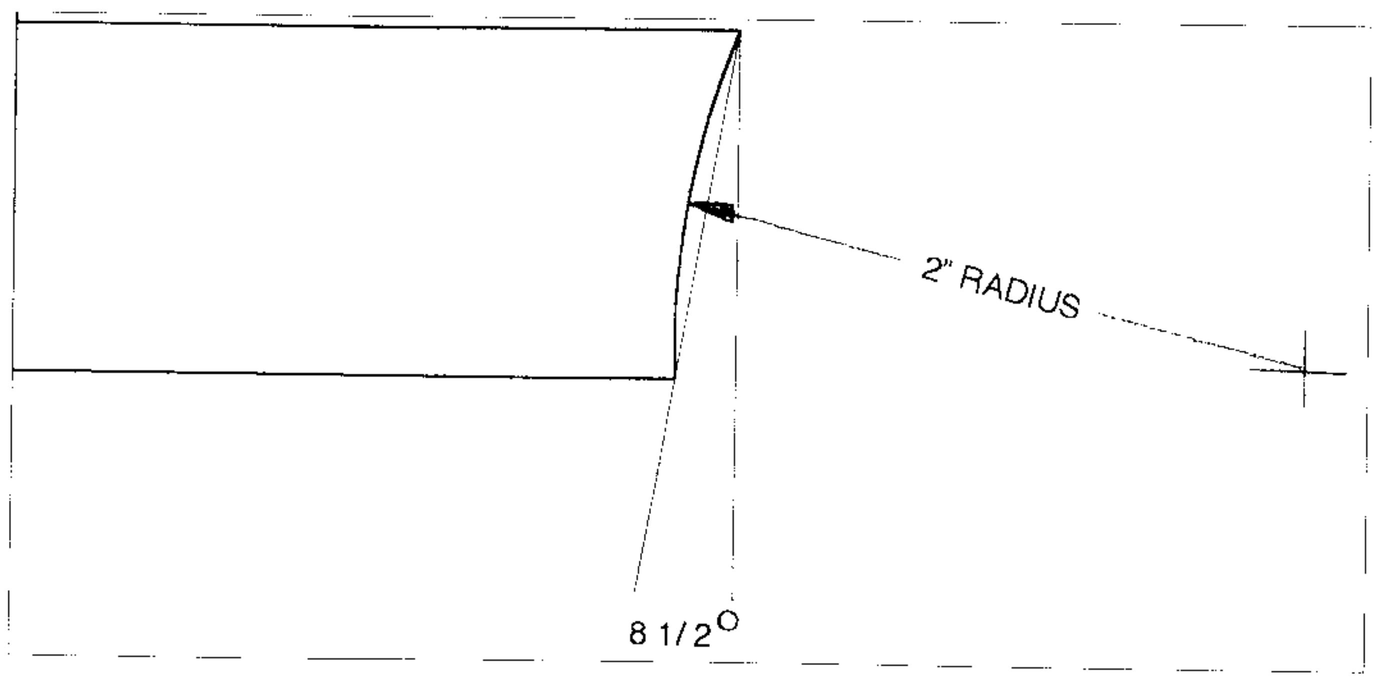


Fig. 63: I grind my blade's locking face with a 2-inch radius but they may also be ground with a flat face.

breaking-in period, there will not be any wear to speak of.

It is important to note that the leading edge of the blade's lock bevel, that is, the edge over which the spring must pass as it begins to lock the blade open, should be slightly rounded and smoothed after grinding or else the blade will tend to shave off material from the spring's locking face each time the knife is opened. I do this on a hard, gray Scotchbrite wheel with very little pressure, just enough to break the sharp edge.

The contact face of the spring is also a critical feature of the linerlock. This face may be ground square or at a negative angle to the blade's lock face. I do not like these angles because they both present a sharp corner to the blade's lock face and can cause unnecessary sticking in the locked position, particularly with a titanium spring. I prefer to grind my

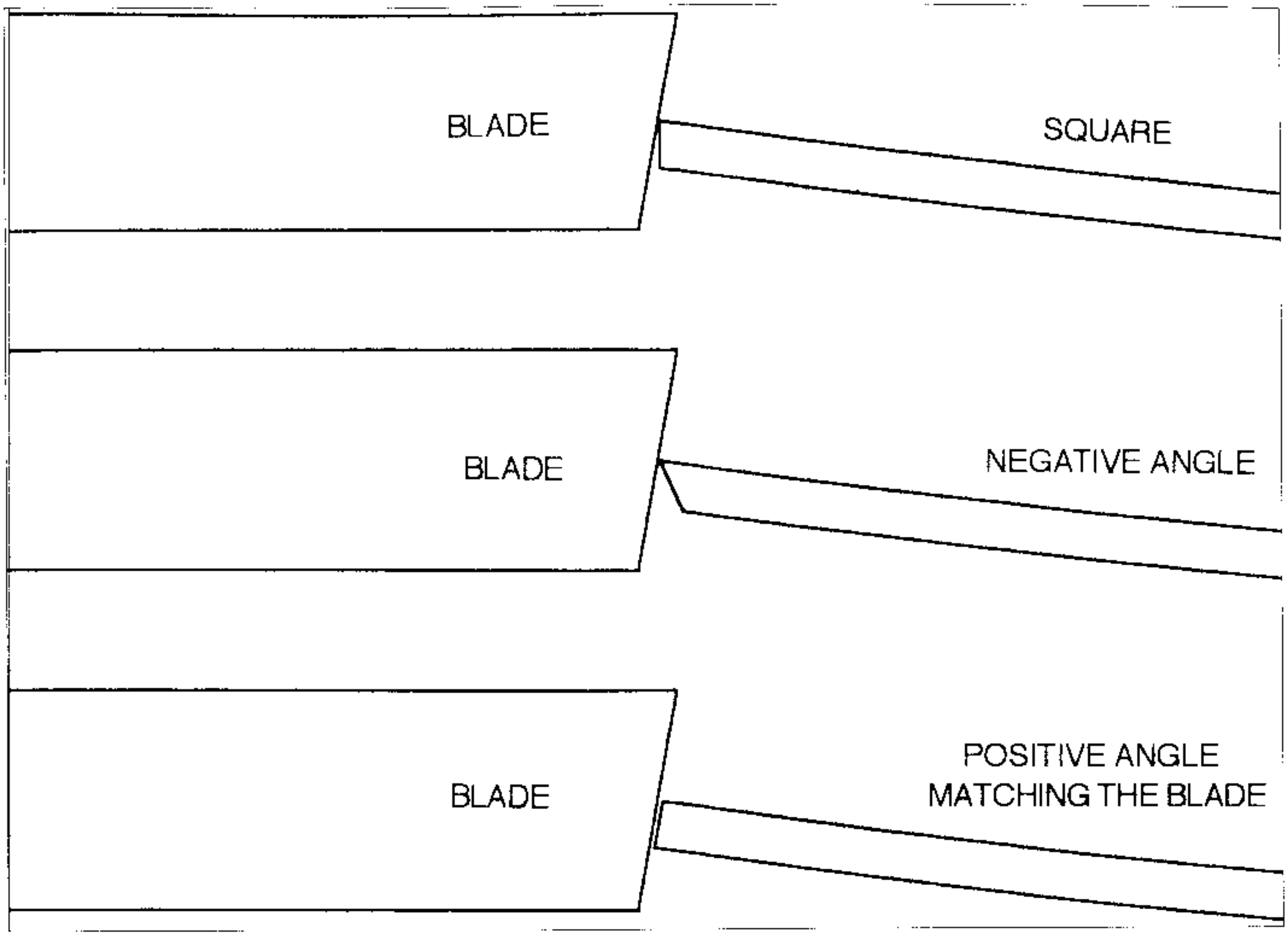


Fig. 64: There are three possible shapes for the locking face of the spring: Square, negative to the blade; and positive or equal to the blade's lock face. I prefer the bottom option which allows for easier operation of the lock.

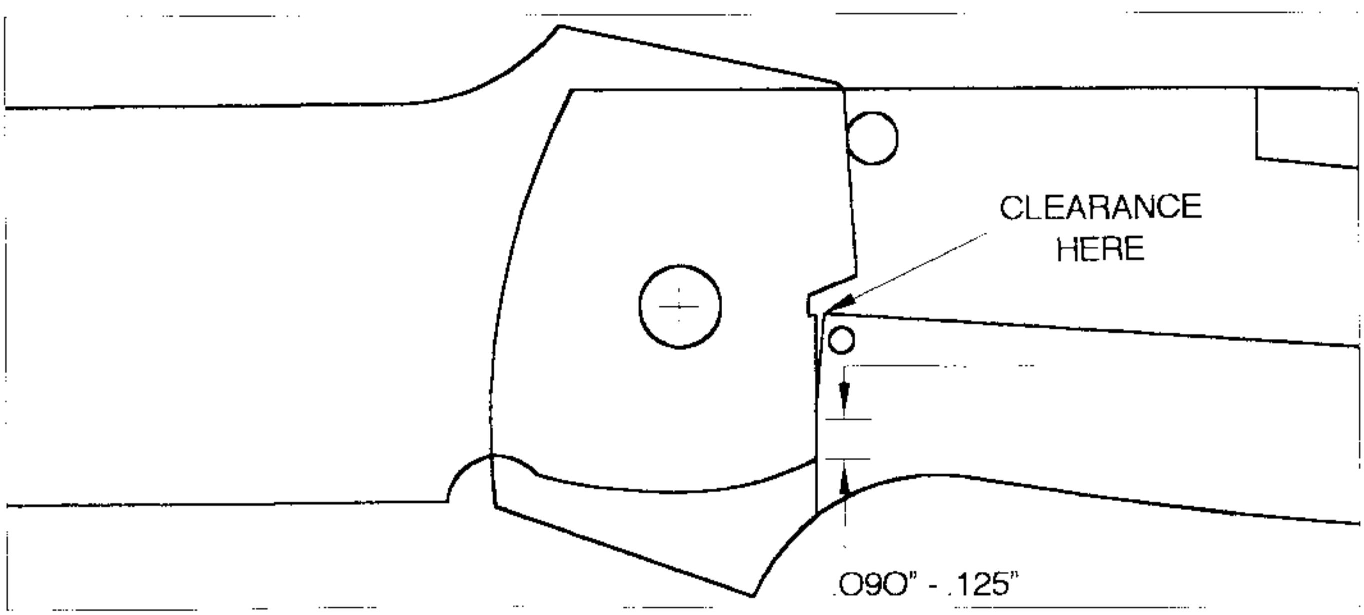


Fig. 65: The blade/spring contact should not be a sharp point but rather a small surface of about .090-.125" with clearance at the top of the lock.

spring's lock face to be at the same angle as the blade's lock face, that is at 8-1/2 degrees, so that there is full contact between these parts (Fig. 64).

As noted above, the vertical edge of the spring's face, looking at it from the side, should not be in full contact with the entire length of the blade's lock face. Instead, the spring should contact the blade at its lower corner and for a distance upward of about .090 inches to .125 inches. If the spring contacts the upper portion of the blade's lock face, it will tend to allow the blade to rock up and down in the open position. I grind my spring faces parallel with the blade's lock face and then buff back the top 2/3 of the spring face on a Scotchbrite wheel, leaving about .005 inches to .010 inches of daylight at the top of the spring (Fig. 65).

The bending of the spring is a critical operation and should be done with care. The bend needs to be gradual from the back to the front and the curve should be progressive. If the spring is bent at only one point and at a sharp angle, it will not lay flat against the handle plate when the blade is in the closed position, but will bulge inward between the liners. This becomes especially noticeable with a long spring. Bend the spring only as far as the opposite handle plate, that is, as far over as the spacer is thick. Excess bending will tend to apply unnecessary force to the lock and it will be difficult to release. If the blade's locking angle and the spring's locking face are correctly ground and finished, the spring need not be tightly forced against the blade for the lock to work properly (Fig. 66).

The finish on the blade's locking face is important. It should be smooth and free of deep scratches with about a 320- to 600-grit finish. If the blade is to be bead blasted, the lock face should be cleaned and smoothed after the process or else the coarse, pitted finish will cause the spring to stick to the blade.

I recess the edge of the spring slightly below the level of the handle profile by about .010 to. 015 inches to minimize the possibility of the fleshy part of the forefinger from inadvertently disengaging the lock when the knife is held in a "white-knuckle" grip (fig. 67). This situation cannot be entirely avoided due to variations in the human hand but it can be minimized. I also checker the leading edge of the spring to provide a positive grip to the thumb when disengaging the spring from the locked open position.

The stop pin is a critical element to the system and should be located with care. It must be firmly anchored to both sides of the handle so that it remains rigid under the constant pounding from the opening of the blade. It should be made of hardened steel to avoid deforming as this will affect the position of the blade and the effectiveness of the lock. I use a double shoulder pin for my stops, made of hardened 416 stainless steel (Fig. 68).

Finally, the location of the spring on the blade needs to be considered; that is, the distance that the spring travels across the face of the blade's lock bevel as it locks up the knife in the open position. In my opinion, the spring should travel no more than halfway across the blade. I prefer about one third the distance, however, as this will allow greater clearance for the inevitable slight wear on the spring and still allow for a firm lockup.

TROUBLE-SHOOTING THE LINERLOCK

Below, I list some of the more common problems encountered with linerlocks and some solutions that I have found useful over the years. If a

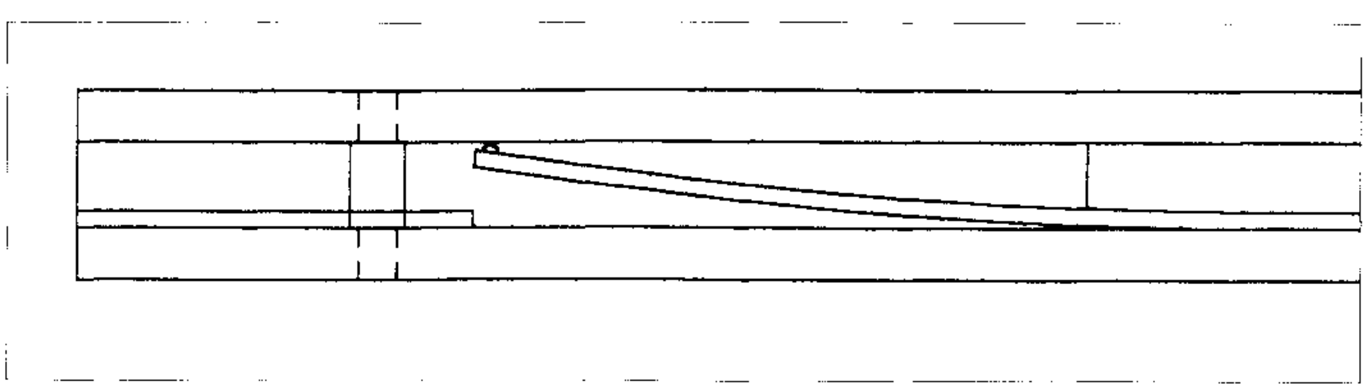


Fig. 66: Bend the spring only until it just reaches the opposite liner. Over bending may cause it to jam the lock.

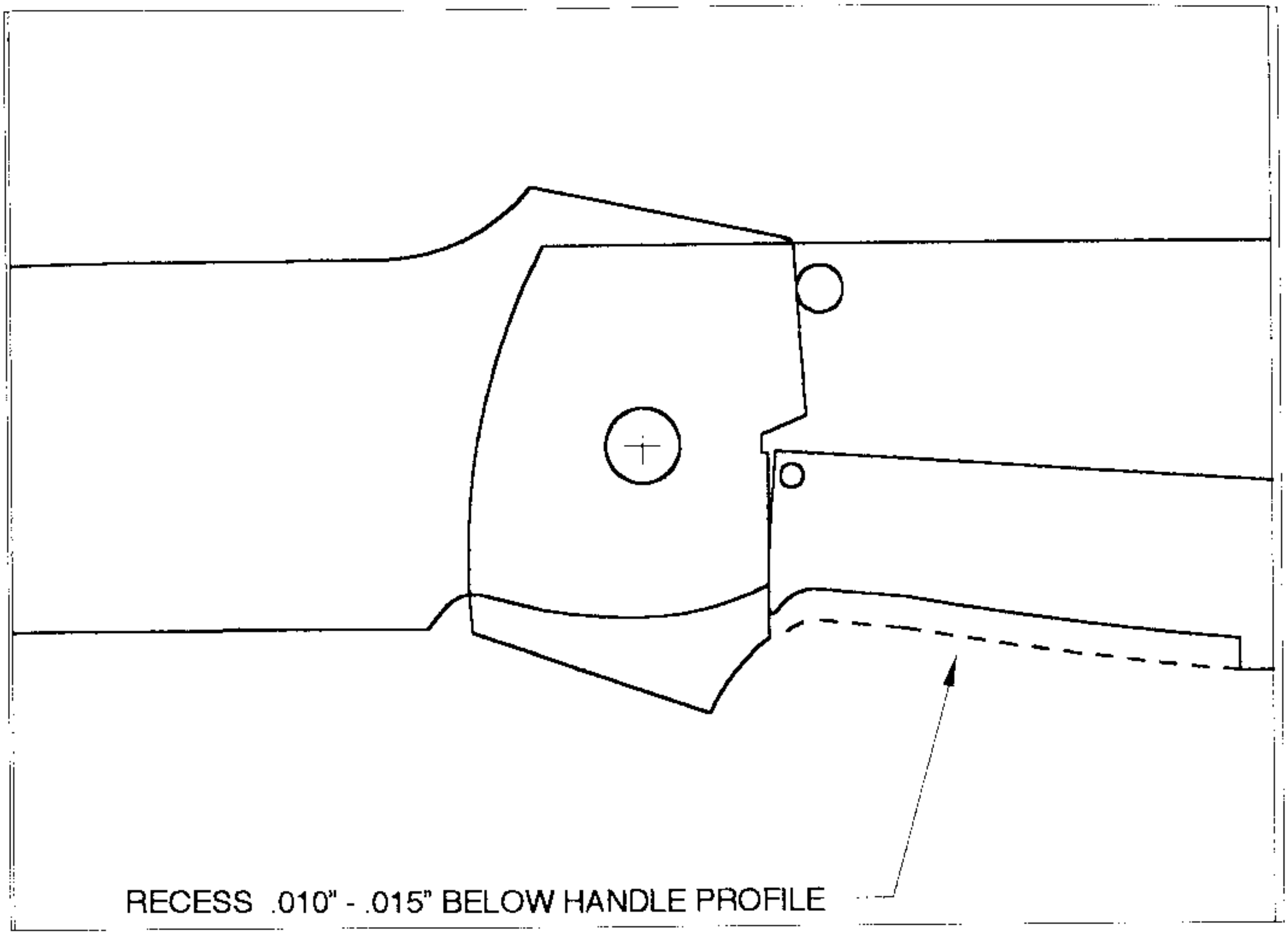


Fig. 67: Recessing the spring bar below the level of the handle's profile will minimize accidental unlocking with some tight grips.

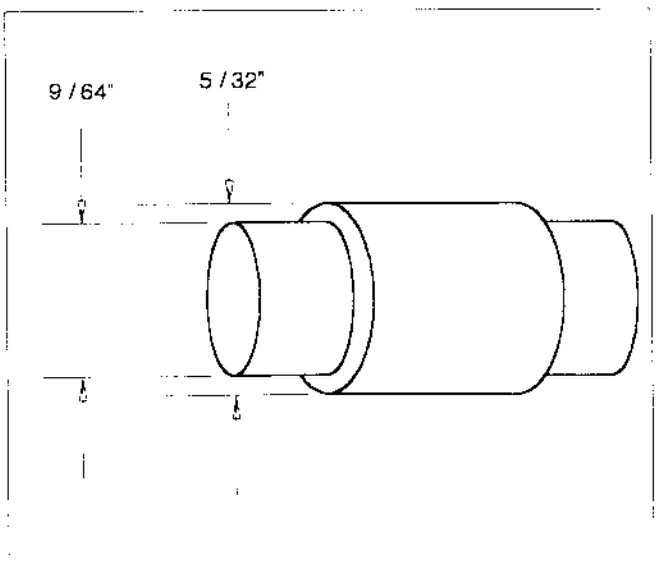


Fig. 68: Dimensions of the stop pin. The length of the shoulders will be determined by the thickness of materials used for the blade and the handles.

lock does not perform well on the first try, it can usually be adjusted with some simple tinkering. Also, I have found that no matter how perfect the knife may be when it leaves the shop and has undergone rigorous testing and approval, the end user may not treat the knife with respect and subsequent hard use may cause the need for later adjustments.

Here are the most frequent complaints:

Blade rocks up and down in the open position

There are two possible reasons for this problem:

1. The spring is too short and is not engaging the blade's lock face. If the spring hits the opposite liner and does not apply compression to the blade, the blade will not be firmly held against the stop pin. If there is only a small gap between the blade and spring, the end of the spring can be lengthened just a bit by peening it on an anvil with a smooth-faced hammer (Fig. 69).

2. The top corner of the spring's lock face is making contact with the blade. Only the lower portion of the spring should touch the lower portion of the tang. If the full faces engage, the blade will rock up and down in the open position. This can be verified by holding the blade and spring up to the light with a pivot and stop pin in place. When the blade is opened and the lock engages, light should pass through the upper portion of the lock but not the bottom portion for a distance of about 1/8 inch. If this is not the case, buff back the top portion of the spring on a Scotchbrite wheel. (See Chapter 6) (Fig. 69)

Blade does not snap sharply into the handle and has play in it when closed

The ball bearing is not properly aligned with its detent hole. This problem occurs when the centers of the ball bearing and the detent hole pass each other as the blade is closed. (See Chapter 6). Also, it is possible that the detent hole is too large for the ball bearing being used, causing the ball to be loose in the hole (Fig. 70). One way of fixing this is to use a larger ball bearing, if possible. If not, the detent hole will have to be drilled out and a plug firmly hammered into the blade and the blade refinished in that area. You can then start over by assembling the knife and allowing the ball to create a track on the side of the blade. Center punch the blade for the new detent hole about .020 inches beyond the clear end of the track mark left by the ball (Fig. 71). The plug will normally not be visible and will in no way affect the strength of the blade.

Blade does not hold securely in the handle when closed

If the blade snaps nicely into the handle but does not hold securely in the closed position, the detent hole may not be large enough, or the ball bearing may not reach far enough into the hole. Try drilling the hole with a slightly larger drill increasing the drill size by no more than one number size at a time. Slightly chamfering the hole with a carbide countersink may also yield good results but the blade will be held more securely if the edge of the hole is square.

Blade unlocks when downward pressure is applied to its top edge

The two most common reasons for this are that the spring has not been bent enough or the blade's lock bevel is ground at the wrong angle.

The spring should be bent so that it reaches the opposite liner. Much more than this will cause the spring to be difficult to release, but much less will not apply enough force to the lock face, thereby allowing it to be wedged off the blade (Fig. 66).

If the blade's lock bevel is ground greater than 9 or 10 degrees, the bevel will act as a wedge and push the spring off when pressure is applied to the top of the blade. Regrind the bevel to about 7-1/2 or 8 degrees. (Fig. 60)

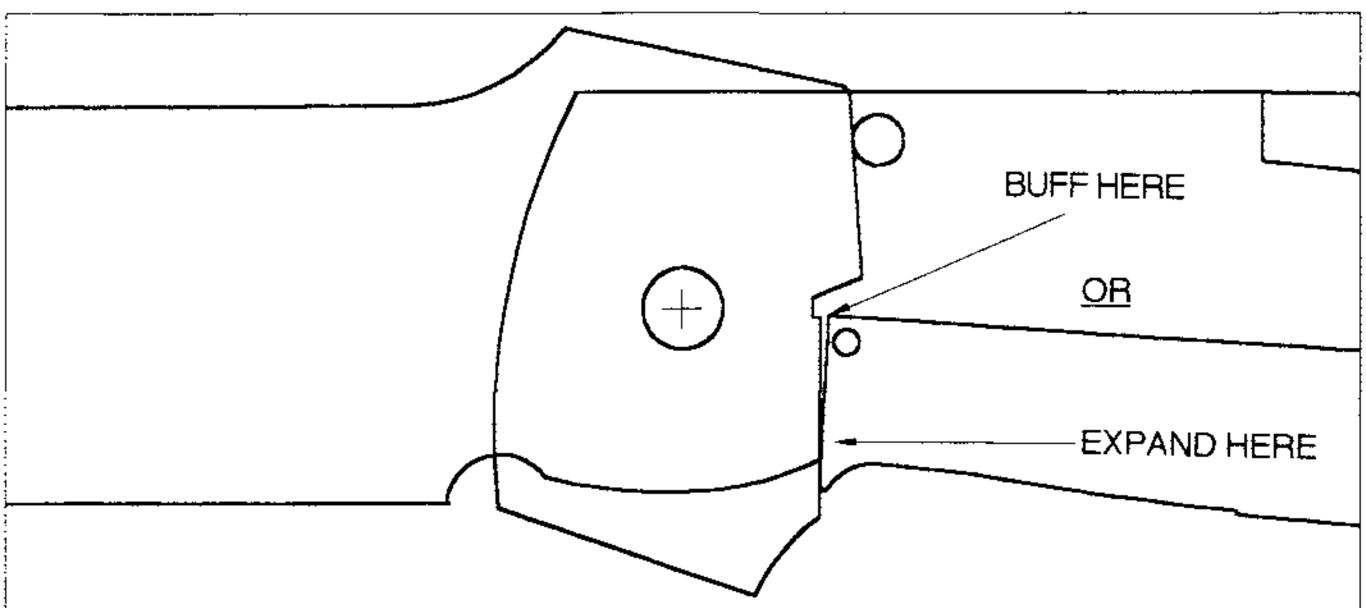


Fig. 69: Two procedures for adjusting a blade that has vertical play in the open position.

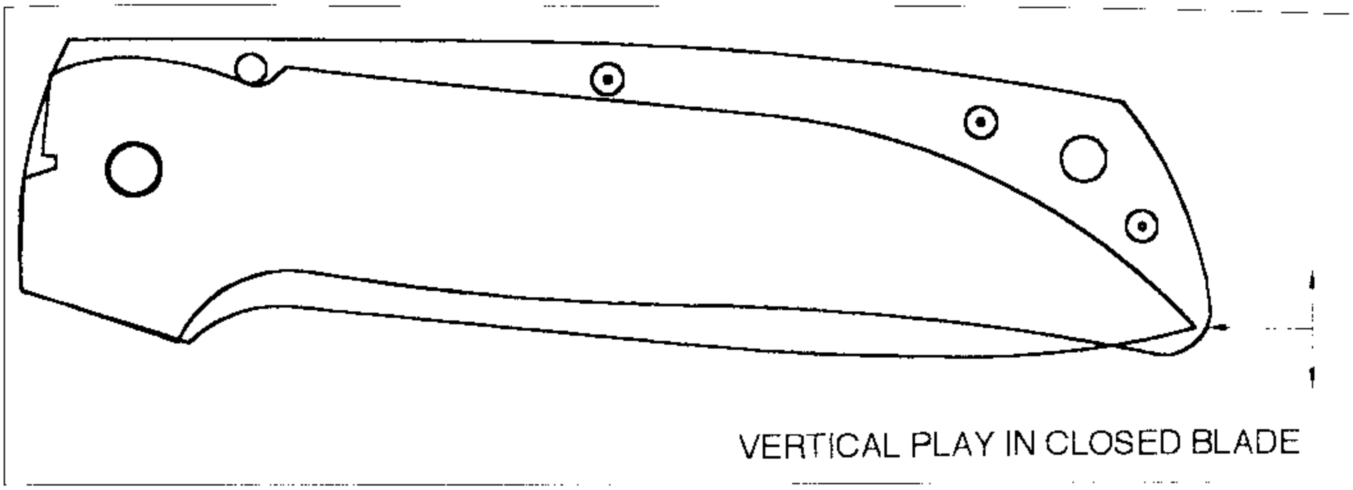


Fig. 70: If the blade has vertical play in the closed position, the ball bearing and the detent hole are not properly aligned.

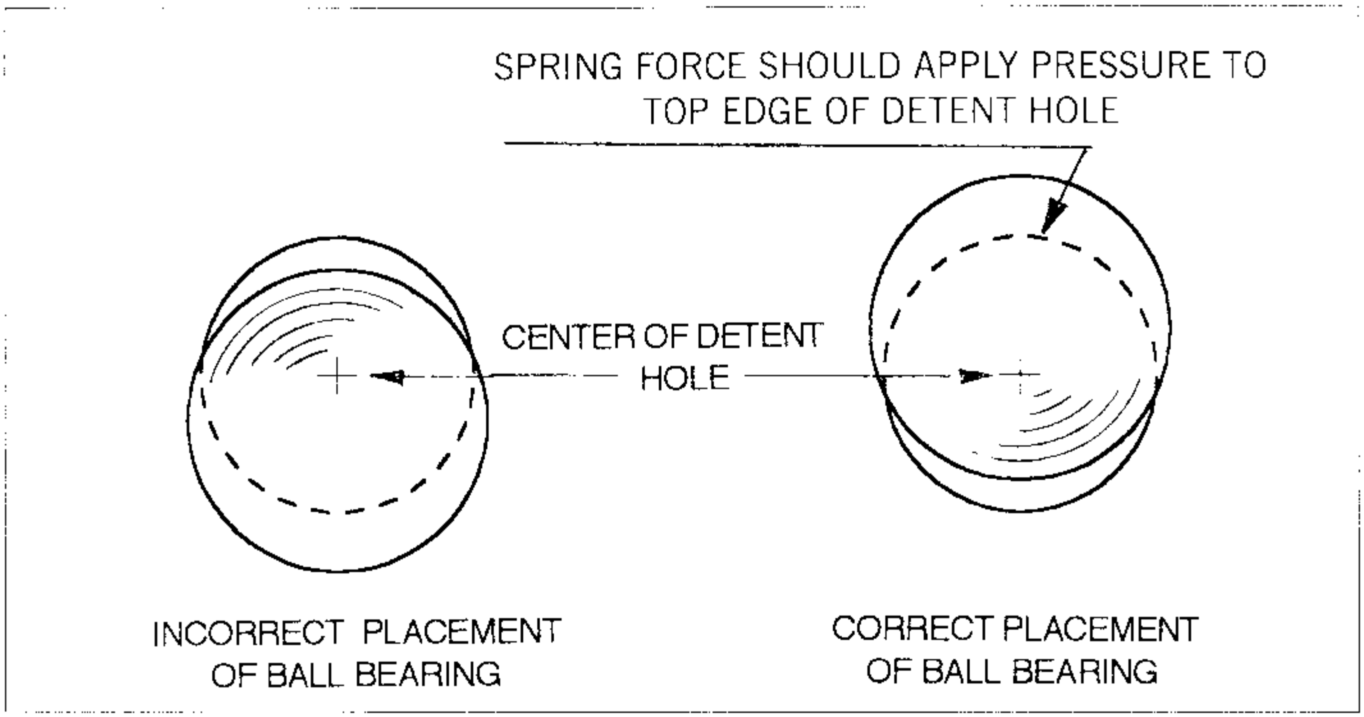


Fig. 71: Incorrect alignment of ball bearing and detent hole (left), shows that the center of the ball bearing has not reached the center of the detent, allowing play in the closed blade. Correct alignment (right) shows that the ball has passed the detent hole and is applying closing pressure against the top rim of the hole, thus securing the blade against the stop pin.

In addition, it is also possible that the spring may not be made of the right materials. If, for example, commercially pure (CP) titanium is used for the spring, constant usage will burnish the locking edge over a period of time and form a very slick and untenable surface which will be easy to push off the blade. (CP titanium is very soft and also makes a poor spring in that it has a greater tendency to stick against a steel lock face). Be sure to use a hardened alloy of titanium such as 6AL4V or a heat treatable stainless steel which can be hardened to about 42- 45 Rc. Also, a rolled stainless steel of the 300 series may be used if it is in the work-hardened or full-hard state.

Blade is not centered in handle in the closed position

Contrary to popular belief, this is not generally caused by the pressure of the spring pushing the blade over to the side in the closed position unless the spring is terribly over-bent or the pivot is not properly tightened or fits too loosely in the blade. If these items have been checked and the blade is still not centered, the culprit is probably a warped liner. If the liners are not flat, the end in front of the pivot can apply tremendous pressure to the back end of the closed blade, pushing the pointed end off center. Disassemble the knife and straighten the liners on an arbor press or in a vise (Fig. 72). (See Chapter 6)

Another possible reason for the problem, though far less common, is that the spacer may be too short and located too far back in the handle. This is particularly troublesome if the spring is very strong or over-bent. The short spacer may not properly support the liners towards the front of the knife and the frame can actually be warped slightly by the spring pressure, thereby sending the closed blade out of alignment. Make a longer spacer which projects farther towards the front of the knife.

The fit of the pivot in the blade and the blade in the handle may also contribute to this problem. Excess clearance of the pivot in the blade may cause it to respond to the pressure of the spring, pushing it to one side. The pivot should be snug but not so tight that the blade does not swing freely to the open and closed positions.

Blade gets harder to close about halfway through its travel to handle

This is caused by the ball bearing detent interfering with the blade's travel. It is protruding too far above the level of the liner. The ball should protrude no farther than the side washers are thick. (Fig. 59). Reset the ball into the spring to the correct depth. (See Chapter 6)

Lock travels too far over on the blade when locking

This is most typically caused by a worn down spring but may also be the result of poor fitting or worn down parts such as the pivot, or stop pin.

As described above, this problem can usually be solved by expanding the front end of the spring. This is easily done by peening it with a hammer on an anvil or steel plate. Be sure the ball bearing detent is off the edge of the anvil so as not to smash it deeper into the liner (Fig. 69).

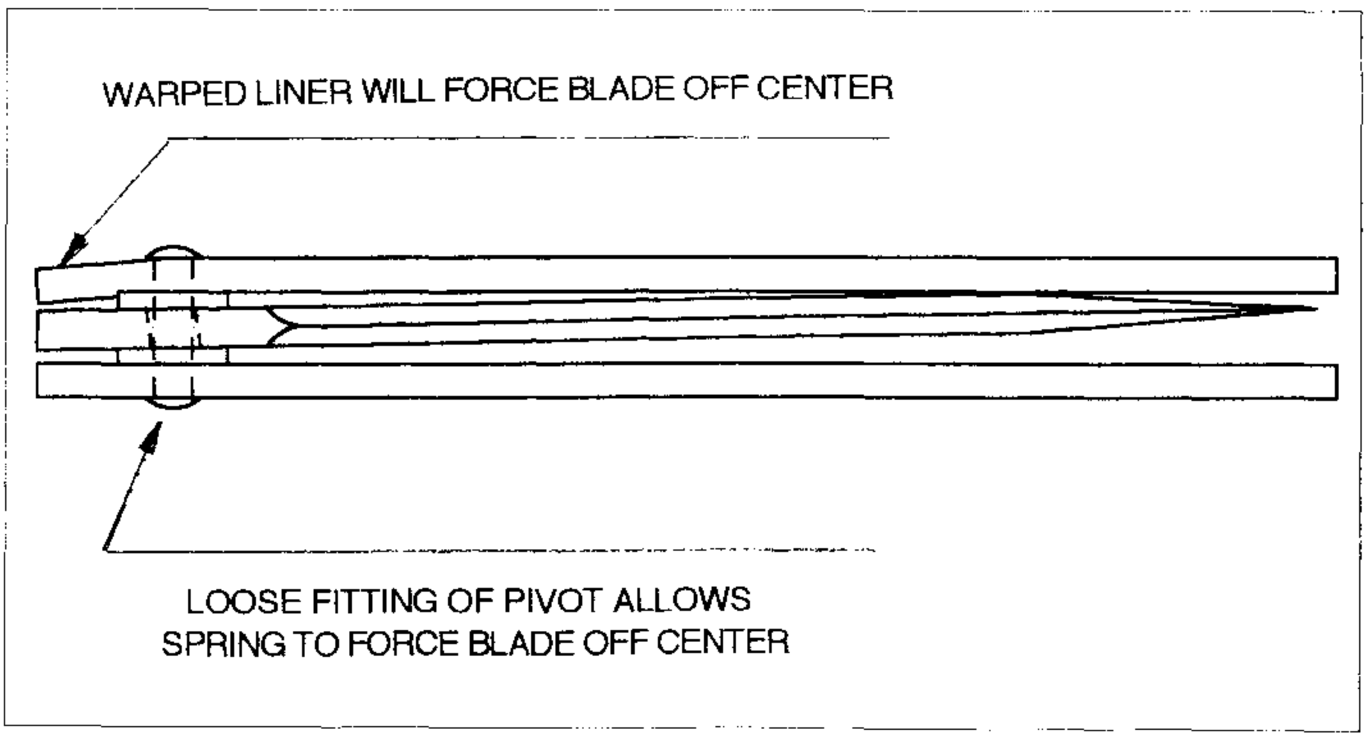


Fig. 72: A warped liner in front of the pivot will cant the closed blade over to one side. Also, if the pivot hole is too large in diameter, spring pressure may force the blade over to the opposite side.

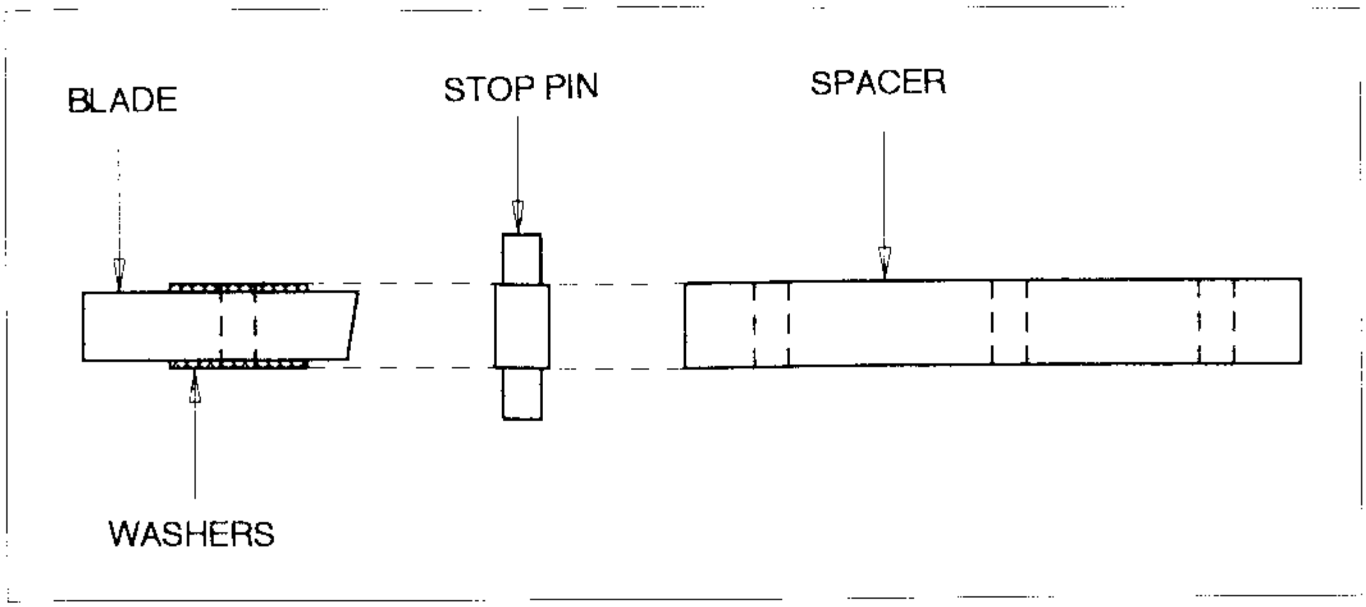


Fig. 73: If all of these parts are not of equal thickness, the sides of the knife will not be parallel. If the spacer and stop pin are thicker than the blade/washer assembly, the extra space between blade and handle will allow the blade to be forced to one side and jam the spring against the lock face of the blade.

This problem can also be solved by changing the stop pin to one of a slightly larger diameter. The angle of the open blade in relation to the handle will also be changed somewhat, lowering the point a bit, but this may be acceptable to your design.

It is also possible that the stop pin hole in the liners may have become oval-shaped by constant battering over time. This is particularly prevalent when the user insists on snapping open the blade thereby creating an intense hammering effect against the stop pin. If this occurs, those holes can be reamed round again and an oversize stop pin used to replace the old one. Also check the stop pin itself to see if it has been worn down, especially if it was not made of hardened steel.

Finally, check the pivot in the blade. It is possible the hardened steel of the blade may have worn down the diameter of the pivot causing excess play at the joint.

Lock is difficult to disengage from blade

There are several defects, any one or any combination of which will cause an overly sticky lock. This problem is most prevalent when using titanium for the spring. This material tends, when under pressure, to stick to steel. This is partly because of its makeup and partly because it will be considerably softer than the blade. However, the lock should release with only slight finger pressure applied to it. The following may cause "frozen" locks:

1. The pivot may not be properly tightened. If there is sideways play in the blade, the pressure of the spring will cant it to one side and create a "wedged-in" situation. I adjust my pivots so that the opening is smooth but the blade is not so loose that it will swing of its own weight when the spring is held out of the way. I prefer a slightly tighter blade to a very loose one.

Additionally, this side play of the blade may be caused by an improper fit into the handle. The spacer and the center step of the stop pin should be the same thickness thereby keeping the two liners of the handle parallel. This space between the liners must also be equal to the thickness of the blade plus the two washers used to separate the blade from the handle (Fig. 73). If there is space between the blade/washer assembly and the liners, the spring will once again cant the blade to one side when opened and jam itself in place against the blade.

2. The spring may be over-bent and jamming too hard against the blade. This is particularly troublesome if numbers 3 and 4, below, are apparent. Again, bend the spring only so far that it just reaches the opposite liner.

3. The spring face may be ground at a severe angle to the blade, looking at it from the side, so that it makes contact only at the bottom, sharp corner of the blade. Since the blade is much harder than the spring, this will cause the edge to cut deeply into the spring, thereby jamming it into position. Buff the bottom edge of the blade's lock face on a Scotchbrite wheel so that it is not sharp and be sure that there is at least 1/8 inch of contact between the two parts in the locked position (Fig. 74).

4. There may be too much contact between the spring and the blade or the spring may only be making contact on its side edge and not on its full face (this is mainly seen with titanium springs for the reasons stated above). If only a side edge of the spring makes contact, particularly with an overbent spring, the harder blade will deform the softer spring and jam it into position. Regrind the spring face and be sure to have the right amount of contact area between it and the blade.

5. The blades' lock face is not smooth enough to allow for the spring to be released. This most typically occurs when the blade has been sand or bead blasted and the lock face has not be smoothed off. The coarse finish on the hard blade will dig into the softer spring and not allow it to be released. Polish the blade's lock face on a Scotchbrite wheel after sandblasting.

There are probably many other solutions to these problems but I have found, over the years, that those described above will generally put a balky knife back into its prime.

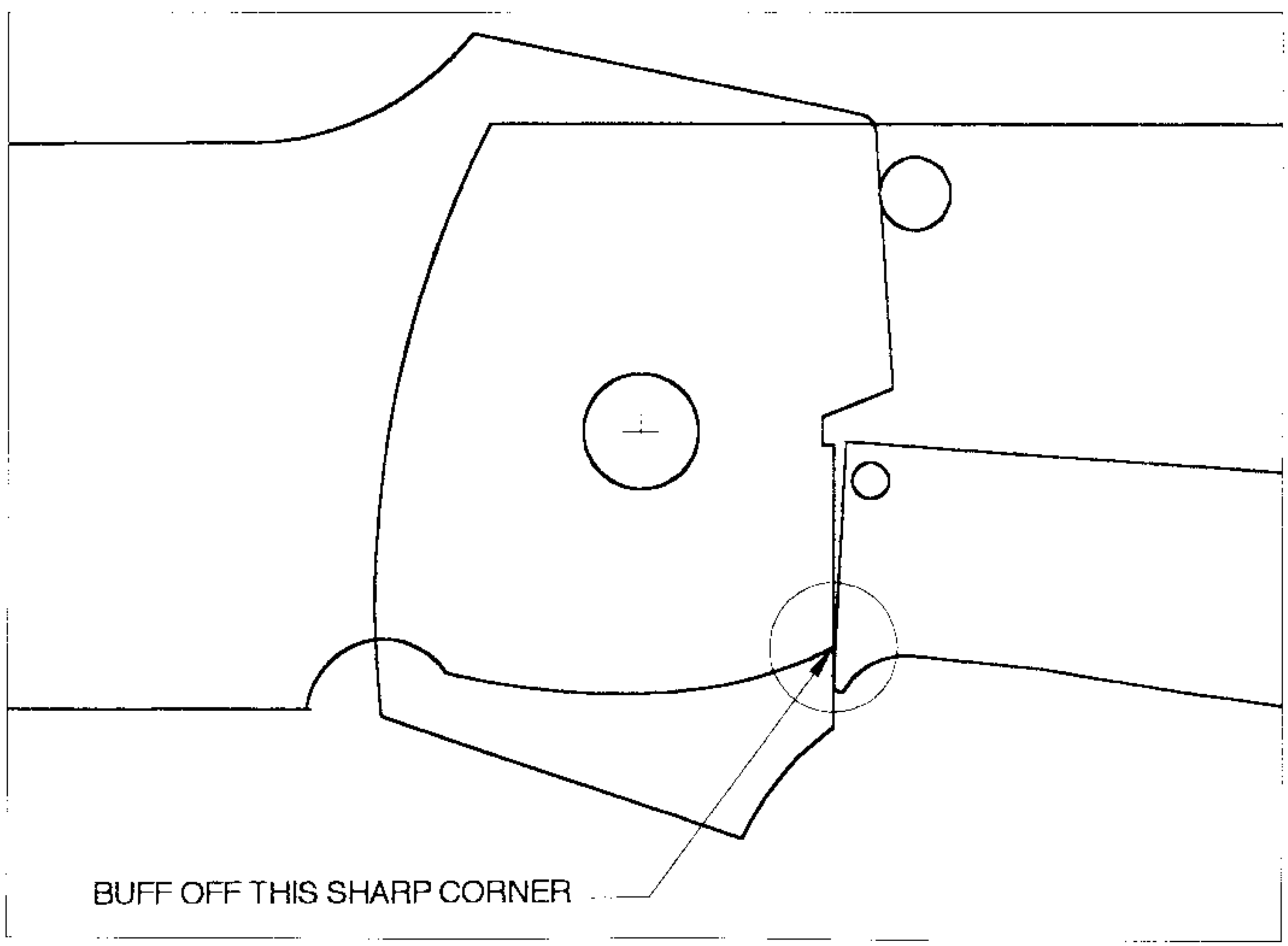


Fig. 74: If the spring contacts the blade only at the lower sharp corner, the blade will dig into the softer spring and jam it in place.

Chapter 5

Blade layout and fabrication

This is a description of how I make my blades. There are many different techniques used by other makers and, once again, I encourage each new knife maker to explore what works best for them. The blade, of course, is the heart of the knife with the handle there only to control and direct the blade. Take care in selecting the steel for the mission you expect your knife to be used for and invest the time in understanding the heat treating process and the relative merits of hardness, toughness, edge-holding and stain-resistance.

Today's sophisticated users of custom knives are well-educated in the fineries of blades and are careful in examining the finish, fitting, whether or not grind lines are even and overall grace of the design. Gone are the days (thank goodness) when a blade with errant scratches or wavy grinds could be sold to the buying public. With these caveats in mind, this is how I make my blades:

1. Select your steel and paint it with Dykem blue or a matte marker so that the scribe lines will show up clearly (Fig. 75).

Fig. 75: Paint the steel to show the scribed lines more clearly.

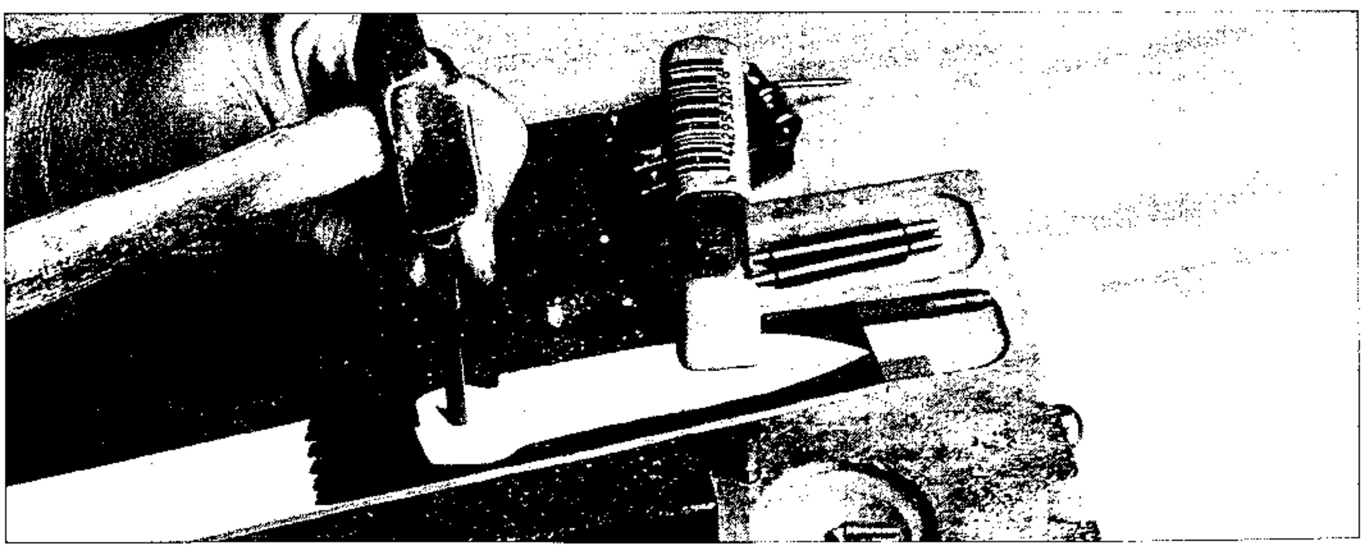


Fig. 76: Using a centering punch, punch through the pattern to mark the position of the pivot hole.

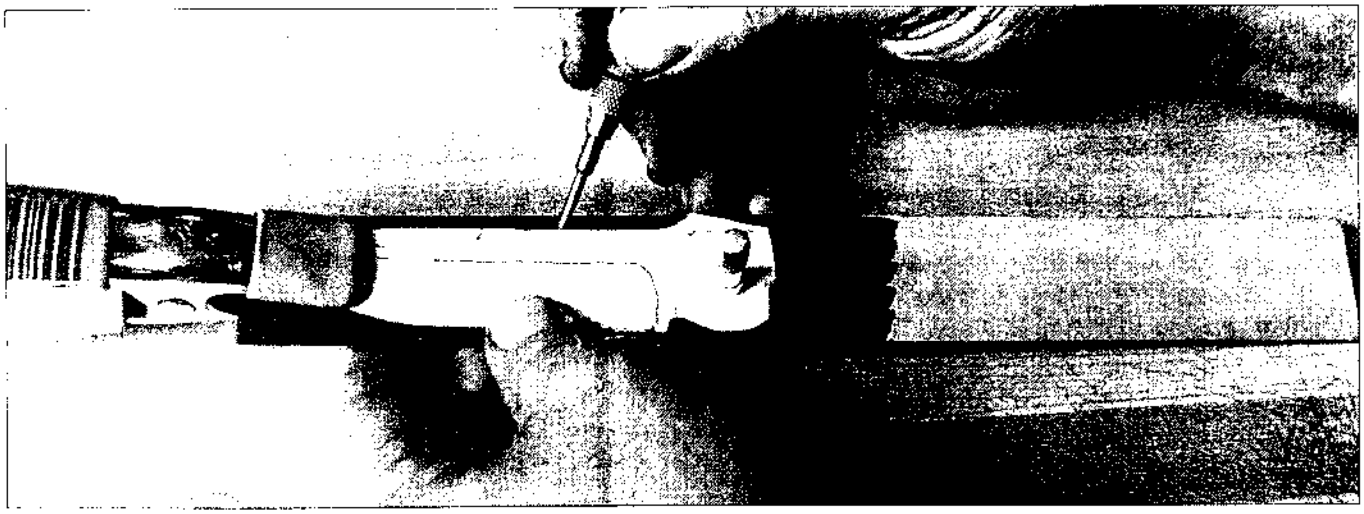


Fig. 77: Paint the steel to show the scribed lines more clearly. Scribe the blade outline onto the steel.

2. Clamp the pattern onto the steel with spring clamps in the correct position but don't scribe the profile just yet. Use a centering punch of the proper size to locate the point through the pattern where the pivot hole is to be drilled (Fig. 76).

3. Remove the pattern and drill the pivot hole with a slightly undersize drill. Since I use a 7/32-inch pivot, I therefore use a 13/64-inch drill. Ream the hole to the correct dimension, in this case, 7/32.

4. Using a try pin of the correct size through both the pattern and the steel, align the pattern with the steel bar and then clamp the point of the pattern securely. Carefully scribe the blade profile onto the steel (Fig. 77).

5. Remove the pattern and cut out the blade profile on the band saw, leaving the scribed line untouched (Fig. 78).

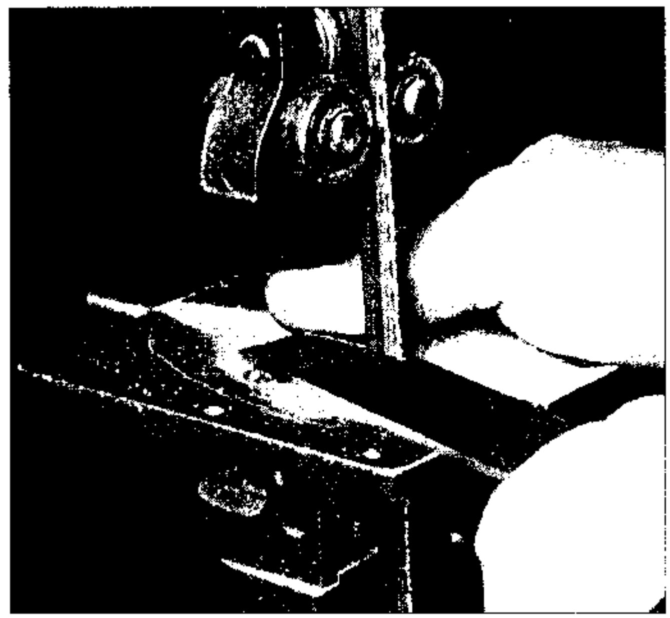


Fig. 78: Cutting the steel on the band saw.

6. Grind the profile of the blade on a used, coarse belt. Grind just down to the scribed line making sure that the curves and straight lines are clean and continuous, without bumps (Fig. 79).

7. A.. If you are going to use a thumb disc as the opener for your knife, set the blade in a drill press vise with the spine side up. The location of the disc (or thumb stud) will be determined by the location of the relief scallop on the handle and the front end of the spring. In any event, it should be placed as far to the back end of the blade as possible to avoid interfering with the cutting action of the knife, yet convenient for a smooth opening action with the thumb. Center punch for the screw hole in the exact center of the blade at the proper location (Fig. 80). Drill and slightly countersink, then tap the hole for the correct screw. I use a 1-72 screw for securing the thumb disc.

B.. If you choose to use a thumb stud instead of the disc, locate the correct placement of the hole as described above. Center punch and drill the correct size hole to press in the stud if it is to be a press fit. I prefer to use a screw-in stud, so I drill a 1-72 clearance hole and countersink the back side for a flat-head screw. I use thumb studs for smaller knives where a disc would just be too large and obtrusive. I make the studs myself out of 5/32-inch diameter, type 416 stainless rod, drill

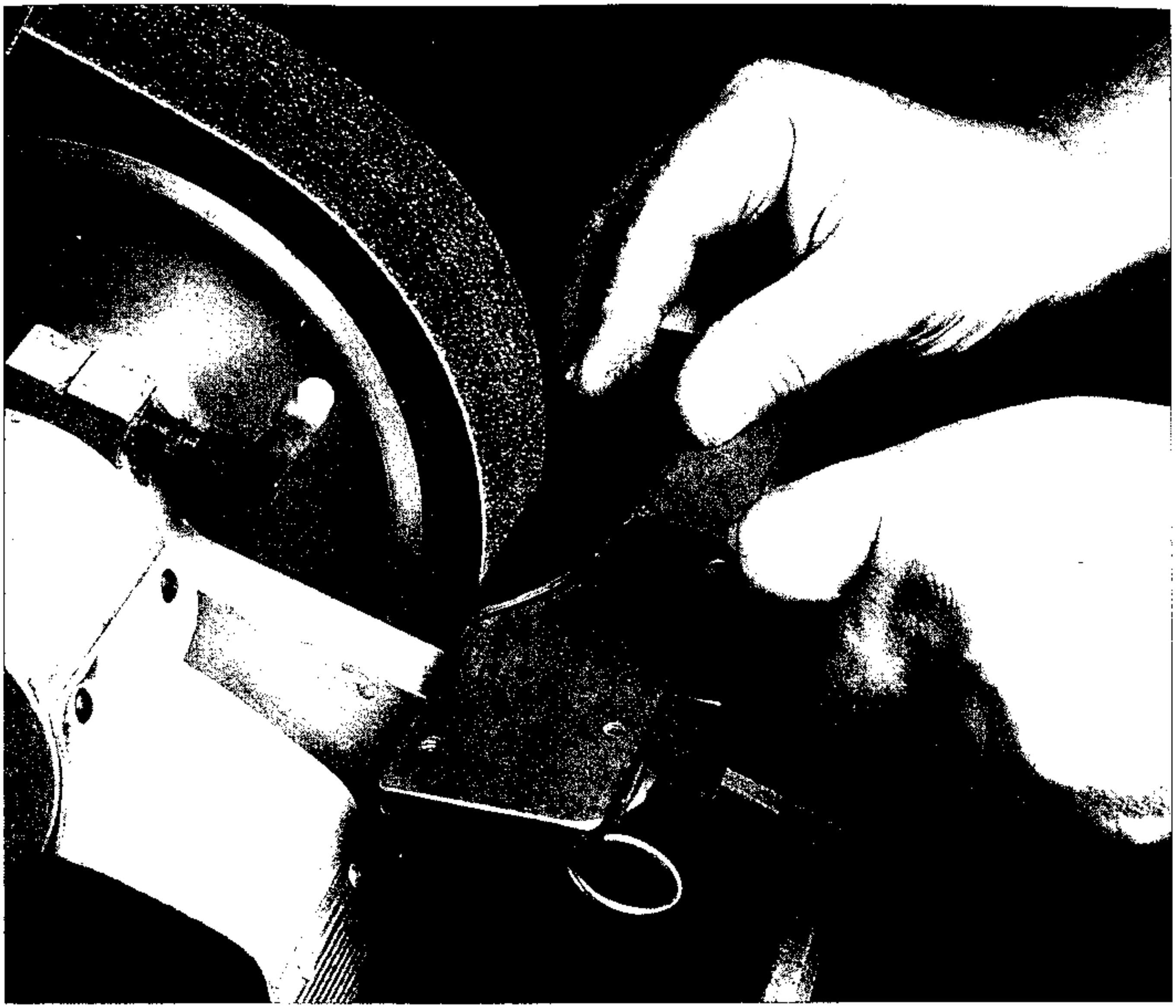


Fig. 79: Grind the profile just down to the scribed lines.

and tap them, then turn the face on the lathe into a dome and groove it for positive traction. Sometimes I make the stud out of 18K gold to dress up a special knife or to say "thanks" to a special customer (Figs. 81, 82).

8. At this point I heat treat the blade and do all of my grinding in the hardened state. Some knife makers prefer to rough grind the blade before heat treating and do the finishing afterwards. This is fine and is solely a matter of personal preference. If you choose to rough grind first, skip down to nos. 9 and 10, then come back here later.

I heat treat many of my own blades, especially when I'm in a rushed frenzy while preparing for a show. However, most of my blades are professionally heat treated in shops especially equipped to handle quantities in bulk.

I'll give a general recipe here that I use for heat treating ATS-34 but keep in mind that heat treating today's exotic steels is very exacting and specific to the individual steel. It should be done with care and, after studying the literature, the protocol should be followed religiously for each type of steel.

Here's how I heat treat my blades :

A. Preheat the electric furnace to 1,450 degrees F. I have built my own furnaces in the past and found that they worked well, but I now use a

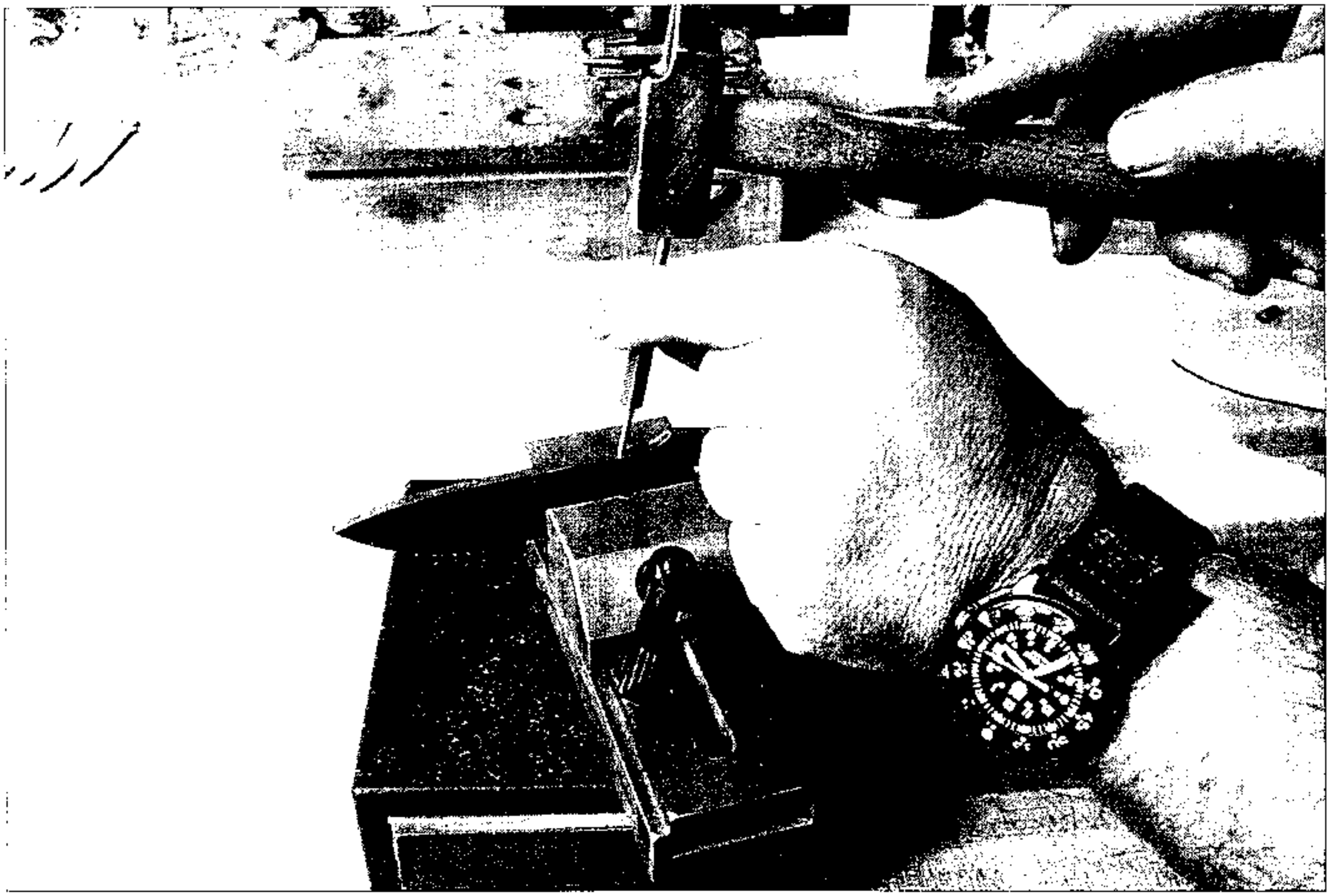


Fig. 80: Center punching for the thumb disc screw hole on the blade's spine.

Fig. 81: Making concentric cuts on the thumb stud to give traction when opening the knife.

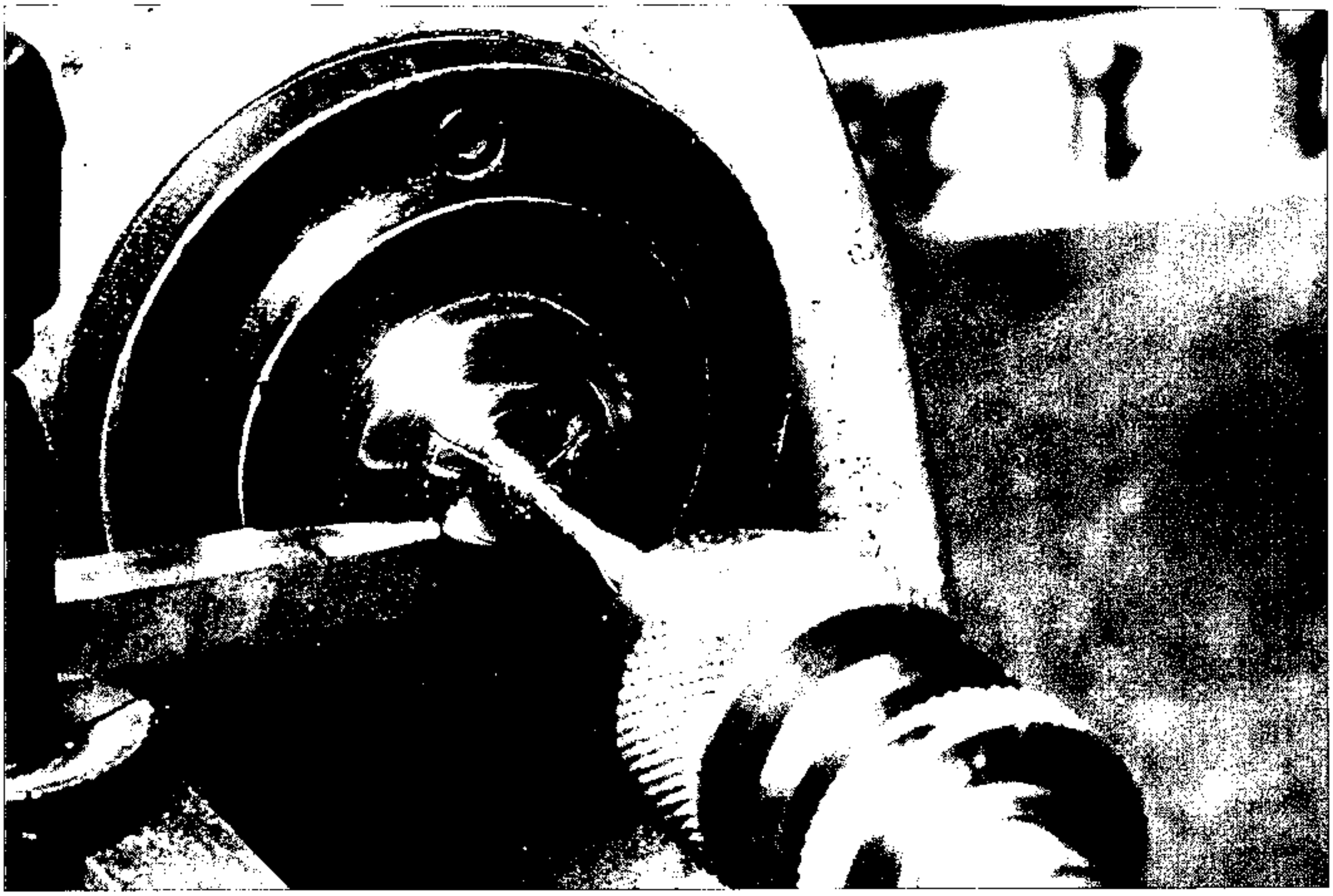


Fig. 82: Tapping the thumb stud for a 1-72 screw on the lathe.

Paragon knife maker's model with manual controls.

B.. Wrap the blade in stainless heat treating foil and carefully seal the edges, expelling as much air as possible (Fig. 83).

C.. When the furnace cycles at 1,450 degrees. insert the blade with a small, slotted. piece of fire brick or a ceramic holder that keeps it standing on its edge. The furnace will cool when the door is opened and the cold blade is inserted, so wait until the furnace recycles at temperature before you start timing it (Fig. 84).

D.. Soak at temperature for about 10 minutes, then raise the temperature to 1,950 degrees and soak for an additional 30 minutes.

E.. Remove the package with tongs and hold it in an air stream from a cooling fan until it is down to room temperature or cool enough to handle. Hold the blade with the edge towards the air stream. If you hold it sideways, it will warp on you (Fig. 85).

F.. Remove the blade from the foil package and immerse it in liquid nitrogen to cryogenically quench it for four hours. Liquid nitrogen can usually be bought inexpensively from a local welders' supply store. I have them fill up a couple of stainless steel thermos bottles for me which costs about five to ten bucks (Fig. 86).

If liquid nitrogen is not available, dry ice and alcohol will do. Immerse the blade in a metal container with alcohol and slowly submerge chunks of dry ice into it until the violent bubbling stops. The container should be sealed shut and it should be in a well insulated outer container such as a Styrofoam cooler, packed all around with sawdust. The idea here is to keep the steel at colder than 100 degrees below zero for four hours to complete the quenching process.

G.. After the cryogenic quench, temper the blade twice in the furnace at 950 degrees F for two hours each time, allowing the blade to cool to room temperature in between (Fig. 87).

At this point, the hardness of the blade should be about 60-61 Rc. There is some controversy about the tempering protocol of ATS-34, so let me try to clarify this point.

This steel has two temperature ranges of tempering, low and high. The low end of the curve, 350 degrees F, will give a hardness of about Rc-62. However there are two drawbacks to this low-range temper. First, the steel does not develop its maximum toughness and is very prone to chipping and breakage. This I have tested extensively and found to be true, particularly with very thin edges. Second, if a blade is heated above its temper point, say while grinding or sharpening, and the steel turns shades of brown or even blue, the temper will be compromised and become uneven along the edge. This is especially important for those of us who grind or finish blades in the hardened state. If the blade is tempered at the high end of the curve, however, (950 degrees), You can grind the blade blue and beyond without affecting the temper.

9. After the blade is tempered, check it for warpage against a straight edge or surface plate (Fig. 88). If there is some curvature to it, grind it flat. Some lucky makers have a surface grinder, but I do not. I grind the blade flat on a disc grinder with coarse, wet or dry paper, holding it with a magnetic holder (Fig. 89).

10. Mark the blade for grinding the bevels, starting with the edge first. I use a surface gage and surface plate for this process. I replaced the surface gage scribers with carbide ones so they will scratch the hardened steel. Set the scriber point to a level about .015 inches below the centerline of the cutting edge of the blade. With the blade on the surface plate, scribe a line along the edge from point to heel. Flip the blade over and repeat the process thereby creating two parallel lines, .030 inches apart, which define the blade's cutting edge (Fig. 90).

Determine the point, up the side of the blade, where the side bevel is to reach. I set the blade into a Micarta holder which holds the blade in an upright position, cutting edge down. Scribe a line parallel to the edge at the point describing the height of the bevel. Repeat the process on the opposite side. Keep in mind that the line on the side of the blade and the line at the cutting edge describe a bevel which is going to be created by the grinders' contact wheel (for a hollow grind), or the platen (for a flat grind) (Fig. 91).

11. Rough grind the blade bevels. Remove the bulk of the steel between the edges and the side lines on both sides of the blade. I use a new, 60-grit Norton, ceramic hogging belt for this step. Don't touch the lines, leave a little for the finishing belts (Fig. 93).

It seems that every knife maker has his own technique for blade grinding and I'll give you mine here. I use an extended tool rest on my grinder and I hold the blade at the proper angle in a fixture that I designed and made for that purpose (Fig. 92). (See Chapter 9). I do free-hand grinding from time to time but I find that the fixture helps

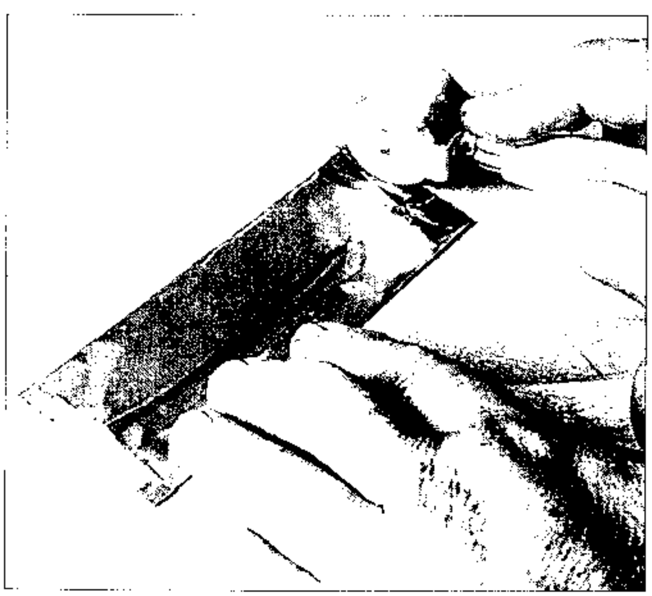


Fig. 83: Sealing the foil before heat treating the blade.

Fig. 84: Place the blade package, standing on edge, in the pre-heated furnace.

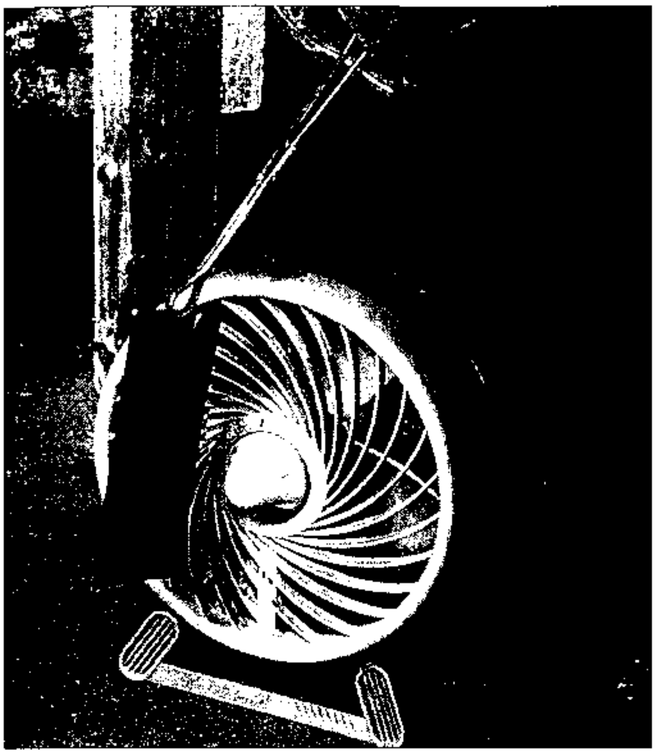


Fig. 85: Quench the package in an air stream with the cutting edge towards the flow from the fan.

me get more consistent results with far less stress. You can use a clamp or holder at the back of the blade and a push stick to control its movement, or, you can cut out two blades joined tang to tang and use one blade as the handle while you grind the other. After the grinding is done, you can then separate the blades with a cut-off wheel.

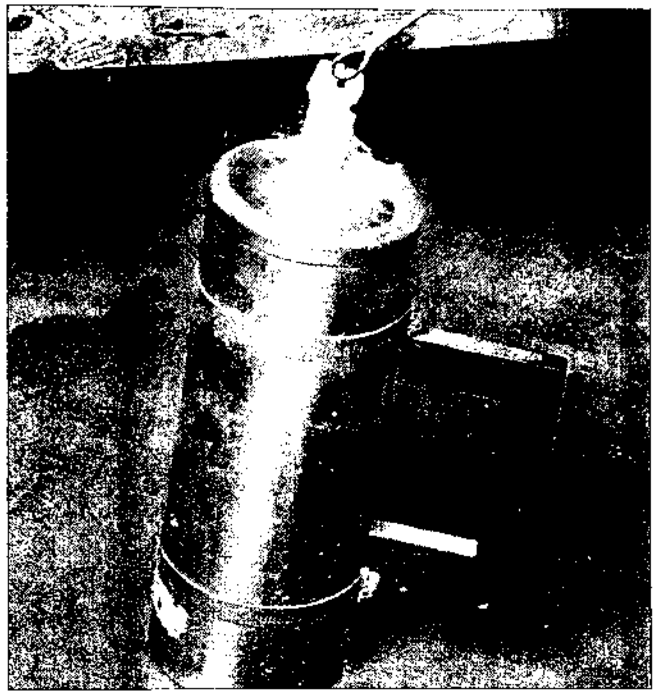


Fig. 86: Giving the blade a cryogenic quench in liquid nitrogen.

12. Mark on the blade spine, the points which will define the false edge (Fig. 94), and grind those bevels as described above. You can use a finer belt to begin with since there is not as much material to remove (Fig. 95).

13. Grind the lock bevel at the back of the blade. As described in Chapter 4, I use an 8-1/2 degree curved bevel with a 2-inch radius. I made a fixture for this process which is described in Chapter 9 (Figs. 96, 97).

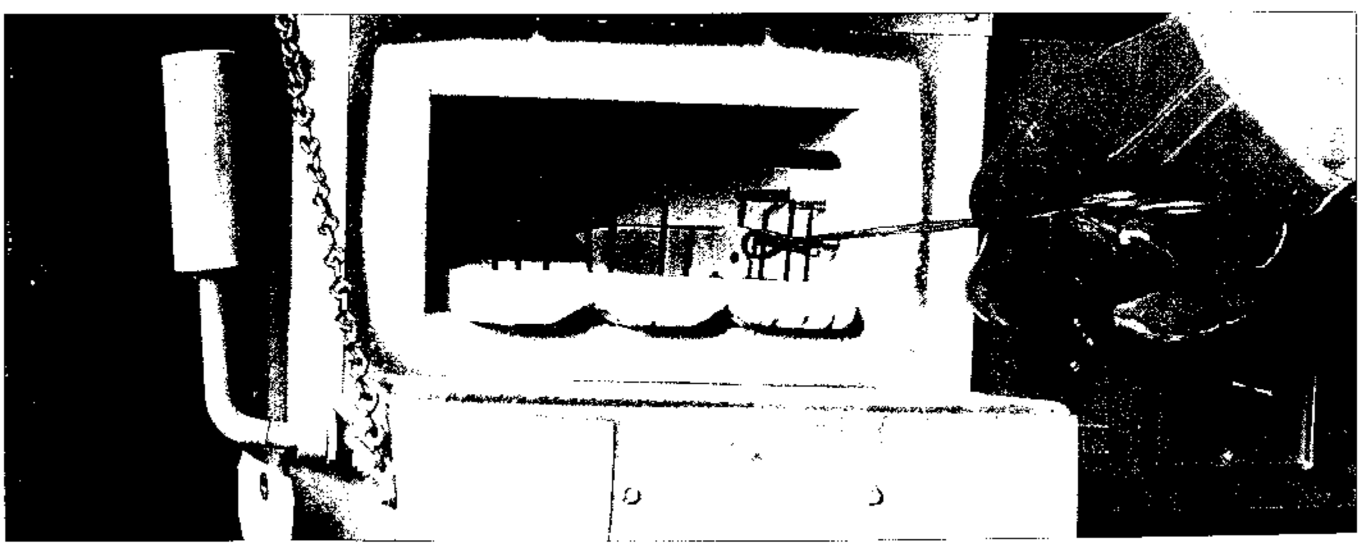


Fig. 87: Temper the blade twice at 950 degrees F

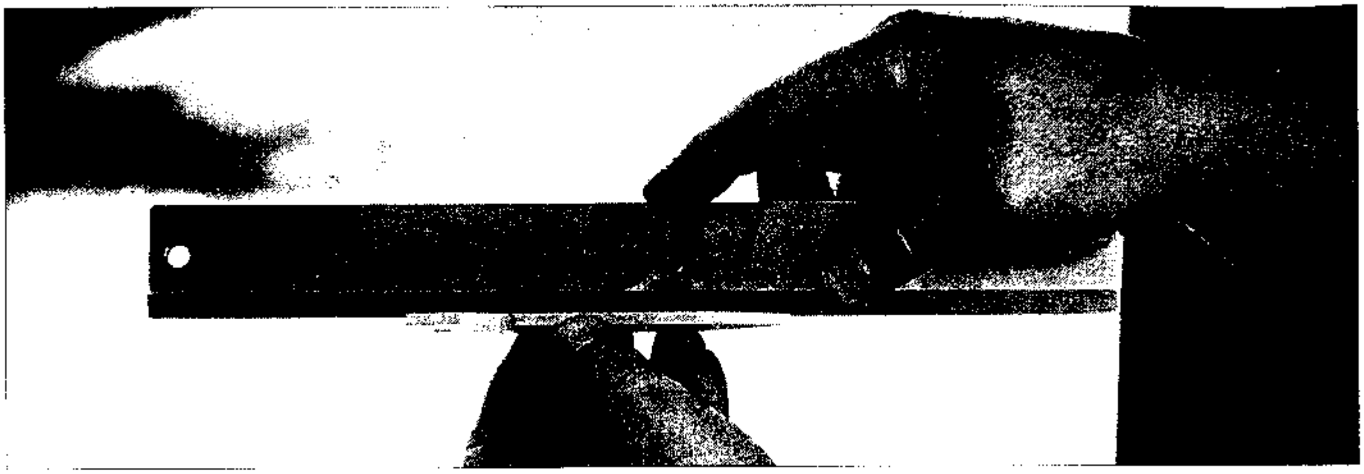


Fig. 88: Check the blade for flatness with a machinist's straight edge. Grind it flat if necessary.

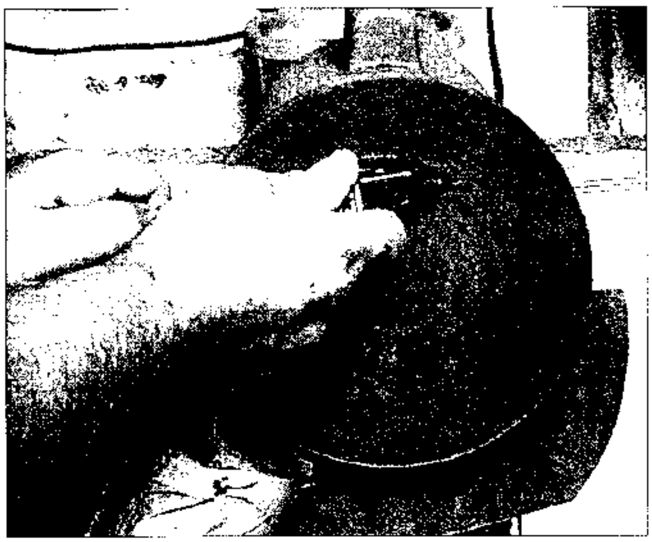


Fig. 89: I use an 8-inch aluminum disc grinder with coarse abrasive to flatten my blades. The blades are held on a magnetic holder which helps to preserve my fingertips.

14. At this point, use the handle pattern to adjust the blade's opened and closed position in the same manner used to create the patterns, discussed in Chapter 2, steps 7 and 8 (Figs. 98, 99).

15. Regrind the blade with a medium belt such as an 80-micron micro-finishing belt and finish the process with an A45 or A30 Trizact belt. I usually use older, worn belts for this procedure. Work down a little below the scribed edge lines so the finished blade will have a cutting edge of about .020 inches (Fig. 100). The blade can be left as-is after finishing the flats on the spine and the top edge or it can be hand-rubbed to a satin finish or bead blasted for a subdued surface. If you bead or sand blast, I recommend running the blade afterwards on a 3M purple-flap Scotchbrite wheel at medium speed to smooth off the coarse effects of the sandblasting (Fig. 101).

16. Grind in the ridges on top of the thumb ramp with a narrow cutoff wheel. If you choose to use a checkering file for sharper edges, this operation should be done before heat treating.

At this point set the blade aside and proceed to making the handle and spring. Save the sharpening and logo marking as the last steps on the completed knife.

Serration

Serrated knife blades are not new and have been around on kitchen cutlery and specialty knives for a long time. They tend to impart an aggressive cutting action to the blade thanks to the toothed configuration but also because the length of the cutting edge is actually lengthened as it follows the curved pattern of each serration. Today's use of serrated blades in tactical folding knives, both custom and factory produced, can be attributed directly to Sal Glesser of Spyderco who has probably done more research and promotion of this feature than anyone else. I personally prefer blades which are half-serrated, at the back end of the blade, where most of the heavy duty cutting tends to be performed. I find serration most useful for cutting difficult materials such as rope, leather and cardboard but less useful for more delicate operations such as sharpening a pencil. (Yes, I know, we're talking about tactical knives here but let's face it, more people will use their knives to cut a clipping from a newspaper than will use them in a serious fight!)

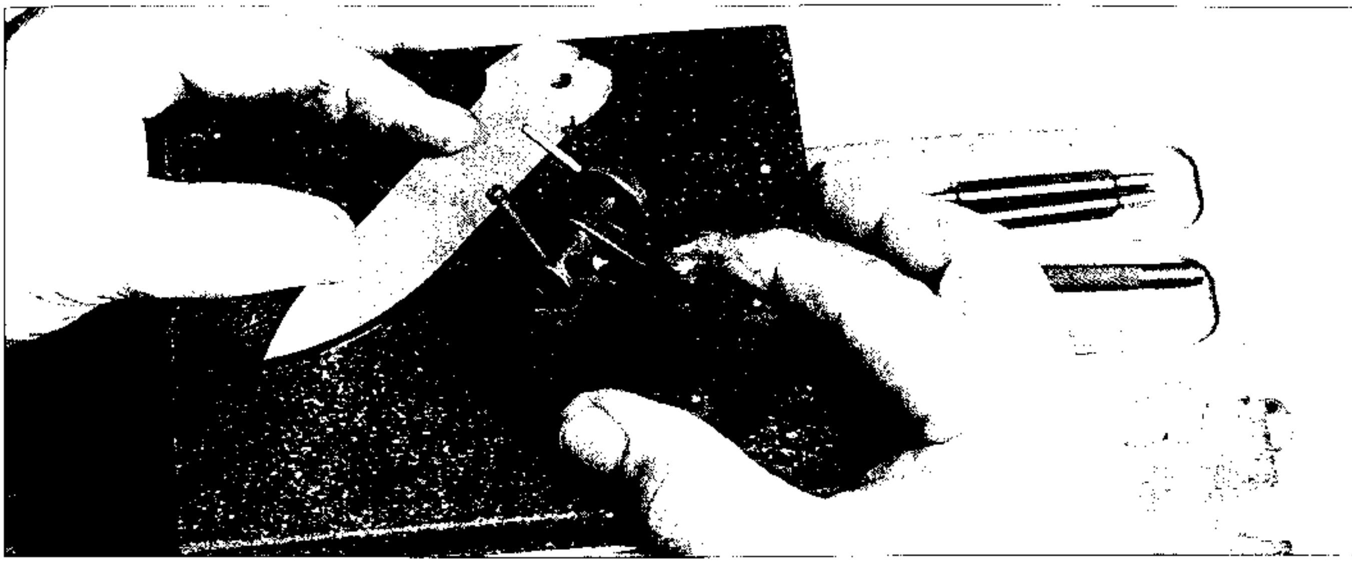


Fig. 90: Scribe two parallel lines on the edge to define the grind lines. The scriber of the surface gage was replaced with a carbide one for marking the hardened blades. I leave a centered space of about .030 inches for my edge which will later be finished down to .020 inches.

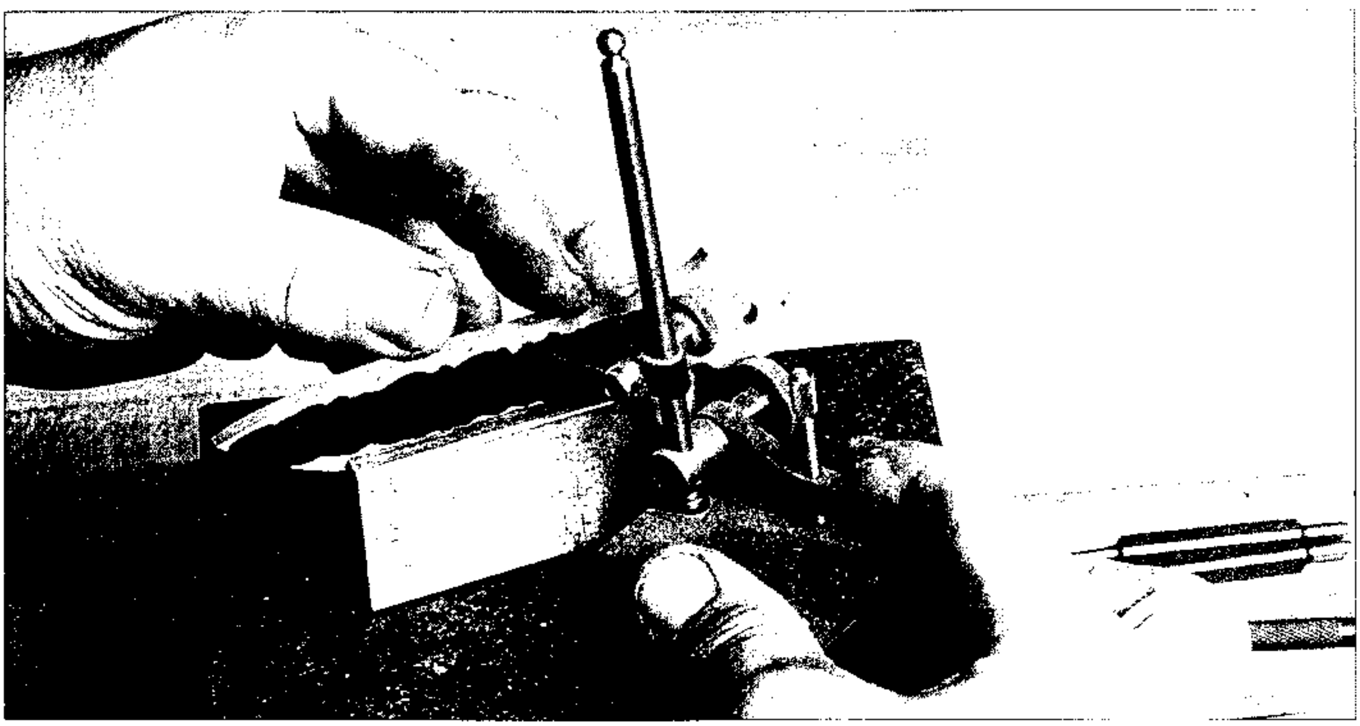


Fig. 91: Scribe a line on each side of the blade to define the height of the bevels to be ground. I hold the blades parallel to the surface plate with a notched Micarta holder. (See Chapter 9)

I make my serrations on a specially formed grinding wheel after putting an edge on the blade but before honing it on a ceramic sharpener. This grinding wheel is of aluminum oxide and each groove is formed into the wheel with a single-point diamond forming tool.

Some makers put the serrations on before the edge but I have found no difference in performance. The most effective angle for serration appears to be about 15 degrees or less and I have had good results with this configuration.

Random Thoughts On Blade Grinding.

It doesn't matter so much what the ground bevels look like just as long as they are the same on both sides and are cleanly and sharply defined. This problem is eliminated, of course, if you choose to use a chisel grind which is only done on one side of the blade. This saves more than half the time in grinding and obviates the need to match up the two bevels. This is a real time and stress saver, but I find that the chisel grind tends to be less than useful in everyday cutting situations. The original chisel grind, as far as I have been able to determine, was used on knives of a highly specialized nature, namely the Japanese sushi knife and the horticulturist's grafting knife. For most common cutting operations, however, I prefer the more challenging but more conventional, double bevel.

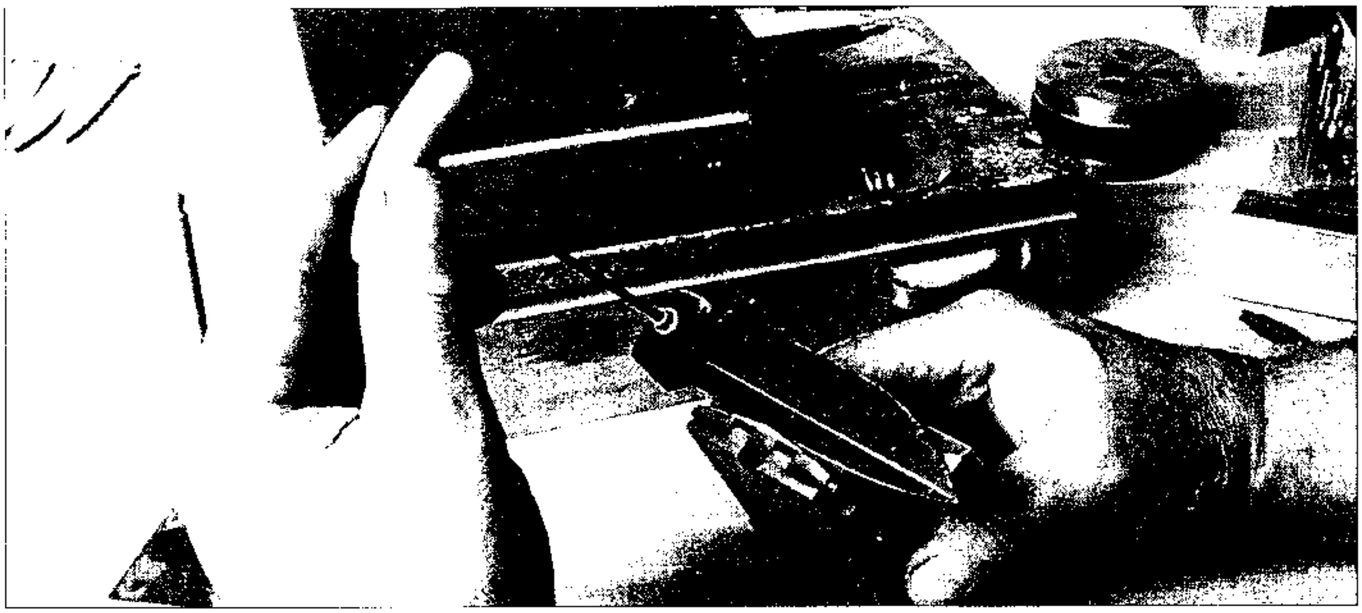


Fig. 92: I use a holding fixture to grind my blades (See Chapter 9). This helps me keep the grinds straight and even with a minimum of effort.

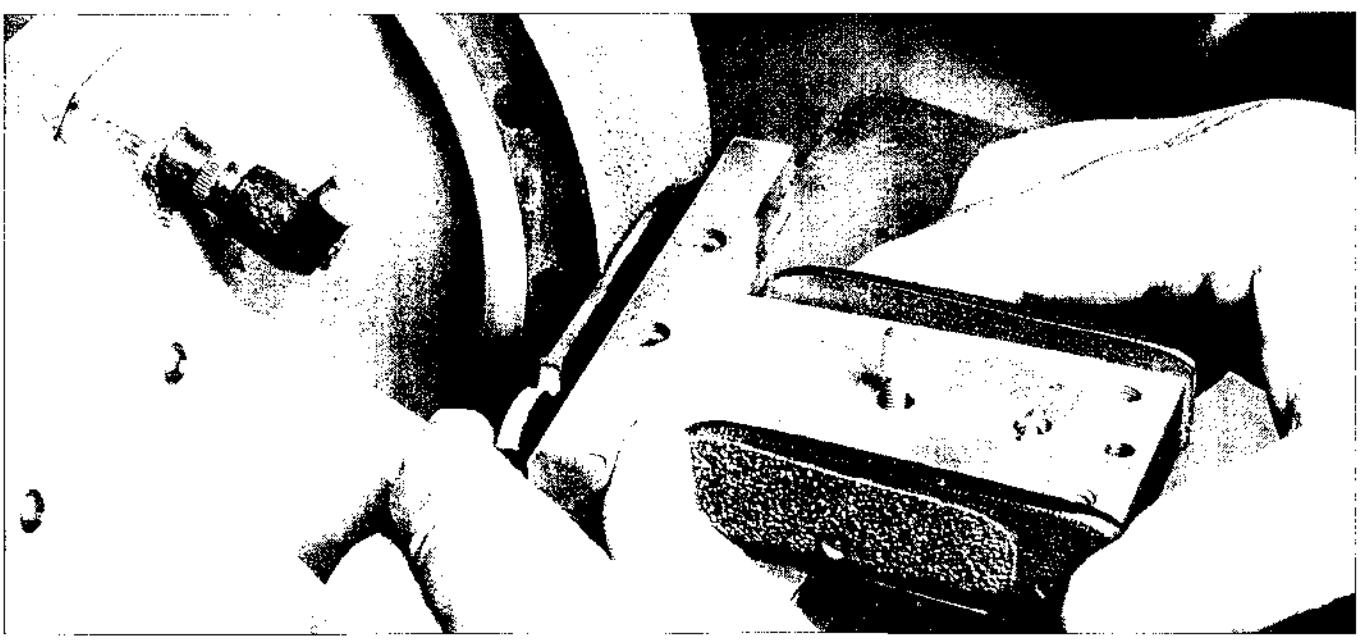


Fig. 93: Grind the side bevels with a new, coarse belt. Make sure the bevels are equal on both sides.

Grinding a blade is far more complex than it seems. If you don't believe me, try teaching it to a beginner and you'll realize that you perform many actions with your whole body and arms and hands than you realized. The key here is some competent instruction when possible and lots of practice. A whole lot of practice!

One of the problems with grinding a blade is that there is no part of the human body that moves in a straight line, since everything from fingers to shoulder function in circular motions around a pivot point. Translating those movements into straight lines requires concentration and repetitive practice.

There are many techniques for grinding a blade. Some makers sit. Some stand. Some use a tool rest while others say that a tool rest compromises the purity of the work. To each his own in what makes him most comfortable and produces the best results.

The act of finishing or polishing a blade's surface is that of creating scratches, replacing large scratches with finer scratches until the eye can no longer see them. At that point you have a polish. I have found that I can save a great deal of time by tumbling my blades in a rock tumbler with ceramic abrasive. Then, I can hand finish the blades or sandblast them if I choose.

A hand-rubbed finish is very attractive and not too hard to do. Use successively finer grades of wet or dry paper down to about 800- or 1200-grit. I use WD-40 on the paper and a leather or hard rubber backing. Move only in one direction. To avoid little swirls forming where the abrasive reverses direction, don't rub back and forth (Fig. 102)

Flat sides are easily hand-rubbed by laying the abrasive paper on a flat plate such as a sheet of glass and holding the blade with a magnet or double-stick tape. Be careful to move the blade on the abrasive paper in straight lines, parallel to the cutting edge. Again, WD-40 helps give a nice finish (Fig. 103).

Fig. 94: Mark the top of the blade's spine at the point you want the false edge to reach, back from the point.

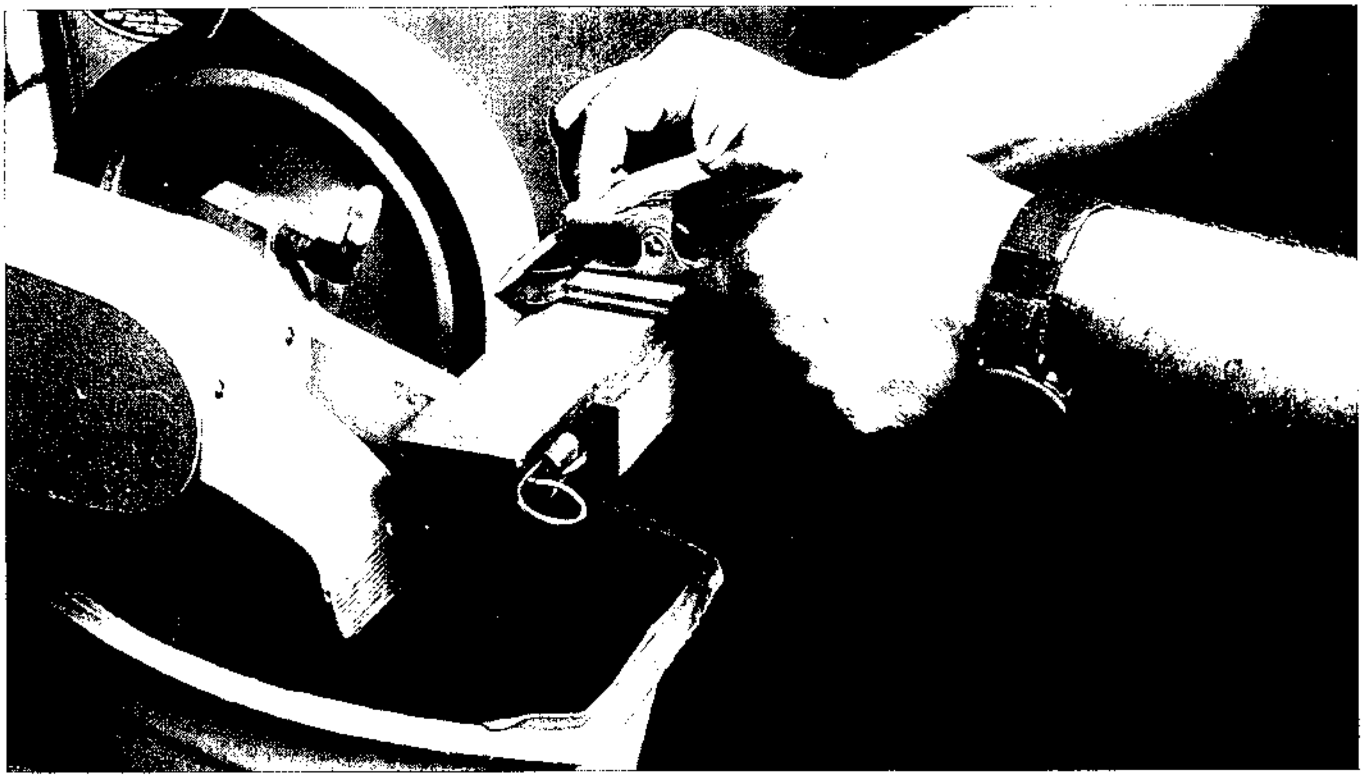


Fig. 95: A holder helps keep the false edge at the proper angle on both sides of the blade. (See Chapter 9)

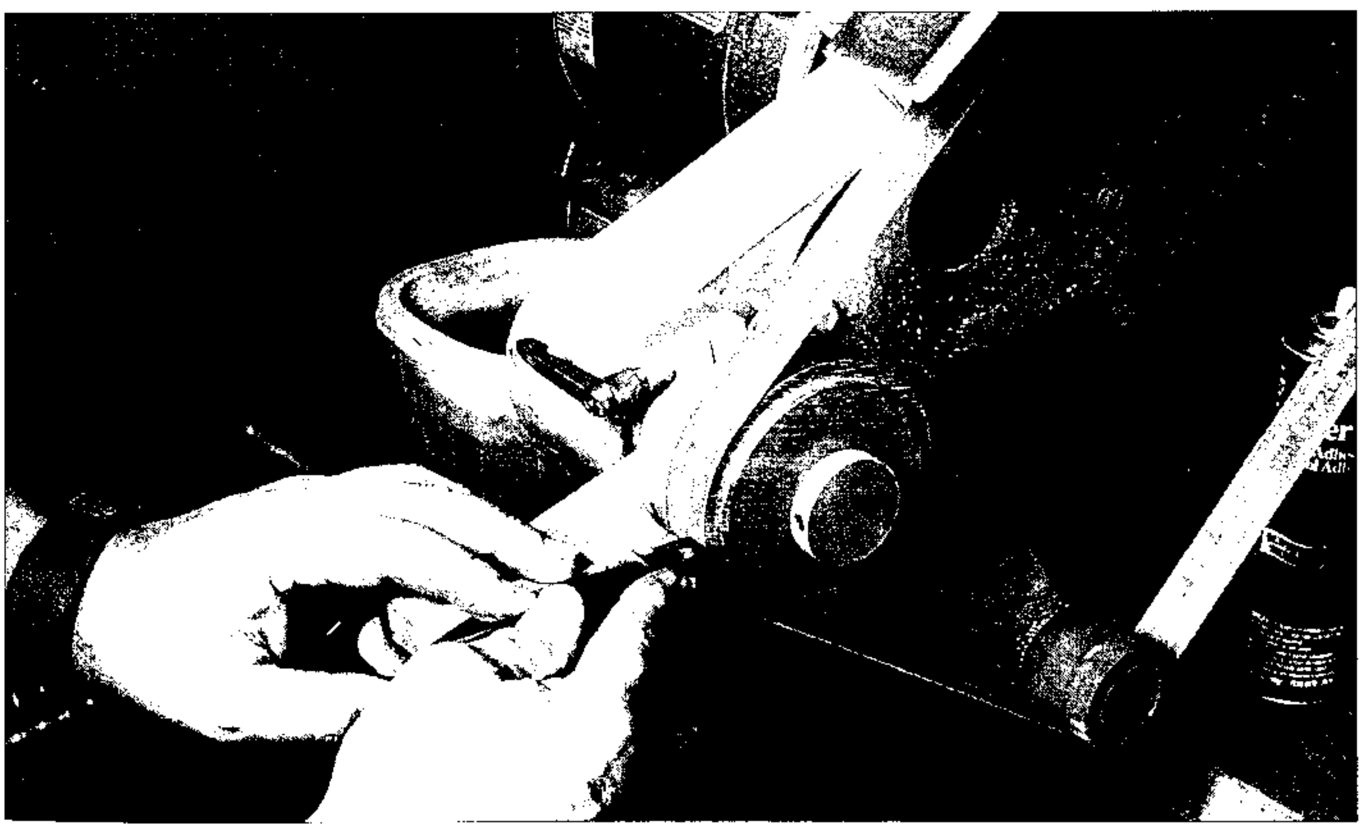


Fig. 96: Grinding the lock bevel on the blade's tang.

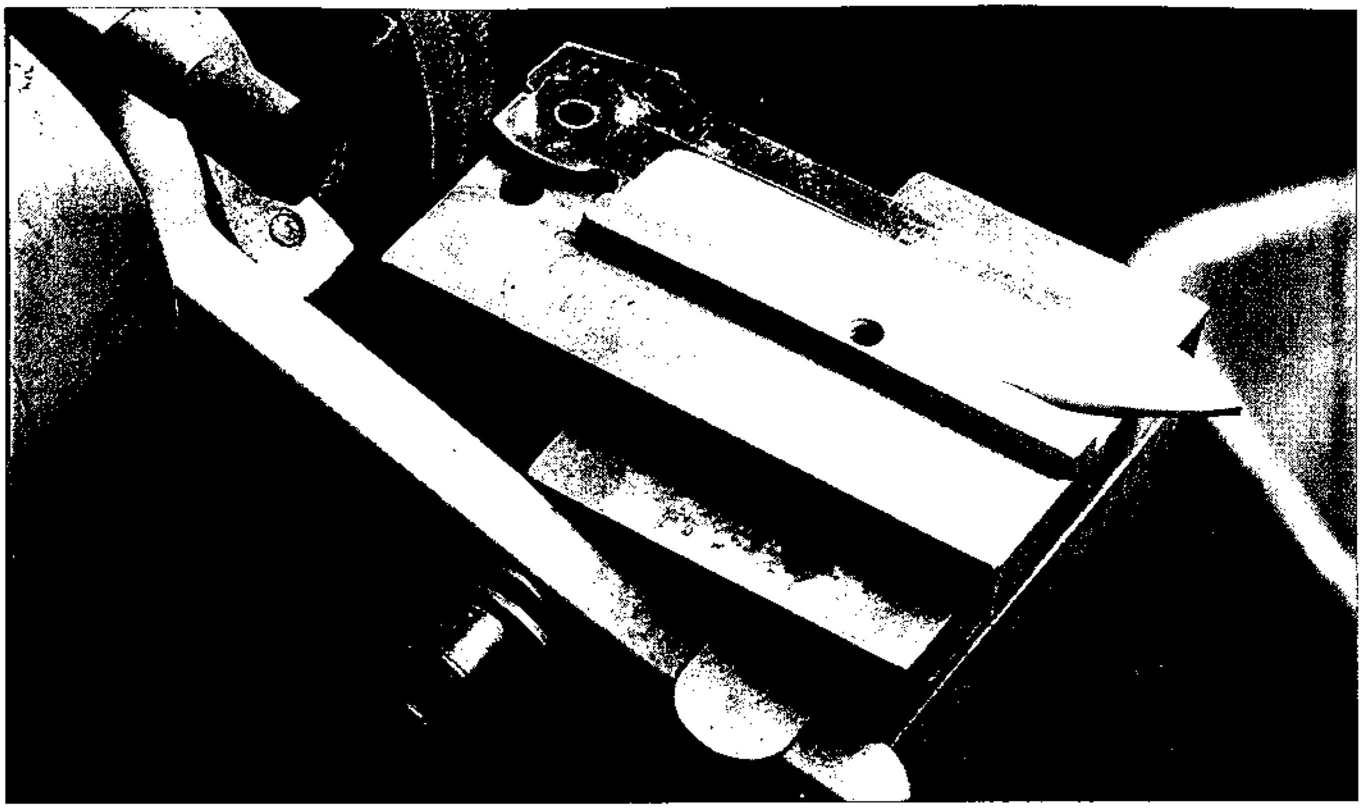


Fig. 97: This is the setup I made to hold the blade at 8-1/2 degrees to the contact wheel for the lock bevel. (See Chapter 9)

Fig. 98: Verifying the open aspect of the blade against the handle pattern to be sure that the blade neither dips too low nor rises too high. Final checking is done with a special gage. (See Chapter 9)

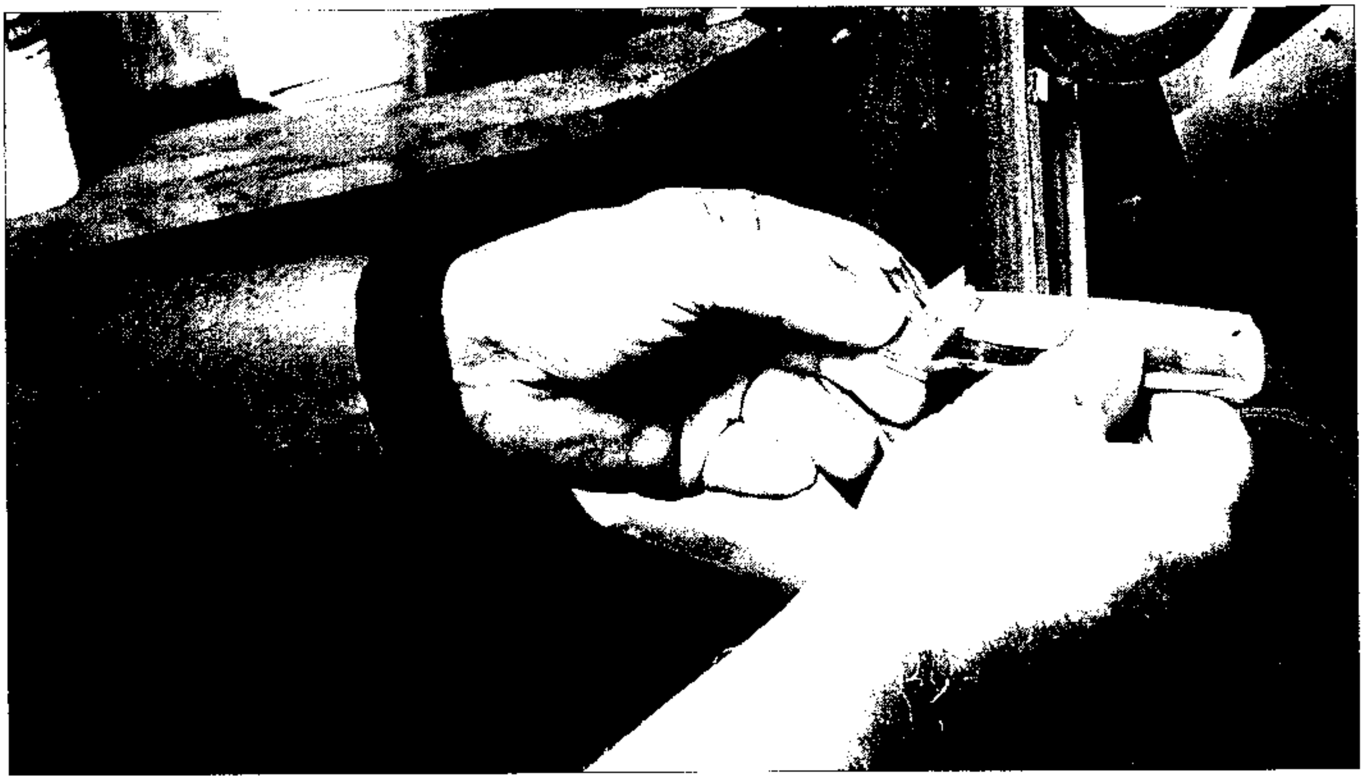


Fig. 99: Verifying the closed position of the blade against the handle pattern to be sure that the blade point is properly shrouded by the handle, yet isn't buried so deeply as to contact the spacer.

Fig. 100: Finish grind the bevels with finer, used belts.

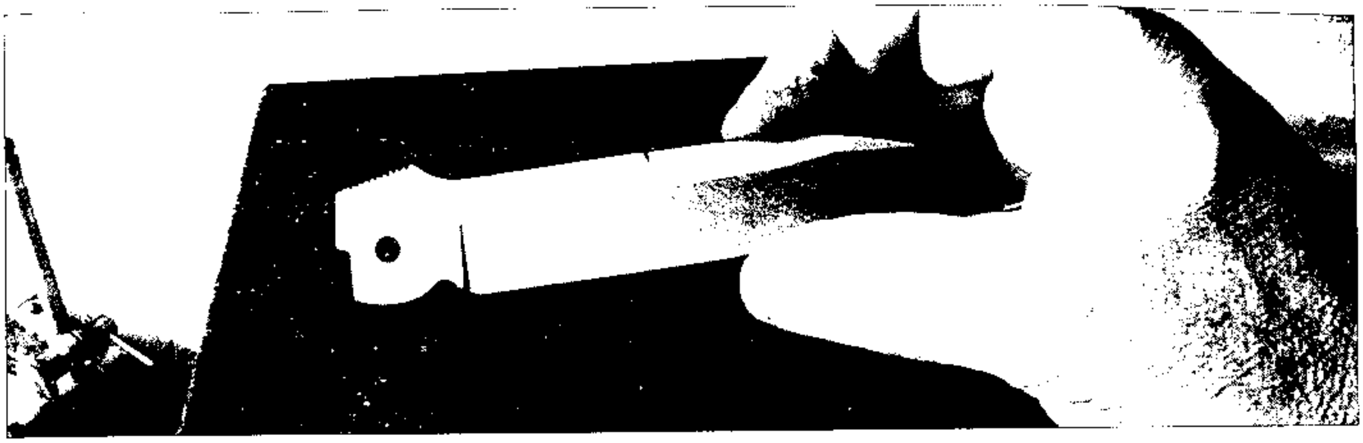


Fig. 101: A sandblasted blade polished with a purple Scotchbrite flap wheel gives a matte but smooth finish.

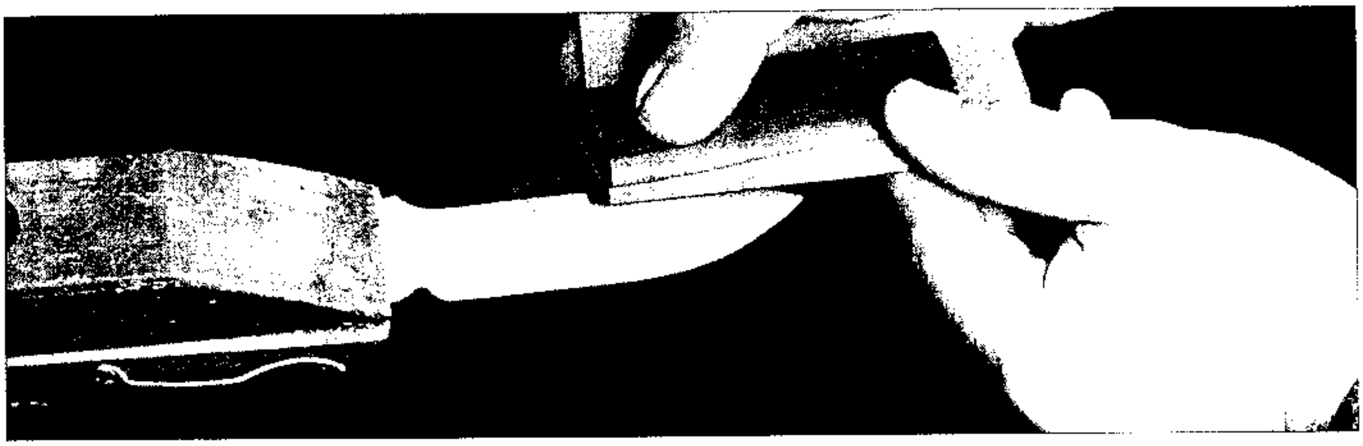


Fig. 102: A hand-rubbed polish gives a beautiful, rich finish to the blade.

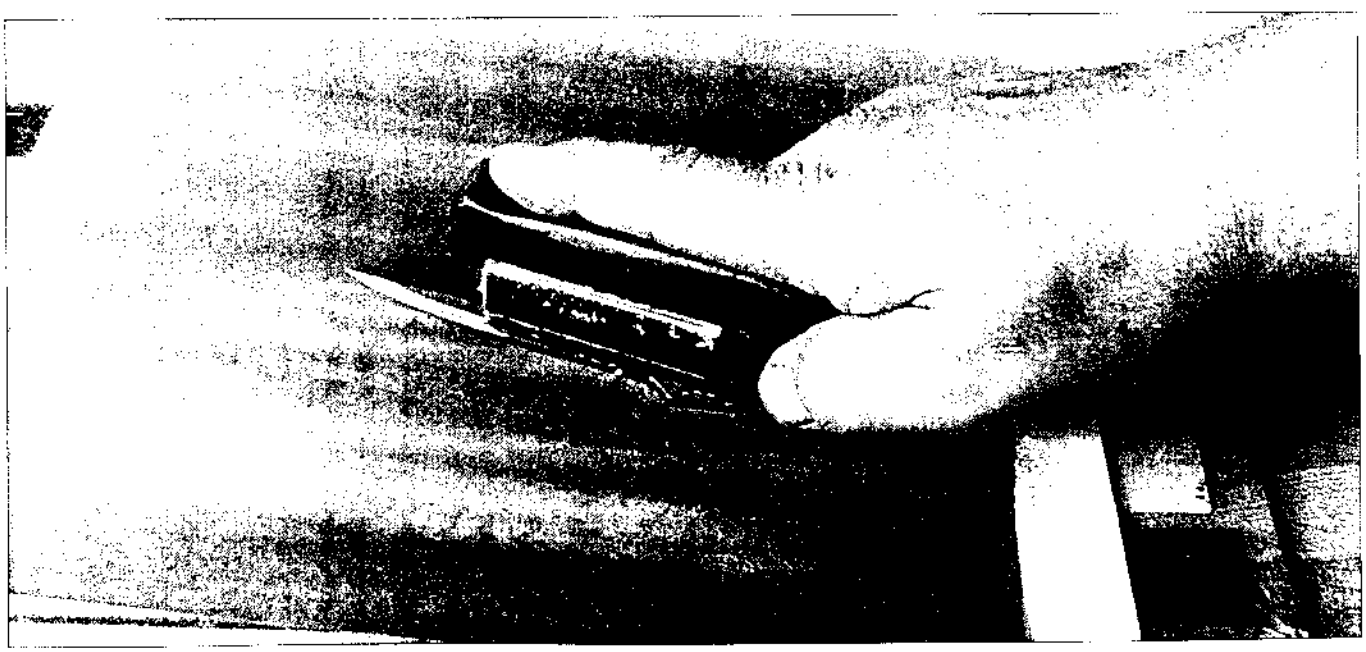


Fig. 103: Polishing the flats with wet or dry paper on a sheet of glass.

Chapter 6

Making the handle frame and spring

For the purposes of this discussion, we are making a standard ATCF folder, that is, two side plates (the handle) and a third, inner plate (the spring plate, also called the liner) (Fig. 104). There is no need for a second liner because the strength of the handle alone far exceeds any force that can be applied to it with the human hand. This is only one of several techniques used to make a linerlock. Another is to use bolsters, (See Chapter 8), in which two liners are used; or the inlaid spring technique in which no internal spring plate or liner is used but instead a small spring is inlaid directly into the handle plate (See Chapter 7).

Once again, we are using titanium for both handle and spring but other materials may be used for the handle frame such as aluminum, laminates, stainless steel, etc.

For the ATCF, I use .080-inch titanium for the handle and .063-inch titanium for the spring plate (or liner).

1. Select two pieces of handle material and one piece of spring material of the proper size. Sandwich them together with the spring plate in the middle and clamp the sandwich securely, along with the handle pattern on the top (Fig. 105).

2. Drill out only the screw holes through the whole assembly with the proper size tap drill (Fig. 106). in this case, for a 1-72 thread, use a #53 drill. Separate the pieces and tap only the bottom plate. A slight countersinking of the holes will facilitate tapping them. Use a tapping fluid such as Molylube and if you are hand-tapping, be sure to break the chip often by reversing the tap, especially if you are working titanium (Fig. 107).

3. Drill out the holes in the top handle plate and the spring plate for screw clearance with a #48 drill.

4. Countersink the handle plate clearance holes to the depth of the 1-72, flat-head screw. I find that a single-flute, carbide countersink works best in titanium (Fig. 108).

5. Assemble the three plates again, but this time, instead of clamps, use screws which will project a bit

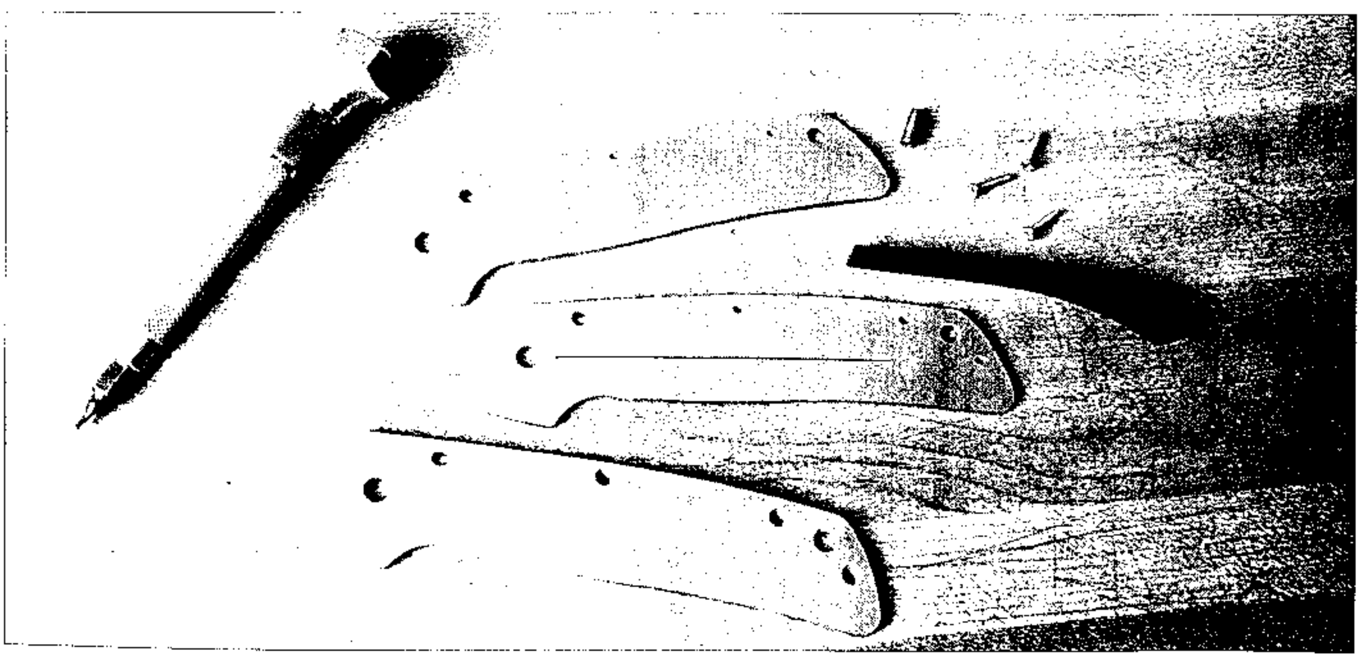


Fig. 104: The basic parts of the ATCF handle; two handle sides and the spring plate (or liner).

Fig. 105: Clamping the pattern to the three-piece sandwich of handle material.

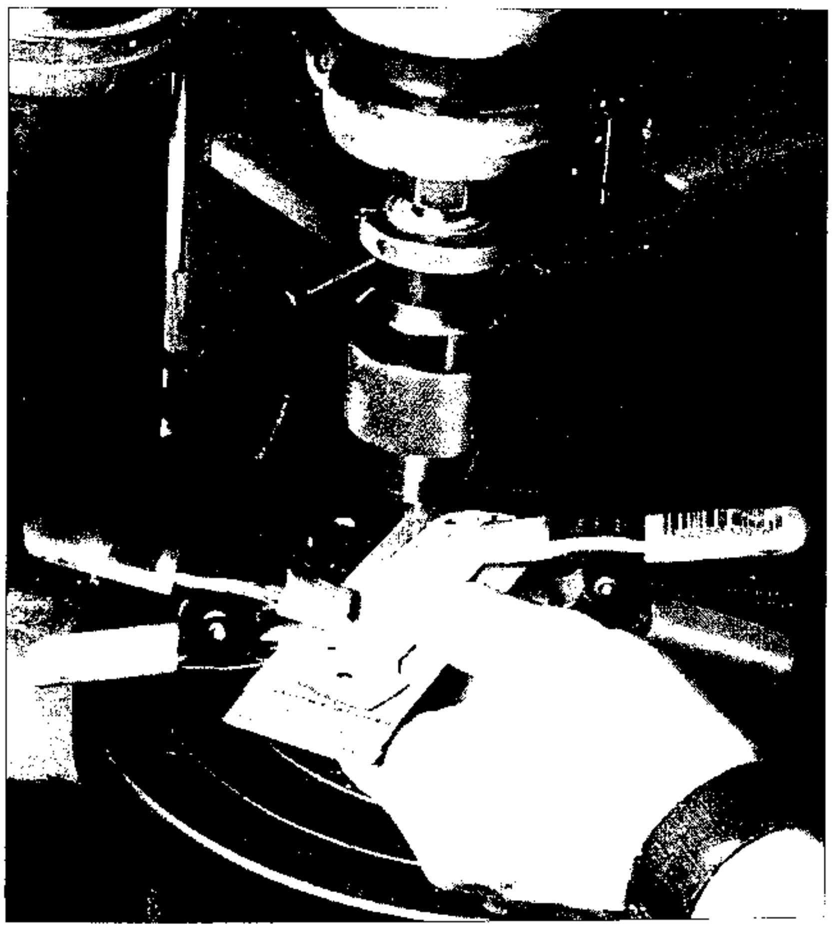


Fig. 106: Using the handle pattern as a drill guide to drill the holes for the assembly screws through the three layers.

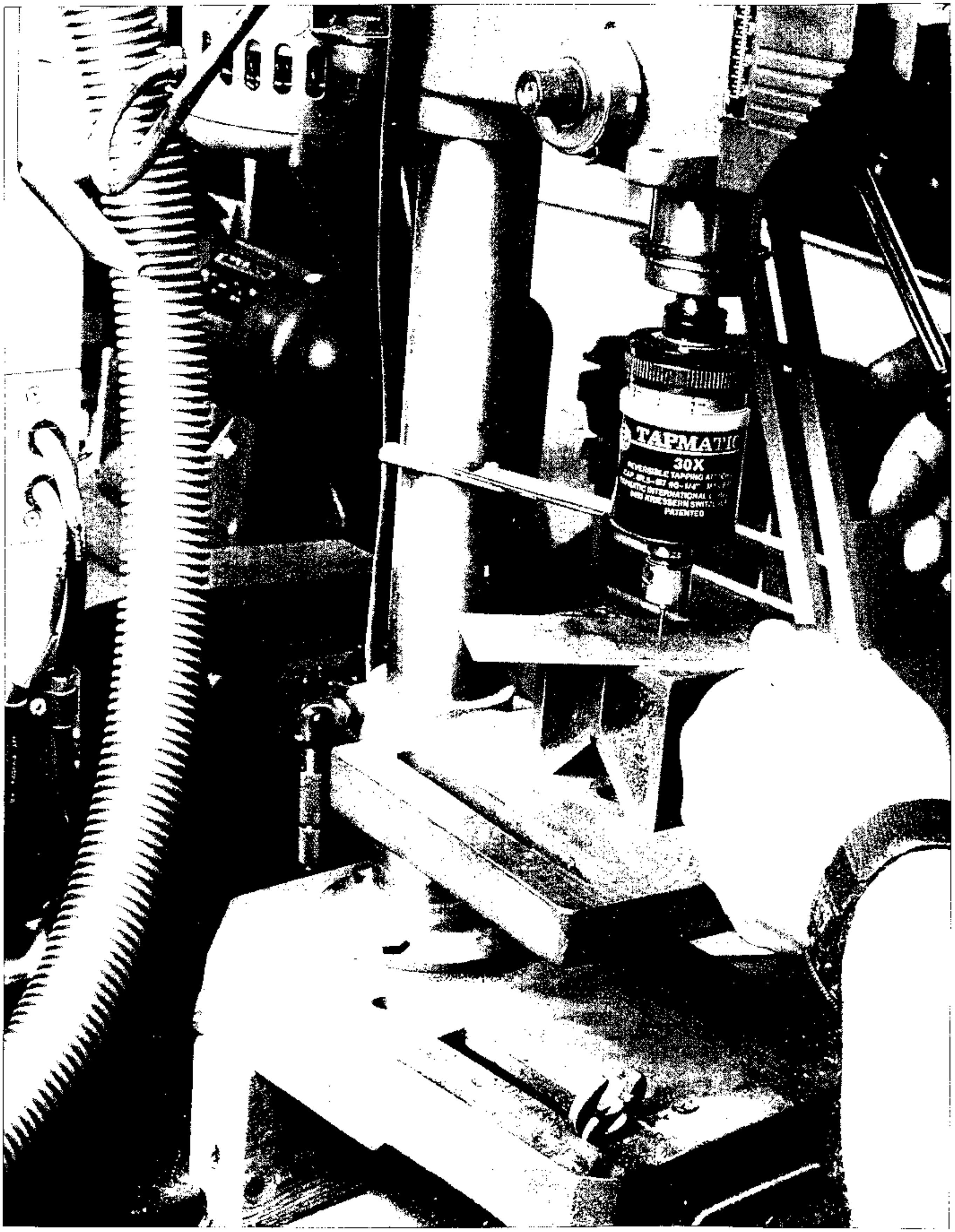


Fig. 107: Tapping only the back handle side.

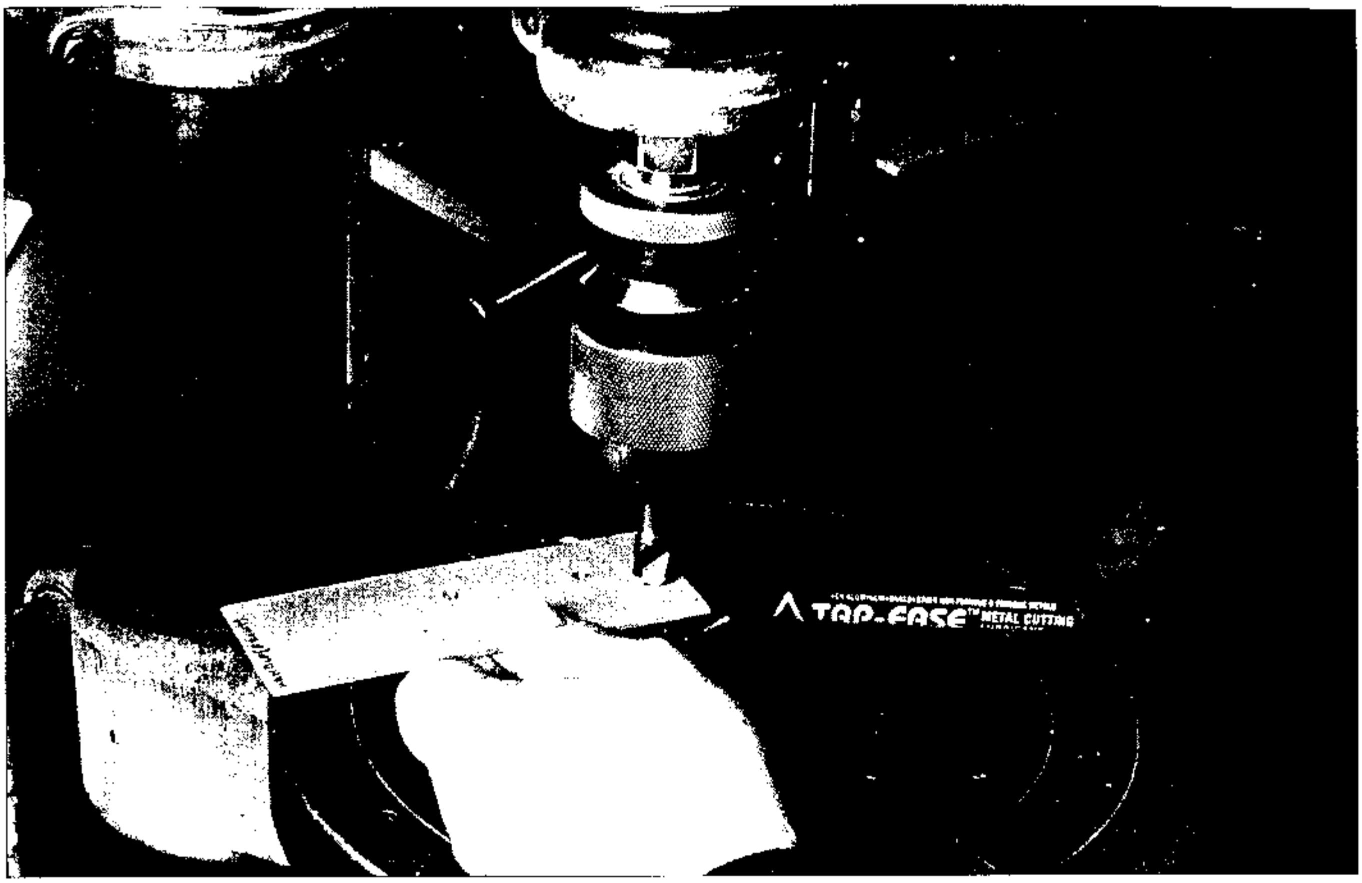


Fig. 108: Countersink the screw holes in the front handle side for 1-72 flat-head screws

Fig. 109: After assembling the three plates with screws, use a centering punch to mark the location of the stop pin, pivot and lanyard holes through the pattern.

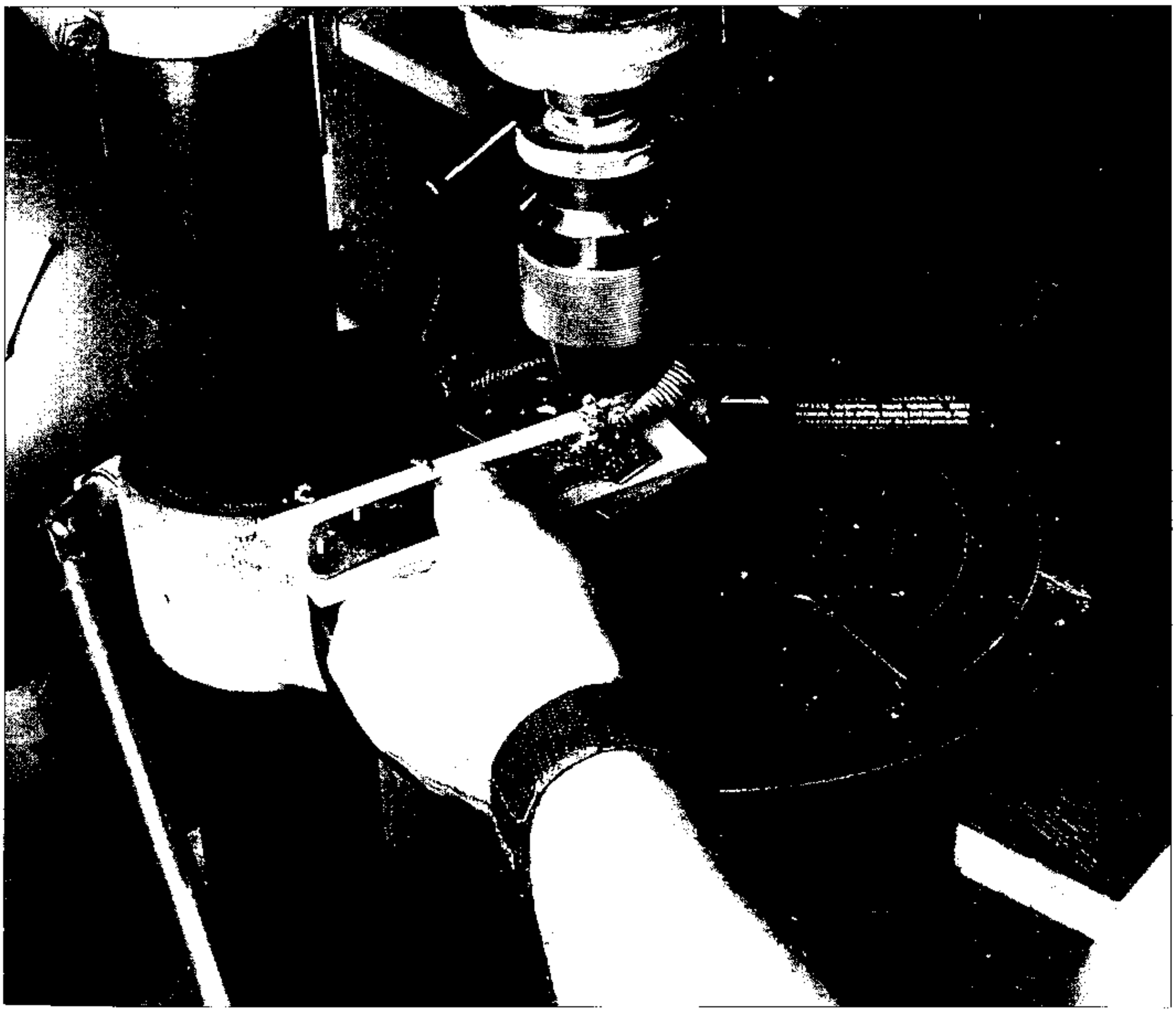
from the back. Slip the pattern onto the three projecting screws so it lies flat against the back side of the assembly. Use centering punches to locate the spots for the pivot, lanyard and stop pin holes (Fig. 109).

6. Drill and ream the three holes to the proper dimensions (Fig. 110). I use a 7/32 inch pivot, 9/64-inch stop pin hole and an 11/ 64-inch lanyard hole. The stop pin is actually 5/32 of an inch in diameter but I turn a shoulder on both ends to hold it securely in between the sides of the knife (Fig. 68).

7. Replace the pattern with a try pin in the pivot hole and the three assembly screws projecting through it, as before. Carefully scribe the profile from the pattern, onto the metal (Fig. 111).

8. Cut out the profile on the band saw leaving the scribed line untouched. I use a bi-metal blade for titanium, 20 tpi and.020 inches thick. They don't last long but they are better than anything else I have tried (Fig. 112).

9. Profile grind the handle against a squared up, flat platen (Fig. 113). A 3M micro-finishing belt of 100 microns works well here and I keep it wet with a soaked sponge in contact with the belt. It's a bit messy, but not too bad, and it keeps the sparks, dust and smell down (Fig. 120). Remove the burrs and sharp edges with a gray Scotchbrite wheel.



Drilling the stop pin, pivot and lanyard holes.

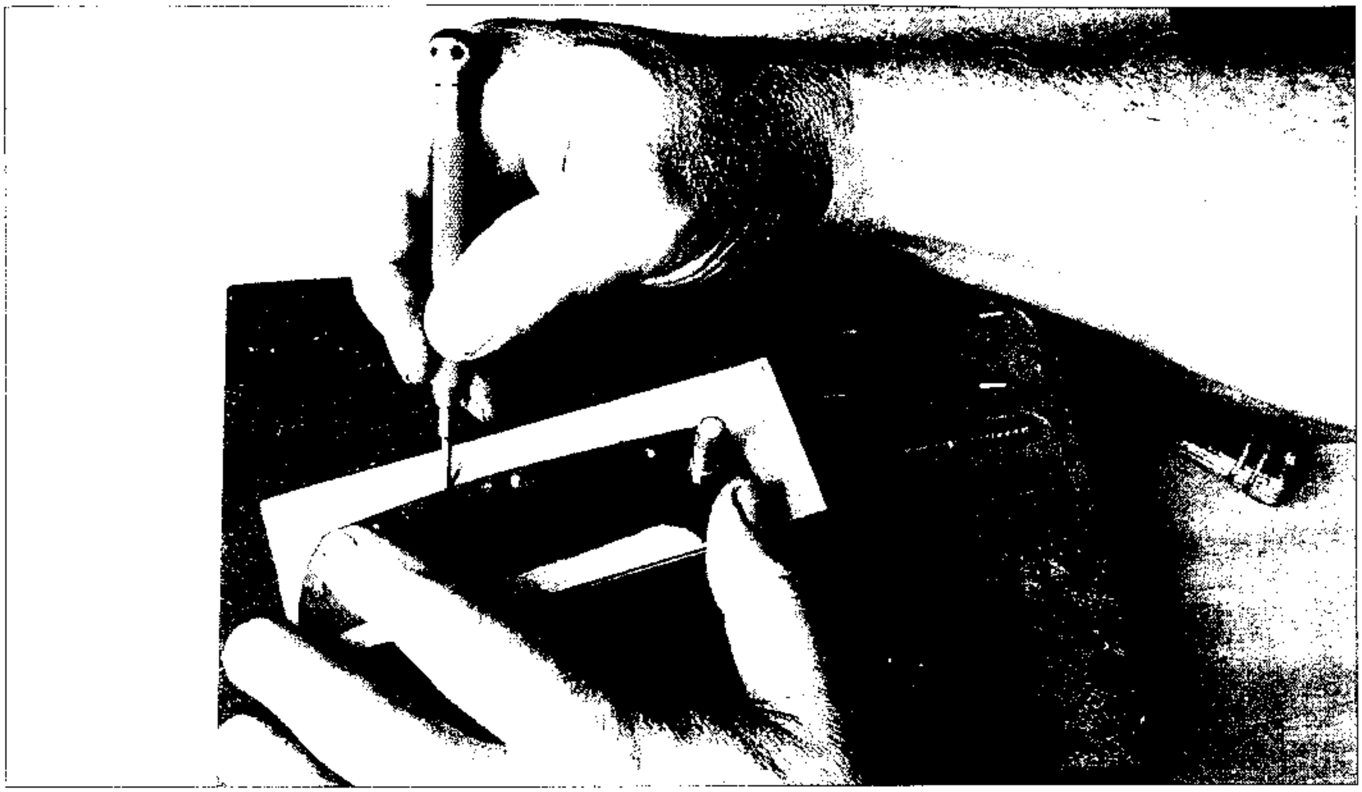


Fig. 111: With a try pin in the pivot hole for proper registration of the parts, scribe the profile of the handle onto the assembled three-part sandwich.

Fig. 112: Cutting the handle profile with a band saw. All three parts are cut at the same time in the assembled condition.

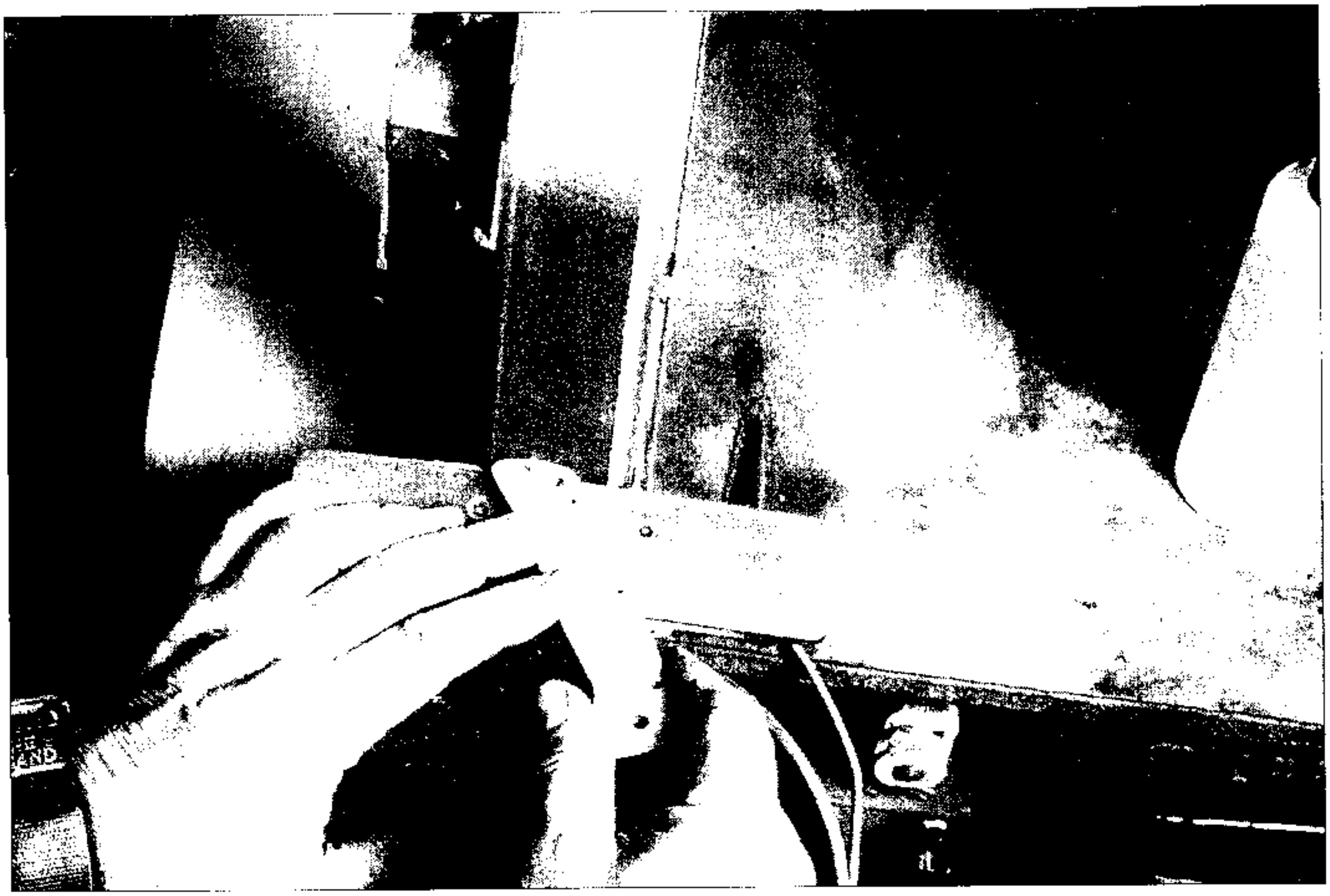


Fig. 113: Profile grinding the handle on the flat platen grinder. All three parts are still together.

G10 OR CARBON FIBER HANDLES

If you choose to make your handle from G10 or carbon fiber, you still only need one metal spring plate as these materials are very strong and really don't need an extra liner.

This is the procedure I use:

1. Use your handle pattern as described above to lay out, cut and profile grind the spring plate alone (Fig. 114).

2. Drill and ream all holes to proper size, but in this case drill the screw holes with the #53 tap drill, then, tap the holes for 1-72 screws. The spring plate will now become your pattern.

3. Super glue two sheets of handle material together with ever so small spots of glue. Don't overdo it, you will need to break them apart later (Fig. 115).

4. Clamp the spring plate to the material sandwich and drill the screw holes only with the same tap drill used above. (Fig. 116)

5. Without removing the clamps, re-tap the holes through all three pieces so that the threads are continuous through the spring plate and the handle material sandwich (Fig. 117). Assemble with screws and remove the clamps.

6. Cut out the profile on the band saw (Fig. 118) and profile grind on a wet belt, following the shape of the spring plate as a grinding pattern. I clamp a sponge onto the wheel guard of my grinder and keep it wet with a spray bottle to hold the dust down as I've mentioned in other sections of this book (Fig. 120).

7. Drill and ream the pivot and stop pin holes. Remove the spring plate and break apart the two pieces of handle material (Fig. 121). The side which was screwed directly against the spring plate will be the back side of the knife and the final assembly will have the screws threaded through both of these parts. The outer piece will be flipped to the front, thereby sandwiching the spring plate. On this front handle part, drill out the

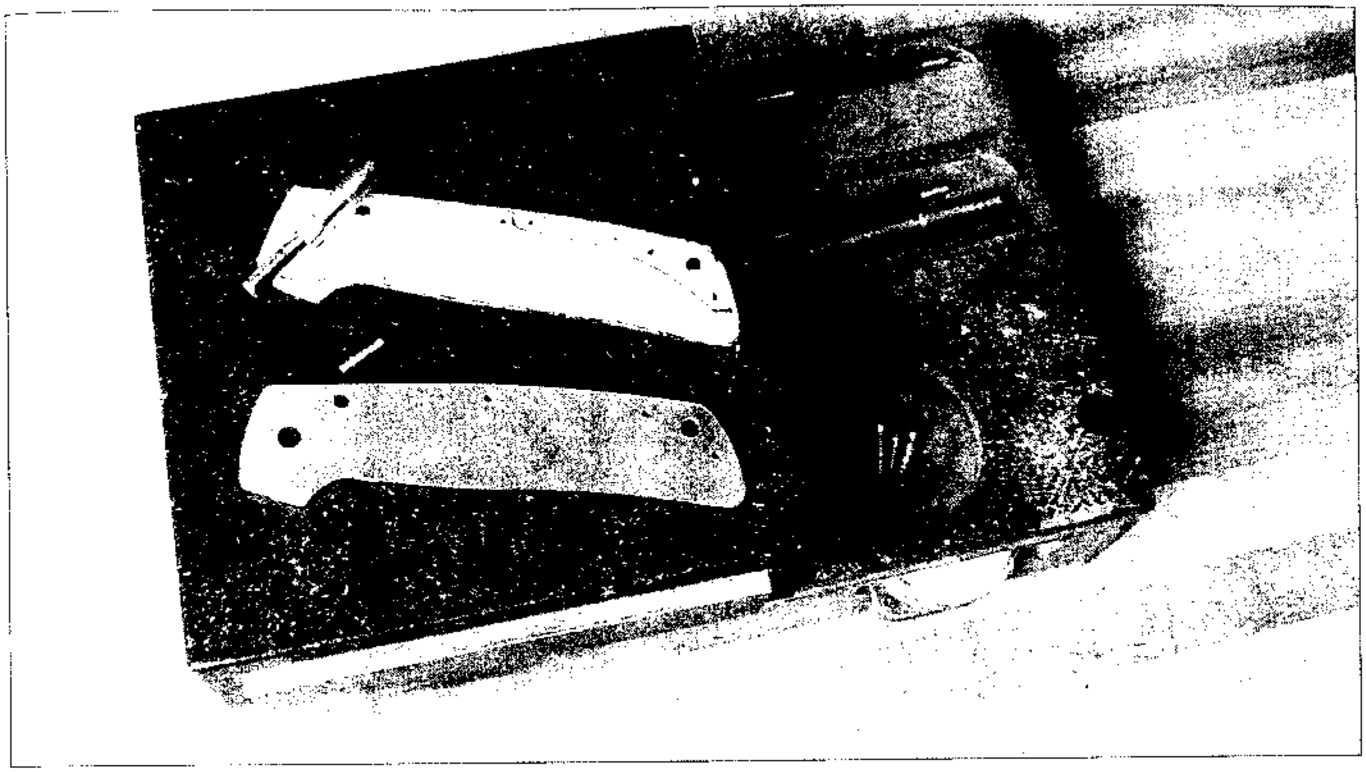


Fig. 114: For G-10 or carbon fiber laminate handles use the pattern as described above to cut out only the spring plate and tap the screw holes. The spring will now become the pattern.

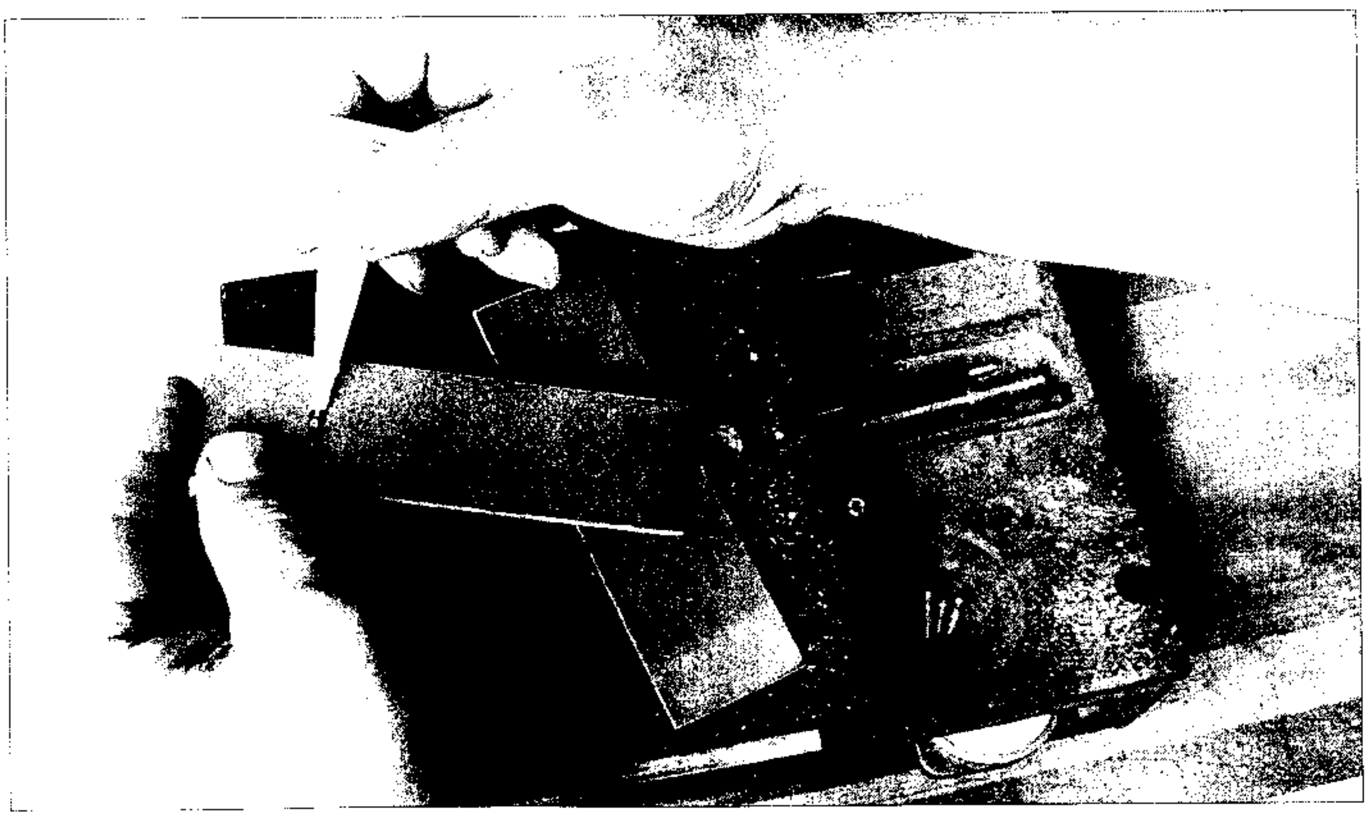


Fig. 115: Use super glue sparingly to join two pieces of laminate material together.

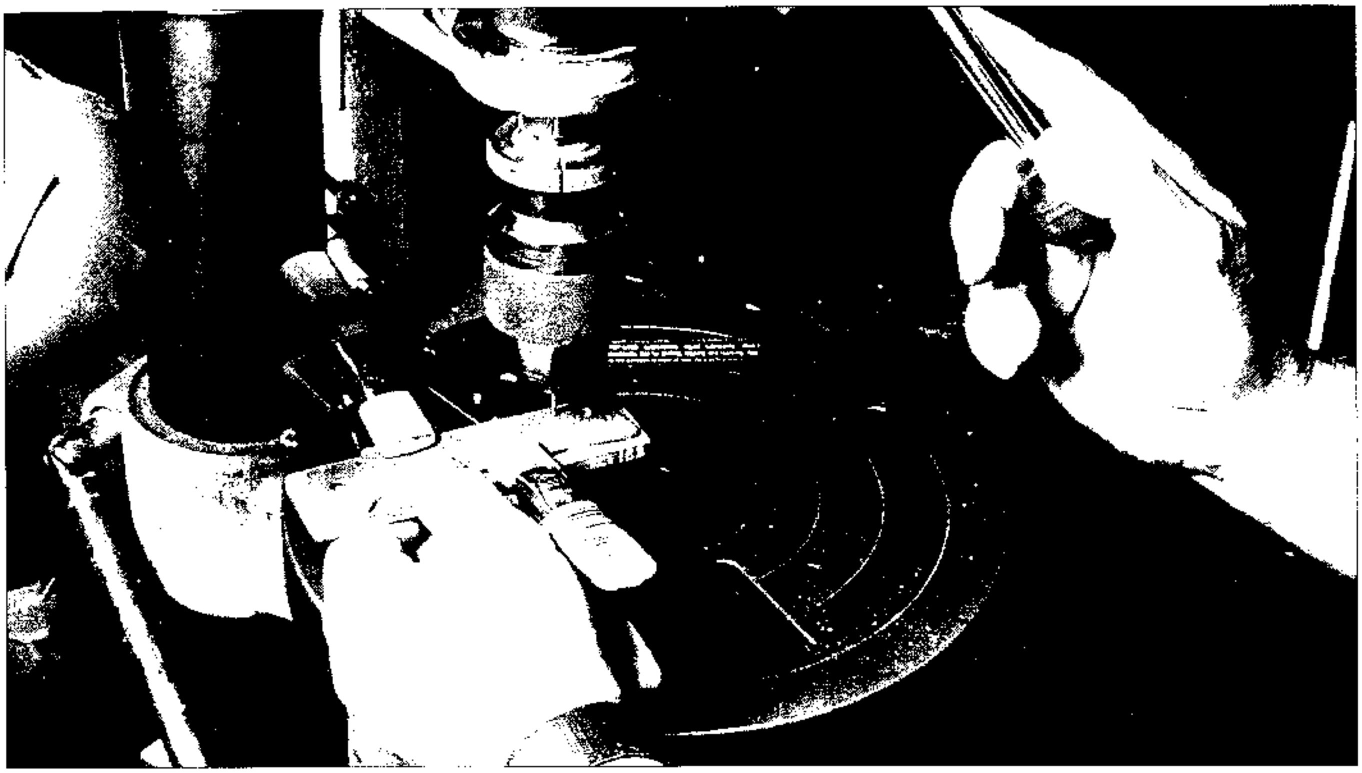


Fig. 116: Use the spring plate, clamped to the laminate sandwich, as a drill guide to drill the holes for the assembly screws.

Fig. 117: Tap the spring plate and laminate sandwich together so that the threads are continuous through the assembly.

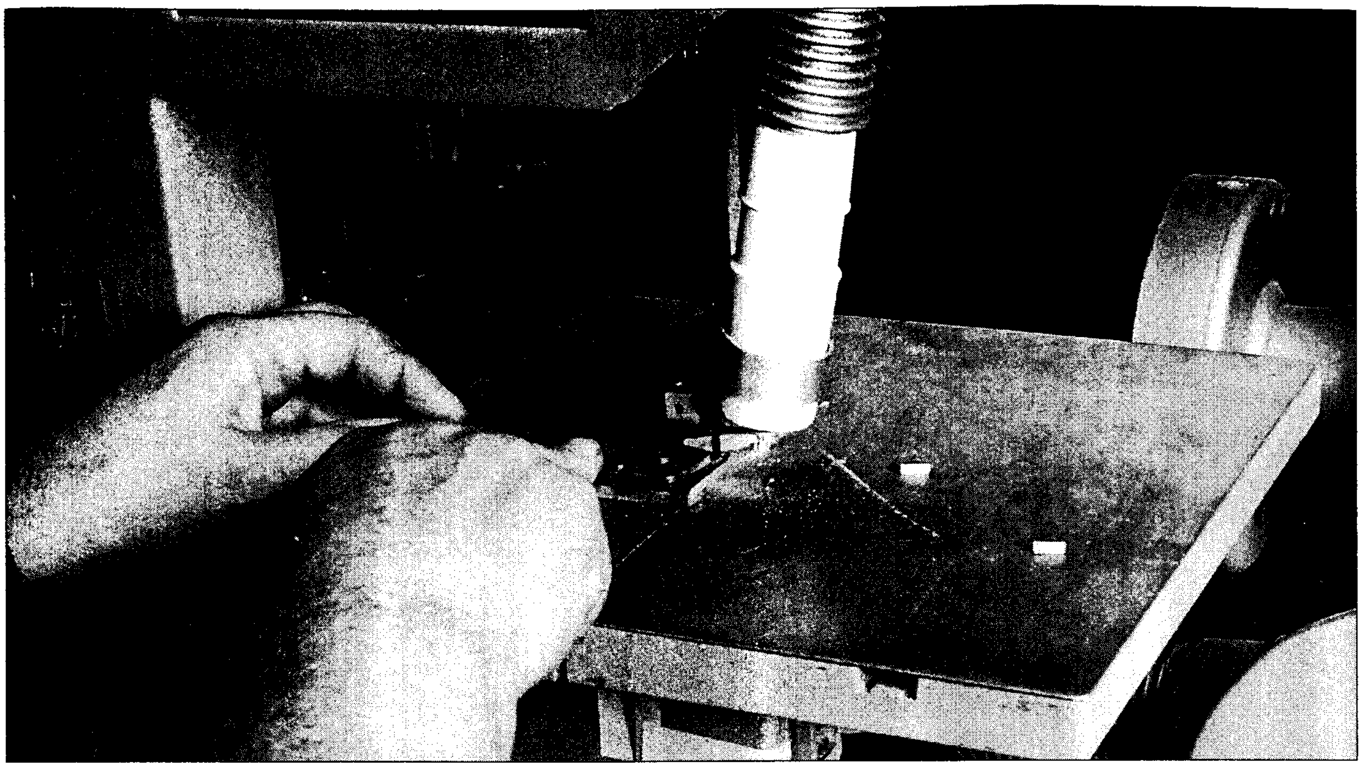


Fig. 118: Cut the laminate handle profile on a band saw. Note the strong vacuum close to the cutting action.

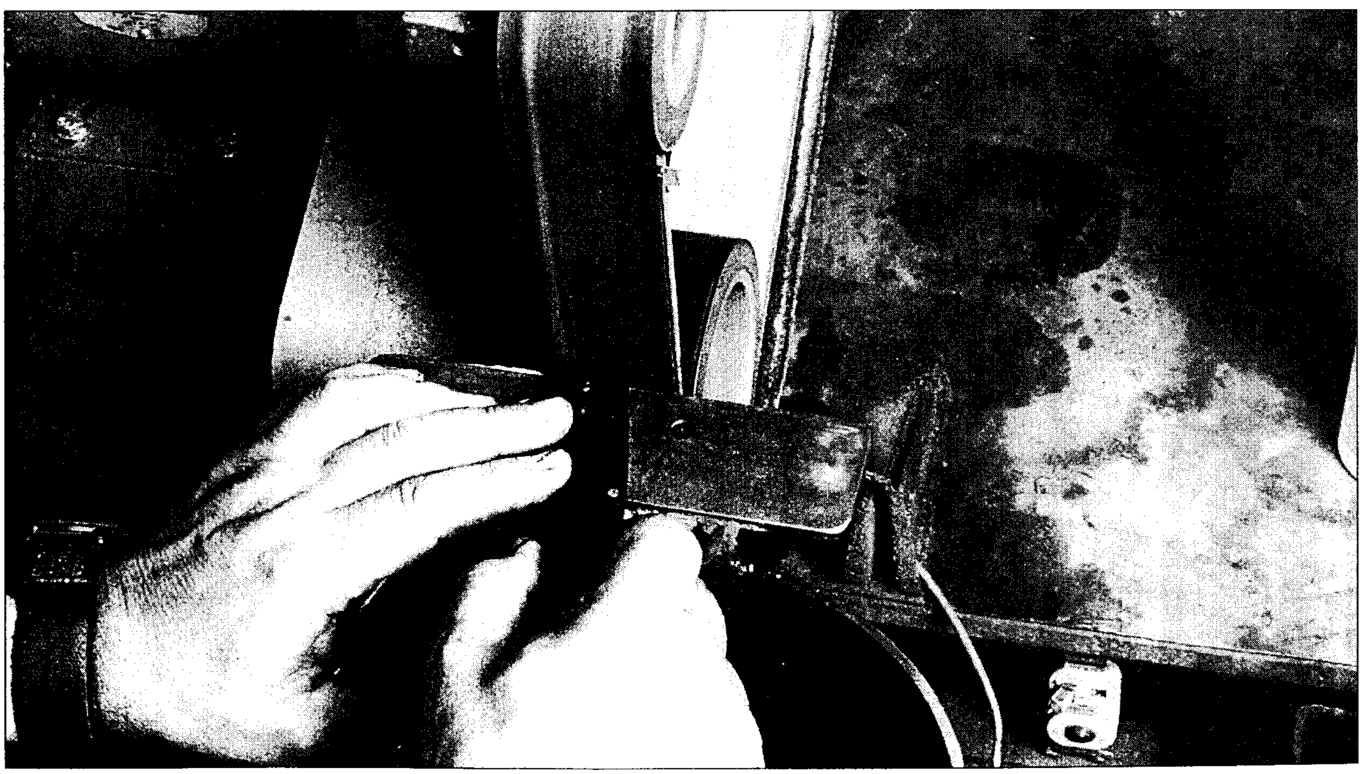


Fig. 119: Grind the profile with a new micro-finishing belt. These have a plastic backing so they can be used wet.

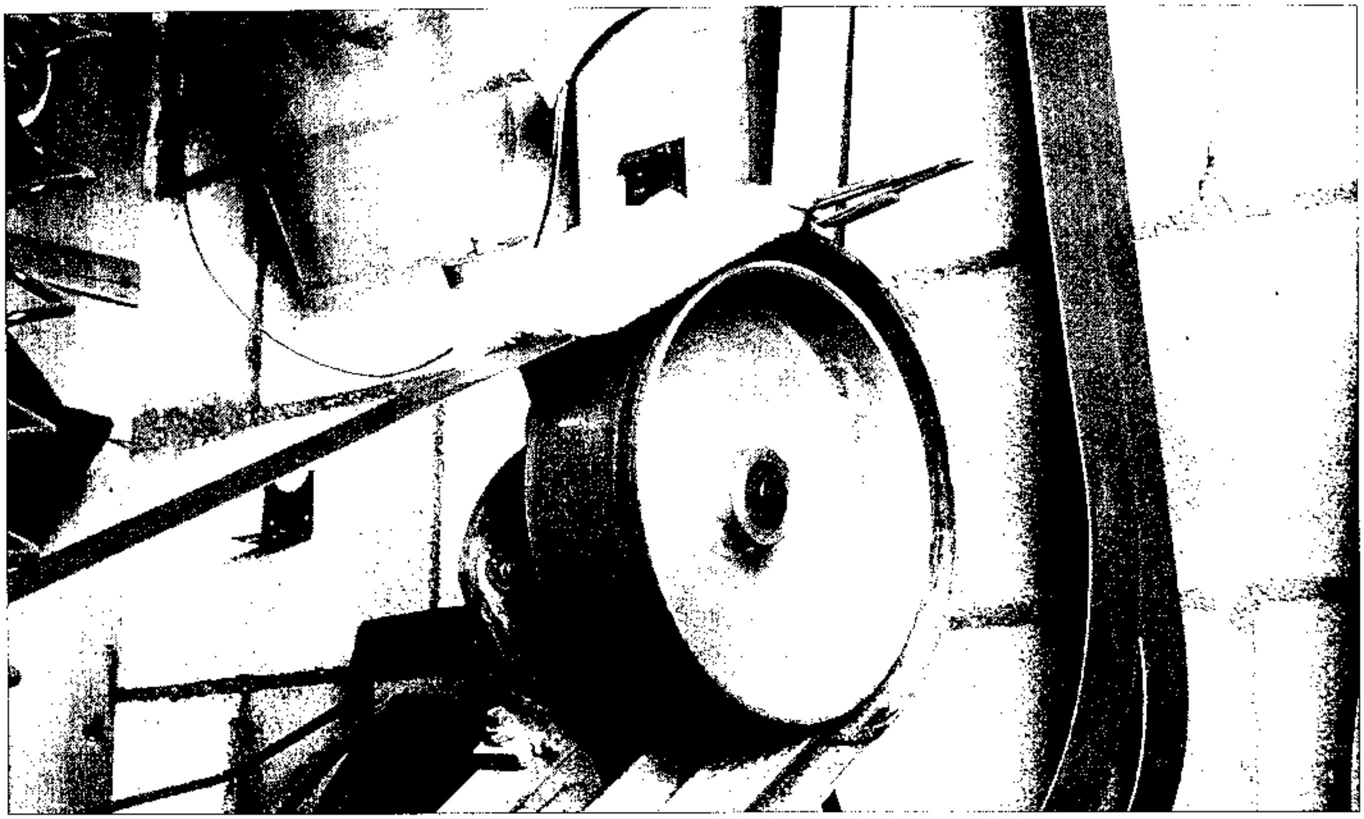


Fig. 120: A wet sponge is clamped to the guard of my grinder so that I can grind laminates without creating breathable dust in the air. Use a squirt bottle to keep it wet.

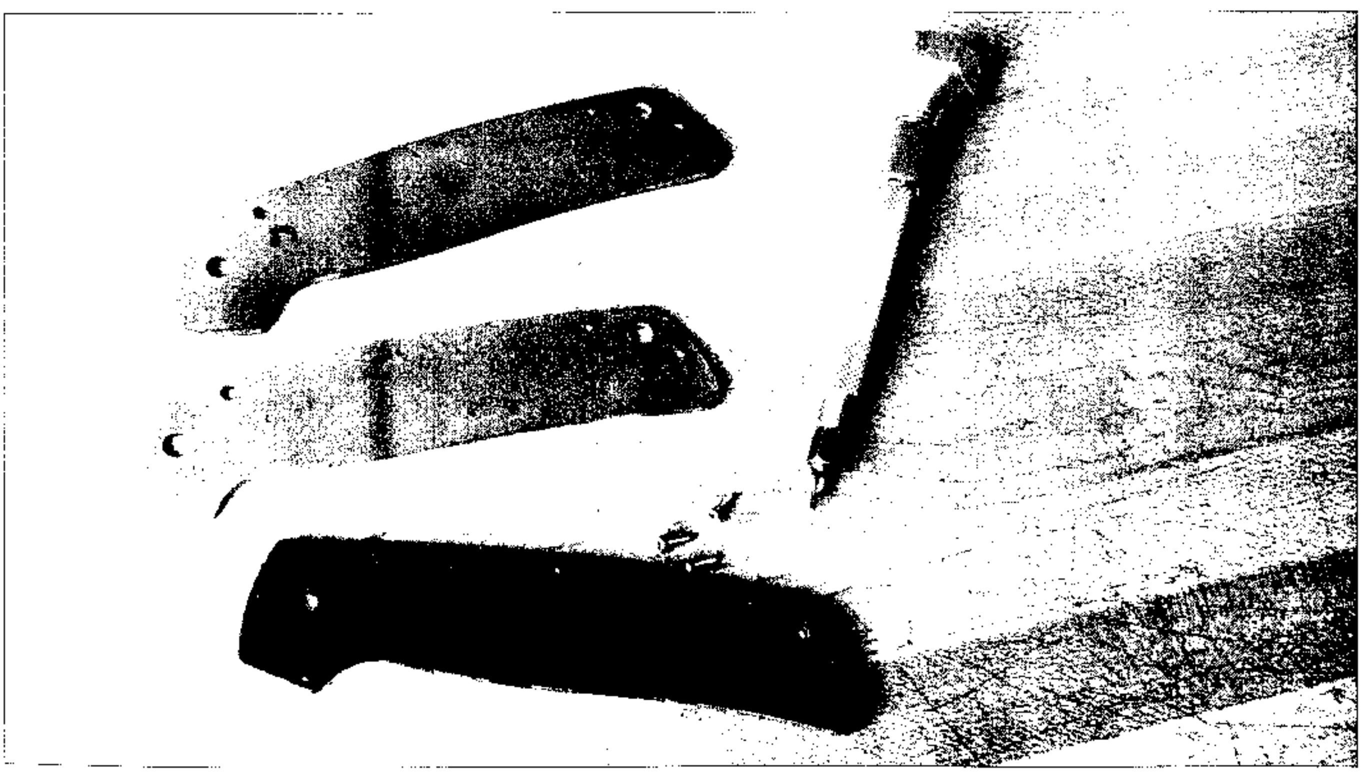


Fig. 121: The spring plate and two laminate handle sides.

screw holes with a #49 drill and countersink them to the proper depth to bury the screw heads.

No matter the kind of handle material you have chosen, proceed now as follows:

FOR BOTH METAL AND LAMINATE HANDLES

1. Locate and cut out the spring release scallop with the milling machine or the grinder. I use the milling machine with a 3/4-inch cutter for the scallop, holding the part in a special fixture. (See Chapter 9) (Fig. 122).

2. On the opposite side handle plate, the one continuous screwed to the spring plate, locate and attach the pocket clip, if one is to be used.

Most knife makers use multi-screw clips of the Spyderco type. Some, like me, make our own clips. I use a clip which sits into a milled slot and is affixed with only one bolt (Fig. 123). I also locate my clips at the butt end of the knife while others prefer the front end. However you do it, I recommend that if G10 or carbon fiber handles are used, the attaching screws pass through the handle and are threaded into the spring plate for greater strength. I tap the hole for my spring with a 4-48 thread. I use a reversing electric drill for this procedure to save time since the tap is more robust than the smaller ones and less likely to break (Fig. 124).

3. Carefully check all of the parts against a straight edge to see if they have warped. If there is a bend in the parts, straighten them with light, gradual pressure on an arbor press (Fig. 125), or in a vise applying pressure between two supporting points on the opposite side. I use a small arbor

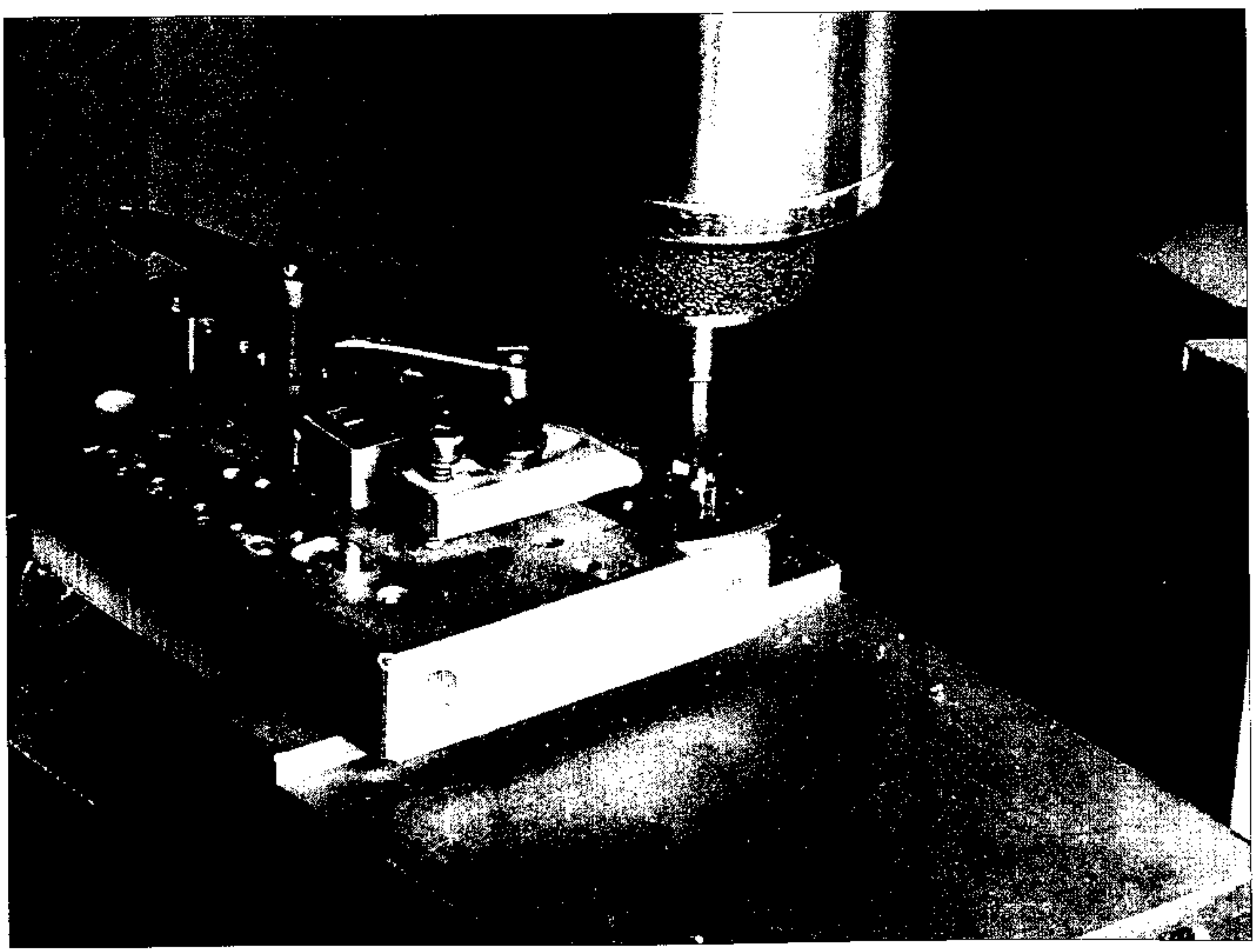


Fig. 122: Milling the spring release scallop or cutout with a 3/4-inch carbide cutter.

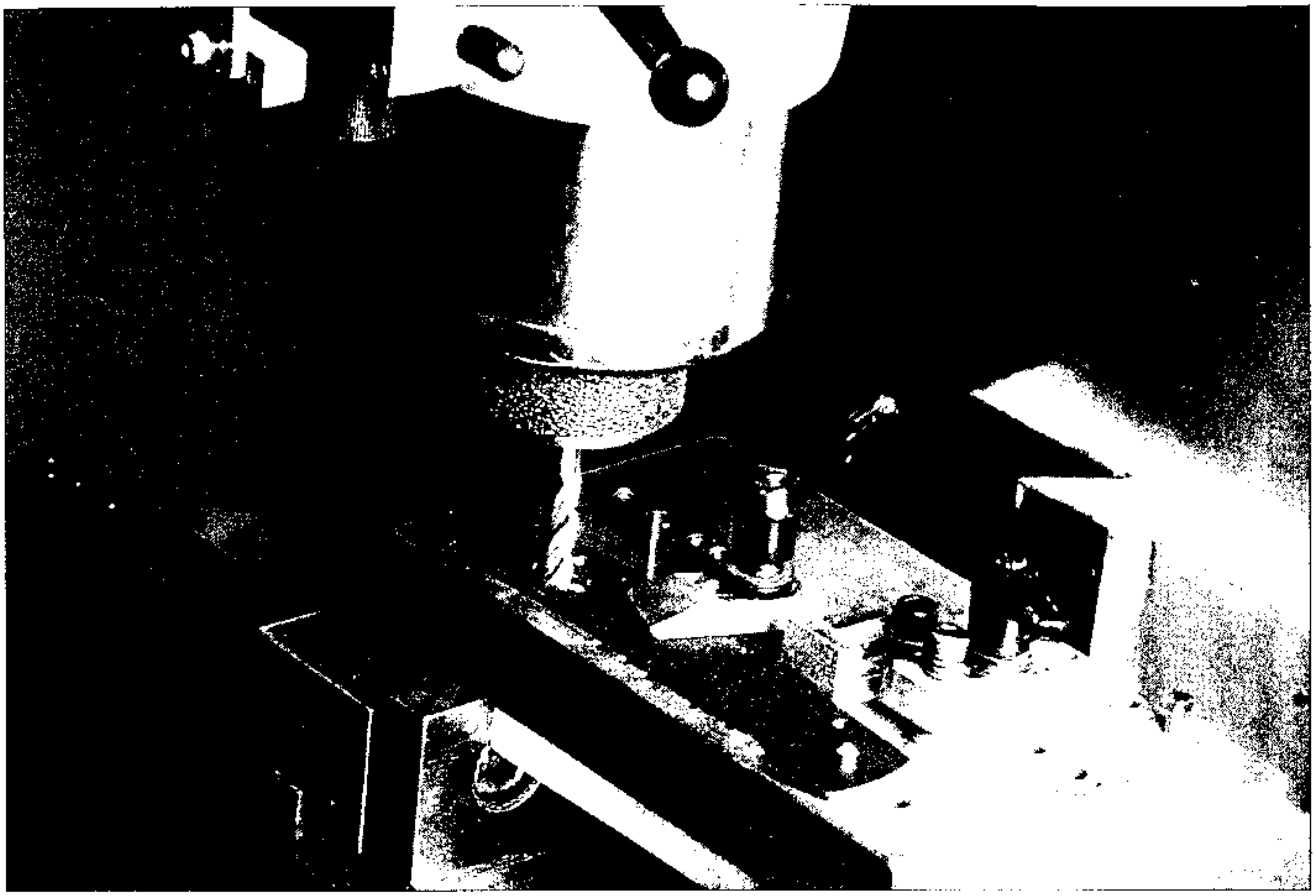


Fig. 123: Milling the recess for the pocket clip with a 5/16-inch carbide cutter.

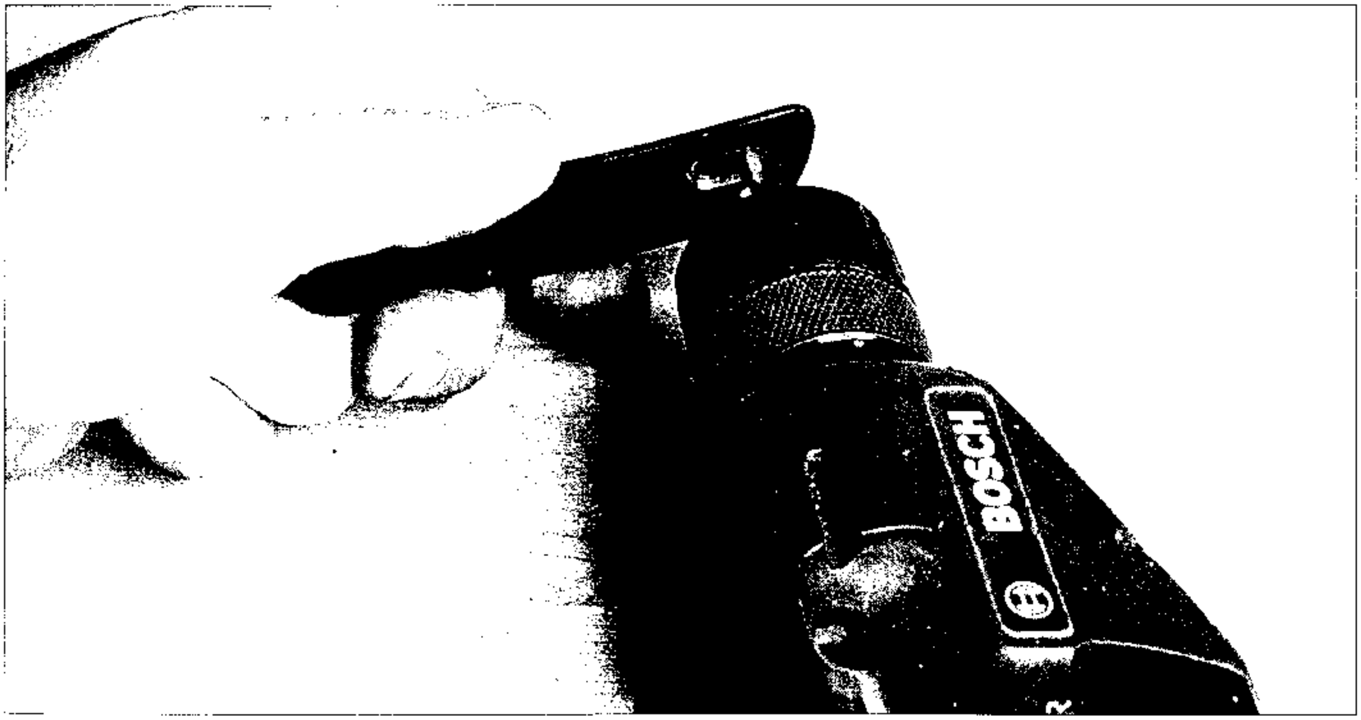


Fig. 124: Tapping the screw hole for the pocket clip. I use a reversible electric drill for this procedure.

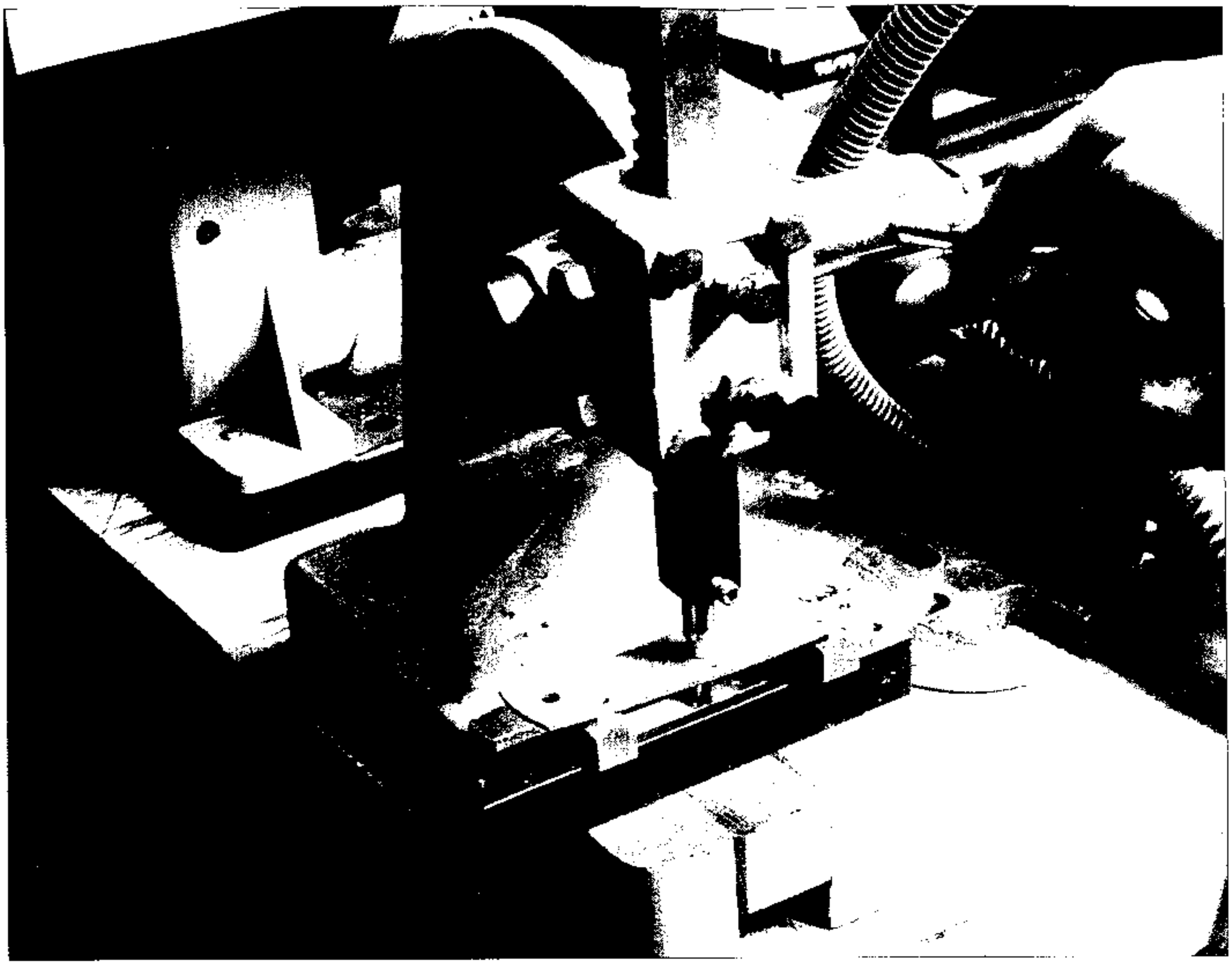


Fig. 125: Straightening all the parts on the arbor press. Note the adjustable base under the handle side for more accurate bending.

press with adjustable supports on the base to accommodate different size components.

The basic handle is now complete, whether of titanium or laminated material. Disassemble and set aside the handle side plates as you are now ready to create the spring and lock.

MAKING THE SPRING PLATE

1. Clamp a stop pin into the stop pin hole of the spring plate. A small pony clamp works well if you grind a notch into the back jaw to allow for clearance of the projecting stop pin (Fig. 126).

2. Assemble the blade onto the plate with a try pin in the pivot hole and check to see that it opens correctly and stops in the right position, and then closes to the right position with the point properly buried in the handle but not so far down that it interferes with the spacer that will eventually be installed at the back of the knife (Fig. 127). If the blade is not properly positioning itself in the open and closed position, fit it following steps 7 and 8 in Chapter 2. If the point of the blade rises too far above the line of the handle in the open position, it can be moved down by making a slightly oversized stop pin.

3. Clamp the blade in the full open position firmly against the stop pin and scribe a line against the blade's lock bevel and mark the top point of the line so the spring will clear the butt extension of the tang (Fig. 128). This line will describe the locking end of your spring. Swing the blade halfway closed and scribe a line around the bottom curved edge (Fig. 129). Remove the blade and you will have a

Fig. 126: For initial layout of the spring cuts, clamp a stop pin securely in the spring plate.

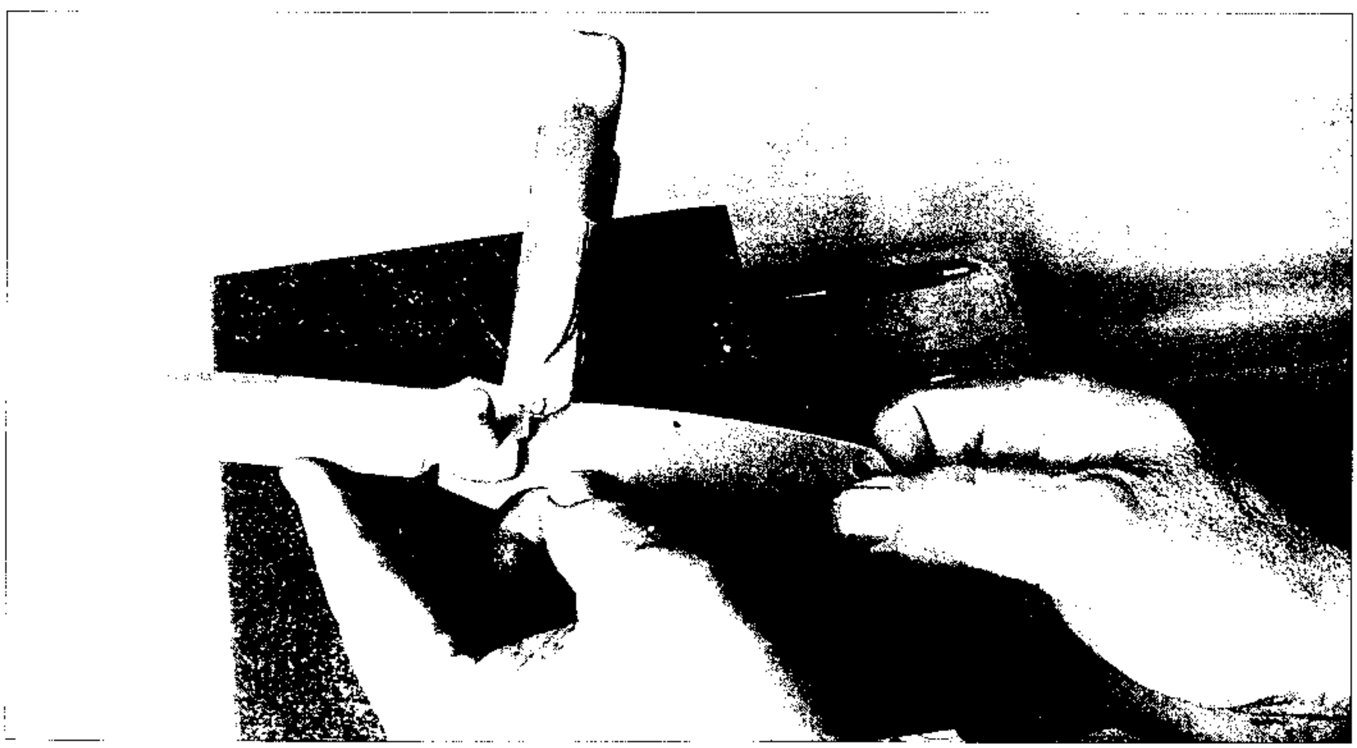


Fig. 127: Verify the aspect of the open blade relative to the spring plate.

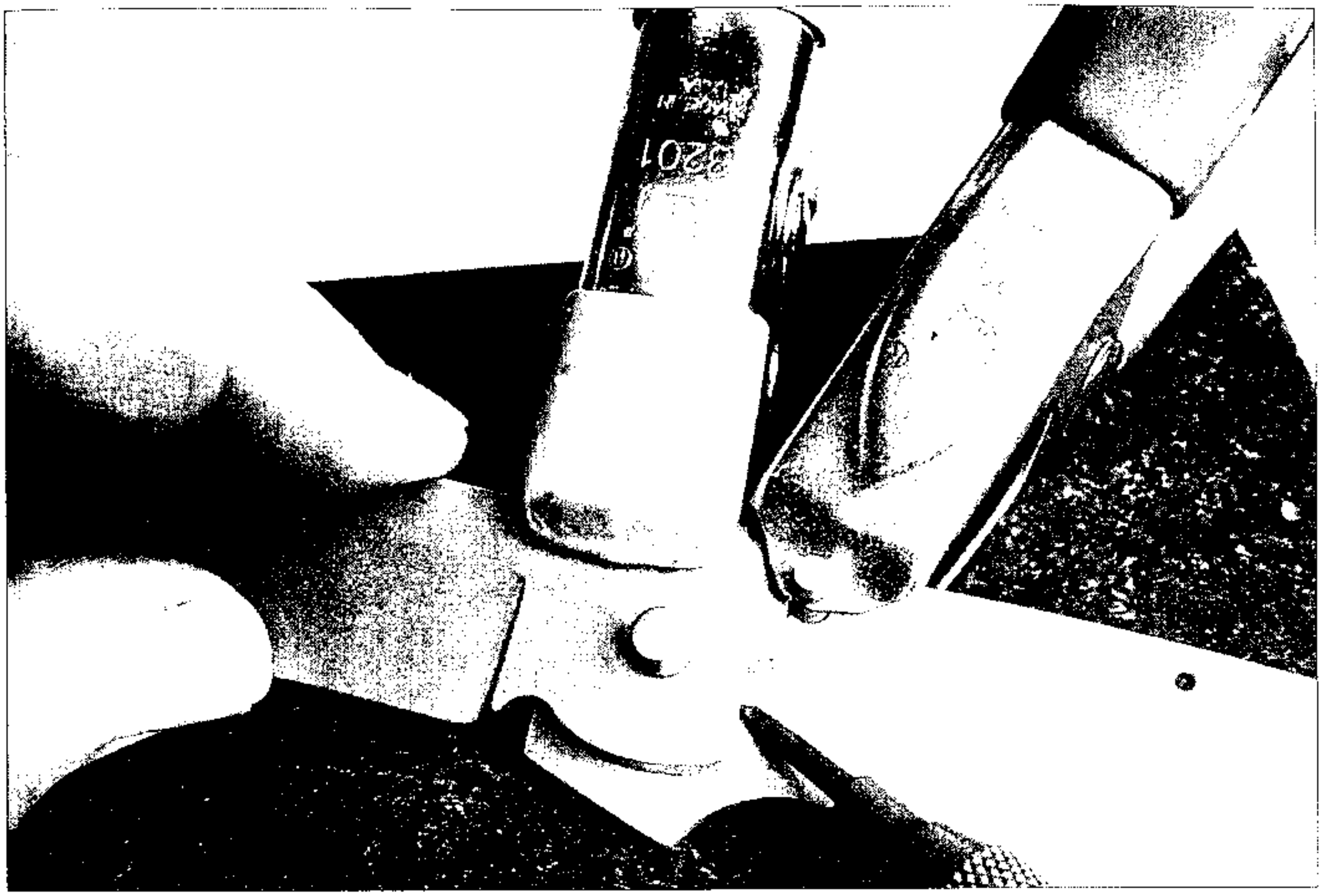


Fig. 128: Scribe the position of the blade's lock bevel onto the spring plate. Also scribe the top leg of the lock bevel which (as seen above) will form the top part of a small triangle on the spring plate.

triangular area describing the top edge of the spring, the forward limit of the spring and the area in which you will locate the ball detent so that it will ride on the blade and not slip on and off when the blade is opened (Fig. 130).

4. Starting at, and in line with, the top edge of this triangular area, scribe a line back towards the butt end of the spring plate (Fig. 131). This L-shaped line describes where the material will be cut to form the spring itself. The length of this cut will determine the relative strength or resistance of the spring. (See Chapter 4). For a 4-inch blade, I use a 3-inch-long spring cut.

5. Set the spring plate in the milling machine vise, taking care to locate it so that the scribed line is parallel to the vise jaws and the travel of the mill's table (Fig. 132). This cut can also be made with a narrow band saw if a hole is drilled at the intersection of the vertical and horizontal lines to allow turning the blade 90 degrees after the short leg is cut.

6. Cut the plate using a slitting saw at low speed and feed, with plenty of lubrication, from one end of the line to the other (Fig. 133). Remove from vise and cut the short leg (front end) on the band saw to fully liberate the spring. Leave a little extra material on the front end of the spring for fitting and adjustment to the blade (Fig. 134).

7. Final fit the spring to the blade using the following procedure:

File or grind down the front end of the spring until it just barely passes over the edge of the blade's lock bevel. Remove material, a little at a time, and check this carefully by placing a pivot in the pivot holes and clamping a stop pin to the spring plate. Open the blade all the way and see how close the front end of the spring is to the edge of the blade bevel. Trim off material as needed to just bring it over the edge (Fig. 135).

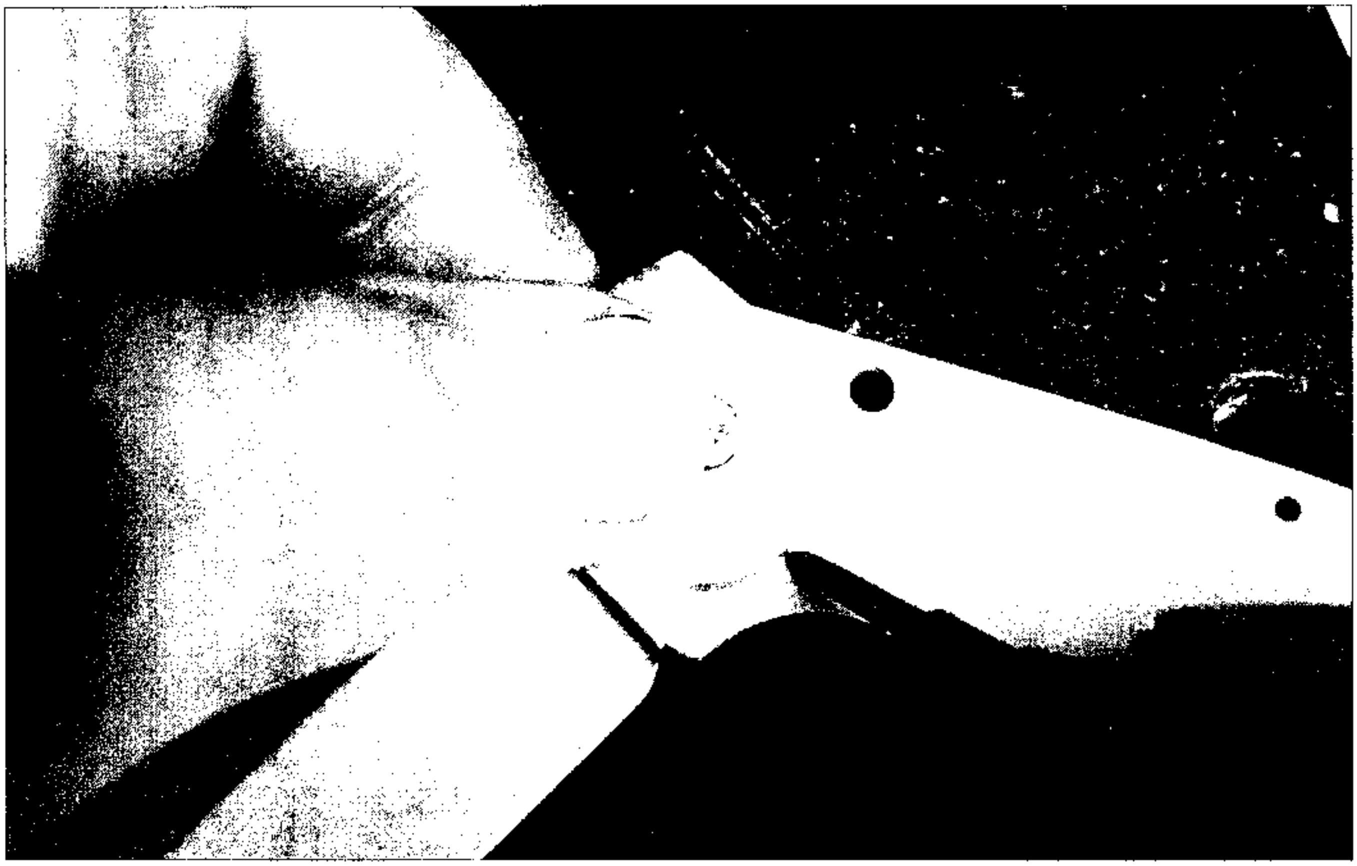


Fig. 129: With the blade half-closed, scribe the radius at the bottom of the tang onto the spring plate.

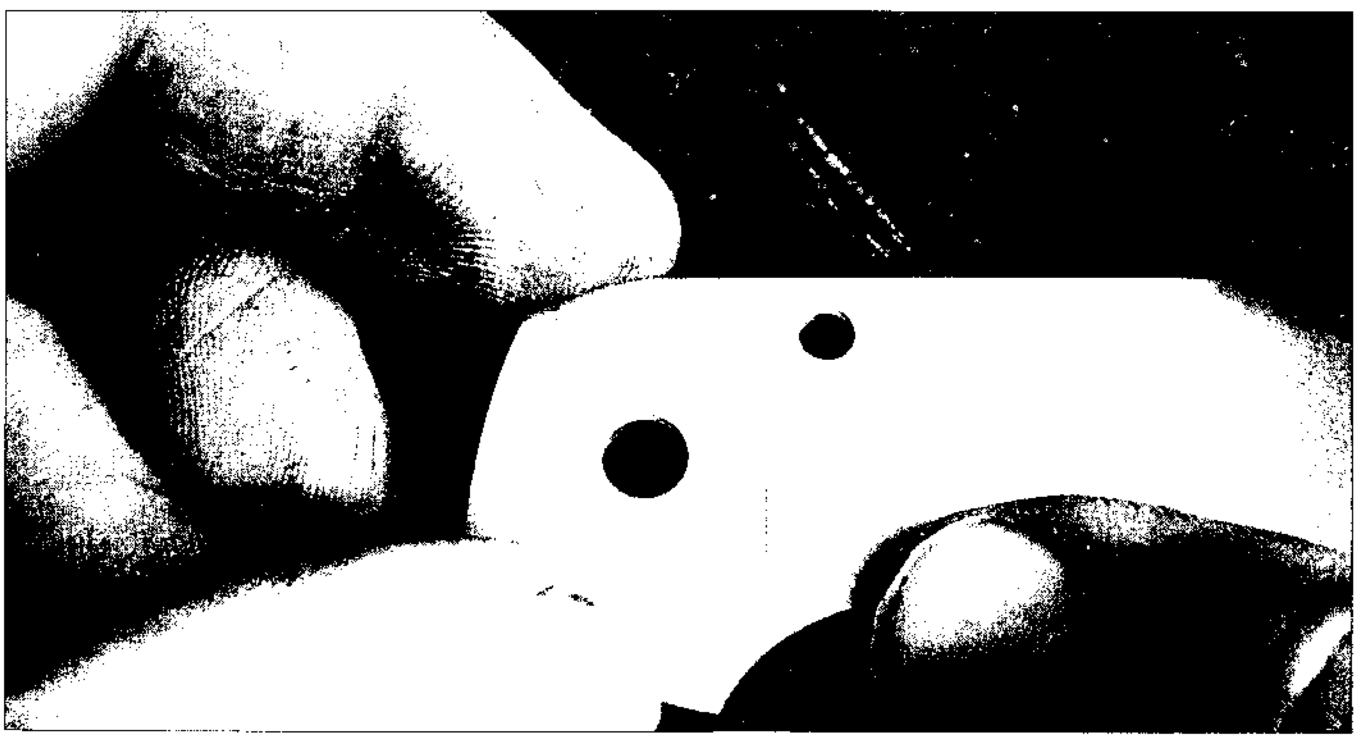


Fig. 130: The triangular area shows where the front of the spring needs to extend to, the height of the spring from the edge and the area in which the ball bearing for the blade detent must be located.

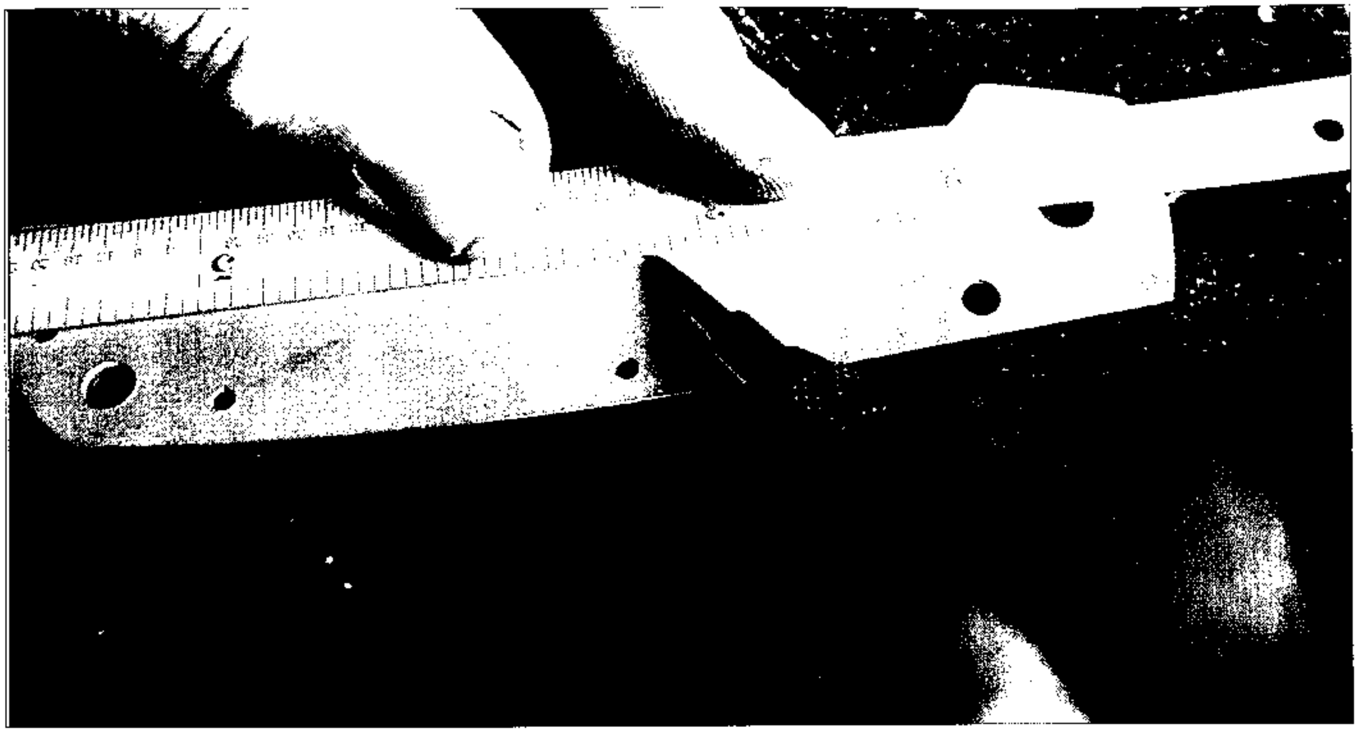


Fig. 131: Scribing the line which will be cut to form the spring's long leg.

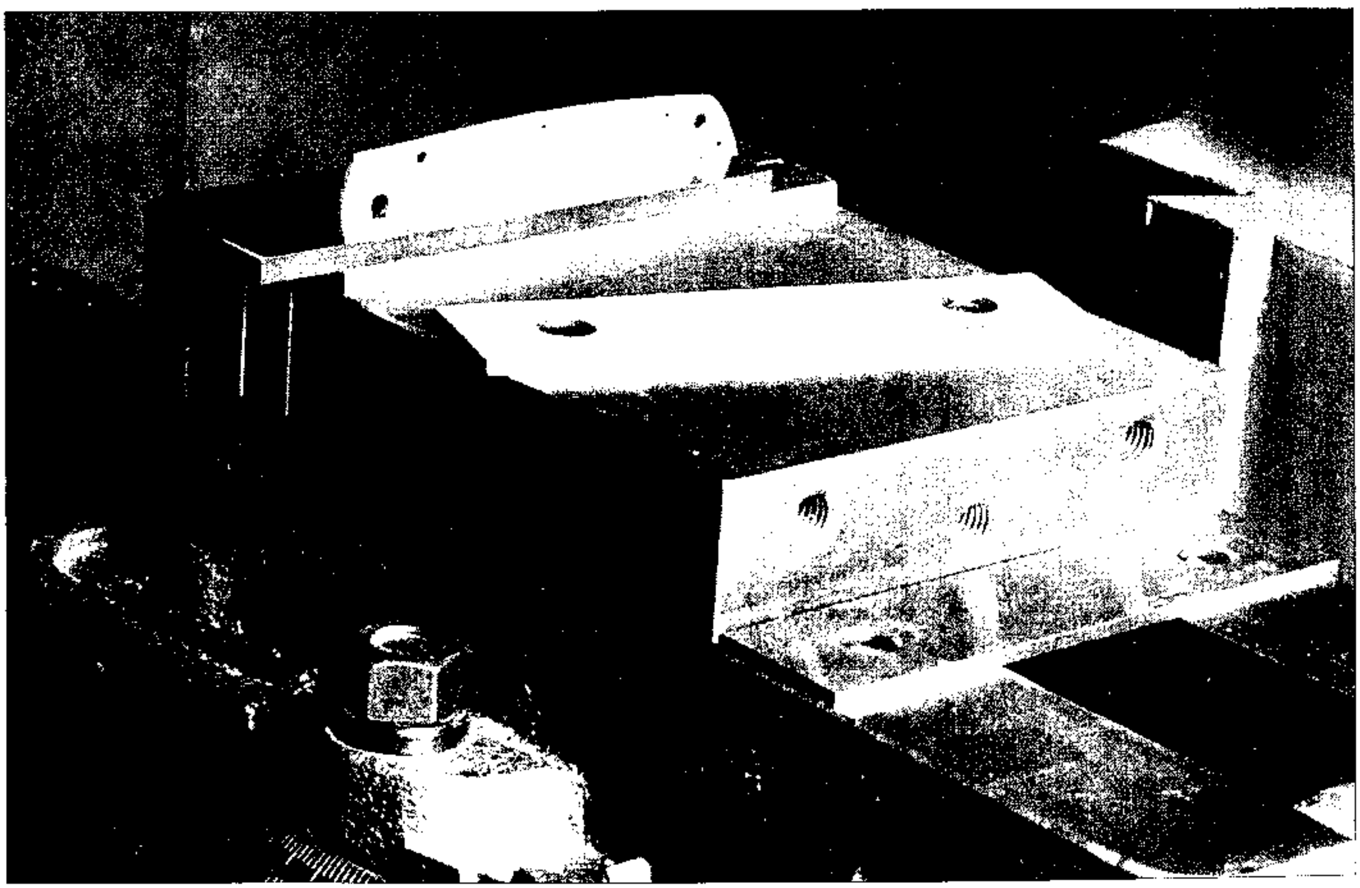


Fig. 132: Setting up for cutting the long leg of the spring. The scribed line is parallel to the vise jaws.

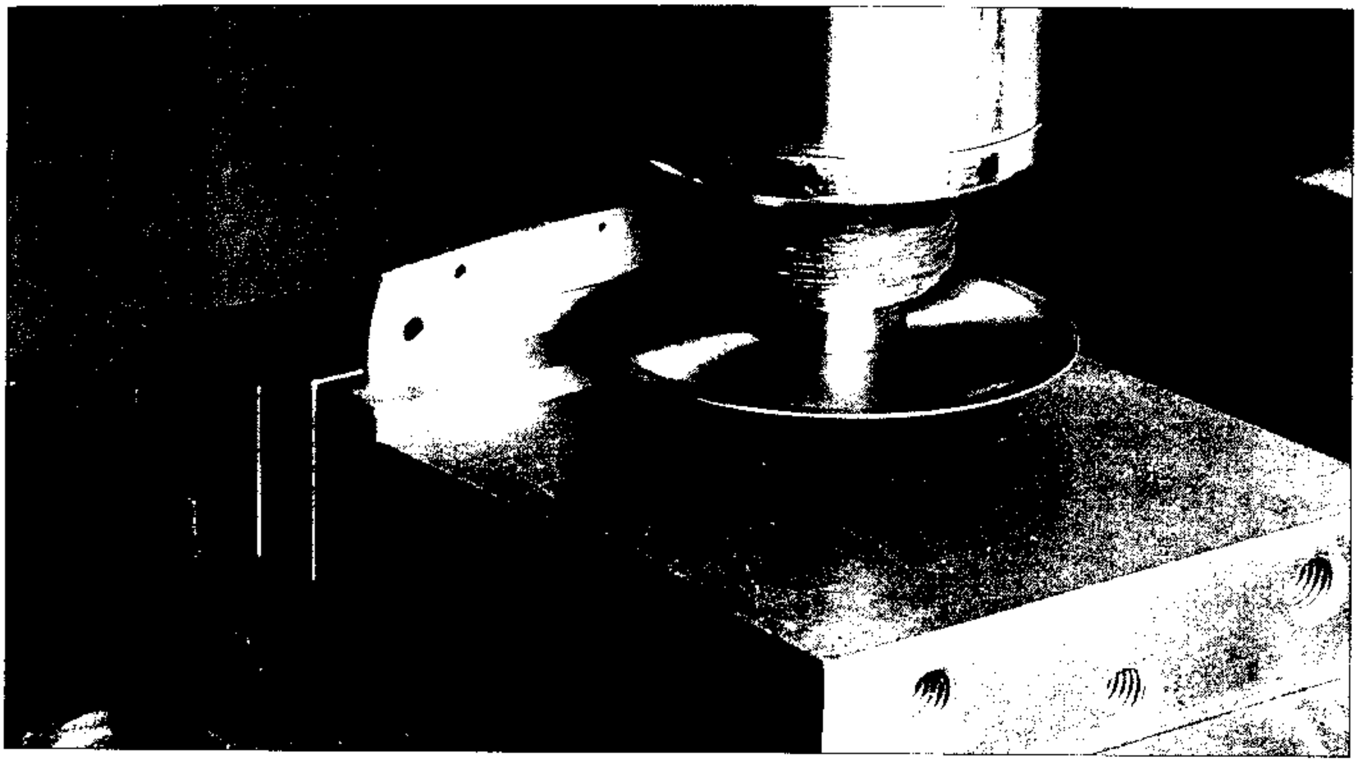


Fig. 133: Cutting the spring with a thin slitting saw at low speed and feed.

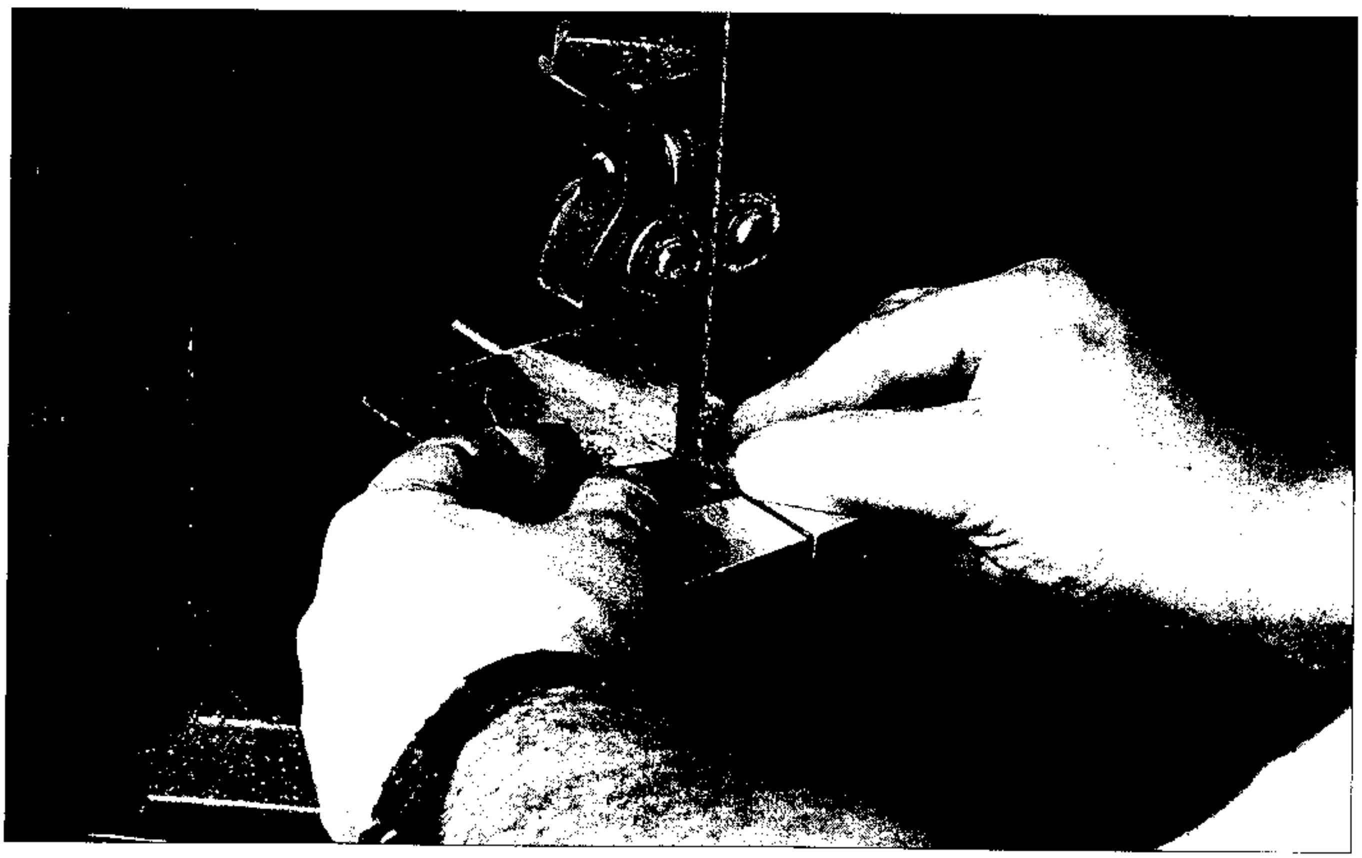


Fig. 134: Cutting the short leg of the spring on the band saw, thus liberating the spring bar from the rest of the handle.

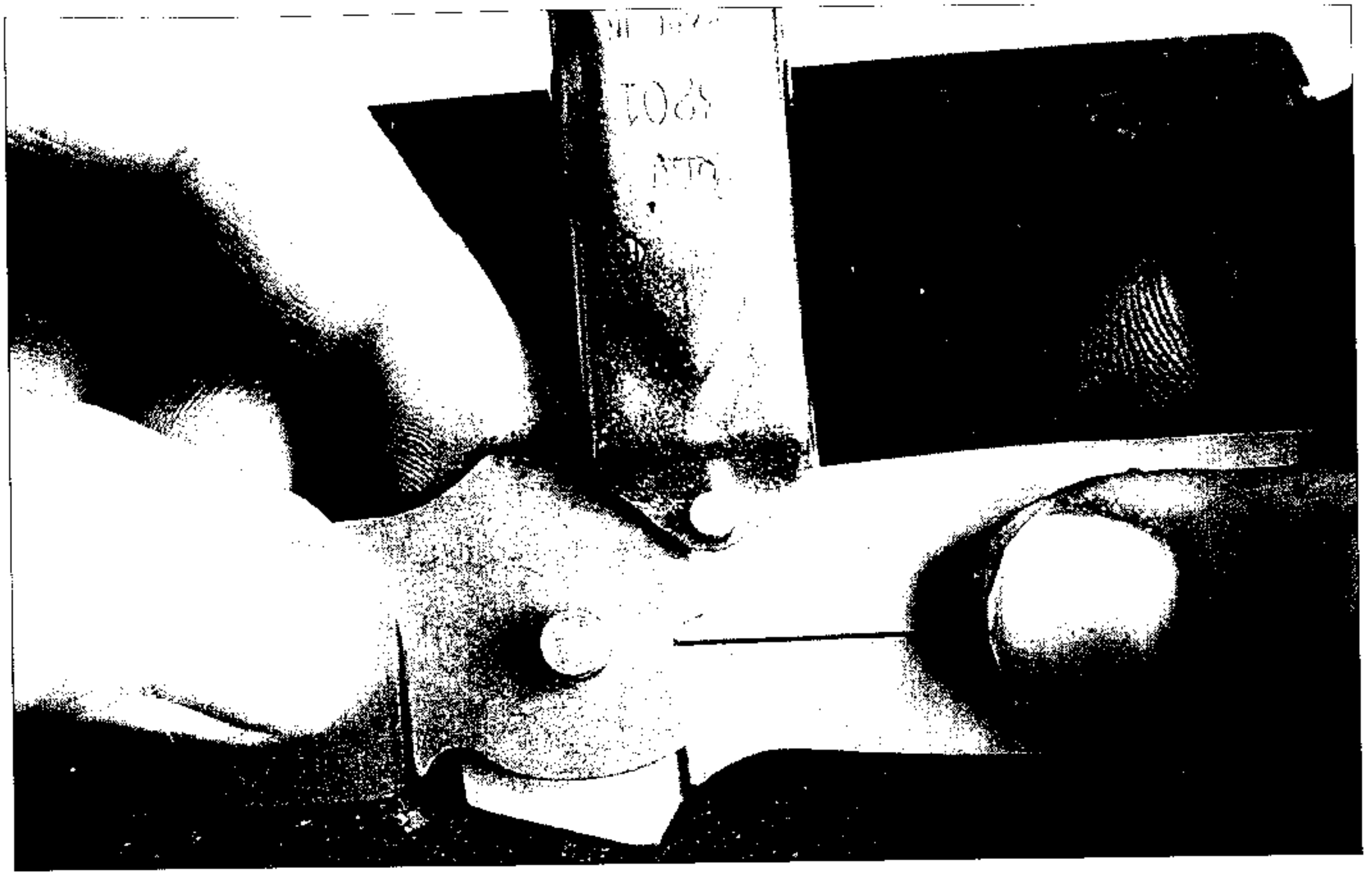


Fig. 135: Verifying the fit of the spring against the blade's lock bevel.

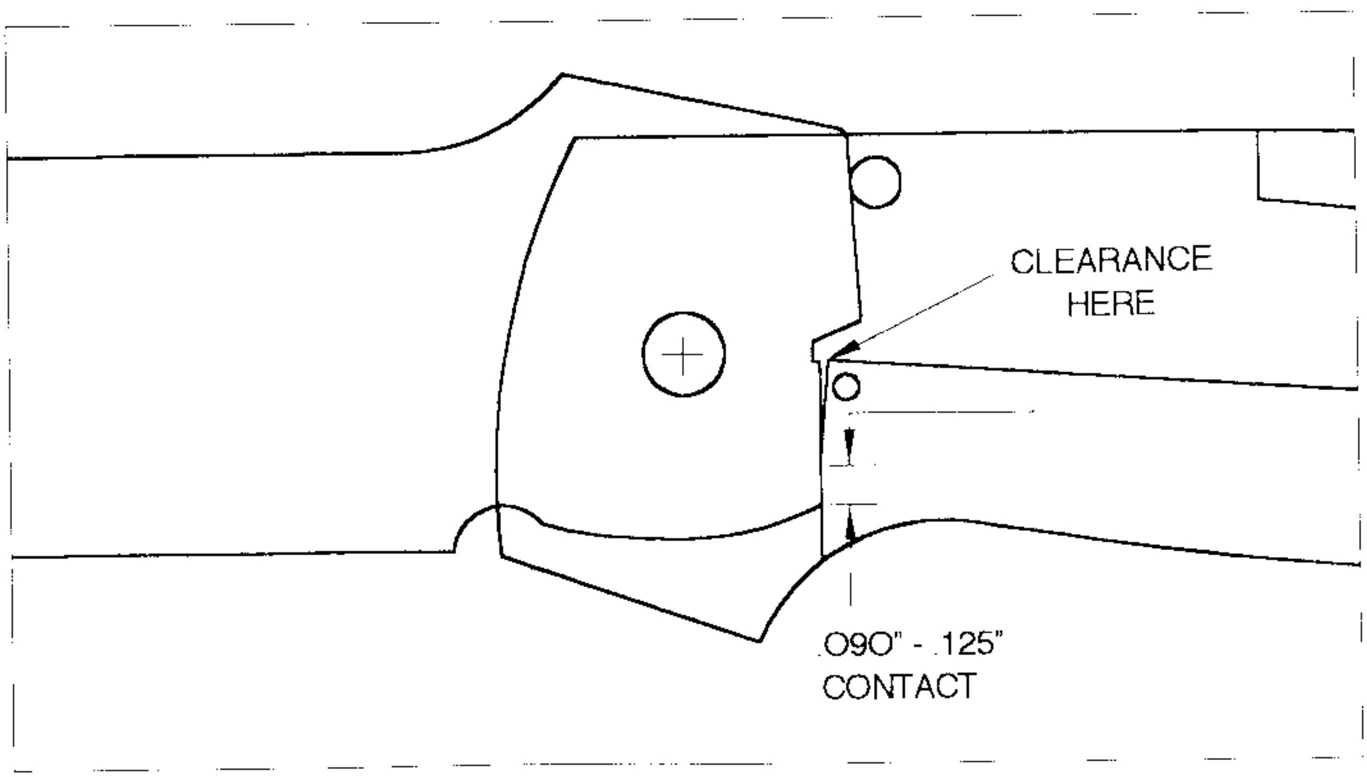


Fig. 136: Correct contact between spring and blade.

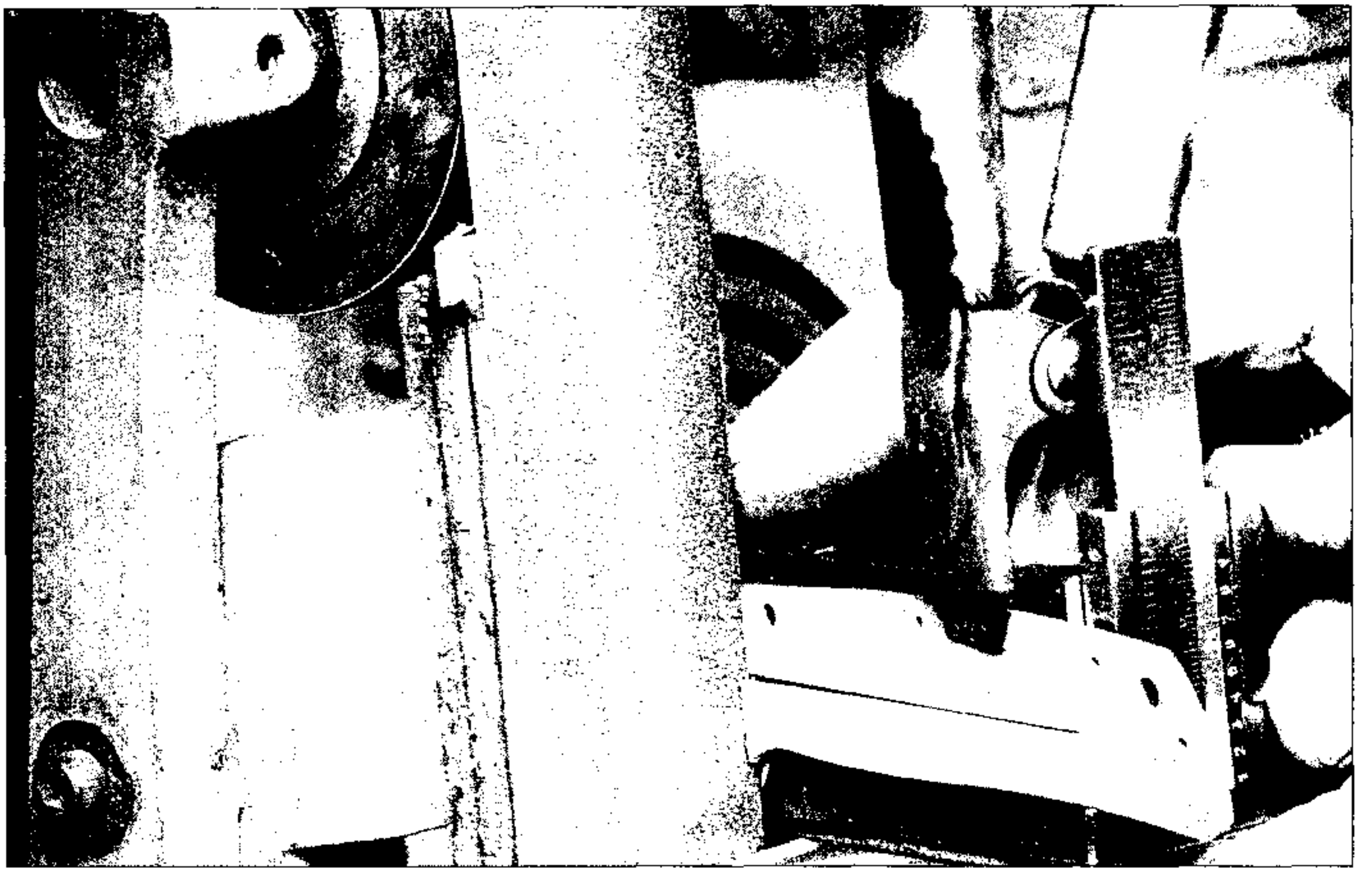


Fig. 137: Grinding the face of the spring in order to fit it to the blade's lock bevel. A special holding fixture is used to grind the spring. (See Chapter 9)

Hold the assembly up to the light and check that the primary contact point is about 1/8 inch of contact at the lowest portion of the blade bevel. If the spring contacts the top portion of the blade bevel, the blade will rock up and down. Adjust the play by removing material at the top part of the front of the spring to allow a little light to pass through there (Fig. 136). For details on linerlock geometry and trouble shooting, see Chapter 4.

Grinding the front end of the spring can be tricky and it must be done with the spring bent outward so as to allow clearance for the grinding belt. I built a special holder for this procedure and it is described in Chapter 9 (Fig. 137).

8. File the checkering grooves into the spring, if desired, at the area exposed by the handle's spring release cutout or scallop (Fig. 138).

9. Punch the anti-rotation "D" into the pivot hole using a slightly domed punch (Fig. 139). My pivots look like a "D" because there is a flat milled into one side to prevent the pivot from rotating when the blade is opened and closed (Fig. 140). A cross pin in the pivot which fits into a small slot in the handle may also be used.

10. Locate the position of the ball bearing detent (Fig. 141). I use a 1/16-inch ball and it can sit anywhere in the triangular area previously scribed on the spring. Drill the hole with a #53 drill and set the ball bearing into it leaving about .020 inches standing out (Fig. 142). The undersize hole will close around the ball, locking it in place. The exposure of the ball is determined by the thickness of the washers which will be used as side bearings between blade and handle after the knife is assembled. I use .020-inch washers so the ball can be that high above the spring, but not more, or else it will interfere with the smooth operation of the blade (Fig. 143).

I have tried many materials from which to make my washers and have found that Nylatron is the best. This is a type of sheet nylon impregnated with molybdenum disulfide, a very tough lubricant. The Nylatron is inexpensive, easy to work and lasts forever. It does not seem to wear out at all, even under gritty conditions, and is self-lubri-

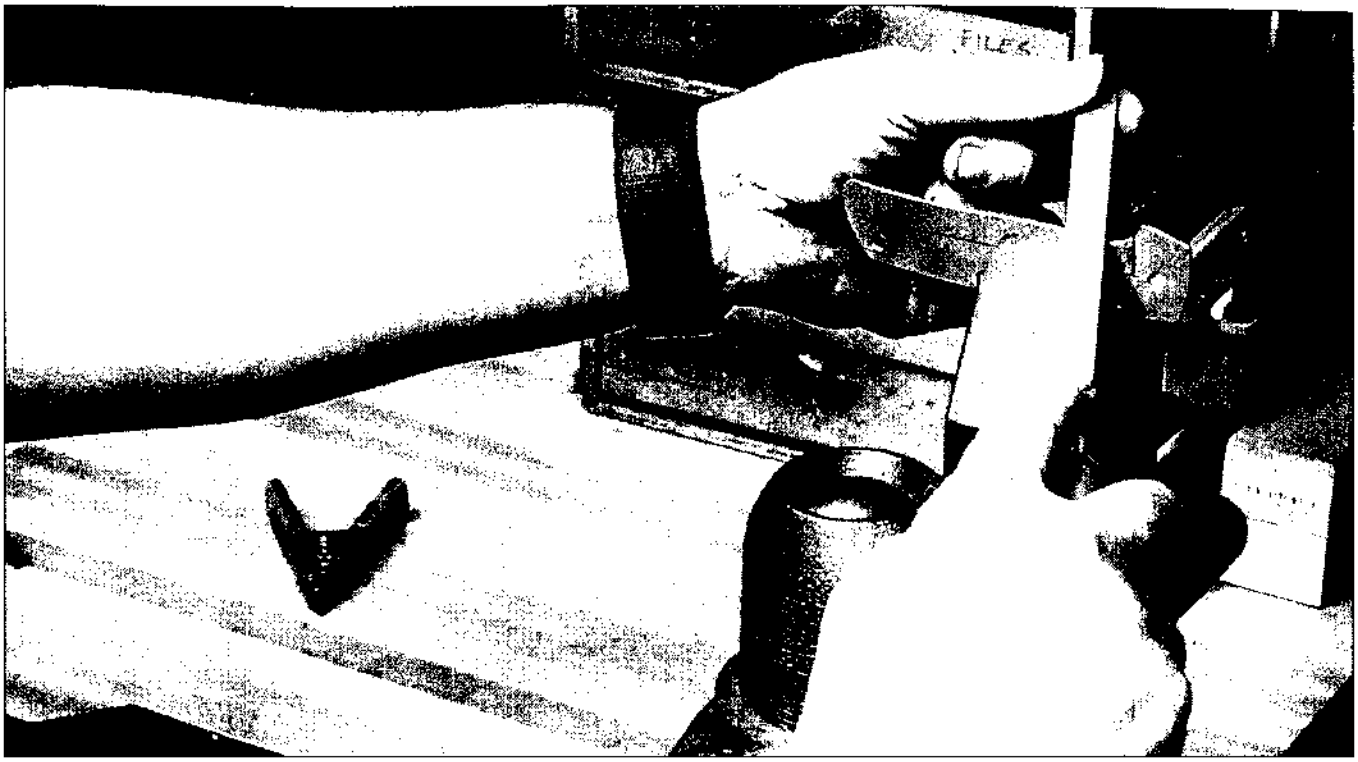


Fig. 138: A serrated edge is put on the spring to afford positive traction to the thumb during release from the blade lock. A medium-gauge checkering file is used for this procedure.

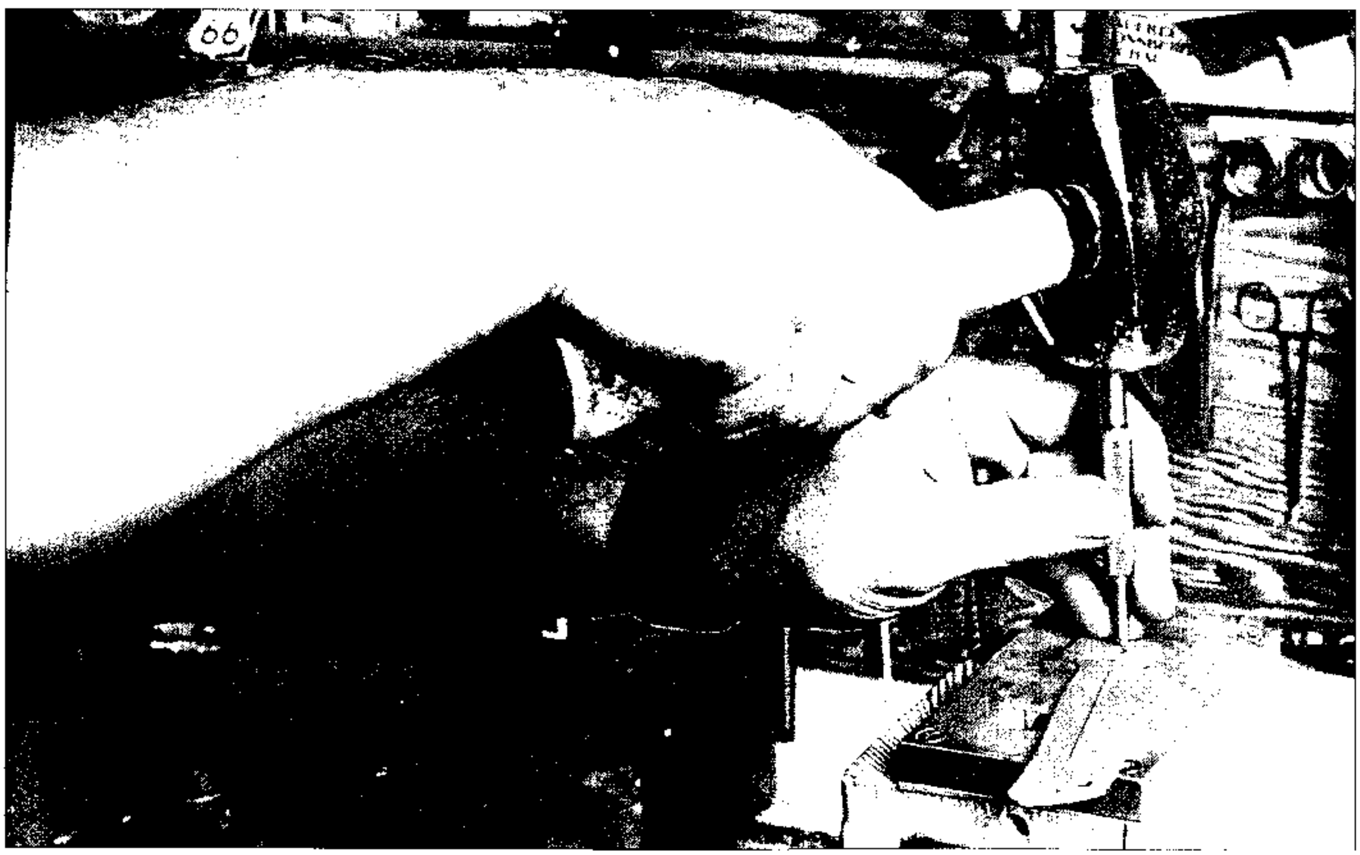


Fig. 139: The pivot hole is formed into a "D" with a rounded punch on the staking plate.

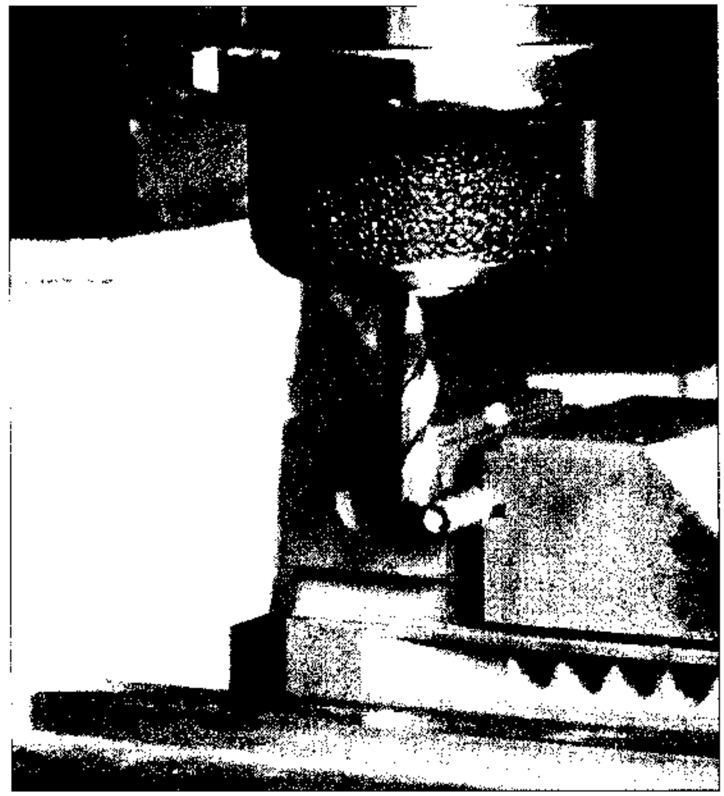


Fig. 140: Milling the anti-rotation "D" shape on the pivot bolt.

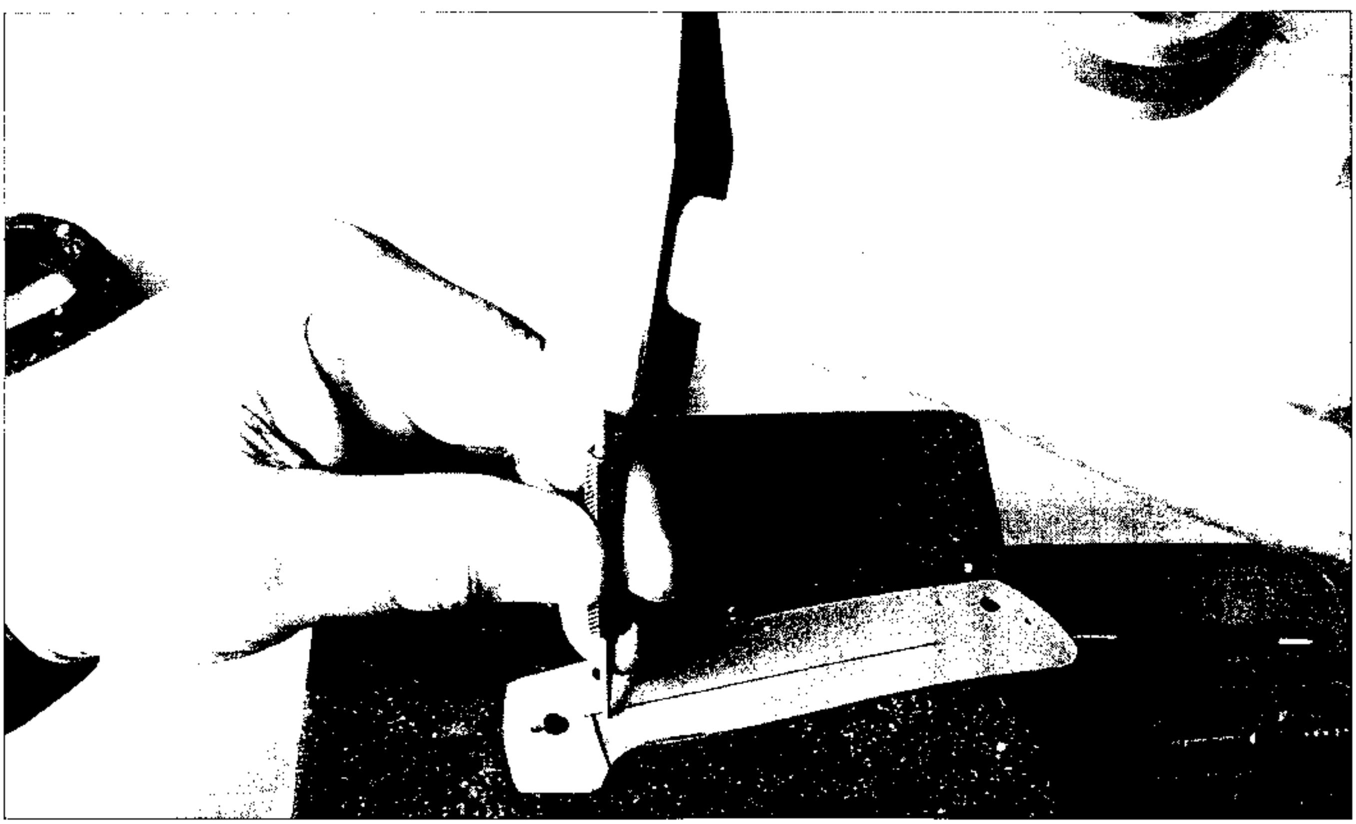


Fig. 141: Punching the location for the ball-bearing detent within the area of the small, scribed triangle described previously.

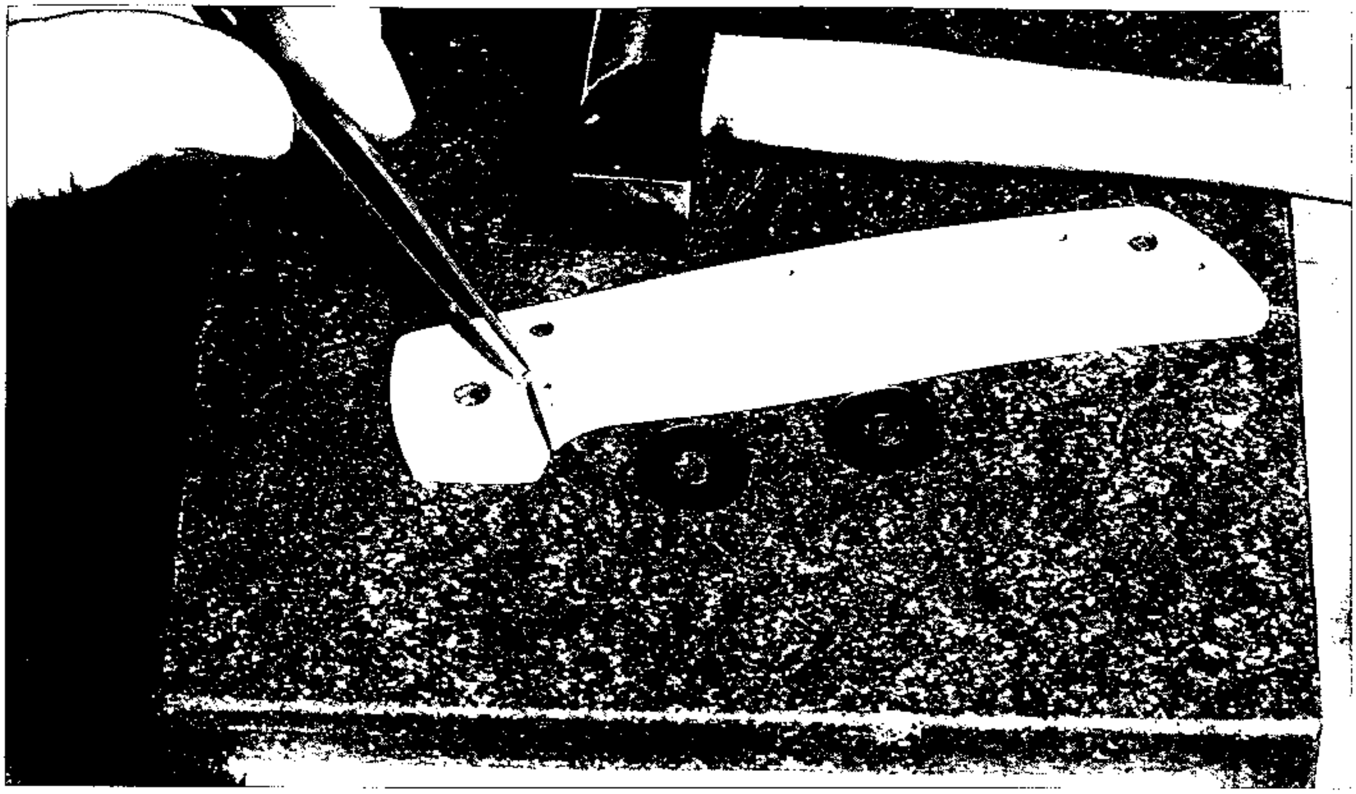


Fig. 142: Placing the ball bearing into the drilled hole. If done correctly, it must be pressed or hammered into the hole.

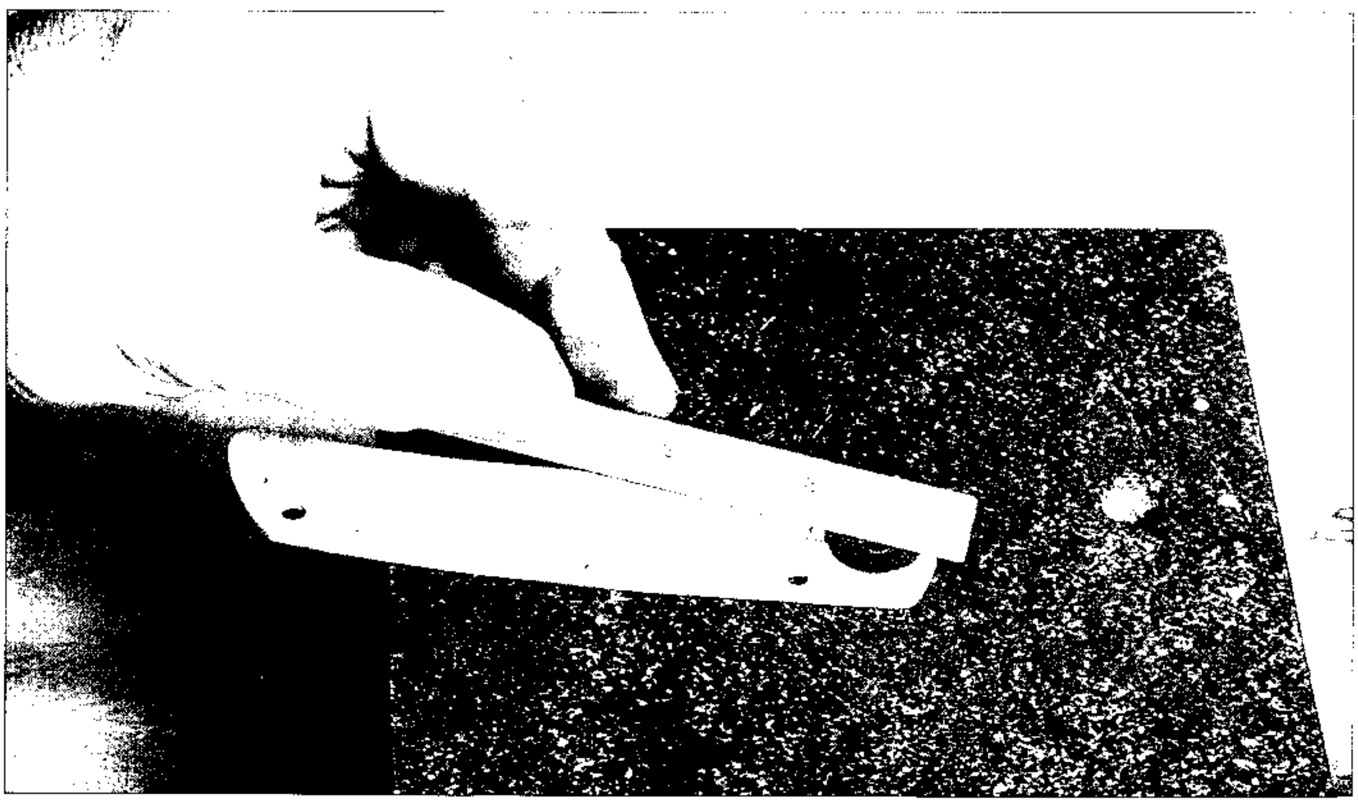


Fig. 143: Using a rule to check that the ball does not protrude above the level of the washer.

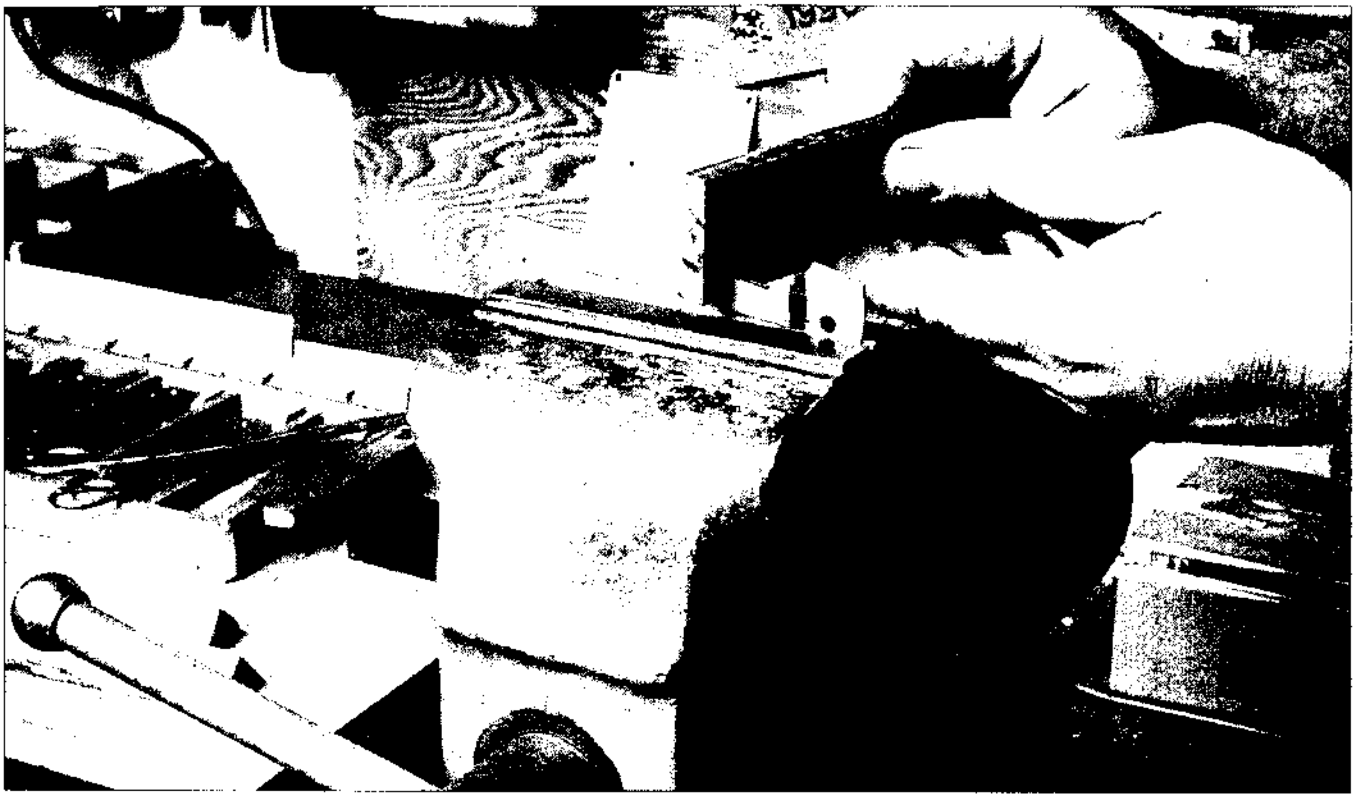


Fig. 144: Bending the spring gradually with a notched wood tool.

cating. It provides very smooth operation of the blade and does not have as much "give" to it like Teflon, which I have found to be somewhat "spongy."

11. Bend the spring carefully. Use a tool like a wood block with a notch cut out to slowly and repeatedly bend the spring along its front two-thirds (Fig. 144). The bend should be gradual and progressive, rather than having a kink in one spot (Fig. 145). Bend the spring over until it is out the same distance as the thickness of the blade plus the two washer bearings together.

12. Make the back spacer according to your pattern and drill for screw clearance (Fig. 146). The

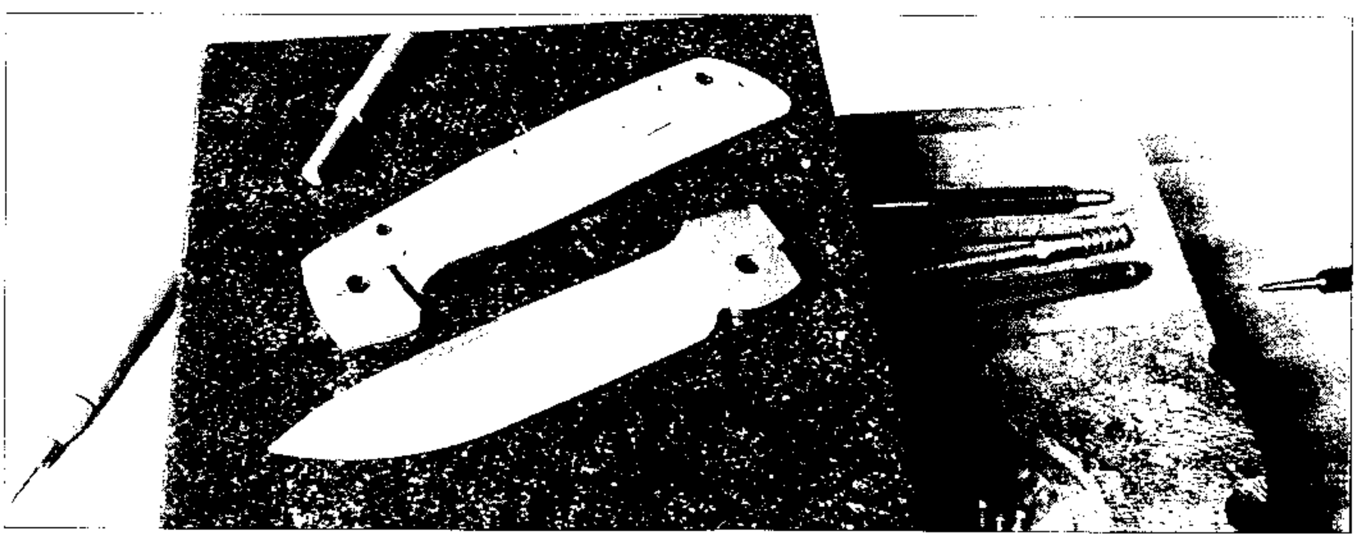


Fig. 145: The completed spring, bent and ready for assembly.

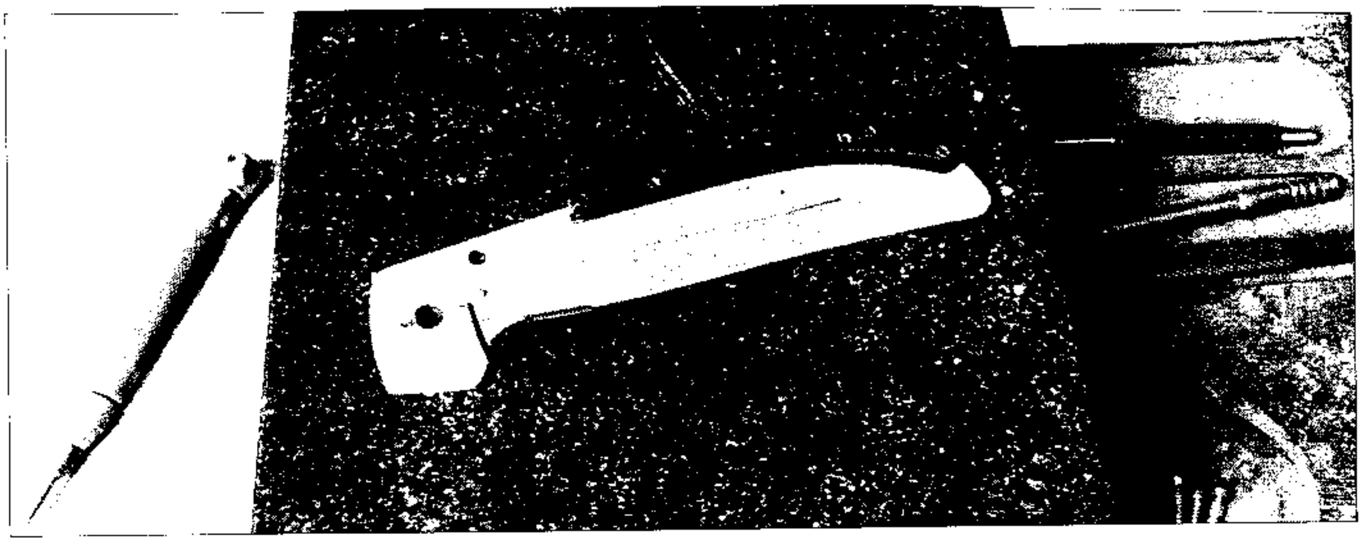


Fig. 146: The spring with the completed spacer in place. At this point, assemble the completed handle.

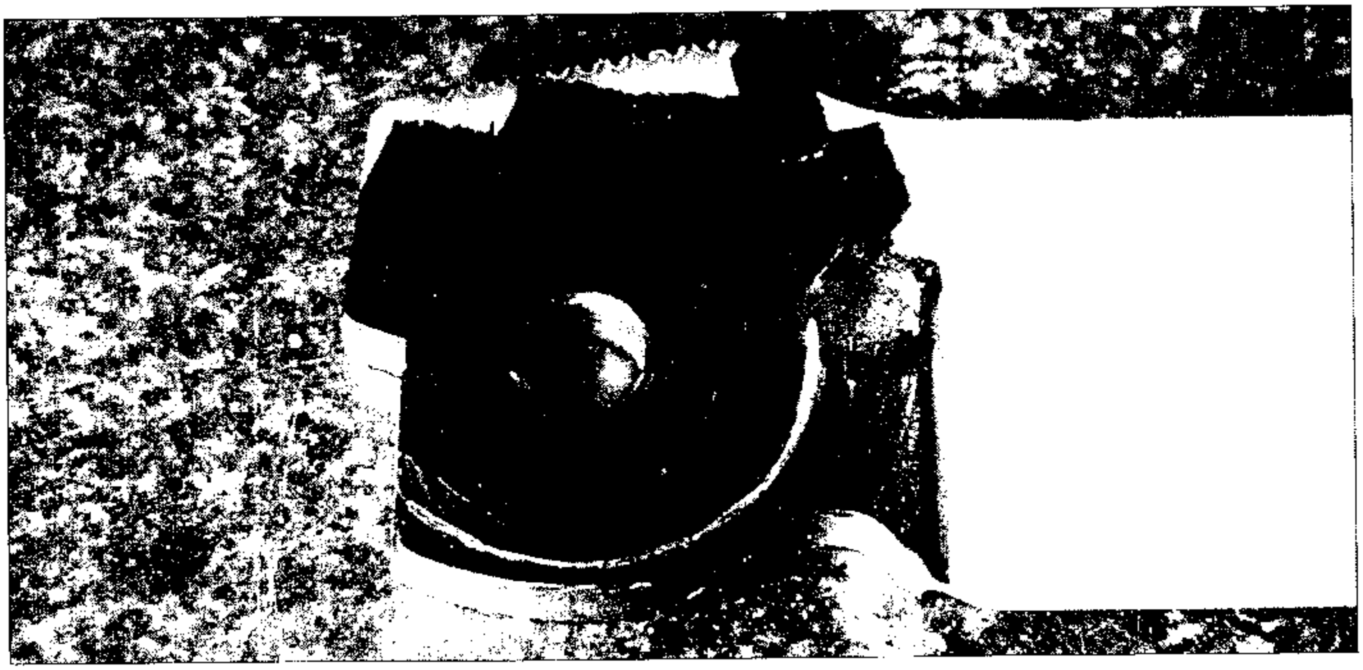


Fig. 147: Open and close the blade several times and, upon removing it from the handle, you will see a track left on the tang by the ball bearing.

thickness of the spacer material should be the same as the blade and washer thickness mentioned above. Assemble the handle, complete with stop pin, in order to locate the detent hole which is to be drilled into the blade tang.

13. When the blade is assembled into the finished handle and it is opened and closed repeatedly, the ball bearing will mark a track onto it and that track will have a definite stopping point, showing the limit of travel when the blade is closed. (I use a red marker to paint the blade side and show this track more clearly to my tired old eyes) (Fig. 147).

Remove the blade and use a carbide center punch to locate a spot about .020 inches beyond the end of the track (Fig. 148, 149). Drill a 1/16-inch-deep hole, using a carbide drill of the same size used to set the ball into the spring, #53. Reassemble the blade into the handle and see that it

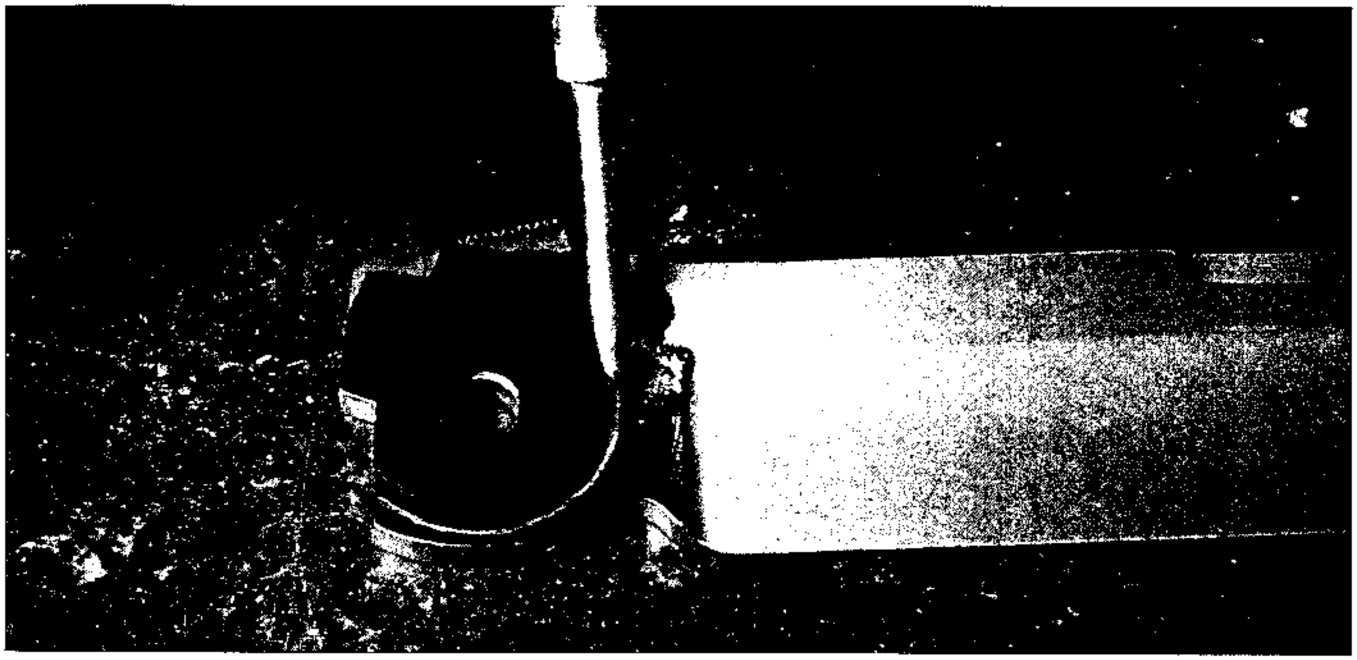


Fig. 148: Use a carbide punch to mark the location of the detent hole on the blade tang, about .020 inches beyond the end of the track.

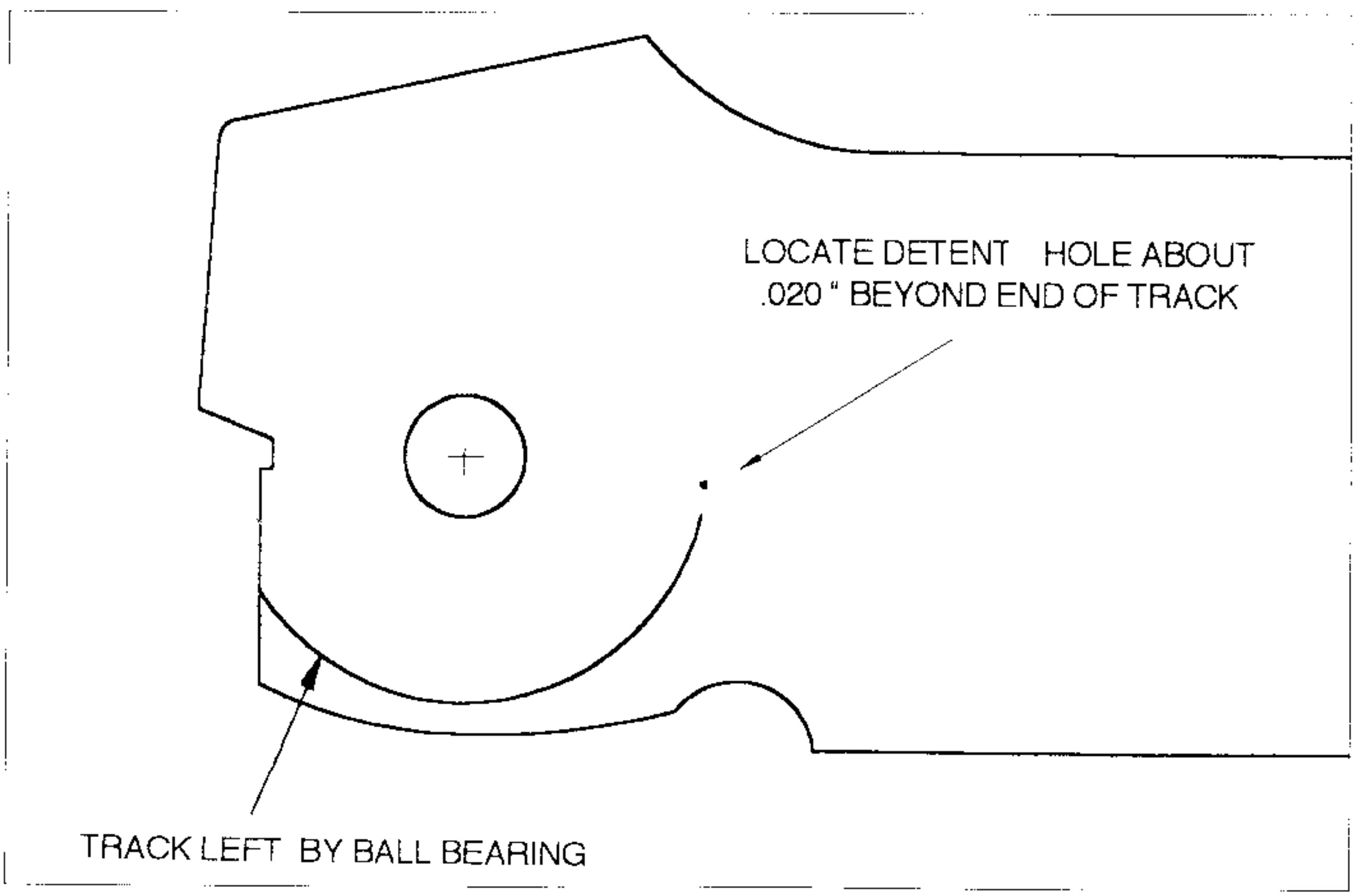


Fig. 149: Where to locate the detent hole on the blade tang.

snaps closed with authority. If not, countersink the hole slightly to open it up. Your goal here is to have the ball just start to snap into the hole and be stopped as the blade strikes the stop pin. If the ball falls completely into the hole or travels beyond the hole, it will not close securely and may have some play while in the closed position. It is better to have the hole too far away from the ball than too close. If the ball does not reach the edge of the hole, the detent can always be redrilled with a slightly larger drill but if the hole is too large or its center passes the center of the ball, you will need to plug the hole and start over. (See Chapter 4).

An alternative method of creating the detent is to assemble just the blade and spring in the closed position with try pins in the pivot and stop pin holes. Using a carbide drill, drill the ball bearing hole clear through the spring but not all the way into the blade, just deep enough to mark the location on the tang. remove the blade and drill the blade detent hole with a slightly smaller carbide drill, about one to two number sizes smaller than the hole in the spring. (If you are using a 1/16-inch ball bearing, drill the spring with a #53 drill and the blade tang with a #54 or #55). This will make the holes concentric, but I don't recommend

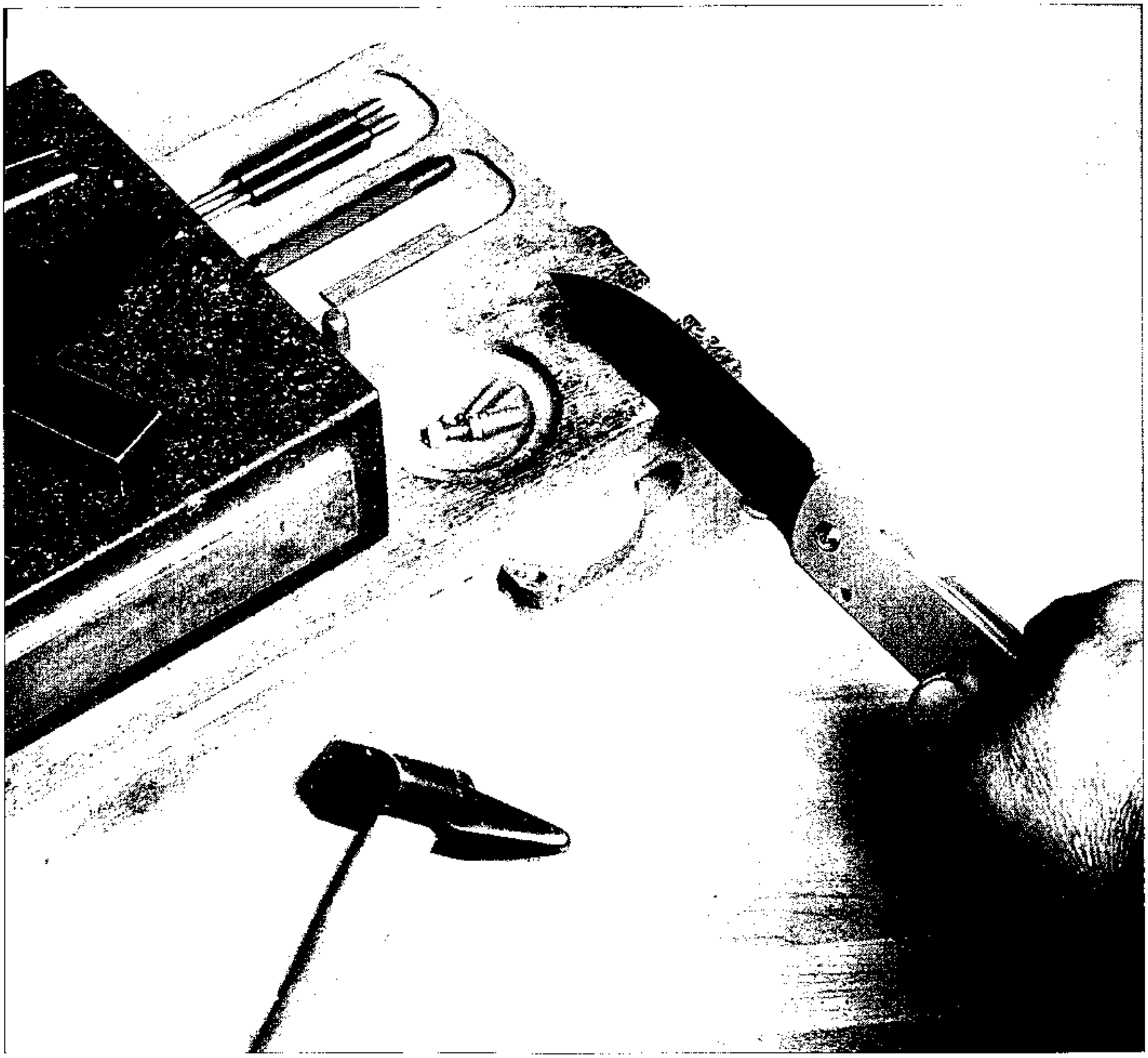


Fig. 150: Set the spring against the blade's lock bevel by sharply rapping against a wood block.

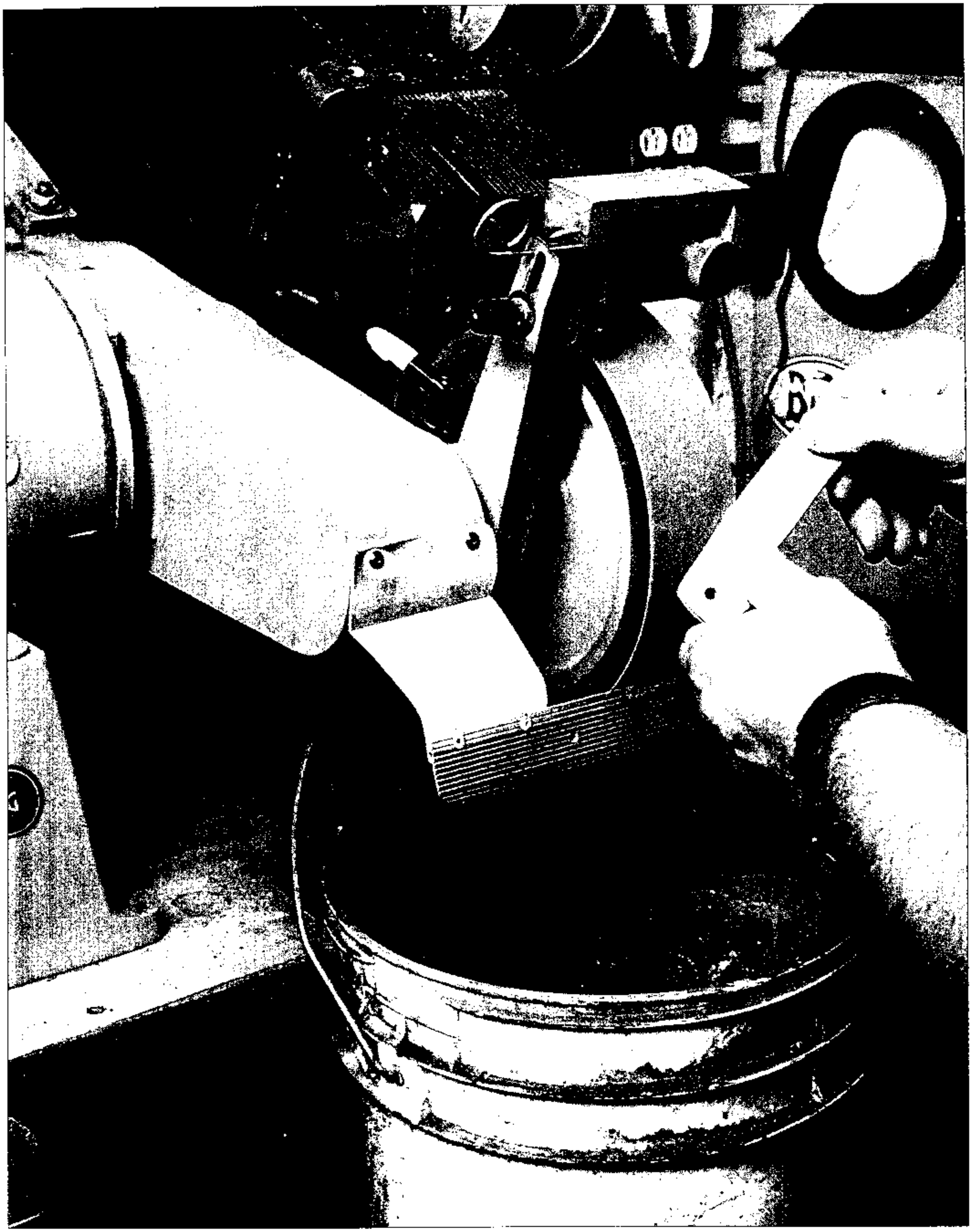


Fig. 151: Chamfer off the sharp edges of the handle to provide a comfortable grip.

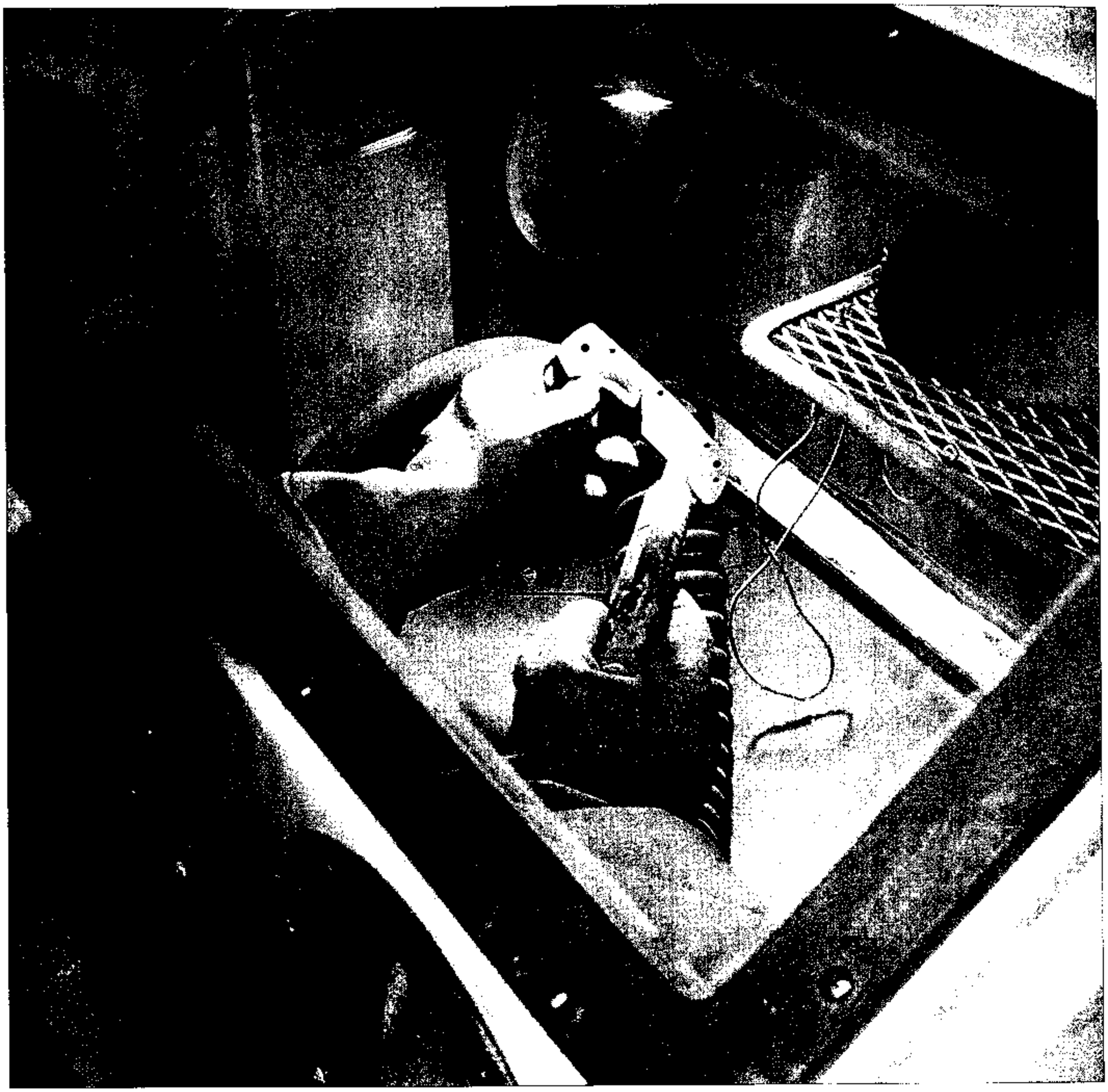


Fig. 152: Sandblasting the completed titanium handle.

this method since it requires great precision and may allow the blade to have play in the closed position if the holes don't line up exactly. (See Chapter 4).

14. Open the blade and check its lock-up. Turn the knife over, cutting edge up, and rap the back of the blade sharply on the bench top or a block of wood (Fig. 150). This will help seat the blade against the spring and show up any defects in the lock. This also helps to virtually eliminate any "breaking-in" period for the spring. If there are problems evident, see Chapter 4 for troubleshooting tips.

The basic knife is now complete and ready for finishing.

15. Carefully chamfer the exposed edges of the handle so that it is comfortable in the hand (Fig. 151). Titanium may be sandblasted for a uniform

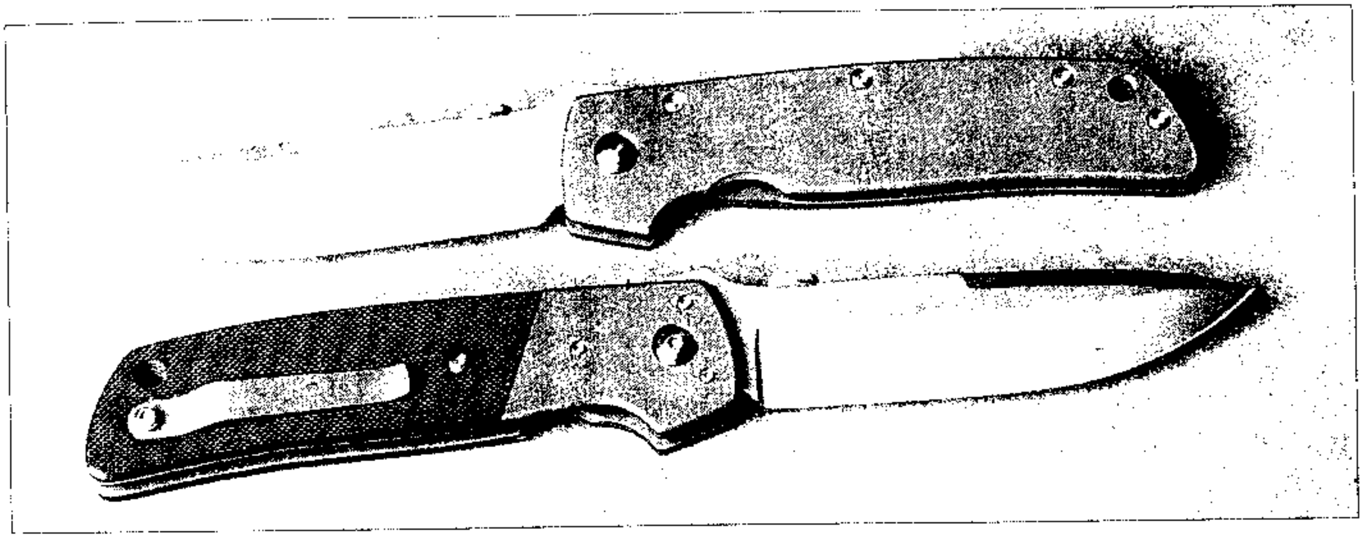


Fig. 153: Finished knives, ready for table space at the next show.

finish or it may be hand-rubbed for a satin finish (Fig. 152). I prefer the sandblasted look for tactical folders because it affords a better grip. G10 should be sandblasted to produce the characteristic waffle effect and grip. However, a type of G10 is now available with a "peel off" surface which exposes an aggressive pattern of texture on the exposed surface. I use aluminum oxide sand of 180-grit at 90 pounds of air pressure. Carbon fiber may be polished (I don't think it looks very nice if it is sandblasted) but I prefer a matte, hand-rubbed, satin finish. I use 800-grit wet or dry paper and I rub it down, wet with water, to eliminate the dust problem.

16. After finishing all parts and before final assembly, mark the blade with your logo. I use an electro-etch machine with a nylon stencil and commercial etchant.

Sharpen the blade and assemble the finished knife.

The inlaid spring alternative

The locking spring does not need to have its own separate plate in order to function. It can be inlaid into a pocket, that is milled into the handle. This is a system I find best for small, gentleman's (or lady's) knives. You will need a milling machine for this procedure in order to cut the pocket into which the spring will rest, flush against the inside of the handle.

There are two methods for securing the inlaid spring into the handle: screws and a dovetail. If the handle is to be made of G10 or carbon fiber, the screw option must be used as these materials may chip or the sharp edge of a dovetail may break under pressure. Screws or a dovetail may both be used with a metal handle.

Since I do not use an inlaid spring for the large ATCF, the illustrations show the construction of my TTF-4 "Baby" folder which does use such a spring. In this case, the handle is of titanium so the inlaid spring is of the dovetailed design explained below.

The shape of the spring can be the same with both methods so we'll start there.

1. Using titanium (or stainless steel) sheet, lay out the spring profile Fig. 154). I use material of .040 inch or .050-inch thickness because my inlaid springs are for smaller knives. The profile shown in the illustration has served me well although I have seen some knife makers taper the sides of the long arm. If the spring is to be attached with screws, a simple, rectangular piece of titanium and matching pocket reaching to the edge of the handle will suffice, but it will leave the spring's edge exposed on the bottom of the knife. The design in the illustration will expose only the release tab.

2. Cut out and grind the spring's profile. I would suggest milling the long leg to ensure that the edges are square and parallel. This is especially important if the spring is to be dovetailed into the handle (Fig. 155).

3. A.. If the spring is to be screwed into the handle, locate and drill two holes towards the end of the spring's long leg. You may choose to expose the screw heads on the outside of the handle, in which case you will tap the spring for the proper size screw, usually 0-80 or 1-72 thread. If you choose to keep the screw heads hidden inside the knife, it is the handle which will be eventually tapped. In either case drill the spring at this time with only the tap drill so the holes will act as a drill guide later (Fig. 156).

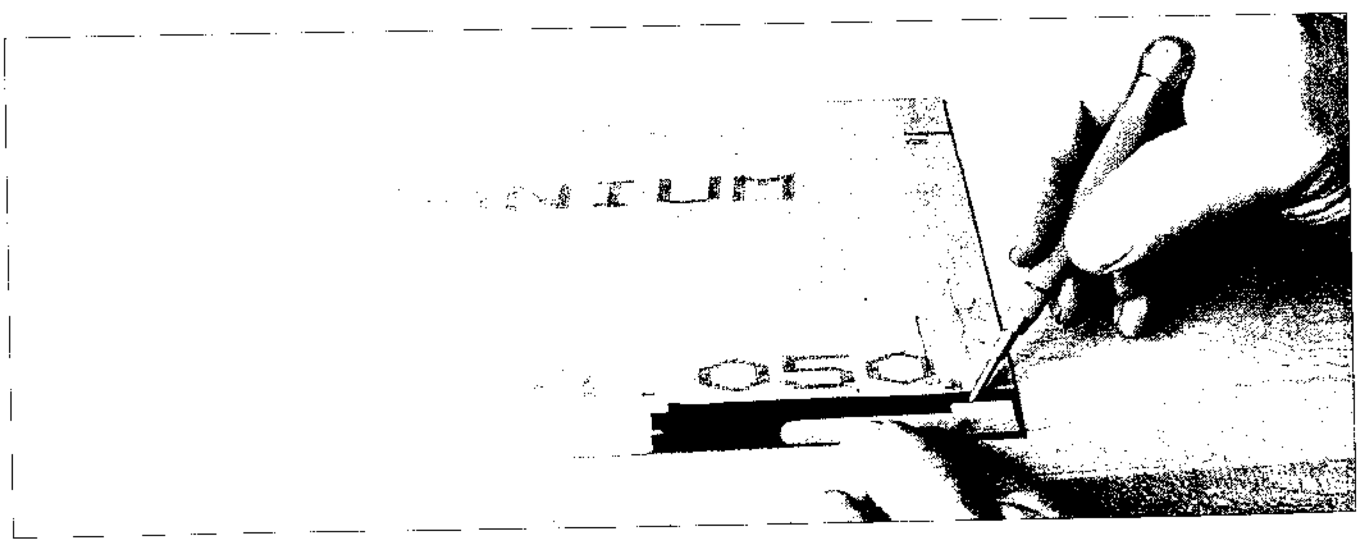


Fig. 154: Scribe the layout of the inlaid spring onto a piece of titanium.

Fig. 155: Mill the edges of the spring to the correct dimension.

Fig. 156: Mark the location of the two assembly screws (if the spring is not to be dovetail fitted to the handle).

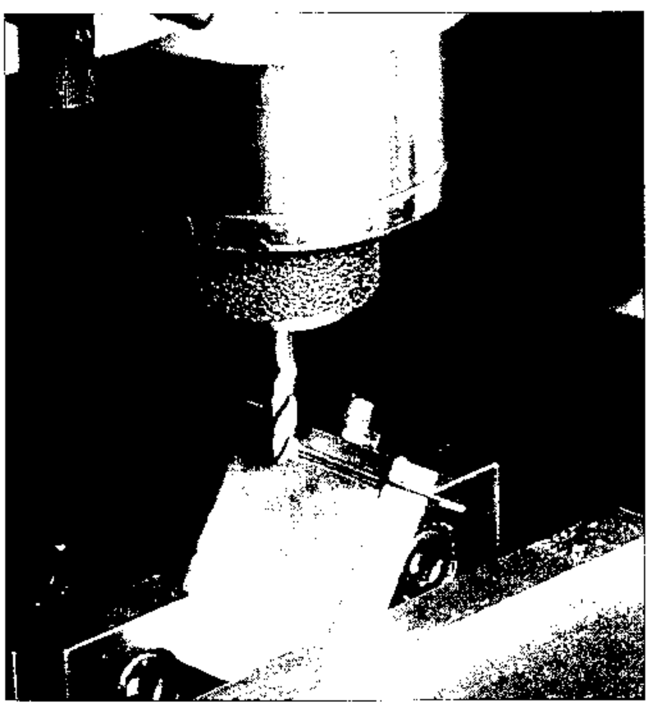


Fig. 157: Mill the edges of the spring at 60 degrees using a special holding fixture for a dovetail fit. (See Chapter 9)

B.. If the spring is to be dovetailed into the handle, mill the sides of the spring to a 60-degree angle on both edges along the long leg (Fig. 157). I built a special fixture for this procedure which holds the spring at the correct angle to the cutter as shown in Chapter 9. Another way of doing it is to clamp the spring onto the top of a milled plate and use a dovetail cutter to create the angled edge (Fig. 158). Be sure the edge of the spring is parallel to the travel of the table.

4. If the spring is dovetailed, generate the same angle, in this case 60 degrees, around the rear, curved portion of the long leg of the spring so that it will fit nicely into the dovetailed pocket in the handle. I use a fine grinding belt on a hard contact wheel for this operation (Fig. 159).

5. Locate the completed blade onto the handle side with pivot and stop pins in place. Open the blade completely and clamp in place. Scribe a line where the edge of the blades' lock face meets the handle (Fig. 160). Remove the blade and locate

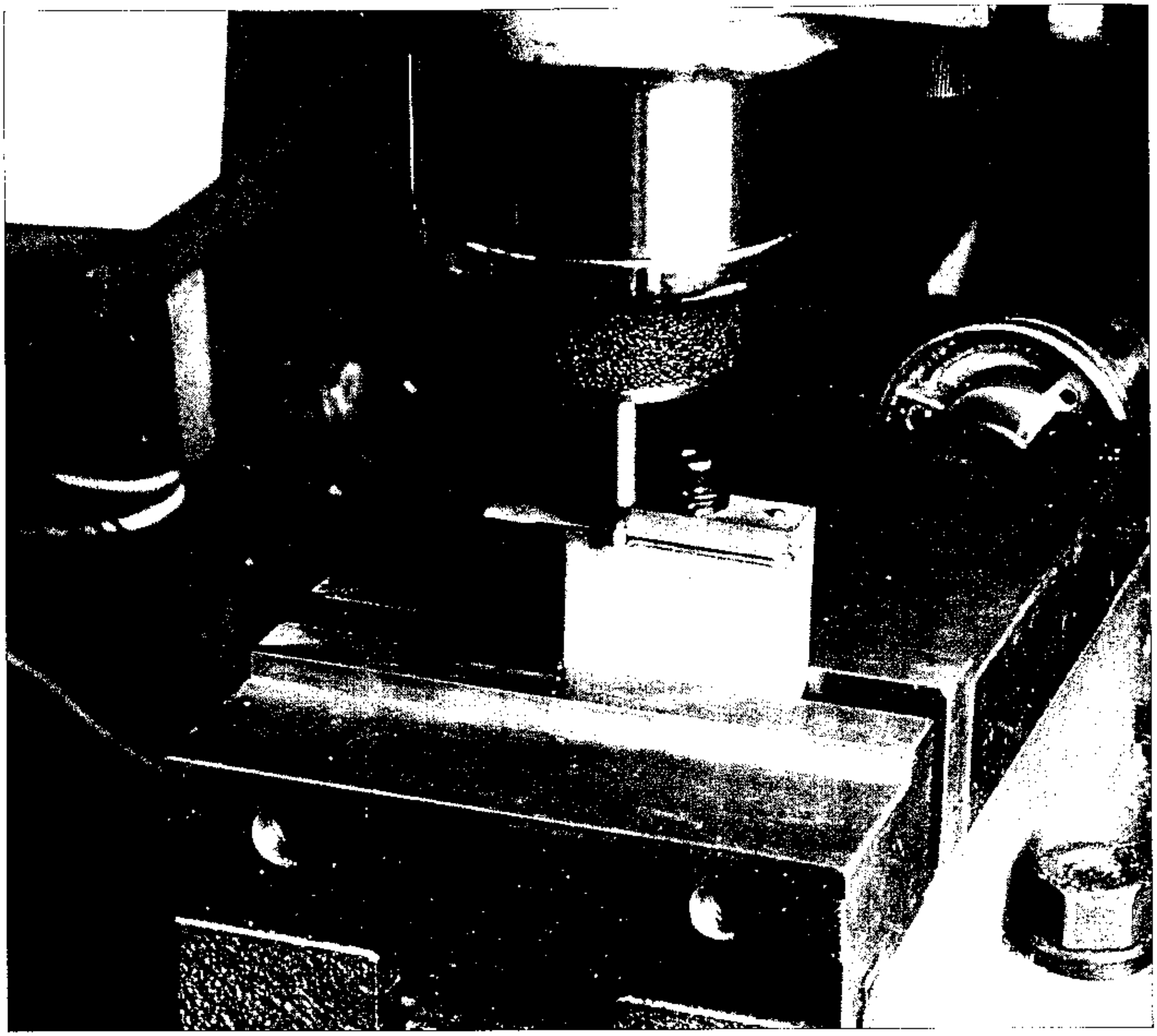


Fig. 158: An alternative method of milling the edges using a 60 degree, dovetail cutter.

and clamp the spring onto the handle, overlapping the scribed line by about .020 inches so there will be some extra spring material to remove later when the lock is fitted to the blade. For this step, I paint the handle with a black marker, just to highlight the scribed lines. Carefully scribe the profile of the spring onto the handle and remove the spring. The scribed line now describes the area of the handle to be milled out (Fig. 161).

6. Mill out the pocket in the handle (Fig. 162). Cut the pocket about .005 inches deeper than the thickness of the spring to allow for some clearance.* When you mill the front end of the pocket where the lock face is, extend your cut beyond the scribed line up close to, but not touching, the stop pin hole. Then, back off to the line and complete the traversing cut. This will leave the corner of the pocket opened so you will not have to round off the spring corner when you attach it. I use a 5/16-inch four-flute carbide cutter for this procedure, running at medium speed and low feed.

A. If you are using the screw-in option, mill to the very end of the scribed line. De burr the part and fit the spring into the pocket. Drill through the handle and tap the chosen part depending on where you want the screw heads to be.

B.. If the spring is to be dovetailed, stop the cut about 3/4 of an inch from the end. Change cut-

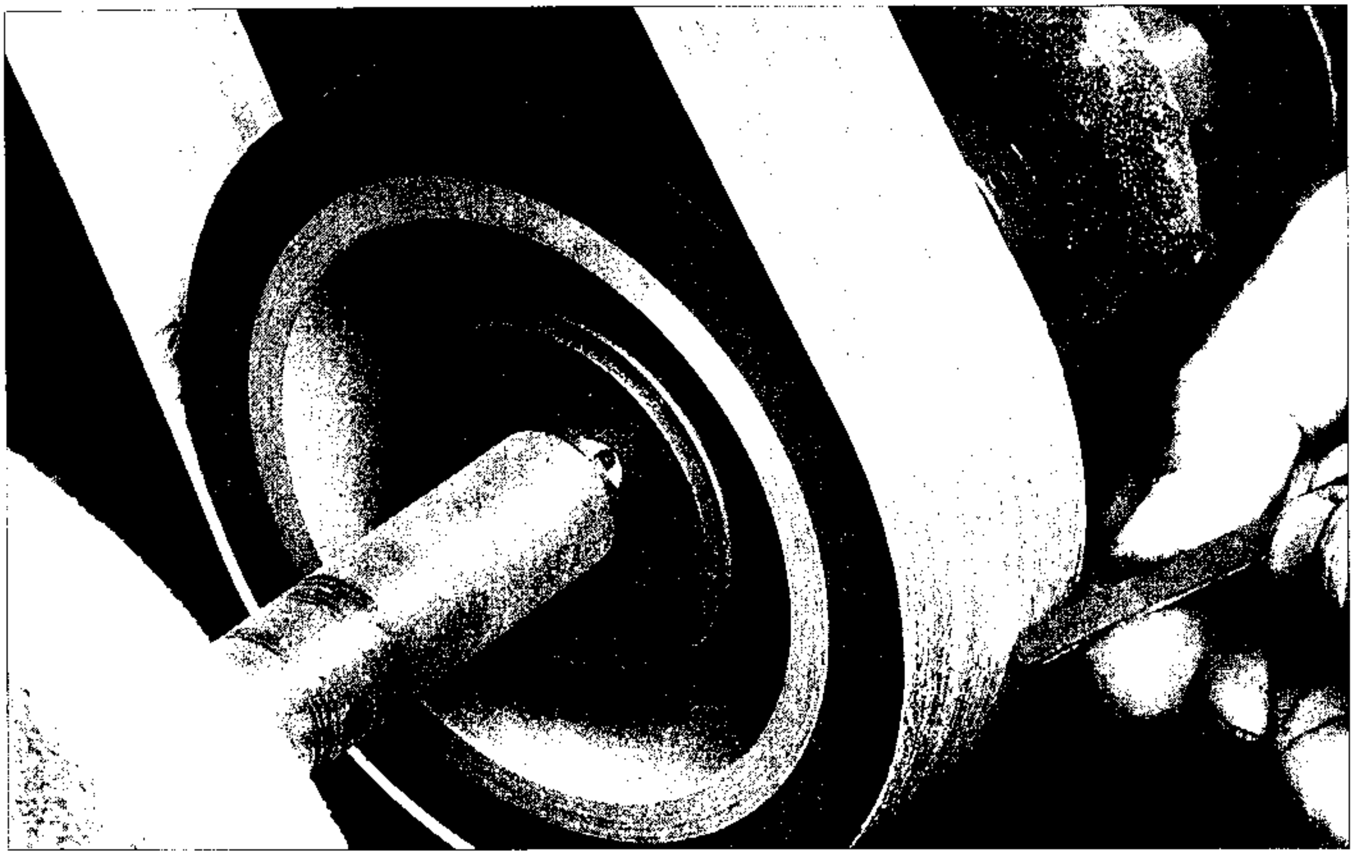


Fig. 159: Continuing the 60-degree angle around the butt end of the spring on a fine-grit belt sander.

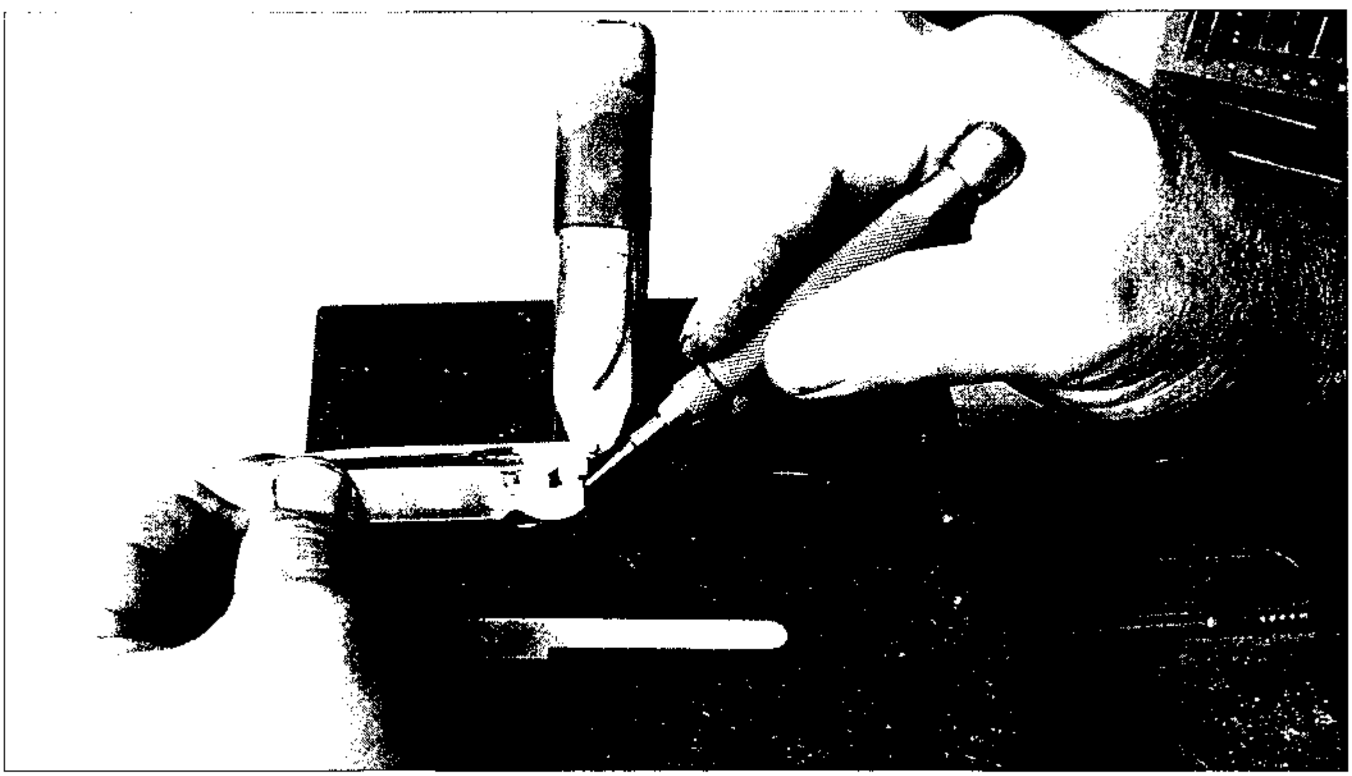


Fig. 160: Scribe the blade's lock edge onto the handle to establish the location of the spring.

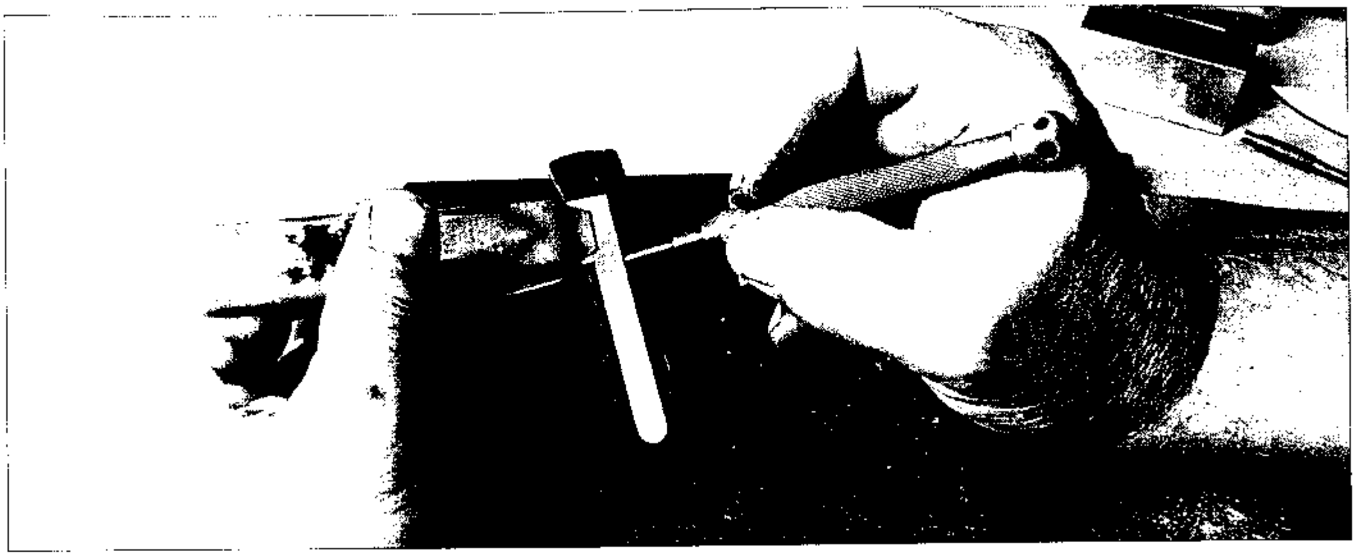


Fig. 161: Scribing the outline of the spring onto the handle.

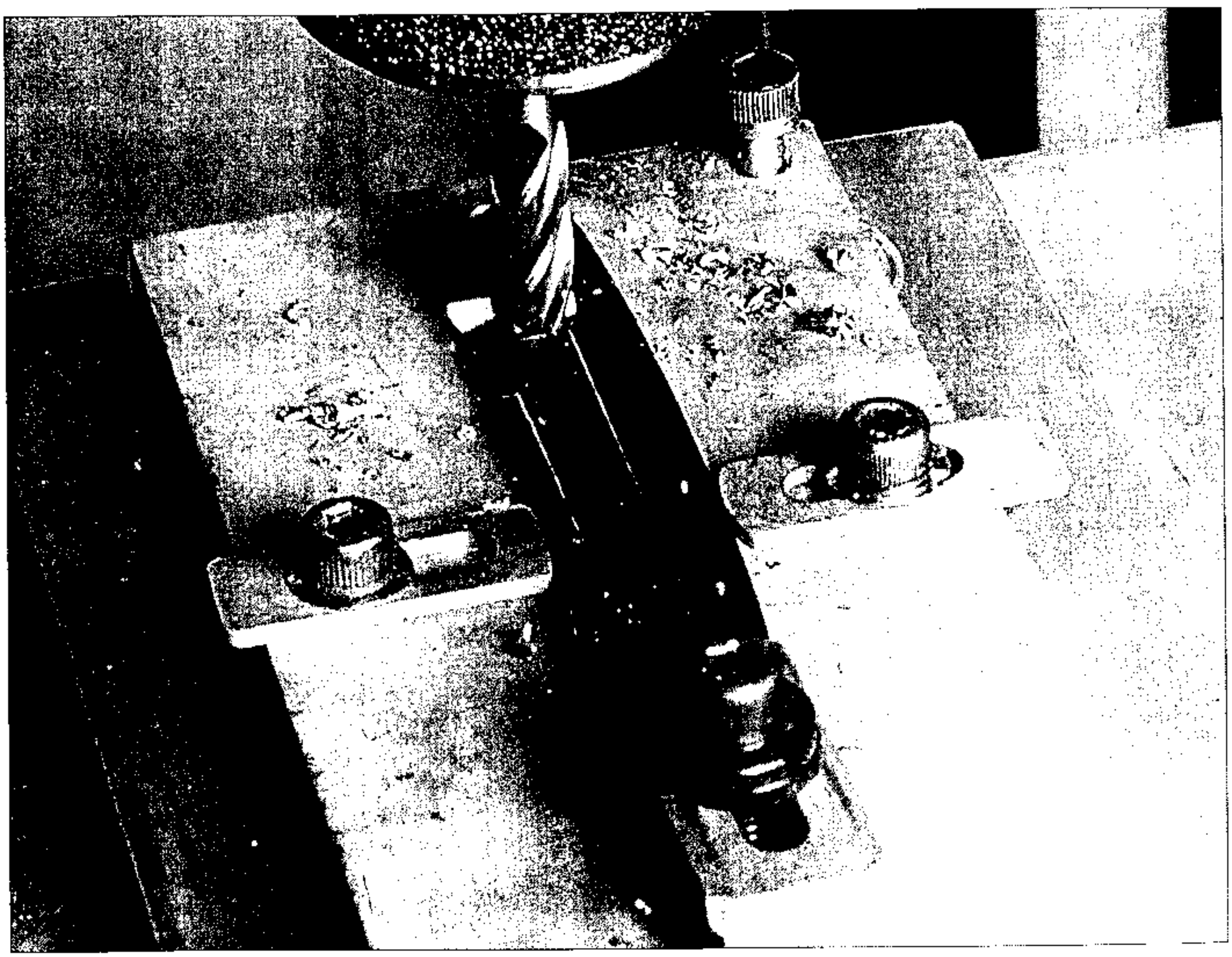


Fig. 162: Mill the pocket for the spring and pass the scribed edge so the square-cornered spring will fit into it.

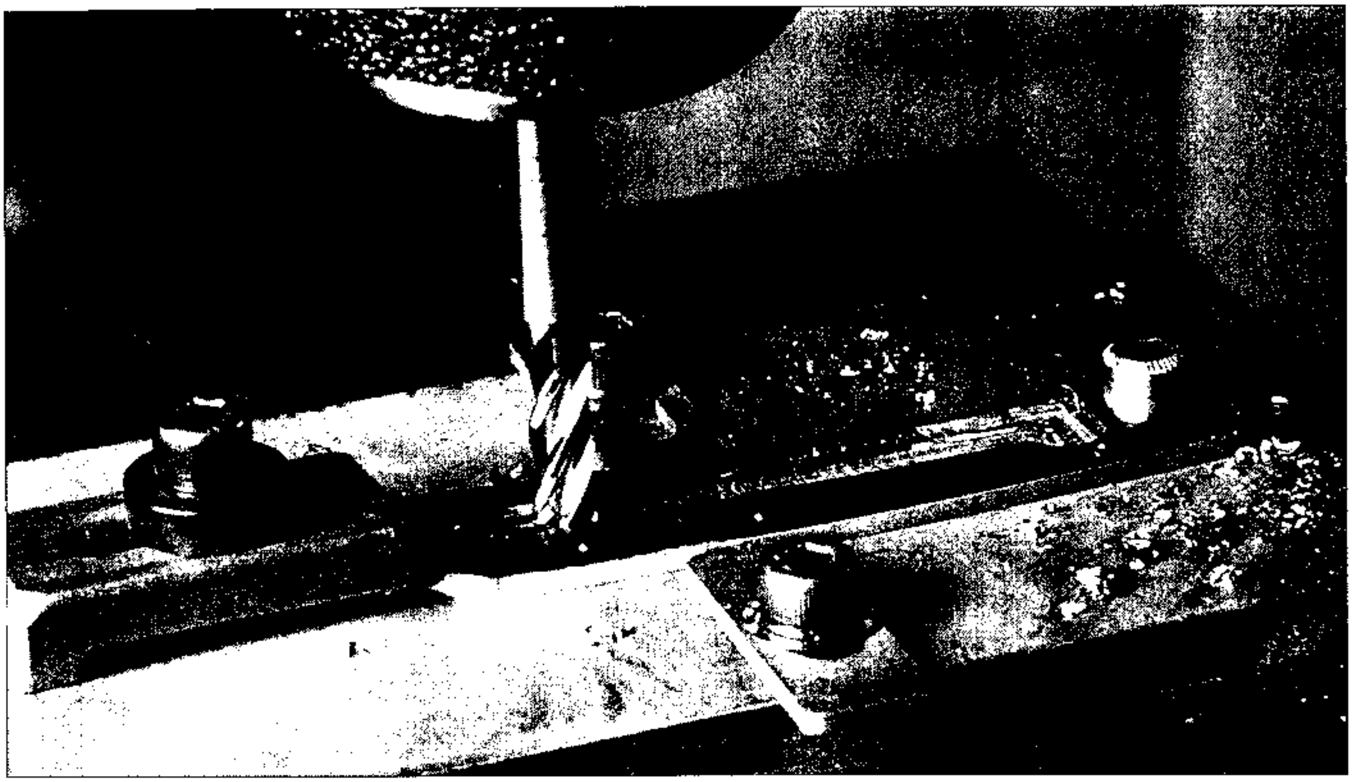


Fig. 163: Change cutters about 3/4 inch from the end. I change from a 5/16-inch groove, (the full width of the spring) down to a 1/4-inch groove to accommodate the dovetail cutter

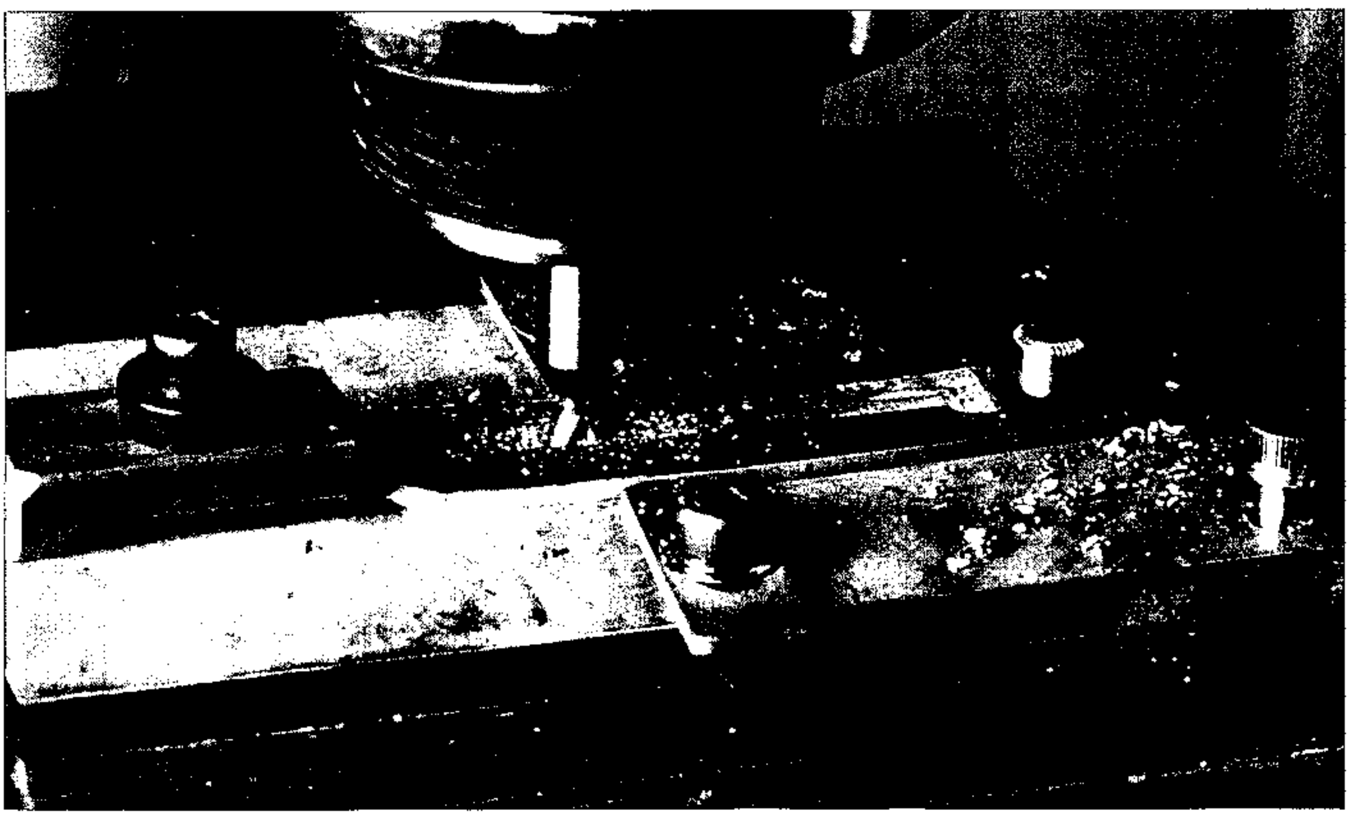


Fig. 164: Mill the end of the pocket with the dovetail cutter.

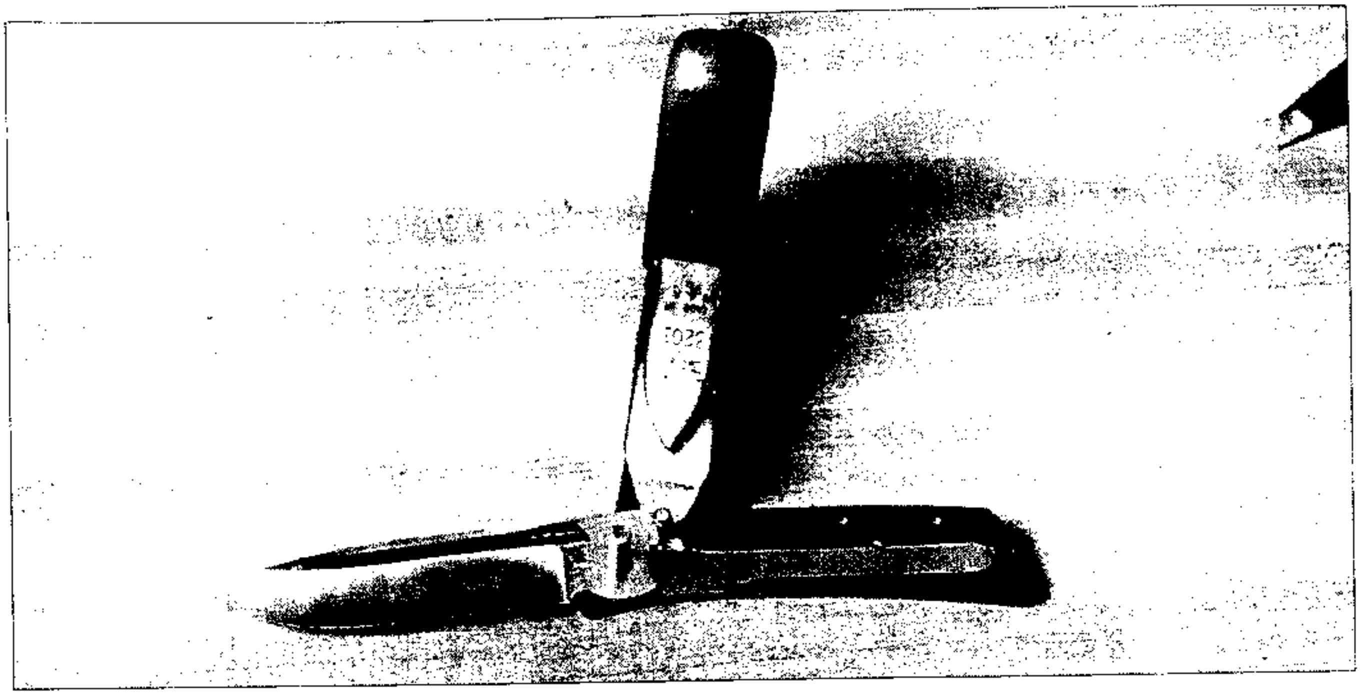


Fig. 165: The knife with spring inserted, ready to fit the blade. (See Chapter 6)

ters to a narrower size (Fig. 163). A 3/16-inch cutter would be about the proper size for the dovetail slot (Fig. 164), but since titanium is so tough and the small dovetail cutters are so delicate, I make an oversized slot with a 1/4-inch cutter. This doesn't give me a full mating surface between slot and spring but it is plenty strong for this application.

The only place I have found small 60-degree dovetail cutters is Brownell's gunsmith supplies. They measure about .282 inches, but tend to vary some so I find, especially with wear on the cutter, that I have to adjust each spring by polishing slightly on a Scotchbrite wheel until it slides, with gentle hammer taps, into the slot. Nothing else is needed to secure this type of spring into the handle.

7. With the spring attached to the handle and properly bent, proceed to adjust it to the blade and locate the ball bearing detent as described in Chapter 6 (Fig. 165).

* A note about spring depth in the handle: As discussed in Chapter 4, the ball bearing used for the blade detent needs to protrude above the side of the spring by about .020 inches for proper security of the blade in the closed position. Clearance for the blade's motion over the ball bearing is created, in my knives, by the use of washers of that thickness between the blade and the handle. As a result, my inlaid springs are virtually flush with the inside of the handle. If washers are not used, and the blade rides on the sides of the knife handle, the depth of the inlaid spring's pocket must be equal to the thickness of the spring **plus the protrusion of the ball bearing so as not to jam the blade's tang against the ball when closing it. See illustrations in Chapter 4.**

Chapter 8

Dressing up the basic knife

At this point, the basic knife is complete and functional. It is comfortable in the hand and the blade moves smoothly with a positive lock-up in both the open and closed position. So now what? How about a few additions which will add to the uniqueness of your creation. Some can be fancy and expensive, others more utilitarian, but all will help to raise your knife above the level of the mundane.

The simplest way of dressing up a knife is to polish or machine turn the screw heads, pivot bolt and stop pin (Fig. 166). This adds the final touch to a fine piece of hand craftsmanship and should not be overlooked. It says to the buyer, "This knife maker cares about his work even down to the final detail." Such finishing, though minor, adds to the sense of value that a buyer feels when laying out a chunk of money and reinforcing your reputation.

In addition, I like to highlight the holes around the pivot, the screws and the lanyard hole with a light countersinking after sand blasting. I believe this really brightens up the drab, gray effect resulting from this process (Fig. 167).

ANODIZING

Anodizing titanium is an interesting process and I have been using it for quite some time to dress up my knives. It is of particular advantage when I make a solid gold knife with titanium spring or spacer. I don't like to leave the gray titanium against the beautiful, warm color of the gold so I will anodize all of those parts. Sometimes I try to match the gold color but more often I will use a contrasting color such as purple. The effect can be quite stunning.

I built my own anodizing set up from a Los Alamos Laboratory surplus Variac voltage regulator and some Radio Shack parts, but the units are commercially available from some of the suppliers listed in the Sources section of this book (Fig. 168).

I use Tri-Sodium Phosphate with distilled water in a saturated solution for the chemical bath, in a plastic jug with a stainless steel anode. TSP can be purchased as a tile cleaner from tile and floor covering stores. I find that I get the best results by having the anode wrapped completely

Fig. 166: Polishing the screw and pivot heads is a simple way of dressing up a knife.

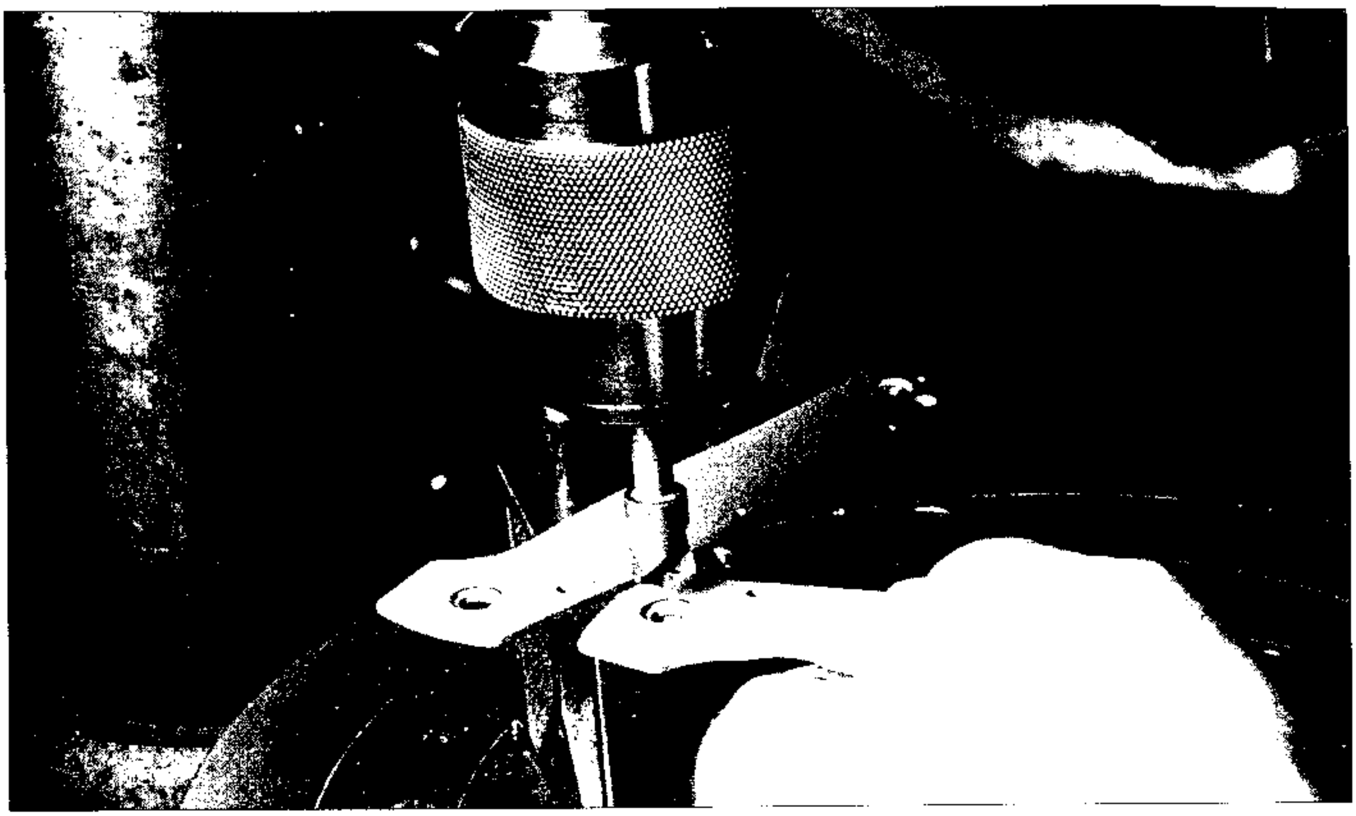


Fig. 167: Chamfering around the lanyard and pivot holes after sandblasting gives a nice, bright highlight.

Fig. 168: The anodizing set up for titanium.

around the inside of the jug so as to unify the current flow around the piece. Be sure to avoid touching the anode with the piece being anodized while the current is flowing as this will short out your system.

Anodized titanium can be quite striking and it is worth the effort to play around with it and develop your own techniques. Different tones and effects can be achieved with sandblasted, rubbed or polished surfaces and the colors can be varied by adjusting the voltage. (Thank you Patricia Walker!)

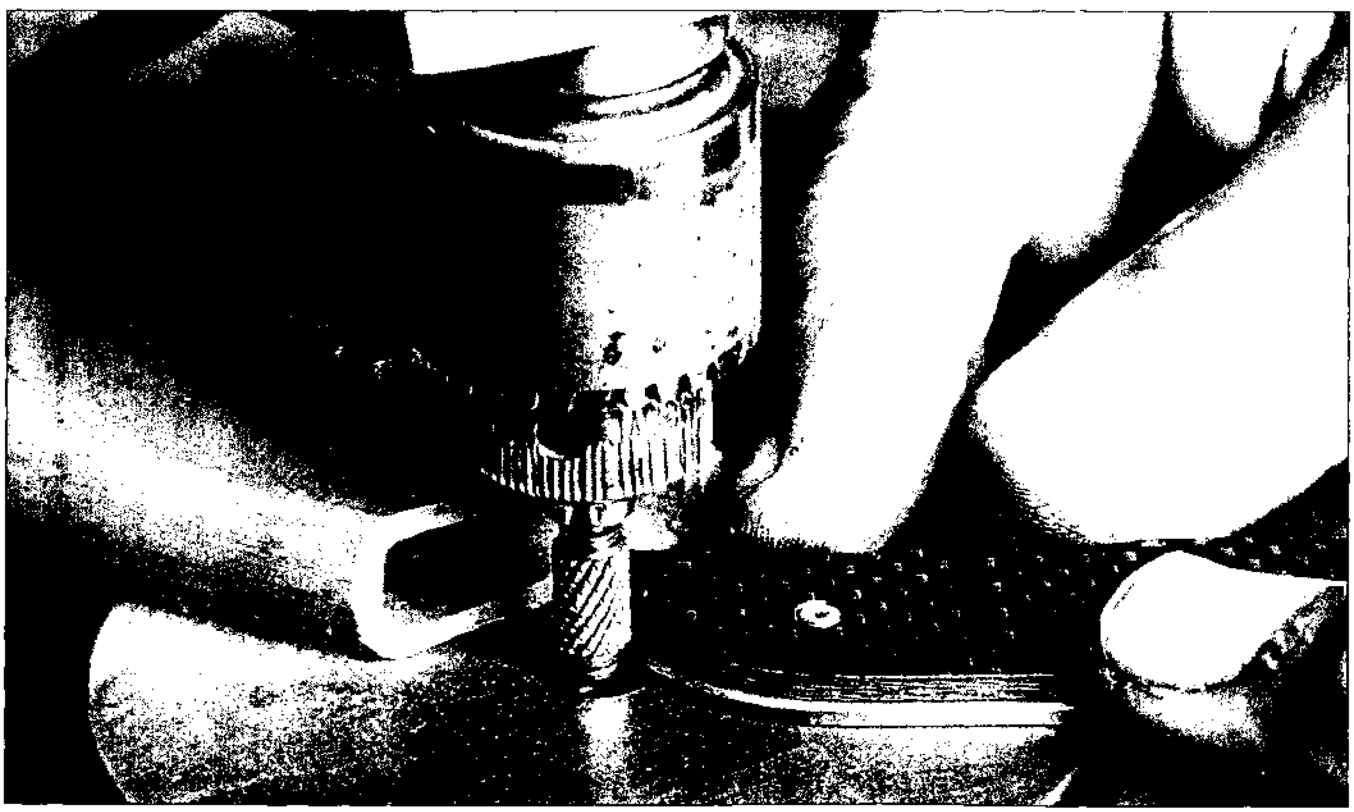
SCALES

Adding scales to the handle of your knife not only dresses it up, but can also add considerable value to it if you use a nice mastodon or other ivory, particularly as a base for scrimshaw. In addition, scales add to the heft of the knife and also, in some cases, the grip of the handle.

My favorite scale materials are mastodon ivory, desert ironwood and burgundy colored Micarta. G10 is a nice material also, particularly if the grip is to be improved as for a knife primarily intended for defense. Carbon fiber, especially when it is matte finished, is also very attractive. Pearl also is popular and makes for a great looking handle. My favorites are the black and gold lip varieties.

I attach my scales to the handles with screws, either 0-80 or 1-72. Sometimes I will dome or curve the handle material and sometimes I will leave it flat, depending on the effect I want to create. Mastodon ivory is usually left in its natural state with only a high polish added. Ironwood is usually left matte with a Danish oil finish, rubbed down with 600-grit paper, but I also like to buff it as this will create a textured surface, depending on the burl pattern.

Rather than bringing the scale material to the very edge of the handle, I prefer to "shadow box" it by removing about .050 inches from the profile (Fig. 169, 170). I feel this is a more professional touch and also serves to protect the material from chipping should the knife be dropped. I do this operation only on "stand alone" scales and not with bolstered knives.



"Shadow boxing" or recessing a scale is done with a carbide cutter and ball bearing pilot holding the cutter a fixed distance from the handle's edge. Note the vacuum nozzle right against the cutter.

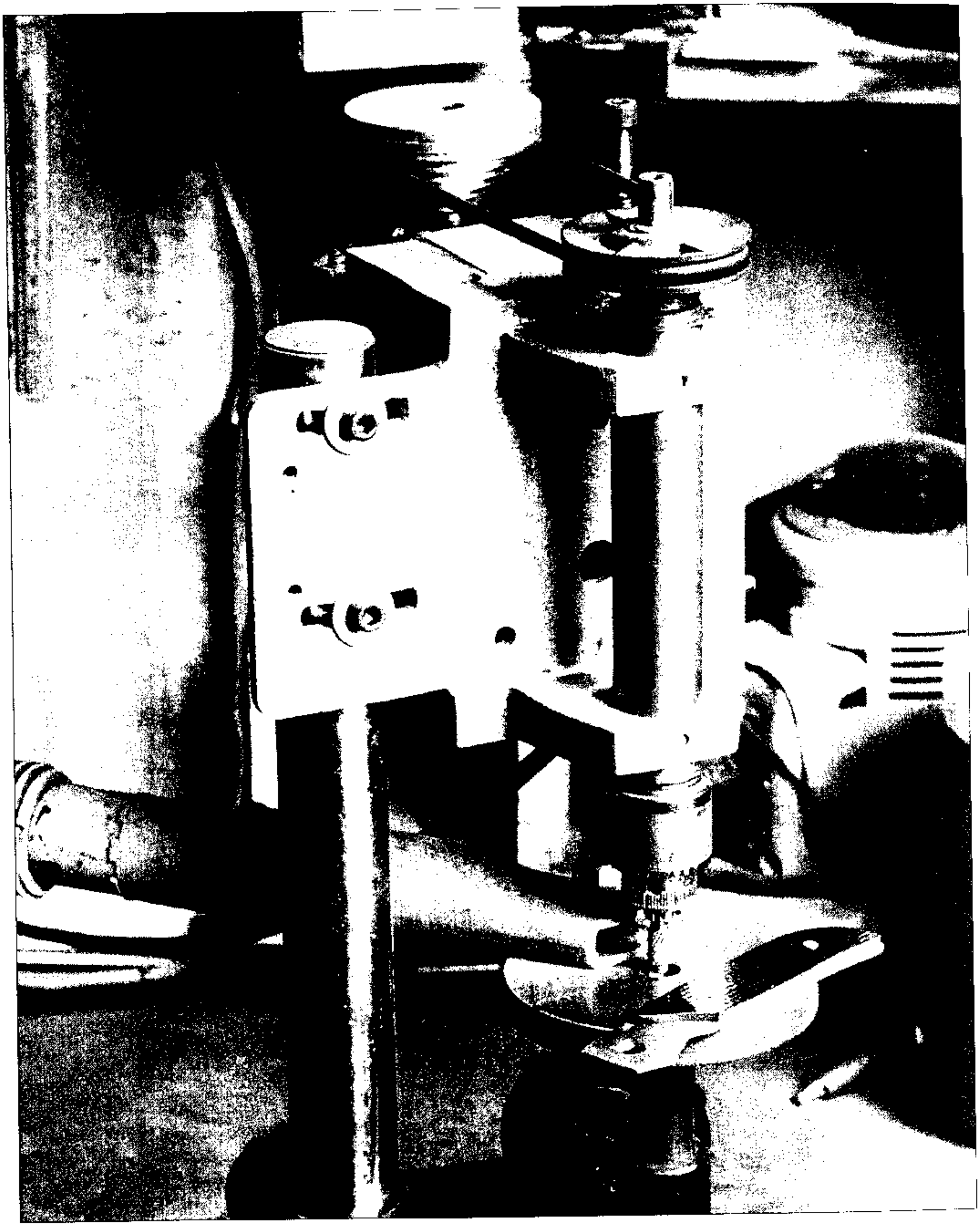


Fig. 170: A home-made rig for "shadow boxing" my stand-alone scales. I don't use this procedure if there are bolsters on the knife.

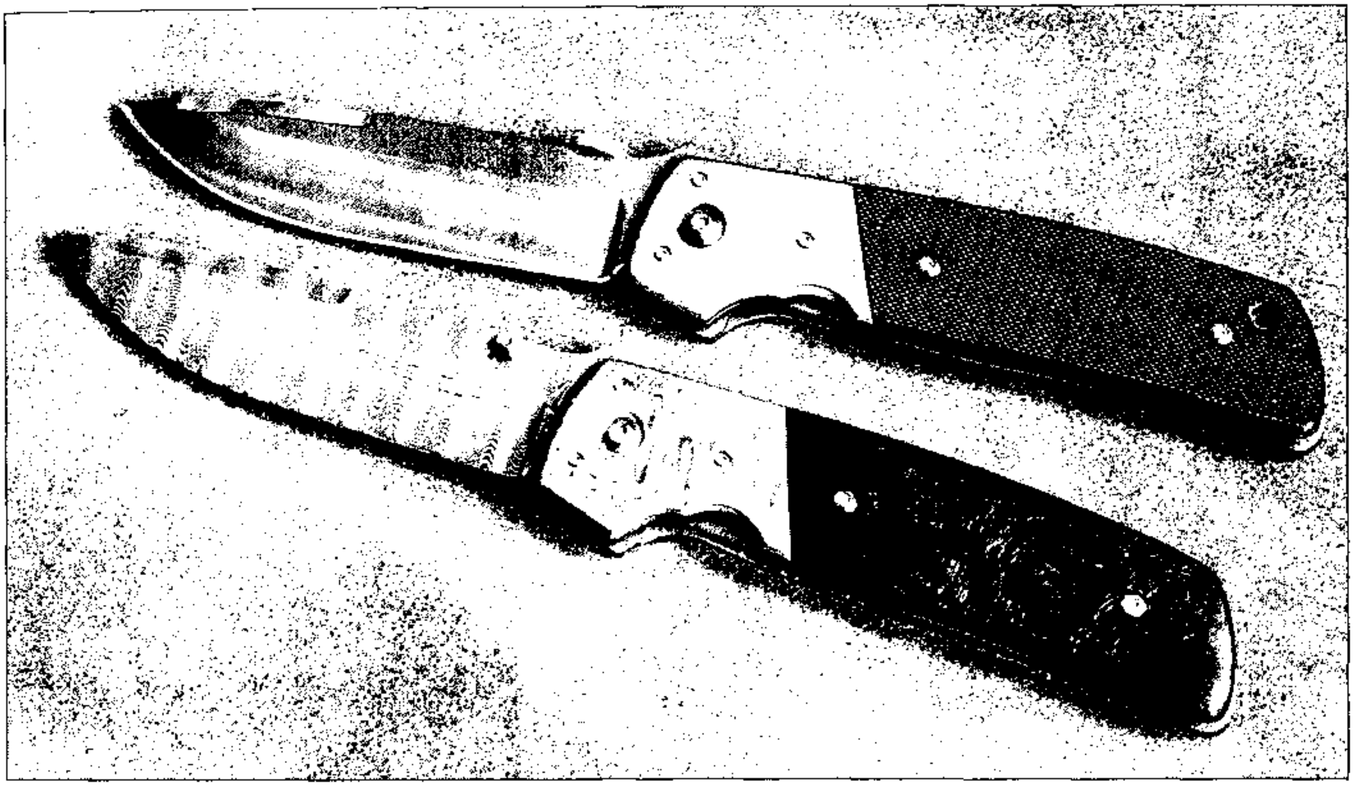


Fig. 171: Though not really necessary on knives made of today's exotic materials, bolsters can still add a touch of beauty and individuality to a folding knife.

BOLSTERS

Bolsters were originally intended to strengthen the pivot area of a pocket knife in the days when small knives had thin liners, usually of brass. The liners themselves were not strong enough to support the forces applied to a blade during use and bolsters also added thickness to a knife for the application of scales. Modern knives, particularly tactical folders, are built of sturdier stuff and don't normally require bolsters for strength, although they do add a lot to the visual impact of the handle, particularly if they are made of Damascus or mokume. If a knife is made with a titanium handle, there is no need at all for bolsters as the strength of this metal is so great that the human hand cannot apply enough force to break or seriously damage it.

I have therefore placed the subject of bolsters into the category of "dressing up the knife" and I treat it as an option for the maker or the customer.

Bolstered knives require two liners, so when I am making a bolstered knife I simply start with two completed spring plates of .063 inches. One plate becomes the lock of the knife and the other becomes the opposite side of the handle. You should have the two handle plates completely profiled, drilled with pivot and stop pin holes and have the assembly screw holes drilled and tapped as described in previous chapters (Fig. 172).

I use screws to attach the bolsters as most makers do. If the materials allow, the bolsters can be soldered to the liners but this is not possible if titanium is to be used for either part.

This is the procedure I use:

1. Select your bolster material and mill or grind it flat on one surface. I use titanium of about .100-inch thickness or mokume or Damascus steel of about .125-inch thickness, especially if I want a rounded effect on the handle.
2. Determine how many screws you want to hold the bolster in place; the angle you want the bolster to have in relation to the lines of the handle; and the position of the screws on the bolster (Fig. 173).

Mark and center-punch the screw positions on the liner and then drill the liner with the proper tap drill. On my knives I use 0-80 socket head screws, so this will be a #55 drill. These holes will eventually be tapped, but not just yet. In order to save time on each knife, I use a pre-made bolster

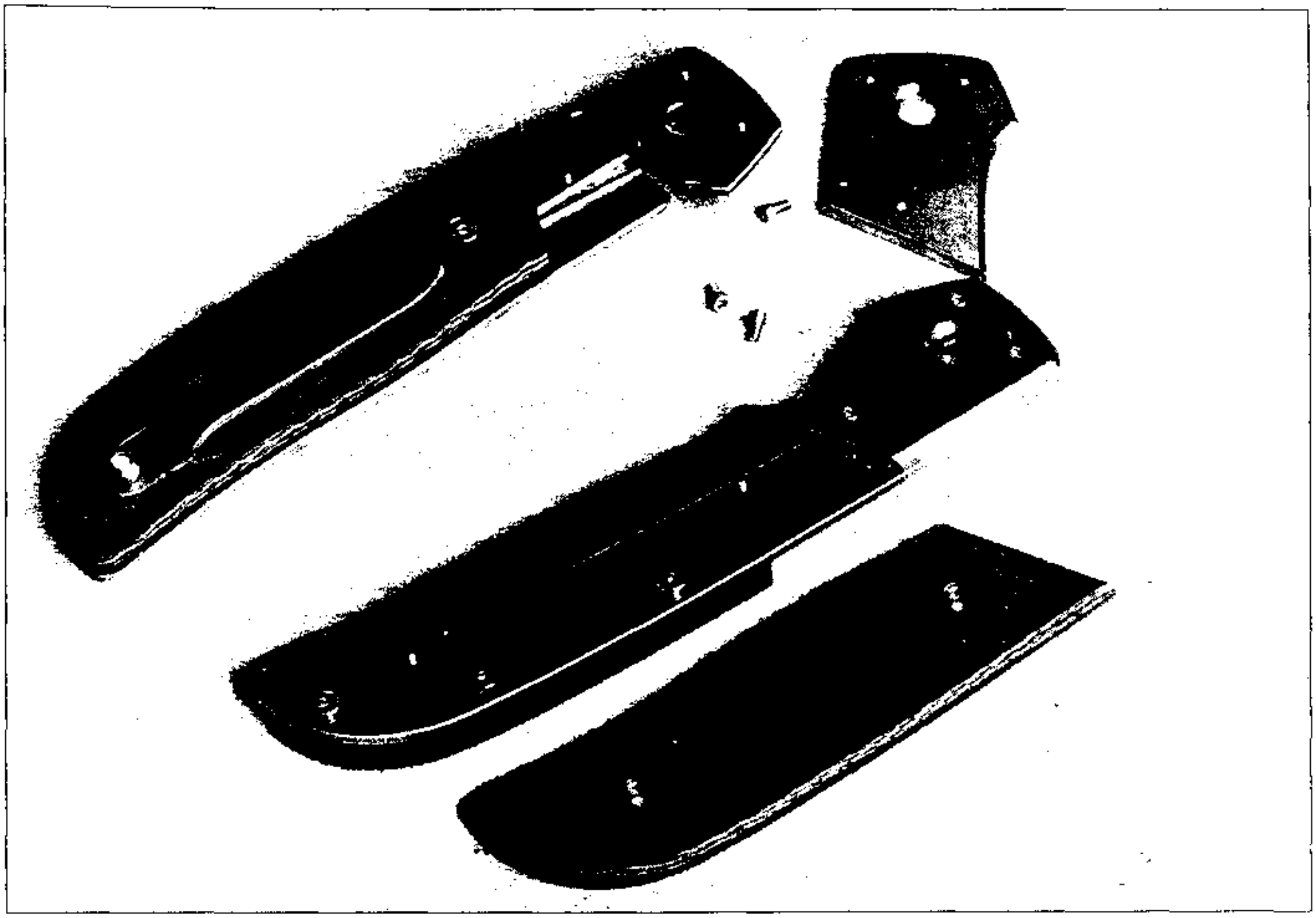


Fig. 172: The anatomy of a bolstered knife.

as a drill guide and clamp it onto the liner using the pivot hole to register the two parts and keep them in alignment (Fig. 174).

3. After the holes are drilled in the liner, position the rough-cut bolster on the liner and firmly clamp it into place.

4. Turn the assembly over, bolster side down, and drill the screw holes into the bolster, using the liner as your drill guide. This will insure proper registry of the holes in both parts so that they will align properly later (Fig. 175).

5. Remove the clamps and drill or ream out the holes in the bolster with the clearance drill for the screws you are using: in this case, a #53 drill. Tap the holes in the liner with a 0-80 tap, taking care to use plenty of lubricant, particularly if you are tapping titanium.

6. Countersink or counter-bore the outside of the bolsters in order to bury the screw heads (Fig. 176).

7. Assemble the bolster to the liner and grind off any extra screw threads that might protrude from the back. If any threads are left exposed, they may interfere with the washers or the free action of the blade later on.

8. Using the liner as a drill guide again, drill out the pivot hole in the bolster and counter-bore the hole to bury the pivot head.

9. Assemble the whole knife with stop pin, spacer and a pivot try pin. Re-profile the knife on the platen grinder so that the bolsters become an integral part of the front of the knife (Fig. 177).

10. Determine the angle you want for the back edge of the bolster against which your scales will be placed. Scribe a line on one bolster at this angle and remove both bolsters from the liners. This edge can be generated by grinding and careful checking with a straight edge but I prefer to mill the faces together to insure a straight line and seamless, identical fit against the scale material

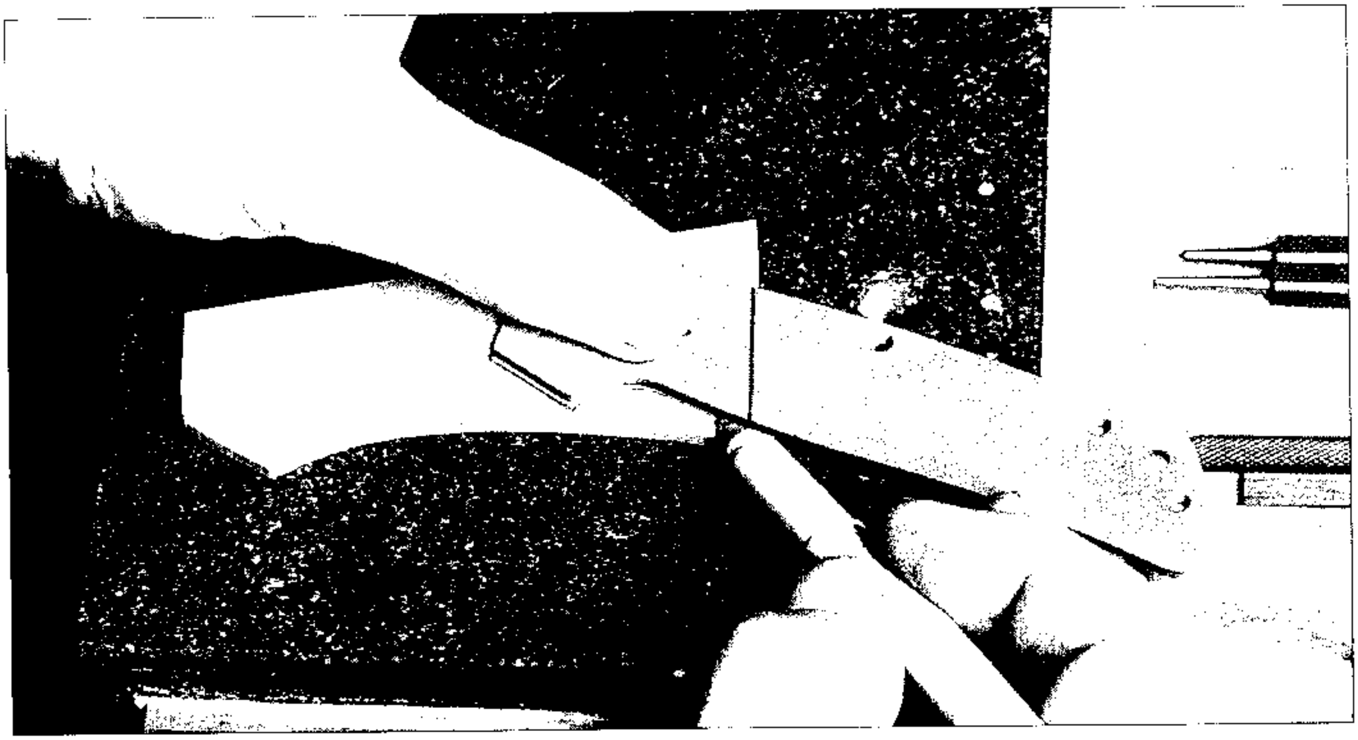


Fig. 173: Using the handle as a pattern to mark the outline of a bolster.

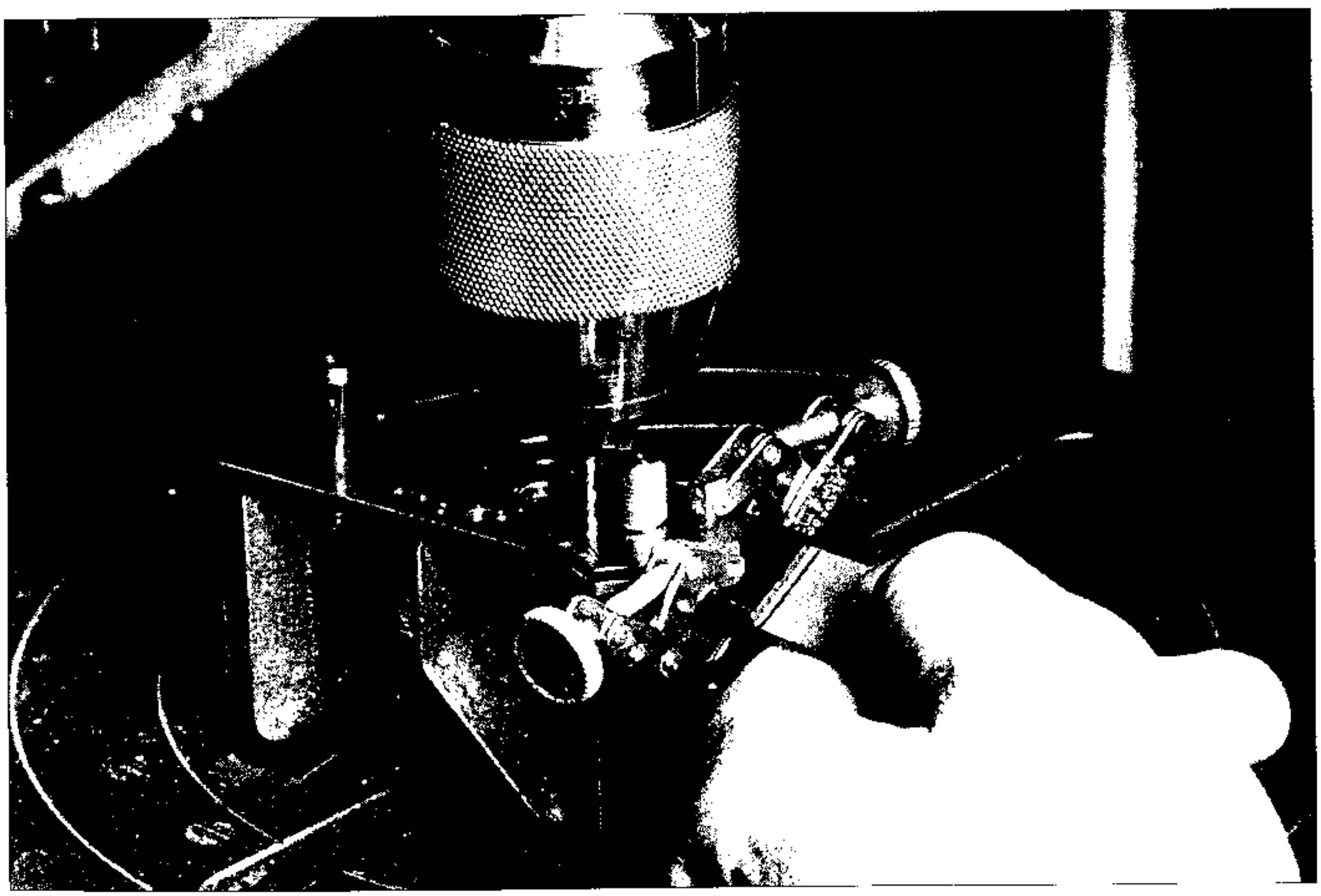


Fig. 174: I use a ready-made bolster as a drill guide to drill the screw holes into the liner.

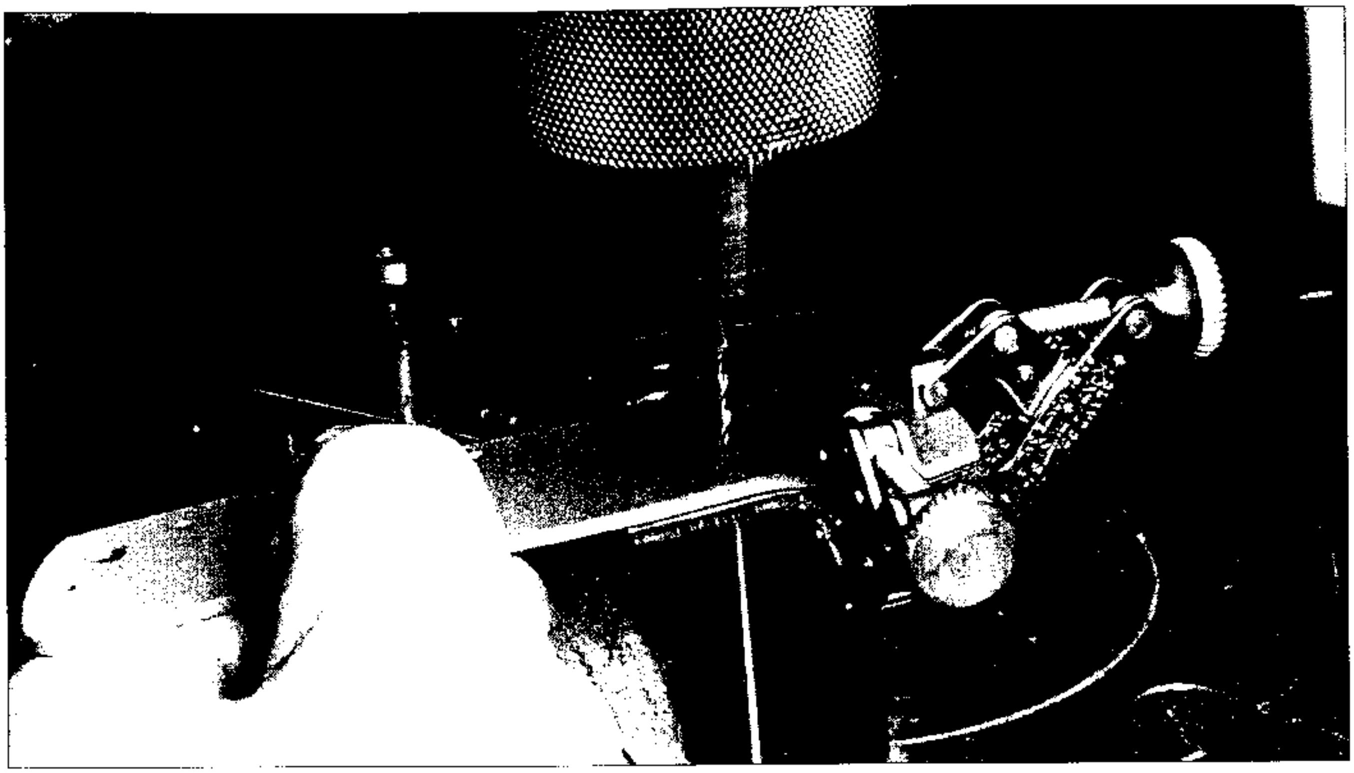


Fig. 175: After the screw holes are drilled in the liner, clamp the rough bolster to it and use the liner as a drill guide.

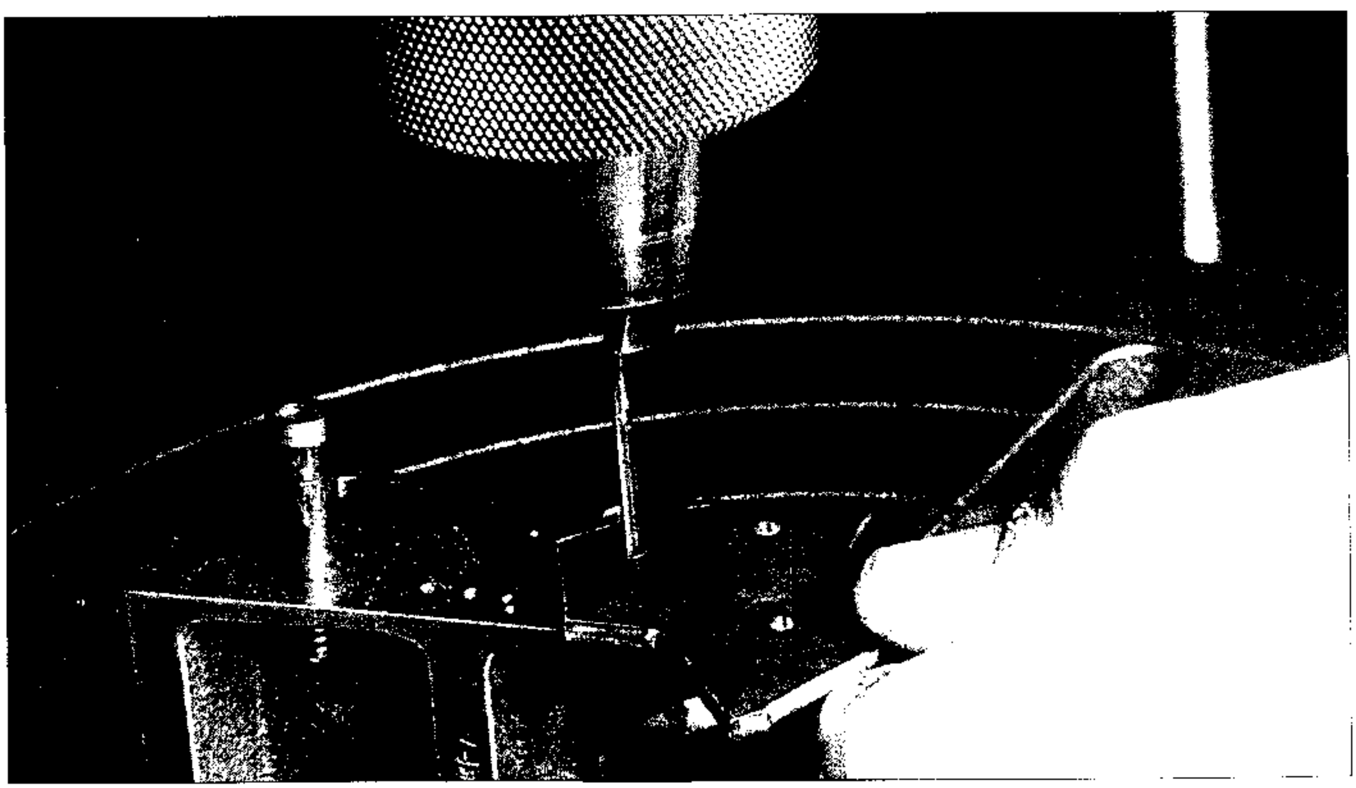


Fig. 176: Counter-bore the front of the bolster to accommodate the screw heads.

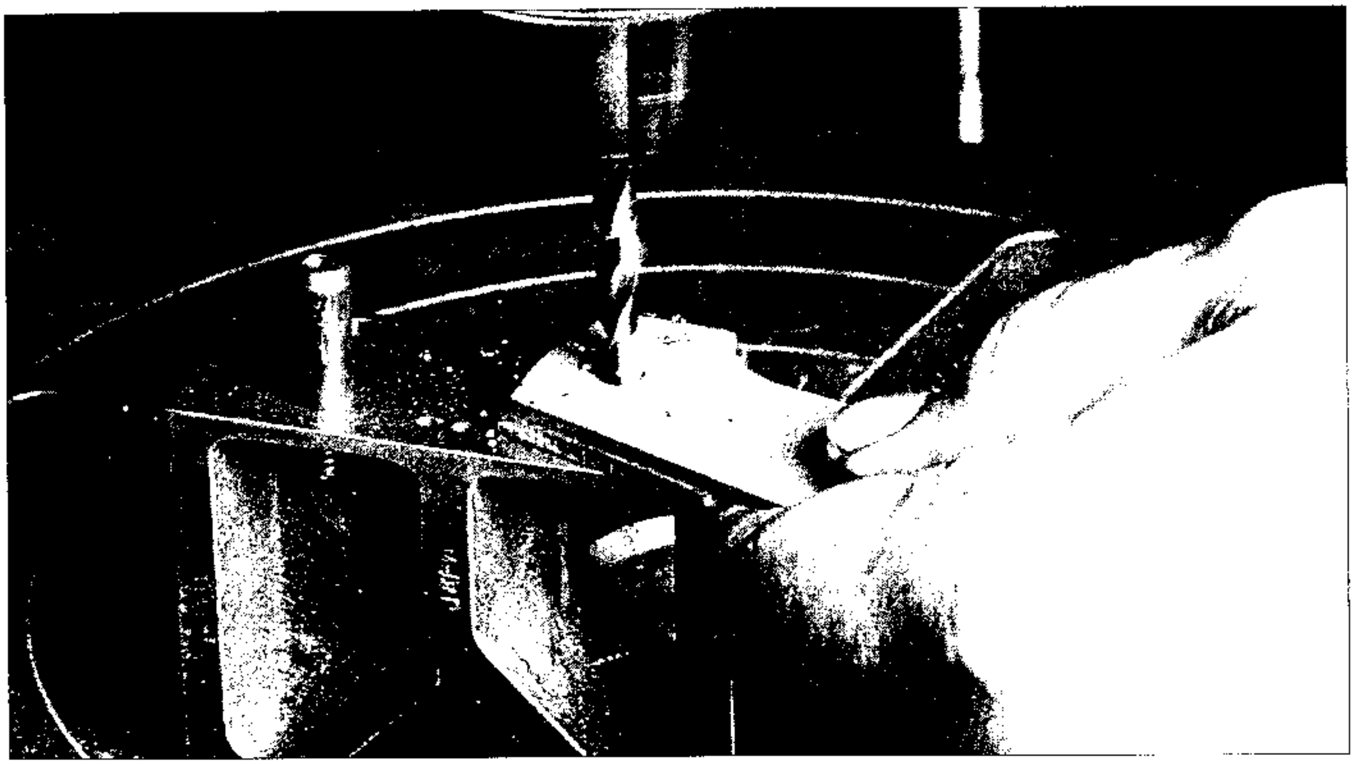


Fig. 177: With the bolster screwed in place, again use the liner as a drill guide for drilling the pivot hole.

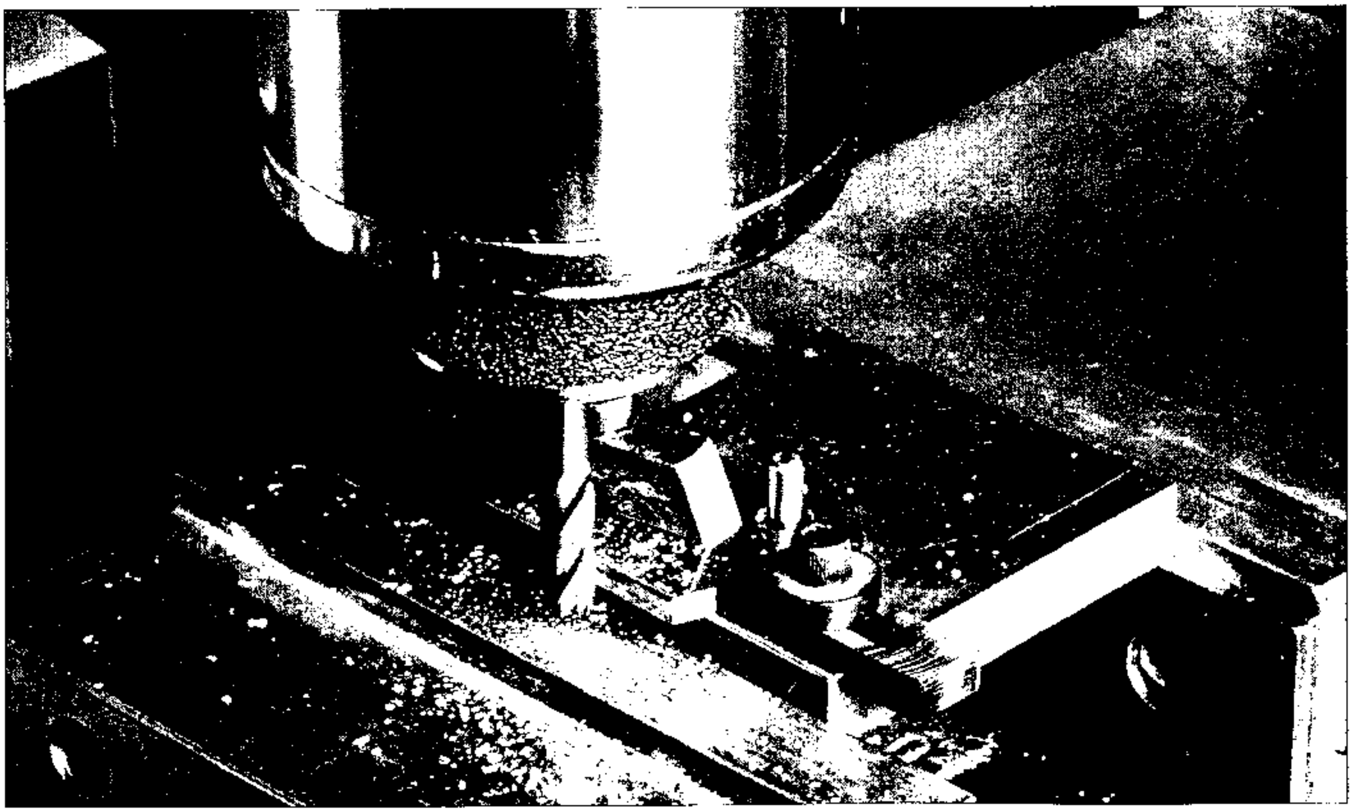


Fig. 178: Mill both bolsters together, registering them off the pivot hole, so that they will match up nicely on both sides of the knife.

(Fig. 178). A homemade fixture holds the bolsters at the correct angle on the milling machine. This fixture is described in Chapter 9. Once this is done, and the bolster is back on the liner, you can fit the scale material against the bolsters' edge and proceed to attach it to the liner with screws, then finish by profiling the scales down to the knife handle.

BAILS, POCKET CHAINS AND HOOKS

Aside from the convenience of having small knives easily accessible with a hook or lanyard, they can be dressed up with a little effort by using silver or gold for bails or hooked chains. The value as well as the esthetics of a knife are changed considerably with these added little touches and the cost of materials can be surprisingly little. I use small bails for my gentleman's knives which are held in place by a pin traversing the bail and buried into each liner on the sides, thereby allowing the bail to swing freely. The hooked chain is attached in the same manner and is used to clip the knife to the corner of the pocket and allow it to hang vertically, away from the bottom of the pocket to avoid contact with keys, coins and pocket fluff (Fig. 179).

DAMASCUS BLADES, BOLSTERS AND HANDLES

Damascus, or pattern-welded steel is most commonly used to make higher priced blades but is also quite beautiful when used to make bolsters and even handle frames, particularly for smaller knives. There is a great variety of Damascus steel available today from several craftsmen and suppliers, usually in the form of bars and ingots. The story of these steels could fill a book by itself so I will not belabor the point here with history, technical information etc. Most of the Damascus steels are unique and each requires its own heat treating protocol which can be obtained by the supplier. Their instructions should be followed faithfully as they have the most experience with their own products.

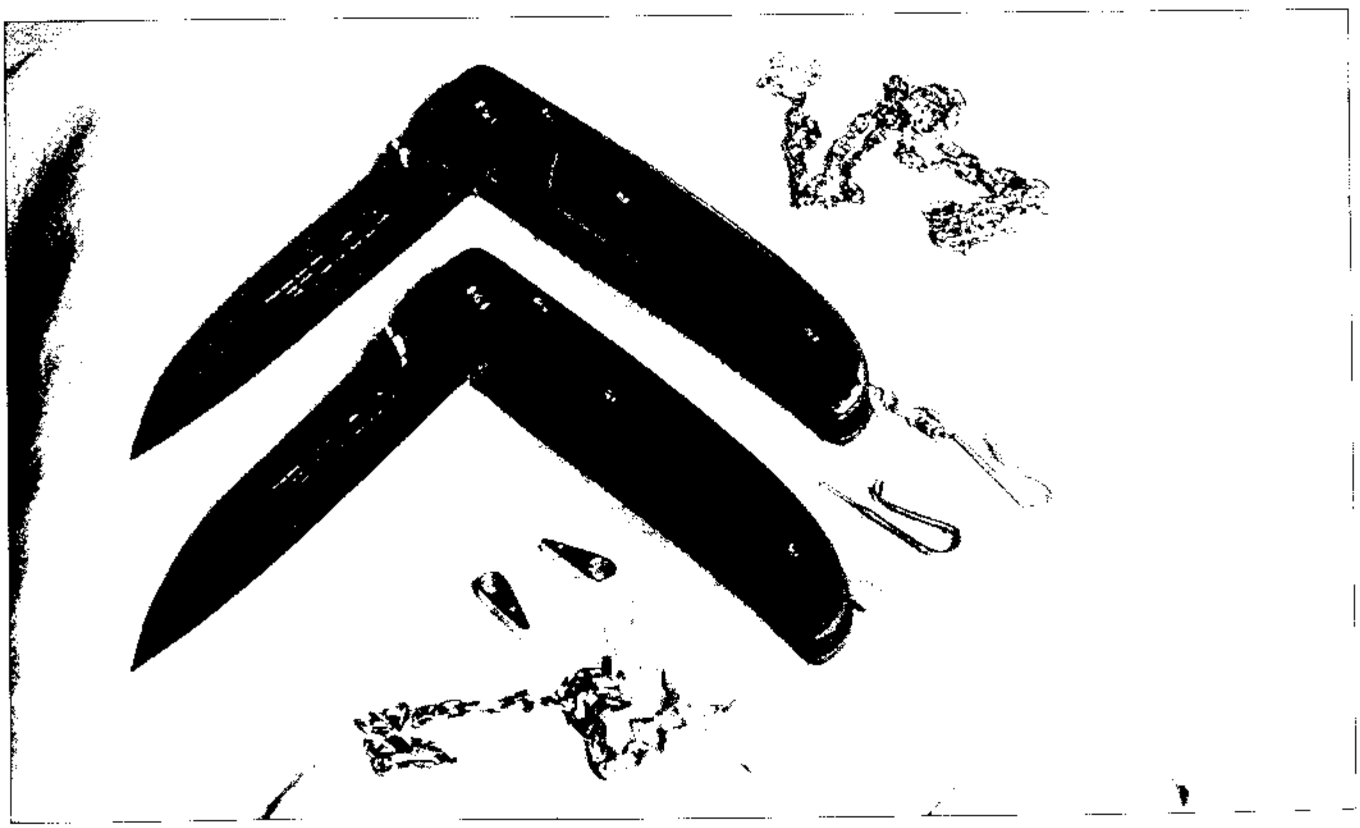


Fig. 179: Pocket chains with hooks and small bails really help to gentrify a small knife. I use mainly gold and silver for these little additions.

I will mention here some things that I have learned over the years from several Damascus makers and my own experiences in working these steels.

1. Grind Damascus blades as you would any other steel blades but if you are grinding in the hardened state, be careful not to overheat the blade as most Damascus is tempered at far lower temperatures than the modern exotic steels such as ATS-34. As such, it is easier to destroy the temper by heating to the point of discoloration into the blue or brown color range.

2. Bring the finish only up to about 400- to 600-grit, using a new, sharp belt. You can, if you wish, hand rub to the same level. Don't buff or polish the blade as this will interfere with the etching process. Keep the steel oil- and wax-free so the etchant can bite into it evenly.

3. After the blade is completely finished and fitted to the handle and lock, carefully mask off the areas where the blade will contact other parts of the knife such as the lock area, the ball bearing detent area and the side washers (Fig. 181). The final finish of Damascus steel, after etching, can be quite rough and bumpy so this step is essential for the smooth operation of the blade. I use clear nail polish cut 50/50 with acetone for my coating. Just paint it on and let it dry, which it will do quickly if diluted.

4. Suspend the piece in a bath of ferric chloride diluted 50 percent with distilled water for about 10 to 15 minutes, or longer, depending on the effect you wish to create (Fig. 182). A warm solution will speed up the chemical etching but I suggest that you experiment to see what suits you best. Ferric chloride is commonly used for etching electronic circuit boards and can be purchased at Radio Shack stores. It is quite toxic so exercise extreme caution when using it and store it safely, out of the reach of children.

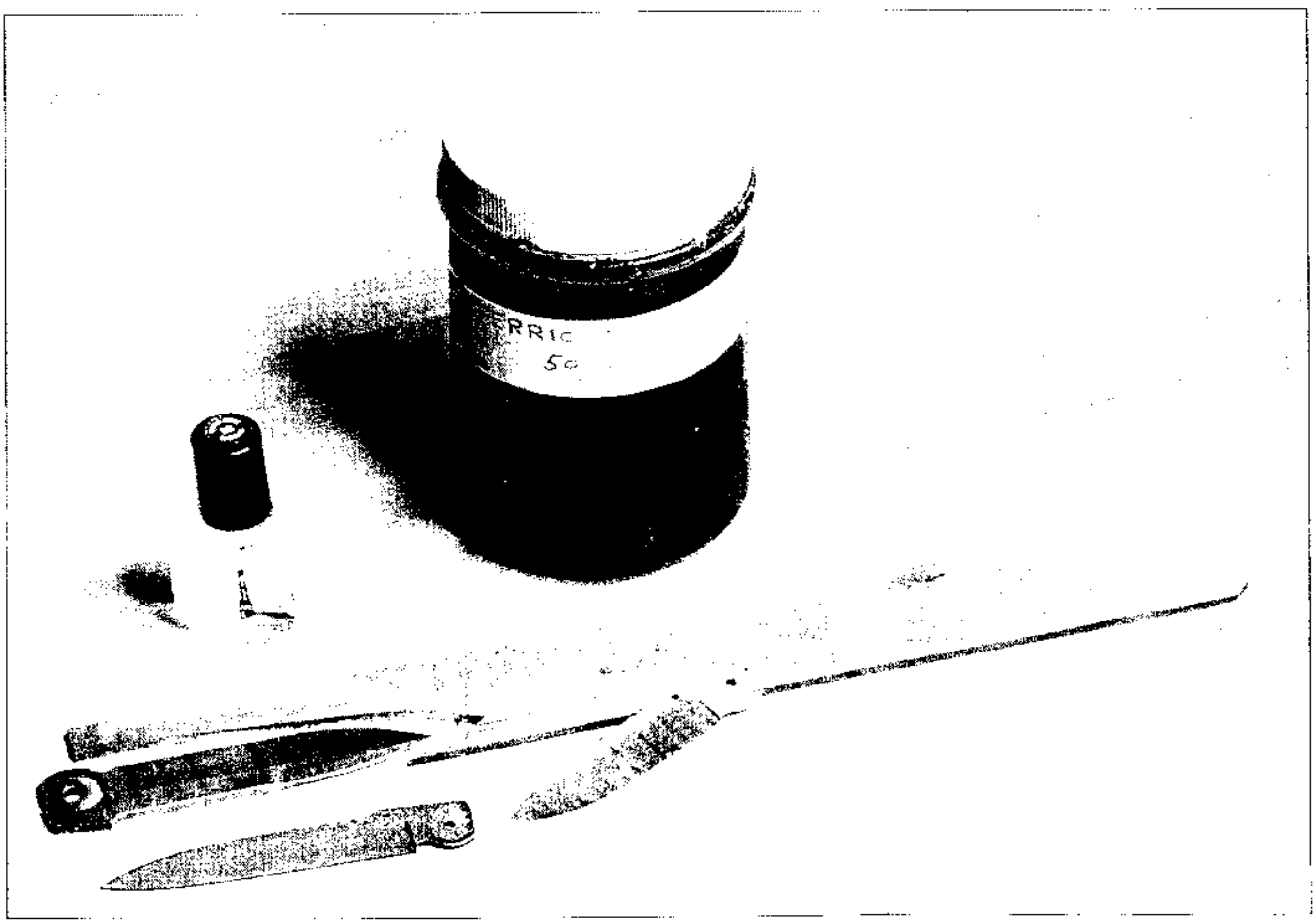


Fig. 180: Damascus steel with etchant and nail polish for masking.

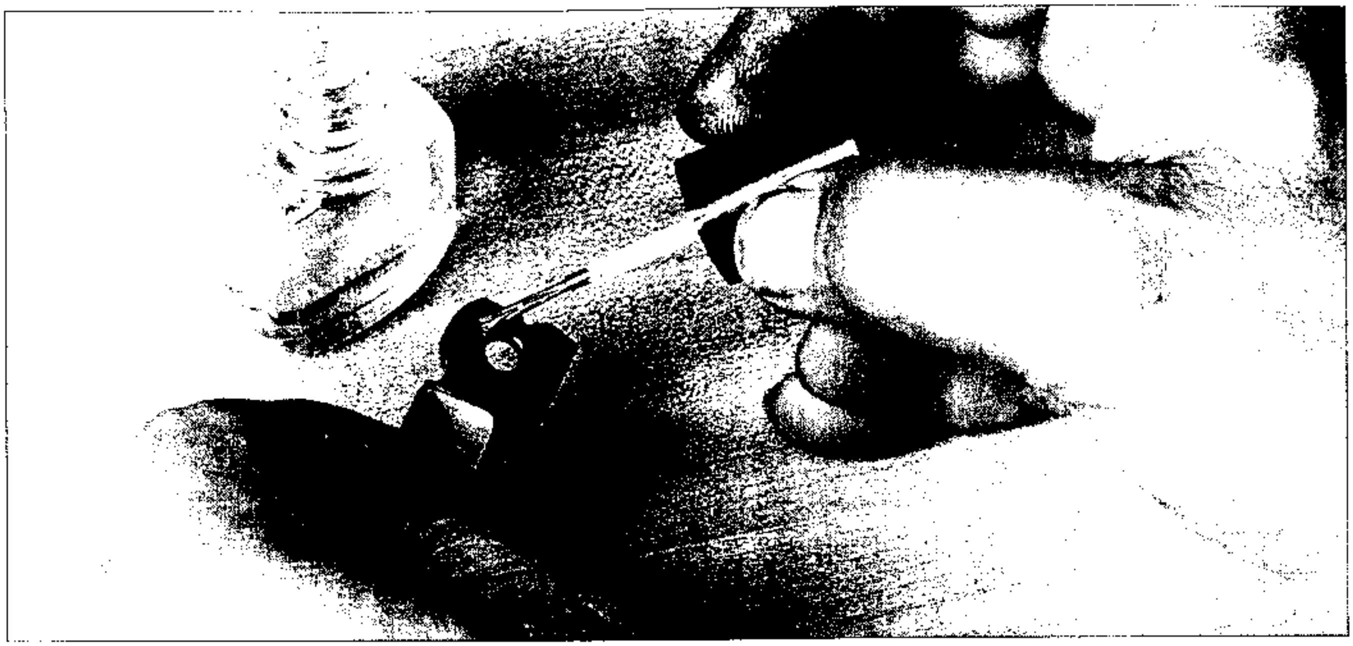


Fig. 181: Painting the areas to be masked and thereby protected from the etchant.

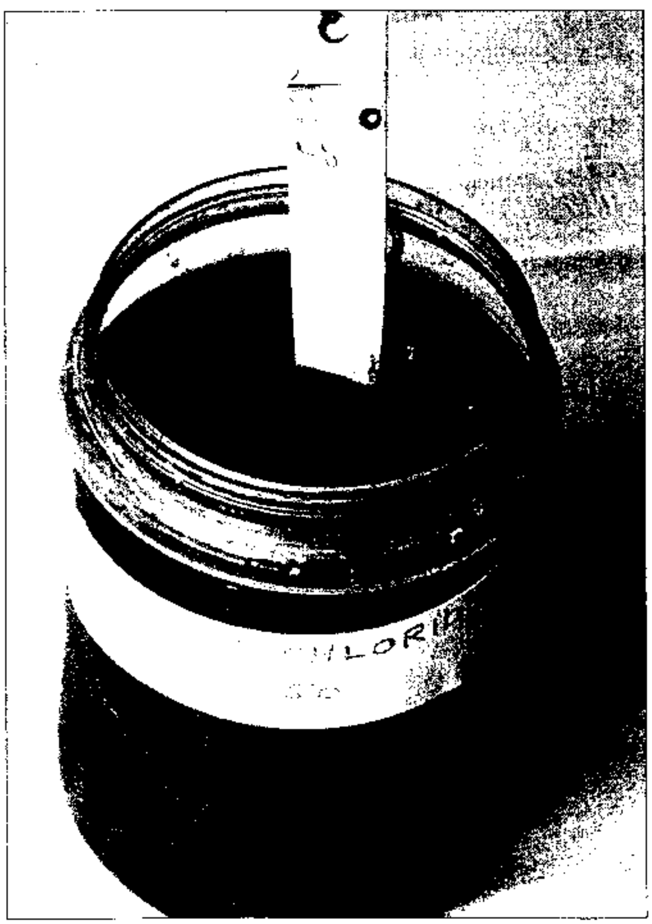


Fig. 182: Removing the blade from the ferric chloride after about 15 minutes of immersion at room temperature. Note the masked, shiny tang which is the bearing surface for the washer.

After the blade or bolster is etched to your satisfaction, rinse the part thoroughly. The etchant can be neutralized with tri-sodium phosphate. the same chemical used for the titanium anodizing solution. I then rub the part down with a scouring powder such as Ajax or Comet under the tap to remove built up, black deposits from the surface.

5. The blade can be left as etched or it can be buffed to varying degrees for a brighter finish. I like to lightly buff just the high peaks of the steel so that they contrast nicely with the black valleys in the pattern.

6. Damascus which is not made from stainless steels should be well protected with a paste wax or other such coating as it will have a tendency to rust, especially since the etching creates little traps in the pattern which can hold corrosive agents such as blood, fingerprints and perspiration.

MOKUME

This is a singular material of overpowering complexity and beauty. It is made by compressing hundreds of thin sheets of alternating layers of various non-ferrous metals (most typically brass, copper and nickel silver) in a vise-like clamp and carefully heating the entire clamped bundle in a furnace until the molecules of the adjoining layers begin to transfer themselves back and forth and the individual layers of metal diffuse (but do not fully melt) into a solid block.

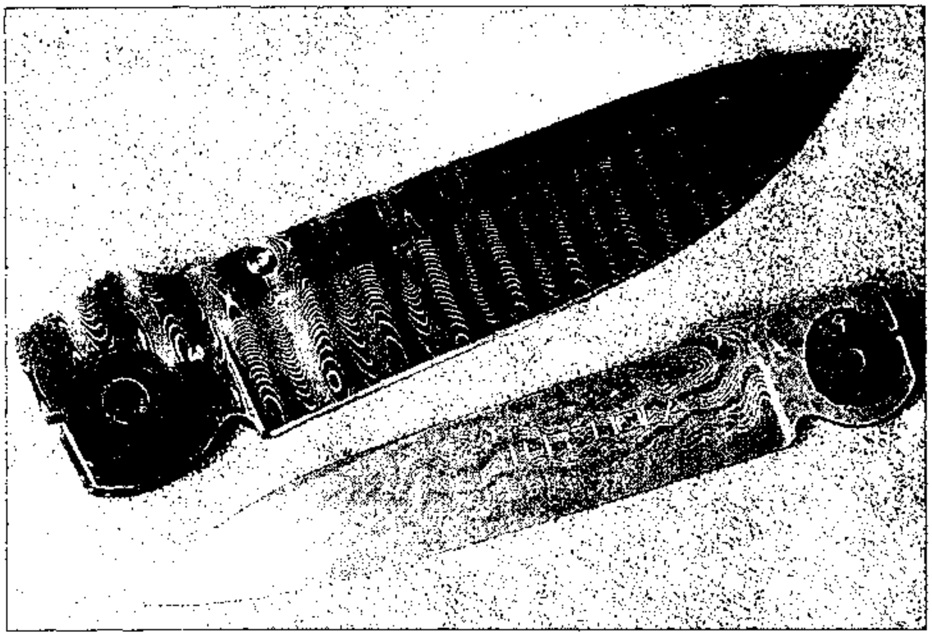


Fig. 183: Two blades of stainless damascus from Devin Thomas (top) and Mike Norris.

This process, in effect, welds the layers together but, unlike a molten alloy of mixed metals, leaves each layer to retain its own properties of color, etchability and ductility. This block of fused and layered material can then be patterned in a variety of ways and forged into bar or sheet stock.

After shaping into a bolster or other knife part, the material is then etched in a diluted ferric chloride solution, (as described above for Damascus steel). The etching not only brings out the patterns of the material but also the different colors. Be careful not to etch Damascus steel and mokume in the same bath, however, because the sloughed off ions of the brass and copper will plate themselves to the Damascus steel and a gold-copper colored surface will result. Of course, you might like this colored effect on your blade. It's your choice.

Mokume can be made from any non-ferrous metal mix including, gold, silver platinum, etc. but this, of course is vastly more expensive.

Dressing up the basic knife is a fun part of the job and I enjoy it immensely. The variations in accessories and materials is endless and I am always amazed at the creative innovations that knife makers are constantly bringing to the craft.

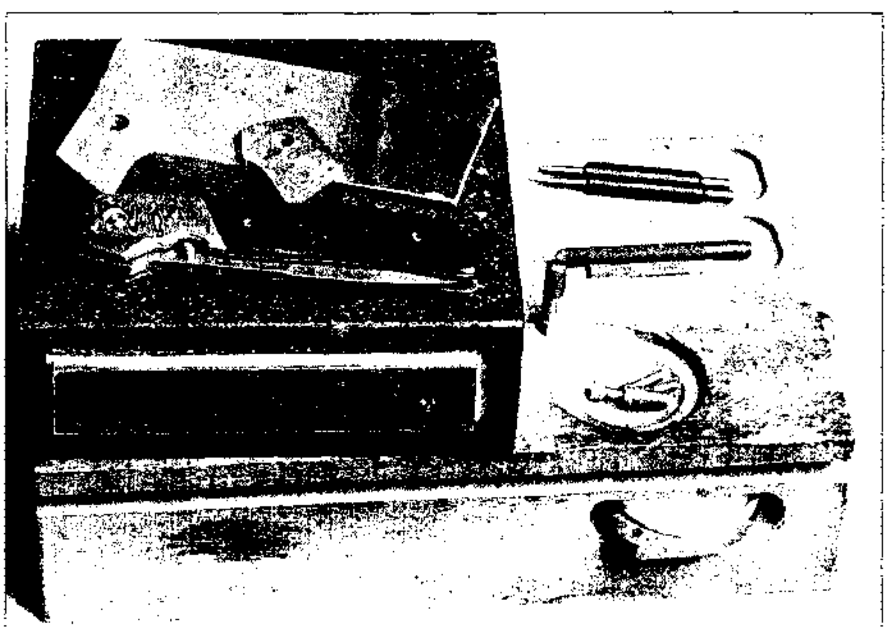


Fig. 184: Mokume plate made by Mike Norris

Chapter 9

Gadgets and gizmos

My father always tells me that I spend more time making tools and gadgets to help me make my knives, than I do making the knives themselves. This is not really true but I am willing to invest energy if I can save effort later on by making a fixture or measuring device which allows me to repeat a procedure with precision and not have to readjust my machines every time the situation recurs. Since all of the operations I perform to make a knife are controlled by my hands in some way, I find it helpful, if not essential to minimize the potential errors which can be occasioned by repetitive and similar procedures.

Below I describe some of the tools I have made which help me in my work and which allow me to produce knives of consistent quality. As I mentioned at the start of this tome that this is my way of working and I would not presume to say it is necessarily the best way and it is certainly not the only way. It works for me and I hope this section will provide some little insight into my shop and my techniques for those who are curious enough to care. Most of my fixtures and gizmos, by the way, were made from parts salvaged from the scrap heap of the Los Alamos National Laboratory where the first atomic bombs were built, but I've checked them all and they do not glow in the dark!

One of the more useful Items I made up for the milling machine or drill press is what I call the

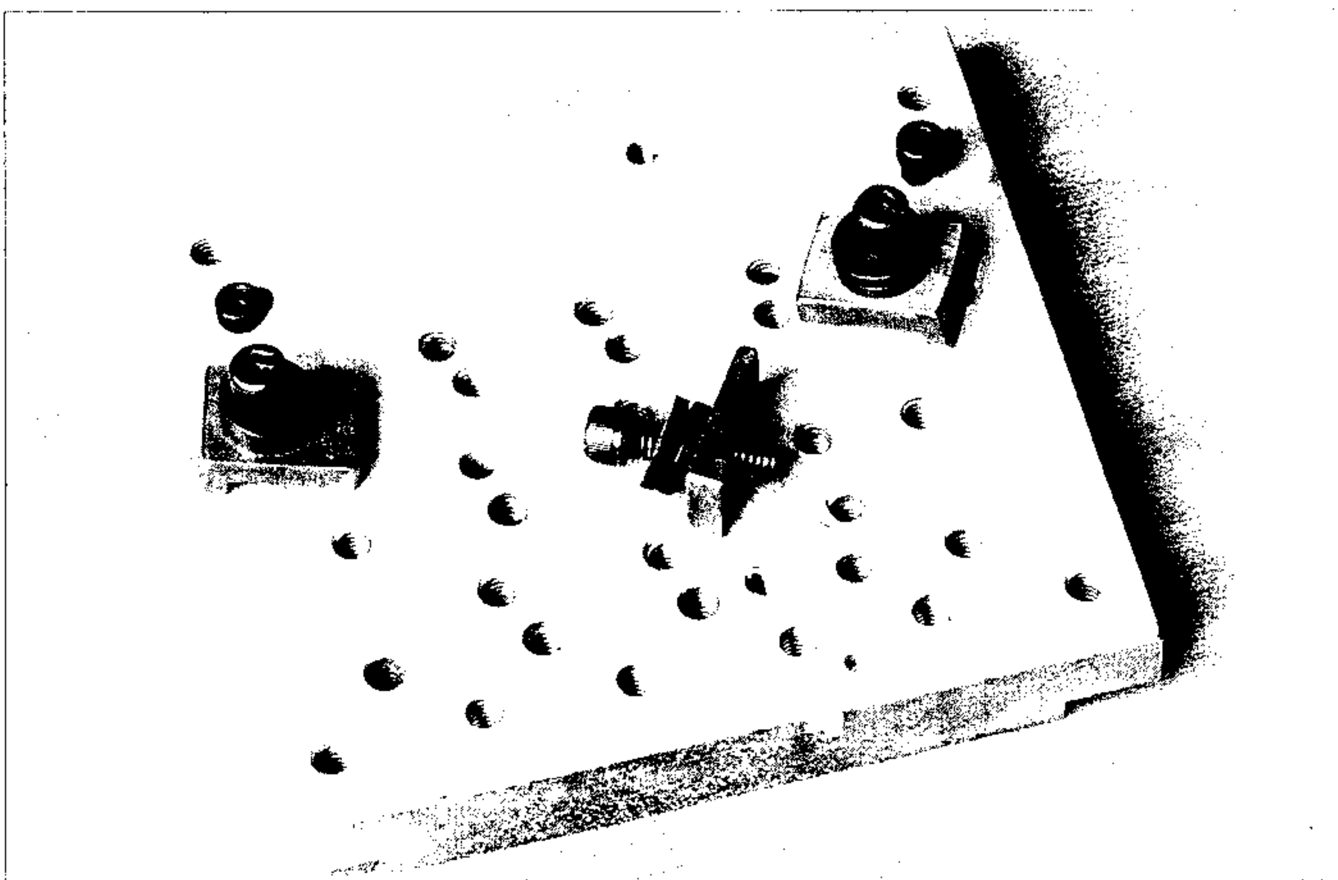


Fig. 185: The universal tooling plate, suggested to me by Ron Lake.

universal tooling plate (Fig. 185). The idea was given to me by Ron Lake who is one of the finest machinists and precision craftsmen I have ever met. The tooling plate simply consists of a machined, flat plate of aluminum, cast iron or steel and has a bunch of holes drilled and tapped into it to accept toe clamps in virtually any position. It comes in handy for milling down sheets of Micarta or Damascus, or for holding unusually shaped pieces of whatever for milling or drilling.

BLADE FIXTURES

1. For consistent scribing of my blade bevels I use a machined Micarta block with slots cut into the top to accommodate different thicknesses of blades (Fig. 186). By placing the blade blank in the slot, it always stands at the same height above the granite surface plate so that I can scribe my grind lines consistently on both sides on a batch of blades with the same profile. Markings on the side of the block allow me to set my surface gauge at the right height for each particular model of knife blade.

2. I use two sizes of blade-grinding fixtures, one for large and one for smaller blades. While all of my grinding is controlled and guided by my hands, these fixtures help me to keep a consistent angle against the contact wheel (Fig. 187). The fixture for large blades has a clamping face whose angle to the wheel can be adjusted slightly with a thumb screw (Fig. 188). This is to allow for the difference in radius between a contact wheel with a thick, coarse grinding belt and the smaller radius with a thinner, finishing belt. The spine of the blade, (at the bottom), is supported on a screw in the center of the fixture so that I can adjust the blade's point, up or down around the pivot screw, to make sure the blade's cutting edge is parallel to the axis of the contact wheel. After grinding one side of the blade, I flip it around and screw it to a corresponding hole on the other end of the fixture to grind the back side. The pivot hole in the blade serves as my clamping hole during this procedure.

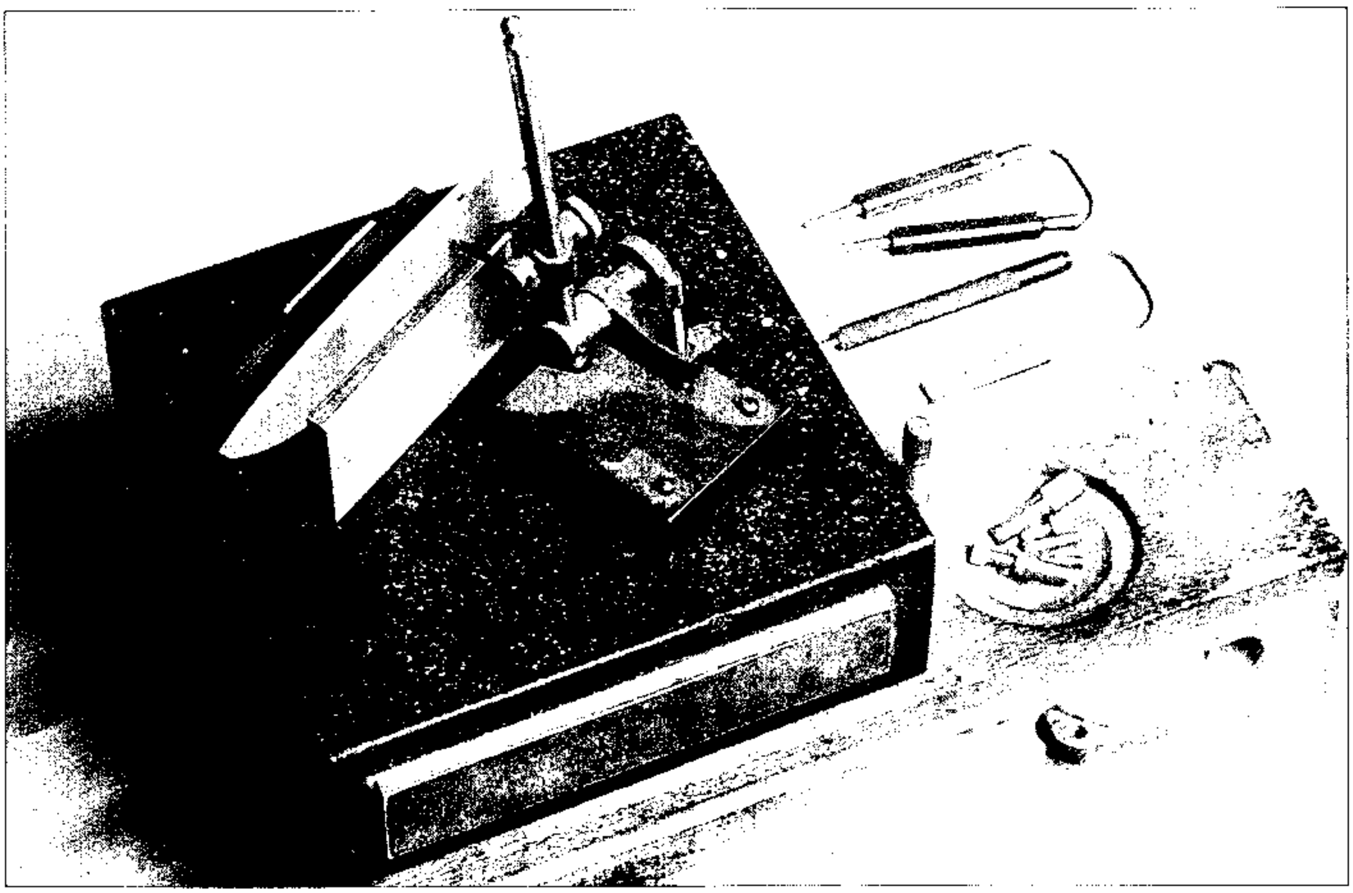


Fig. 186: A notched Micarta block holds the blades at a consistent height for scribing the grind lines with a surface gage.

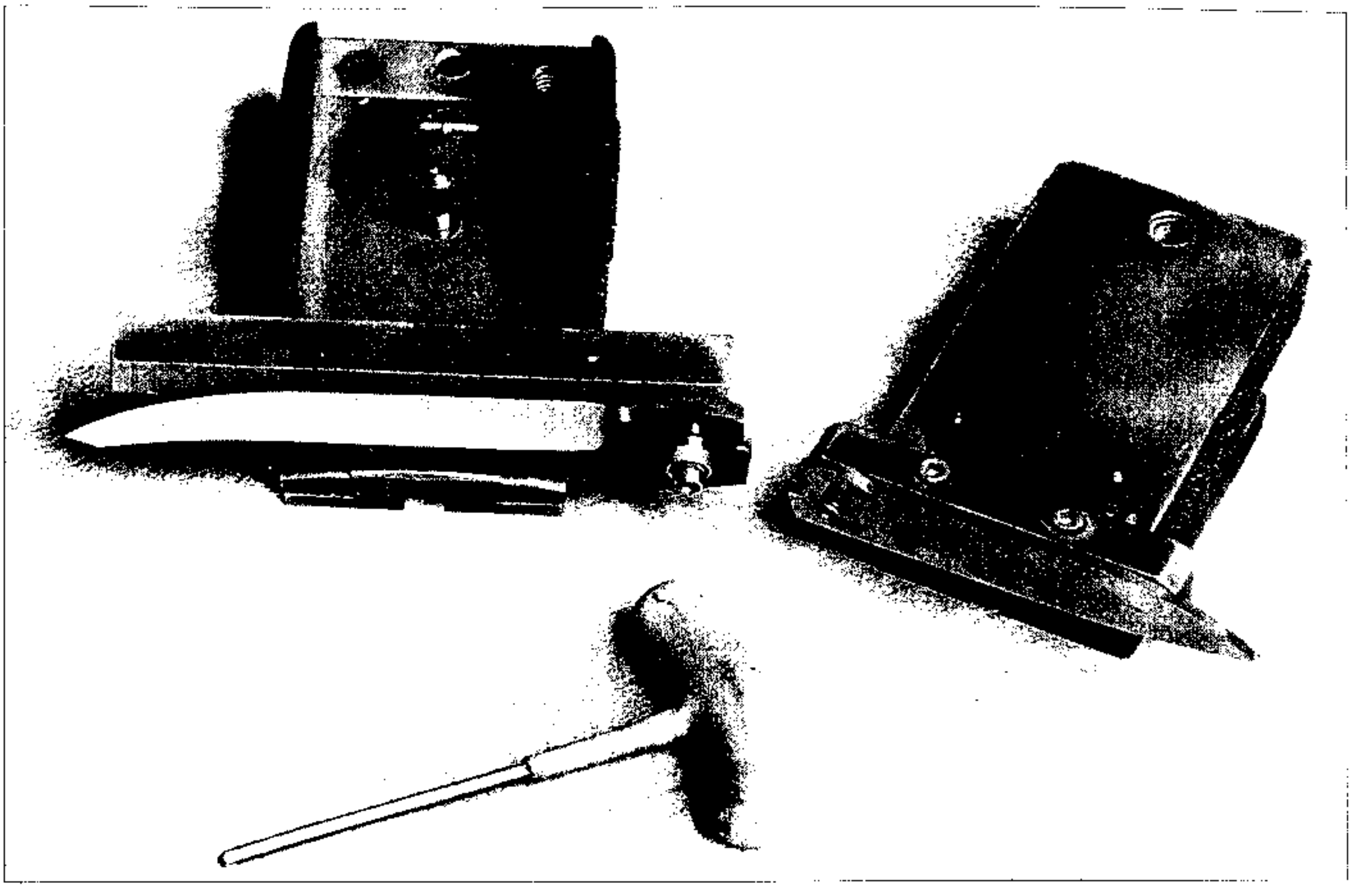


Fig. 187: These are holding fixtures that are used while grinding my blade bevels.

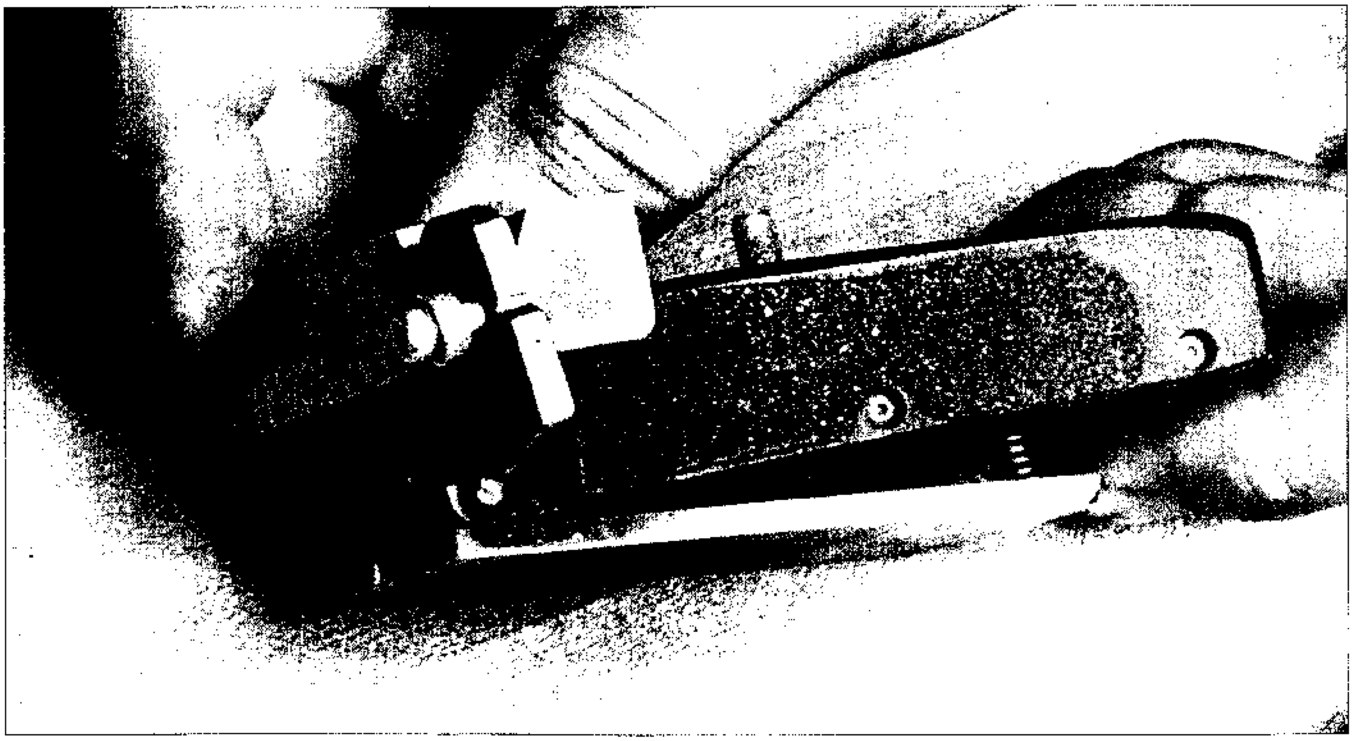


Fig. 188: The blade-grinding fixture has an adjustable base so I can match the angle of the blade against the contact wheel.

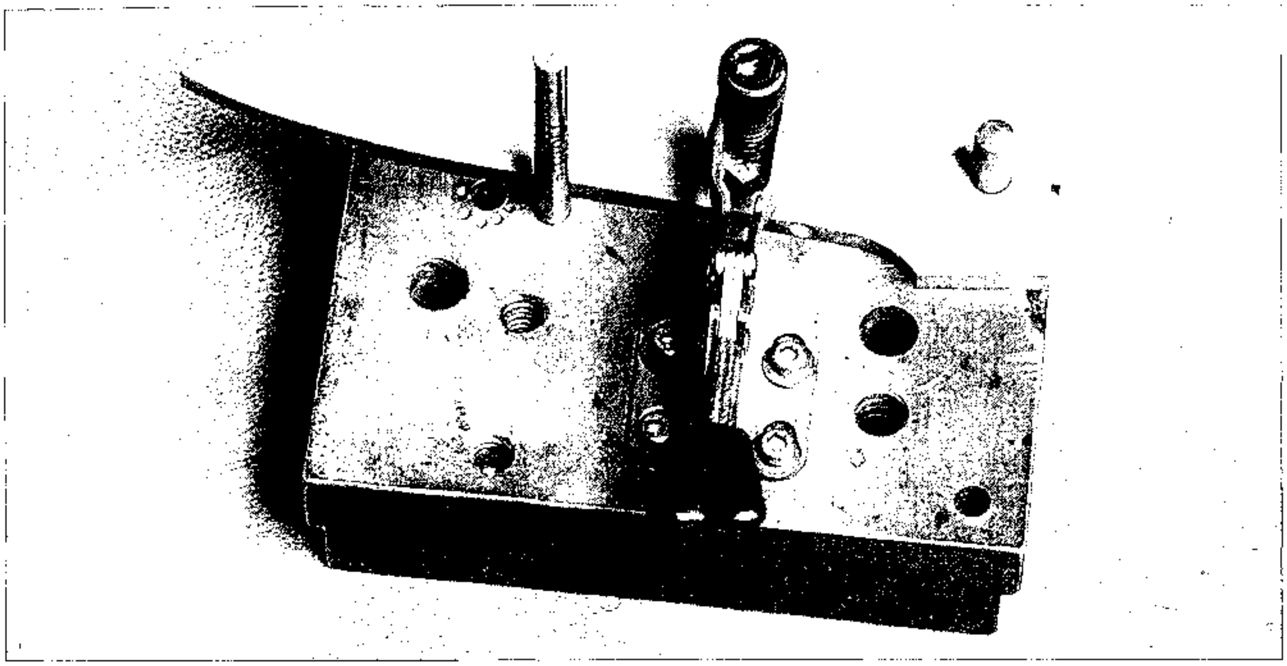


Fig. 189: The milling fixture I use when fitting the blade to the stop pin in the open and closed position.

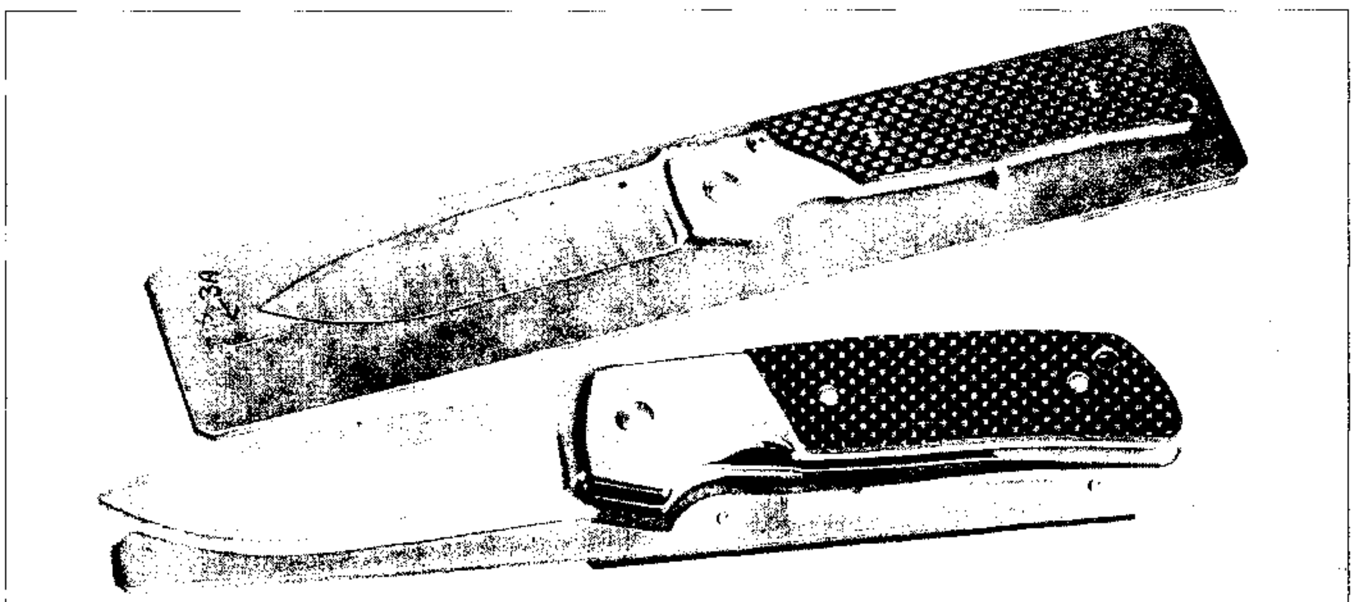


Fig. 190: Testing gages which assure that the blade to handle aspect is correct.

3. The points of the blade tang which contact the stop pin, (the back end in the open position and the forward part of the lower radius in the closed position, see Chapter 3), are critical points and must be carefully made in order to allow for the proper functioning of the knife. To insure repeatability in each of my blades, I mill both areas with a holding fixture that serves a dual purpose for the back end as well as the bottom of the blade (Fig. 189). Once the milling machine is set to the proper travel, the blades can be trimmed, one at a time, in a precise and consistent manner. I can do this with a cobalt end mill before heat treating or afterwards with a carbide end mill.

4. In order to secure consistency in the blade-open aspect of the finished knife, I made a gage into which the handle sits (Fig. 190). The edge of the correctly fitted blade then sits on the front por-

tion of the gage. I mill the backs of the blades with the fixture described above, but I verify the results on this gage.

5. The blade's lock bevel is one of those critical areas that must be attended to with care. I grind the bevel in, as described in Chapter 5, by using a setup plate which is bolted to the tool rest of my grinder (Fig. 191). This helps insure a consistent and straight bevel. (See chapter 11 for a different technique which I also use)

The center of the fixture has a raised section against which rests the edge of the blade so that all of my bevels are at the same angle, relative to the cutting edge. Also, I can set the blade against the opposite side of the raised section in order to make a left-handed knife which, in a linerlock, requires a mirror-image lock bevel on the blade. The contact wheel is made of rosewood so there is no "give" at all, and the bevel face is precise and straight.

6. When I grind a false edge or clip point on the top of the blade, I use a device which holds the blade with a dedicated spring clamp (Fig. 192). The angle of the blade, relative to the contact wheel is adjustable with a screw at the front.

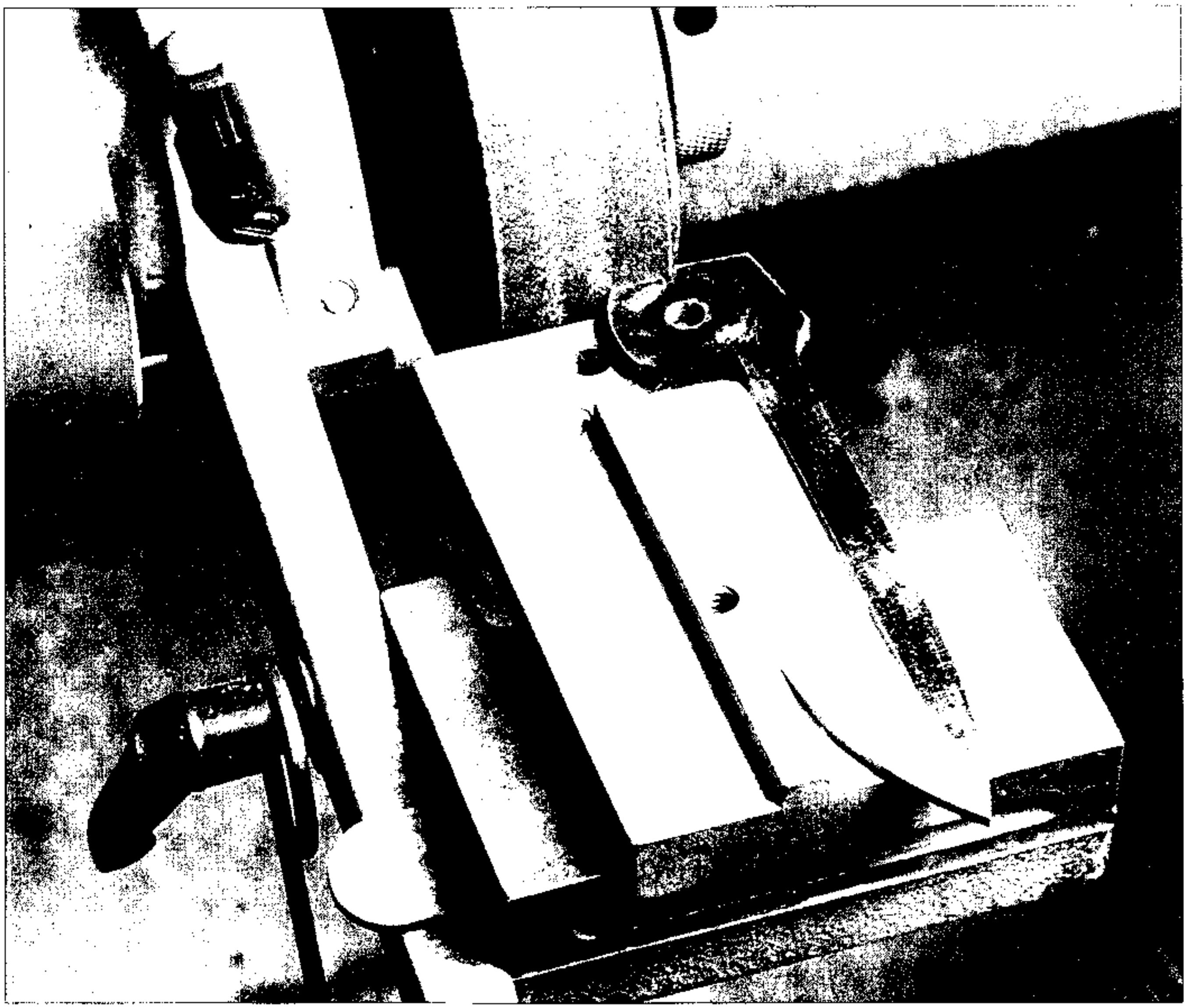


Fig. 191: My fixture for grinding the blade's lock bevel, set at 8-1/2 degrees to the 4-inch hardwood contact wheel. Note the raised ridge at the center, against which the blade's edge rests, which allows me to grind a mirror image bevel for a left-hand opening knife by turning the blade over and laying it on the left-hand portion of the fixture.

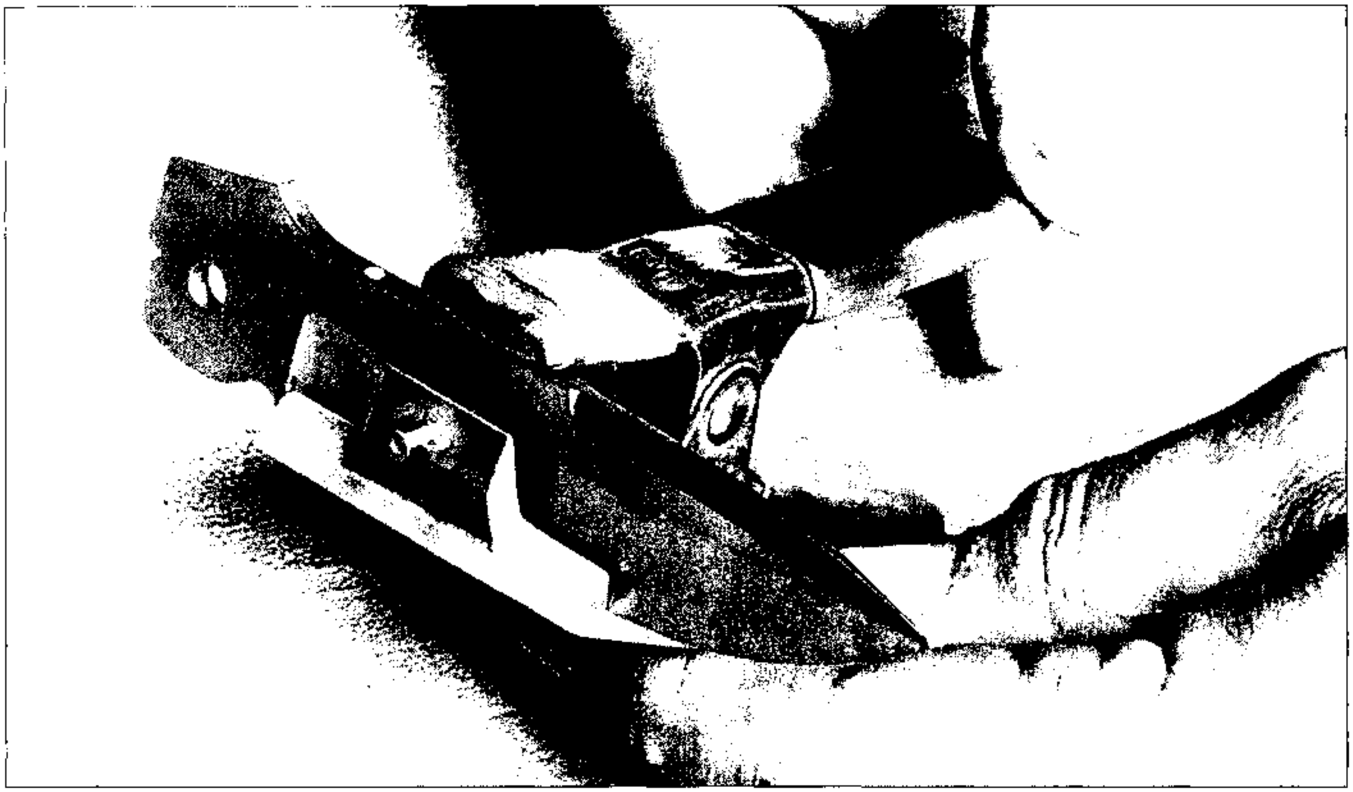


Fig. 192: A fixed pony clamp holds the blade against the angled front of this fixture which is made for grinding the false edge or clip points on the top of the blade point. A screw on the front allows me to vary the angle of the grind.

HANDLE FIXTURES

1. An important milling fixture that I use serves three purposes: milling the spring release scallop (or cutout) on one side of the handle; recessing the spring bar below the profile of the handle to minimize inadvertent release of the spring during heavy use; and, on the opposite edge of the fixture, to mill the recess for the pocket clip. I use the pivot hole as my registration point for all operations and place a steel dowel of the pivot's size in a hole to fix the handle in the same position each time I mill (Fig. 193).

For milling the recess for the pocket clip, I have drilled holes in the plate at various points into which I can place a small dowel pin which acts as a registering stop for each model handle. The part is then clamped in position with a dedicated toe clamp.

With the handle plate registered by the two dowels, I can assure repeatability to the operation and keep the clips parallel to the handle of each model without having to lay out the individual piece before milling the recess.

2. For milling the pocket of the inlaid springs on my smaller knives, I use a milling fixture which, like the one described above, uses the pivot hole to register the handle in position (Fig. 194). In this case, the pivot pin is a screw which also helps to lock down that end of the handle when it is in position. I align the scribed line (showing the spring's outline) with the edge of the fixture so that the cut will be parallel with it (Fig. 195). To prevent side play during the milling operation, the fixture has two sliding stops, one on each side of the handle. In this way I can use the fixture for parts of any shape. Finally, after the handle plate is registered and correctly aligned, I clamp its butt end with a toe clamp. The pocket is milled out and the sides are dovetailed without removing the fixture from the milling vise to ensure parallel alignment of the cuts.

3. The back edge of a bolster, which contacts the scale material, must be straight and true whether it is squared or beveled. Some knife makers use a curved rather than straight joint which is fine but the principle still applies that the meeting of the bolster and handle scale must be clean and with

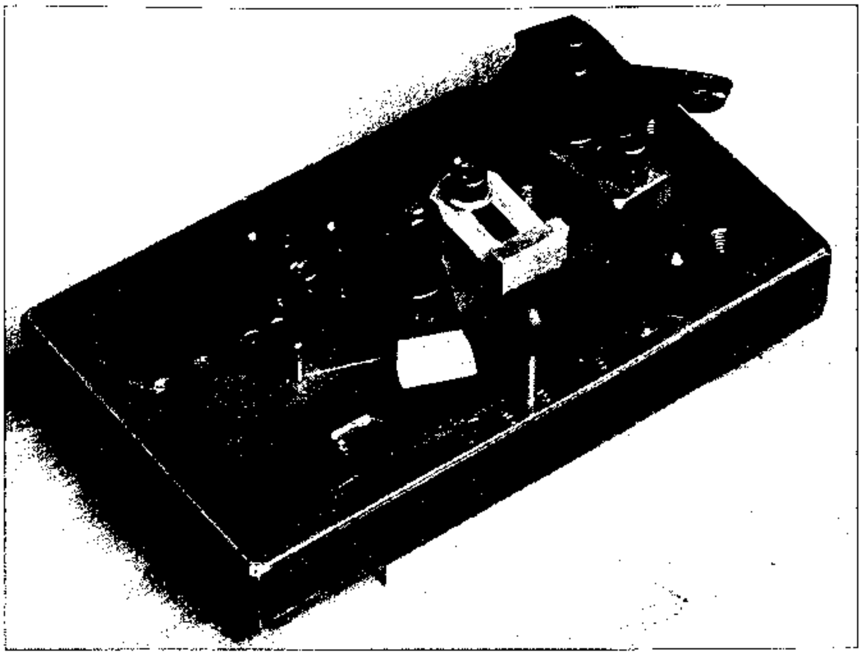


Fig. 193: A multi-purpose fixture for milling the release cutout or scallop on one handle side (top setup) and for milling the recess I use to hold my pocket clips (bottom setup) on the opposite handle side. Note the dowel pin and holes in the bottom setup which allows me to align each different model parallel to the milling table. I also use the top setup for recessing the spring below the level of the handle profile.

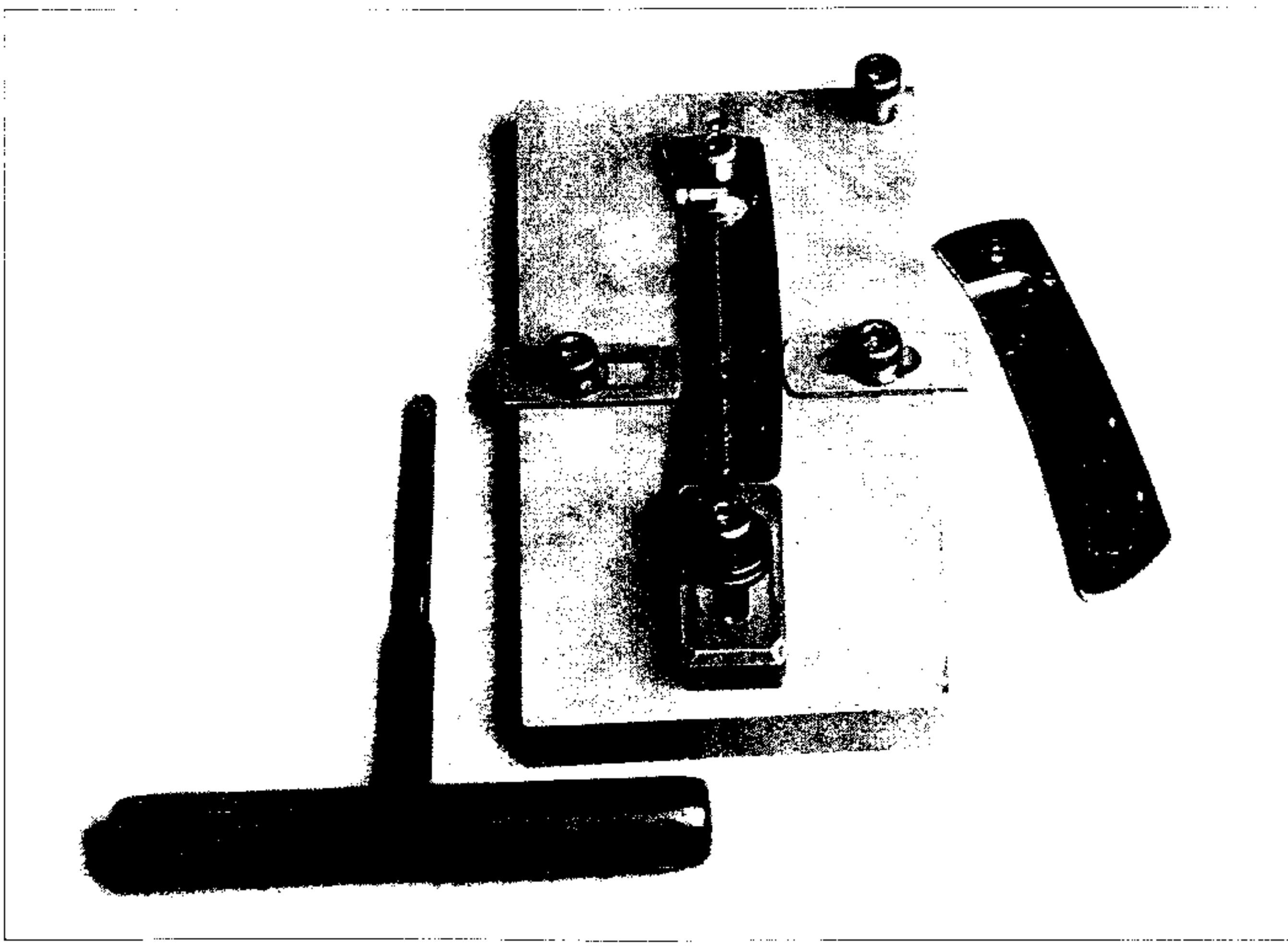


Fig. 194: This is the holding fixture I use for milling the recess and dovetail for the inlaid springs in my smaller knives.

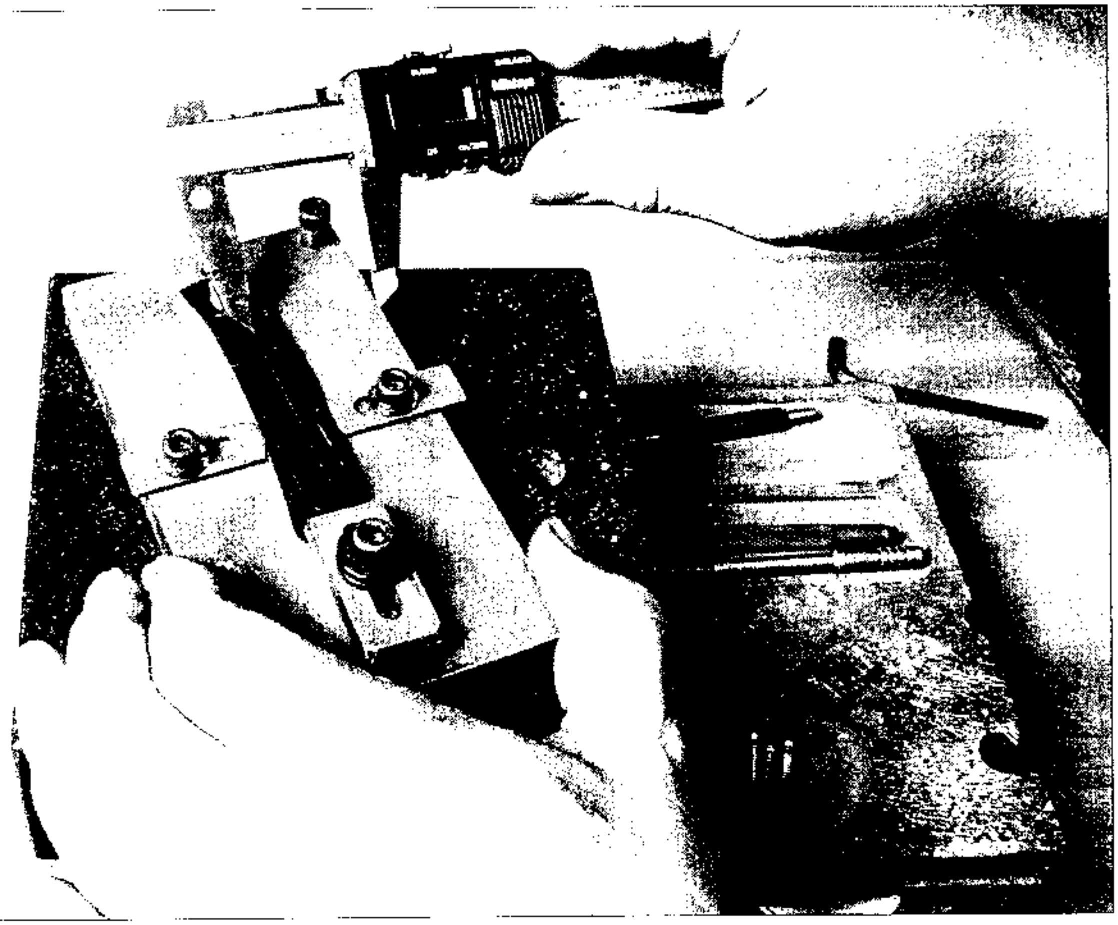


Fig. 195: Checking that the spring outline is parallel to the fixture's edge and therefore to the travel of the milling table.

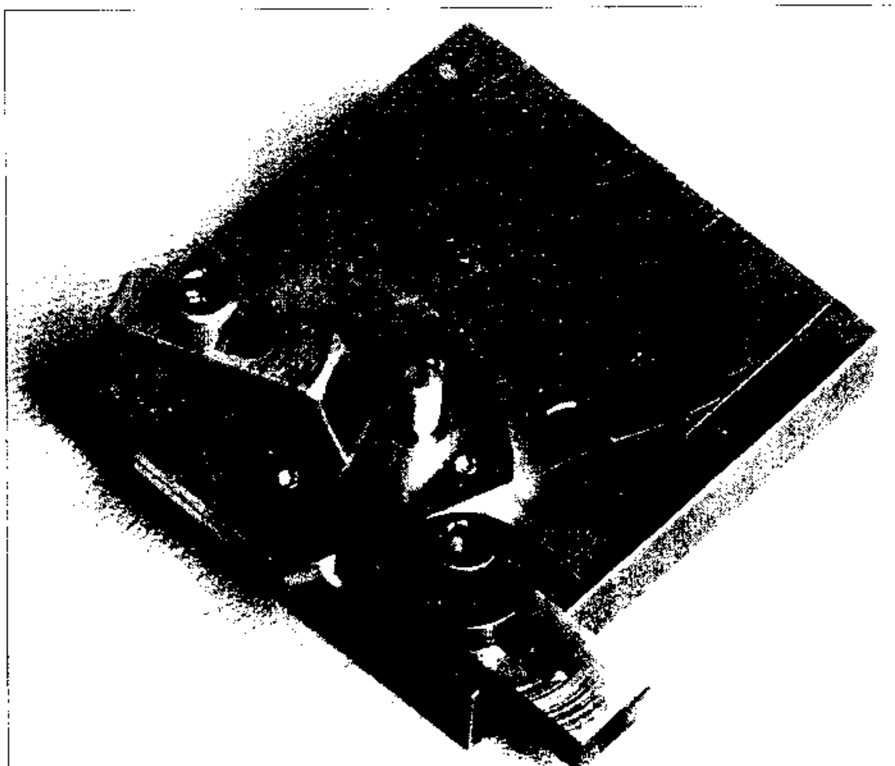


Fig. 196: The setup for milling the back edge of the bolsters.

no gaps between them. I use a fixture to mill the bolster's edges by clamping them horizontally and milling them with a carbide end mill (Fig. 196). An adjustable stop allows for different angles or different size bolsters and I register off the pivot hole with a gauge pin to keep the parts properly aligned. I mill the bolsters in pairs to insure identical parts.

SPRING FIXTURES

1. As explained in Chapter 6, I grind my springs to fit the finished bevel on the blade. To do this requires that the spring, before final bending to shape, be pushed away from the handle to expose the locking face to the platen grinder. The scribed line describing the lock face must also be parallel to the grinding belt (and therefore perpendicular to the tool rest). To accomplish this, I use a fixture which can be set up in a convenient position to align and clamp the spring, and then be rotated 90 degrees to sit on the tool rest and perform the actual grinding (Fig. 197).

I modified a cast iron V-block and placed a dedicated pivot-sized dowel in one end to register the handle. With the help of a magnifier, I use a square to align the scribed line of the spring face (Fig. 198) with the edge of the V-block by adjusting the back end of the spring plate with a sliding

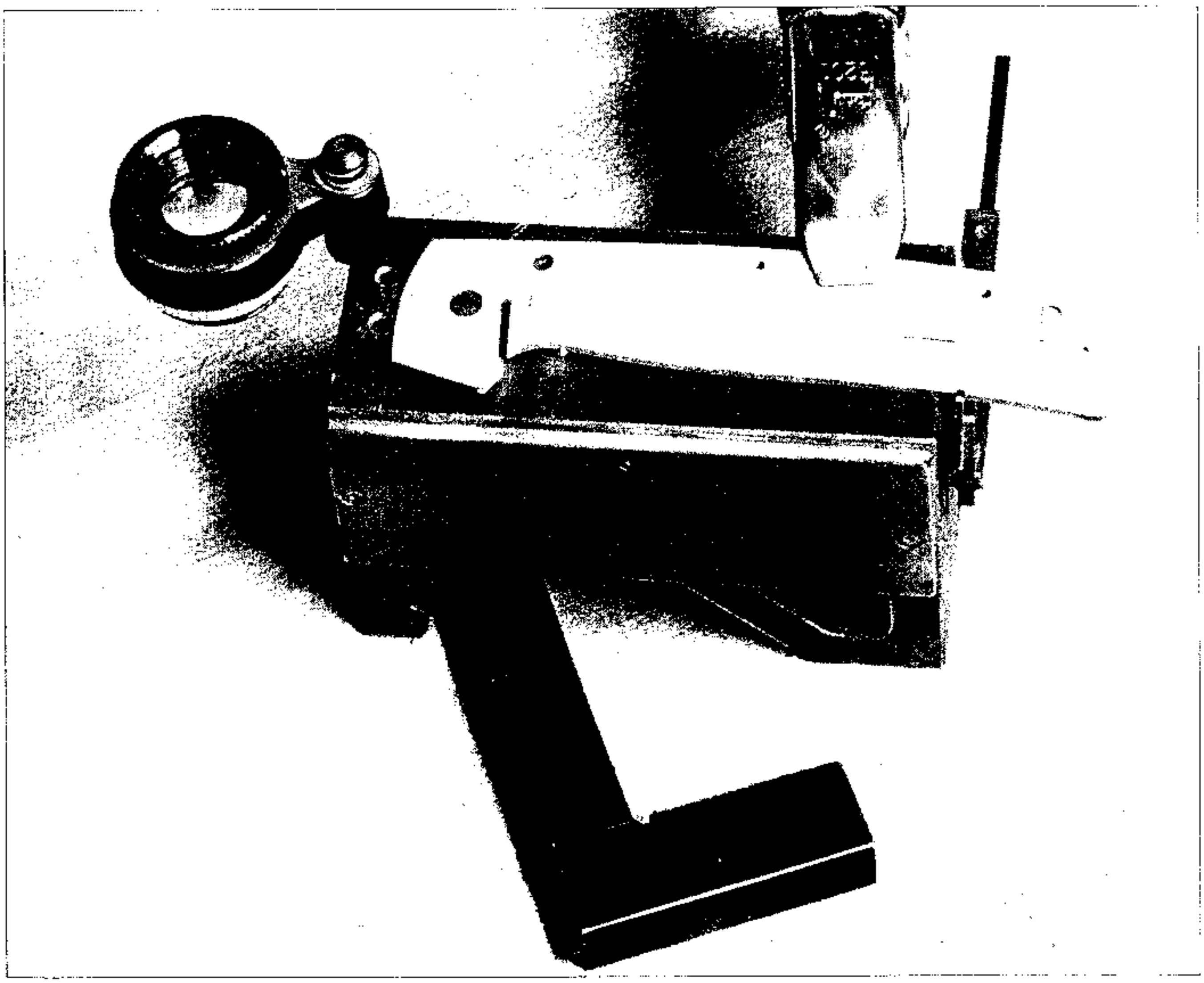


Fig. 197: Fitting the spring to the blade is a precise operation. This modified V-block holds the spring plate at the proper angle after it is set up with the aid of the square and magnifier. A screw under the front end of the spring bar then lifts it up and away from the rest of the piece so it can be ground. The whole fixture sits on the grinder, resting on the flat plate seen on the front side.

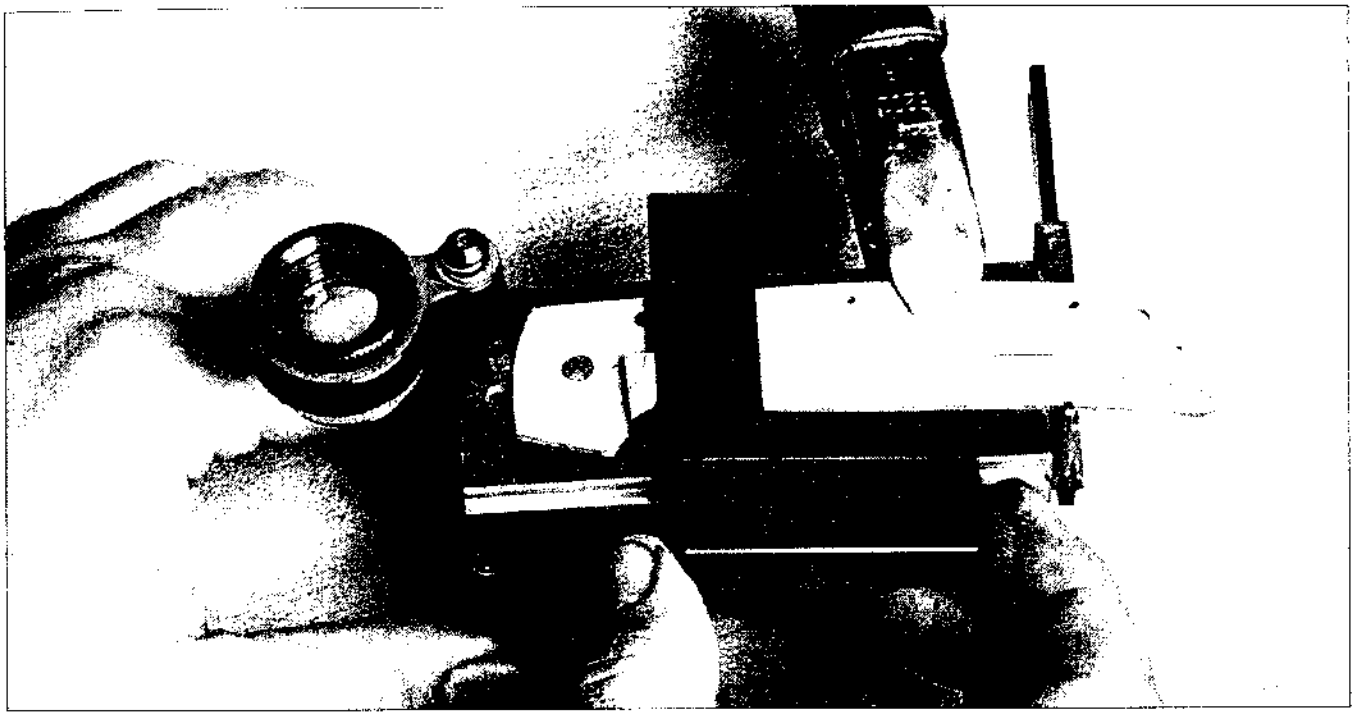


Fig. 198: Use the square to check that the scribed line for the spring face is perpendicular to the base.

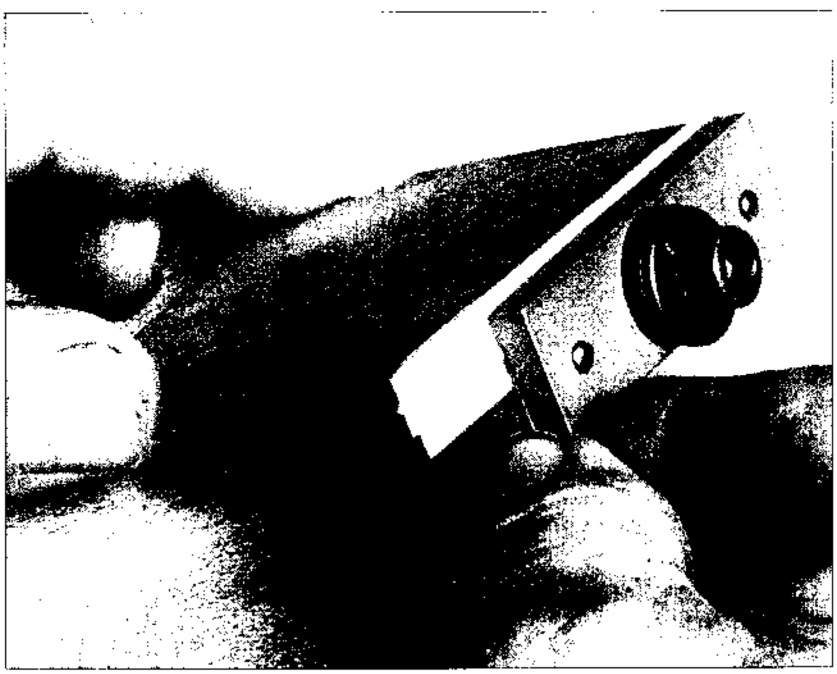


Fig. 199: This is the fixture I use for milling the 60-degree angle on the edges of the inlaid spring. Note the angled step which sits on the vise jaws at the predetermined angle.

and locking stop. I then clamp the spring in place and use a screw under the spring to push its end up and lift it away from the rest of the clamped handle. The fixture can then be placed on the tool rest of the grinder and the spring face slowly worked down to the scribed line.

2. On my small knives, I use an inlaid spring as described in Chapter 7. The springs that I use are dovetailed into the pocket of the handle and therefore require that a 60-degree bevel be milled on both edges of the spring's long leg. After the edges of the spring are milled parallel and to the correct dimensions, I use a fixture which locks the

piece against a milled ledge on its top to provide for a parallel cut (Fig. 199). The fixture has a 60-degree step milled into each side so that the fixture can be clamped in the vise at the correct angle. I can then use a conventional, straight milling cutter to mill the dovetailed angle.

OTHER USEFUL GIZMOS

1. My main working surface is a 6-inch by 6-inch granite surface plate sitting on a large wood block (Fig. 200). I use it as an anvil for center punching and as a guide plate for scribing and layout. It raises the work above the bench and causes less eyestrain (now that I need glasses to see up close) and provides me with a nice flat, hard surface to center punch, scribe, measure, etc., with everything right at hand. The wood base is full of holes and niches which hold my most-used tools such as scriber, thickness gage, center punches etc. The whole thing is not fixed in one place so I can slide it out of the way when I want to. (Ron Lake reminds me that a workman in a tool shop would be fired on the spot for hammering on a granite surface plate, but I bought this one not for precision measuring but for everyday tasks.)

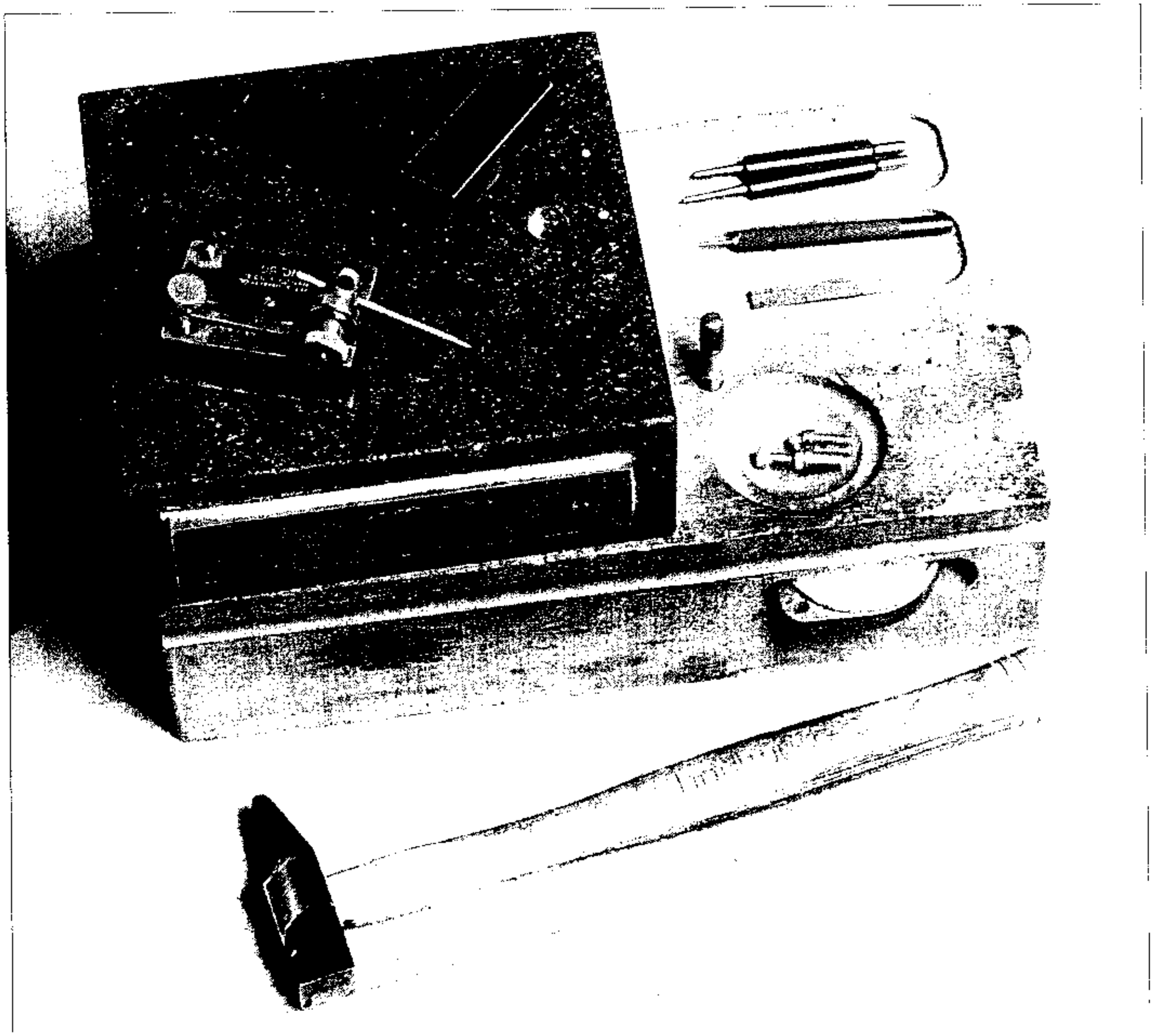


Fig. 200: My main work station consists of a granite surface plate and wood base.

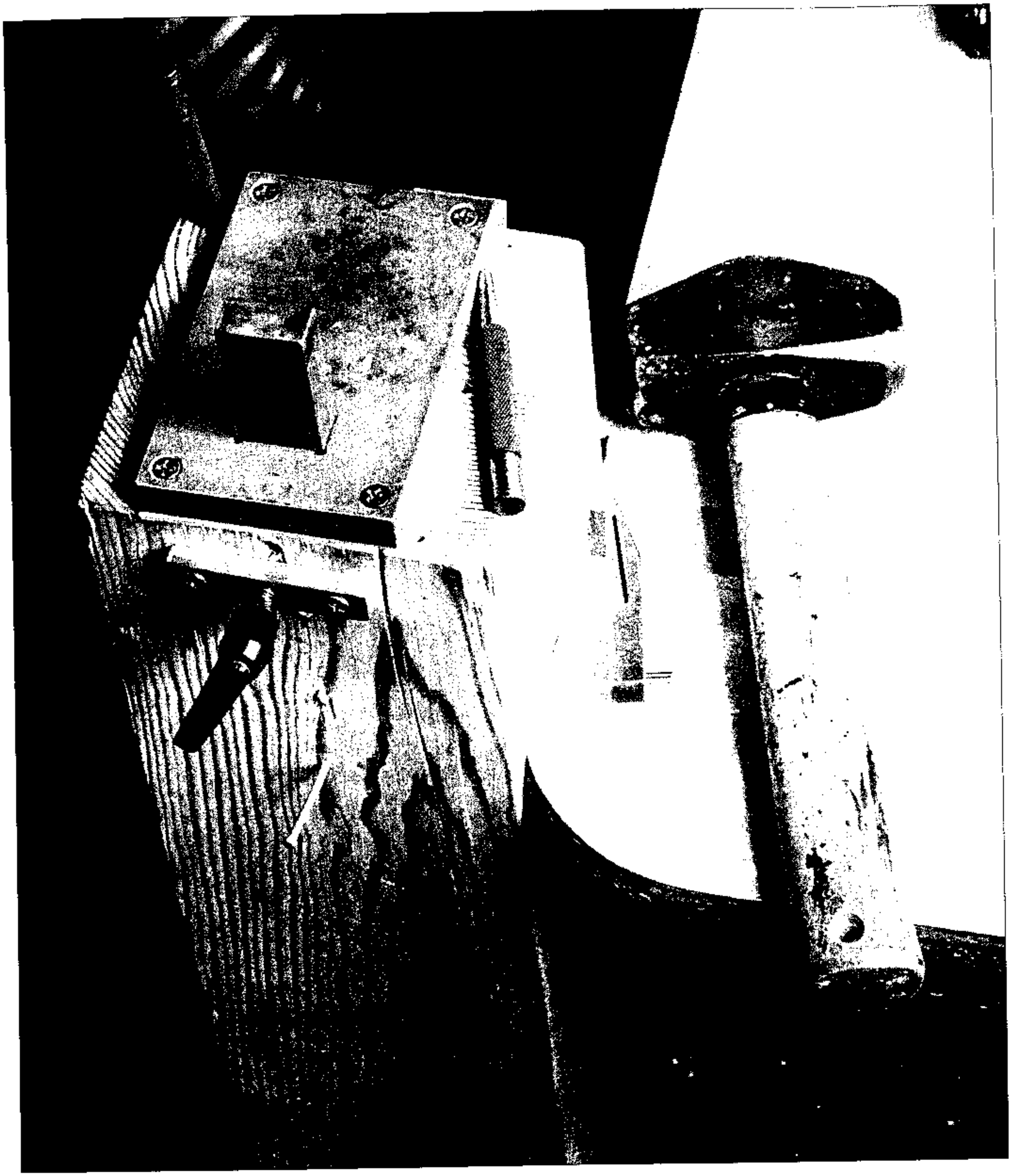


Fig. 201: This is the staking plate I use for punching in the anti-rotation "D" in my pivot holes and for adjusting springs which may be worn.

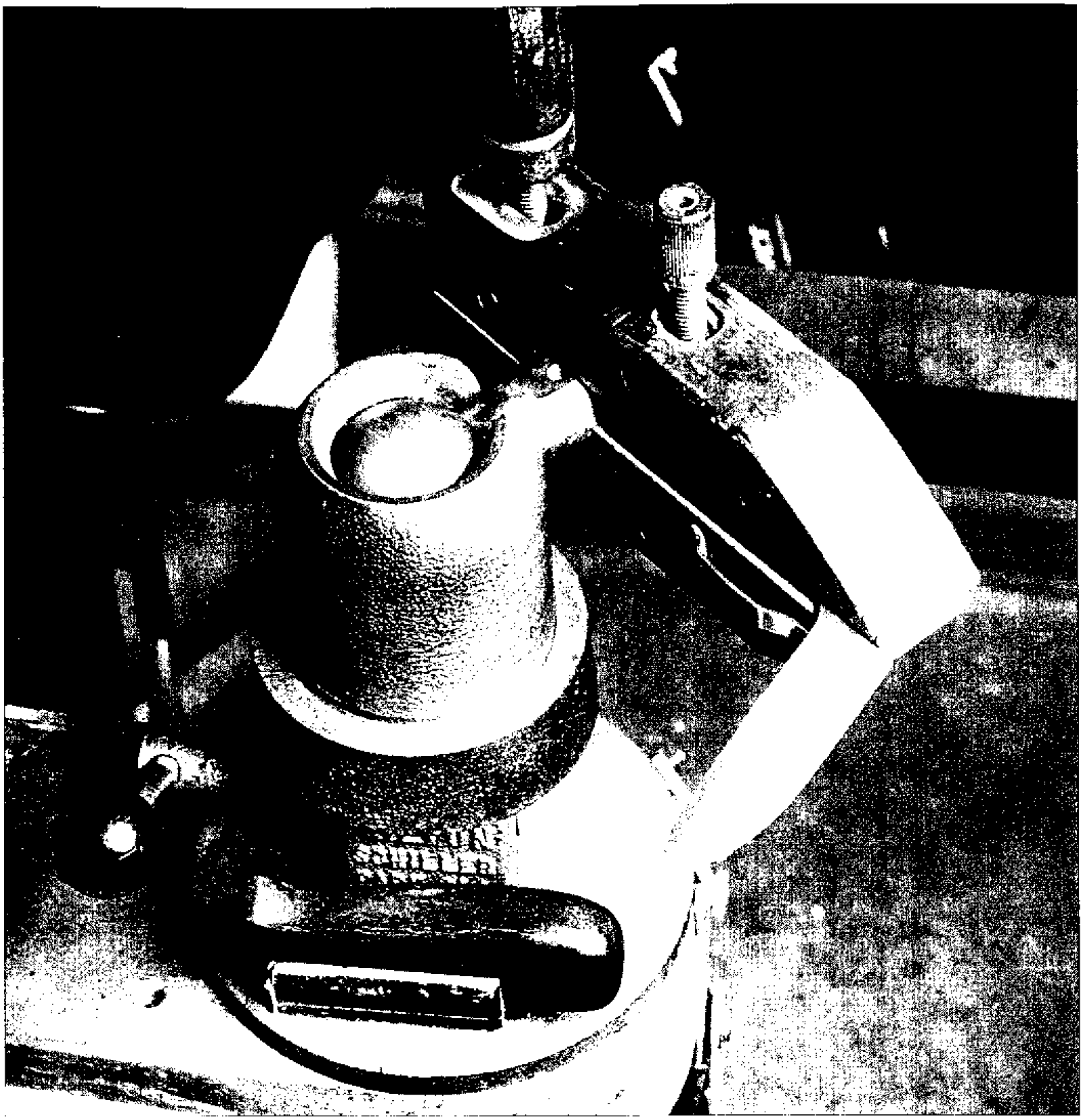


Fig. 202: A modified Jorgensen clamp mounted to a Wilton swivel head holds things at any angle.

2. I use an upright 4x4 post for general pounding and staking. There is a hardened steel plate screwed to the top for coining the "D" in the pivot holes, and a locking but removable steel stake which I use for adjusting springs (Fig. 201).

3. I modified and mounted an 8-inch parallel wood clamp, also known as a Jorgensen clamp, to a Wilton revolving base (Fig. 202). The ability to rotate and lock the clamp in virtually any position is a real help with odd-shaped pieces that need finishing at weird angles. All of my hand-rubbed finishes are applied with the help of this vise (Fig. 203).

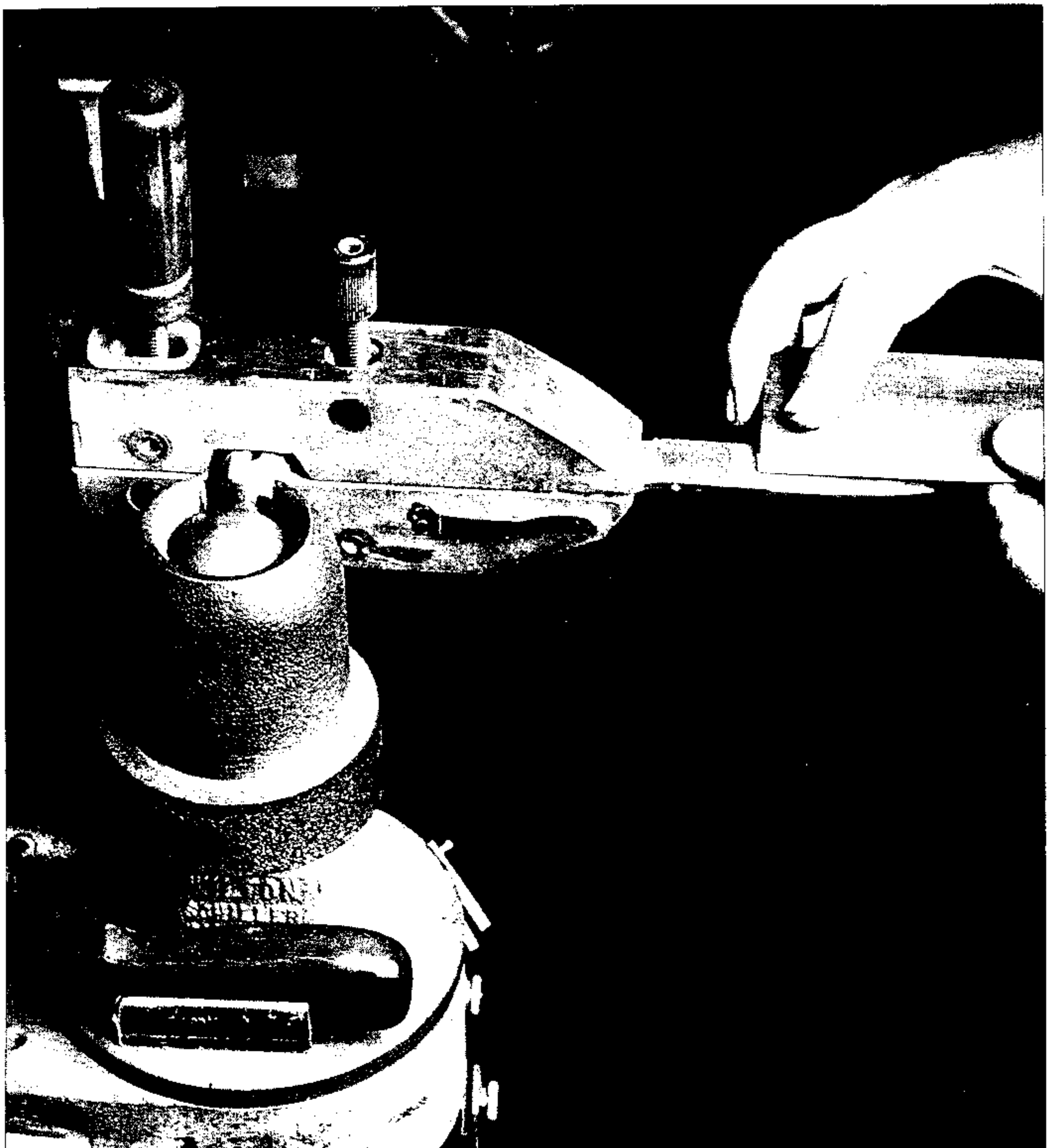


Fig. 203: This vise really comes in handy while applying a hand-rubbed polish to a blade.

Chapter 10

Care and feeding of the folding knife

A custom-made knife can be a beautiful and expensive acquisition. Knives are made to be used, no matter what they are made of or who made them, and it often saddens me to see batches of knives locked away in strong boxes for fear of damaging their pristine condition. It is anathema to me why someone would purchase a knife and not want to use it or even to feel and handle it. With a little care and attention, even the most expensive knives built today can be carried about and yet kept in good, serviceable condition. Here are a few tips:

KEEP YOUR KNIFE SHARP

Sharpening a knife is not so much a mysterious art as it is an acquired skill, achieved through study and practice. I won't go into the interminable esoterica of edge angles, but suffice it to say that the more acute the edge angle, the better the blade will cut but the more delicate it will be. The angle of sharpening will also depend heavily on the geometry of the blade, its thickness and the mission for which it is intended.

In my shop, I create the cutting edge on the belt grinder with a 60-micron finishing belt and

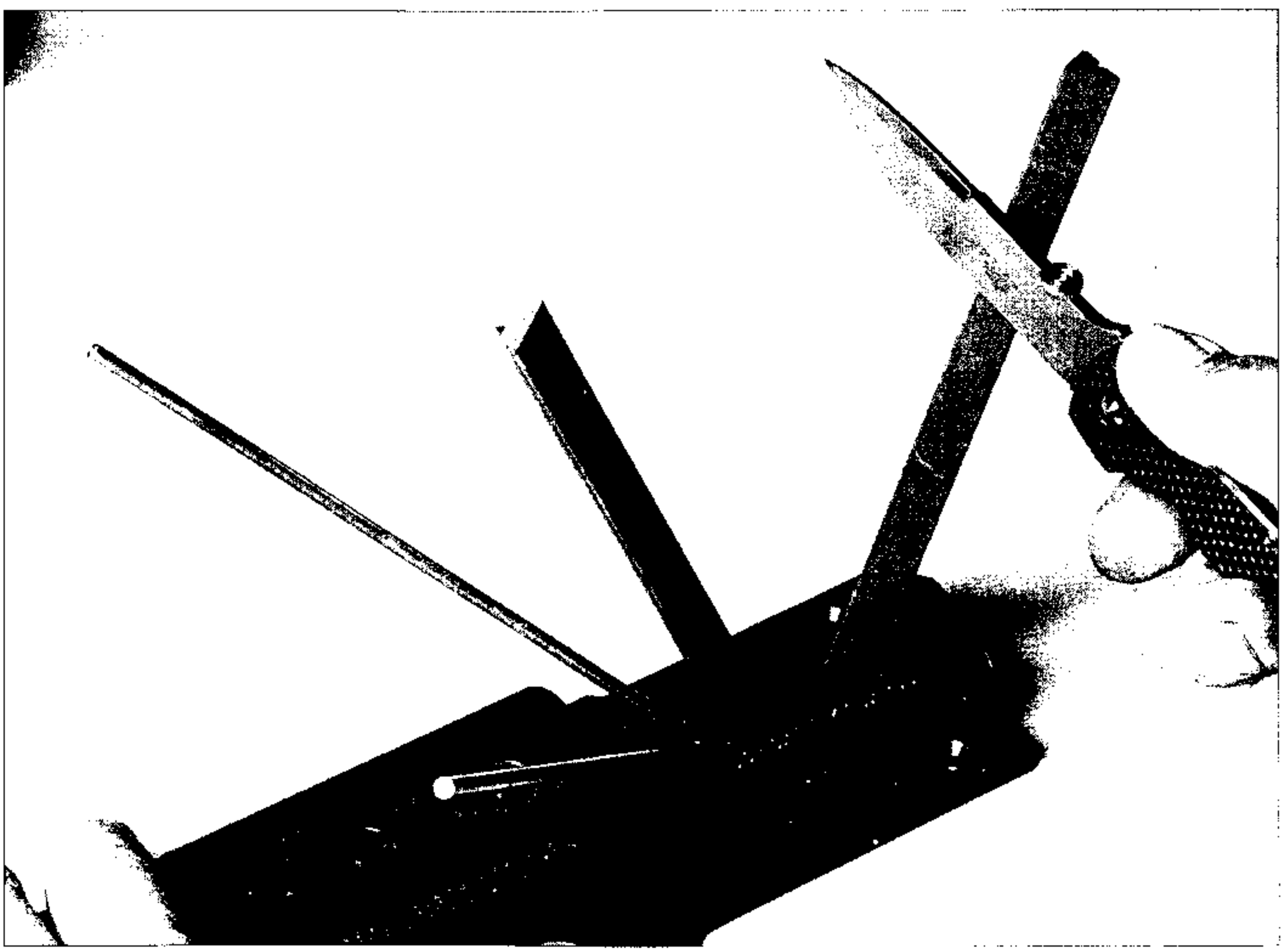


Fig. 204: Honing the blade on a Spyderco Sharpmaker.

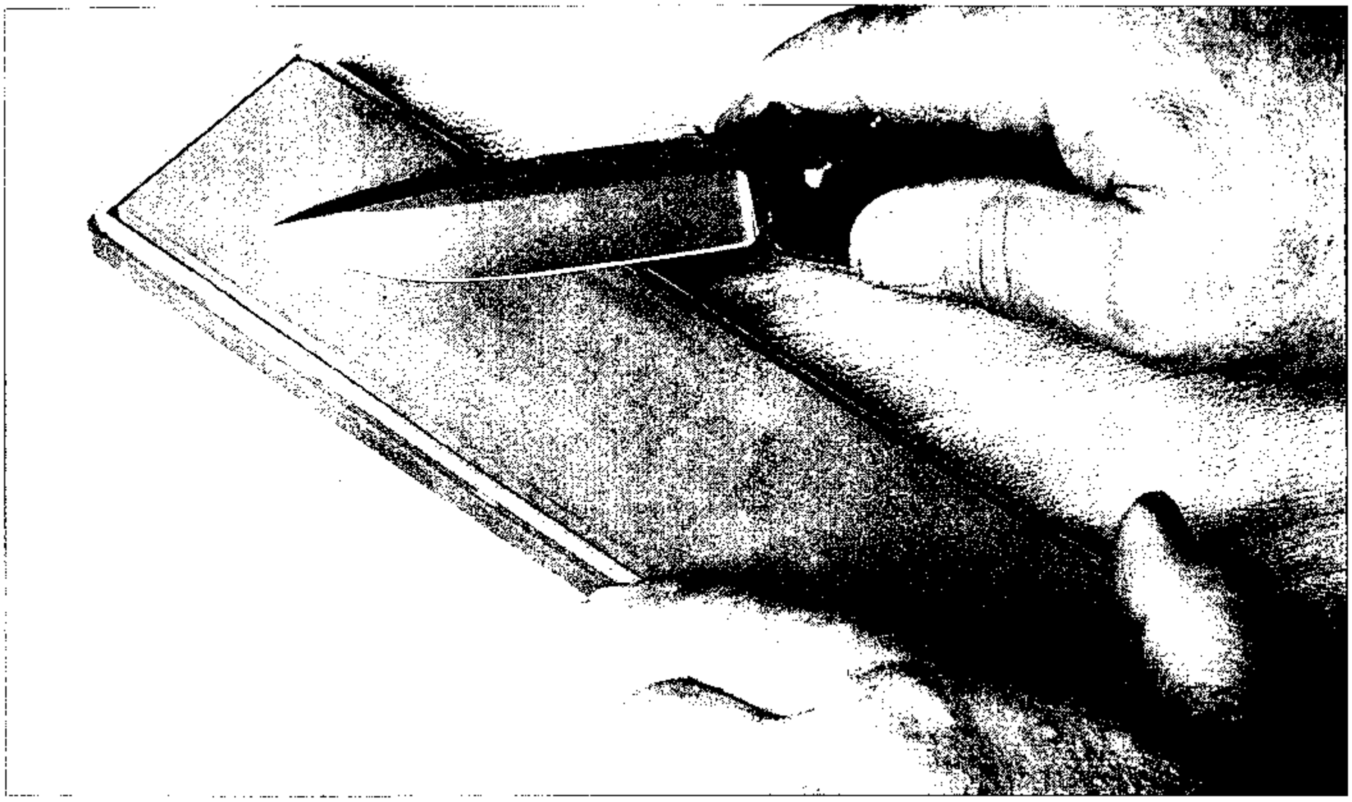


Fig. 205: When honing on a flat whetstone, hold the blade at a constant angle and try to slice off a section of the stone.

then hone the edge with a Spyderco Sharpmaker with ceramic sticks (Fig. 204). This gives me a finished edge of about 20 degrees which I find to be serviceable for most jobs. There are several sharpening systems on the market and most are pretty good but I find that those which require a guide to be clamped on the blade may trap loosened grit from the stones and seriously scratch the blade spine if not used with care.

The most efficient method of sharpening is to move the blade against the stone as if one were trying to take a slice out of the stone. This works best with both the ceramic stick design as well as the flat, whetstone. When sharpening with a whetstone, it really pays off to practice holding the blade at a constant angle to the stone (Fig. 205). Most blades sent back to me for resharpening have simply had their cutting edges rounded as the users' hand rotated the blade against the whetstone.

Sharpening serrated blades is best done with a triangular stone with slightly rounded edges. Again, the Spyderco system works well but a machinists' slipstone of aluminum oxide can be used, if it is of the proper shape. Carefully hone each side of the serrated section and be sure to touch not only the peaks but the valleys as well.

Keep your sharpening stones clean, as the metal removed during the honing process will build up and reduce the stone's ability to cut. Ceramic should be used dry and can be cleaned with water, a Scotchbrite kitchen pad and some scouring powder like Ajax or Comet. Silicon carbide, Arkansas or aluminum oxide stones can be cleaned the same way but should be used wet with light oil or kerosene.

CLEANING THE KNIFE

If you have a compressor or access to one, blow out the inside of the knife frequently to get rid of pocket fluff, dust, etc (Fig. 206). If compressed air is not available, a Q-tip or toothpick with cotton and some patience will suffice. If the knife is heavily gunked up with mud, blood or (perish the thought!) peanut butter, rinse it under clear water and apply a toothbrush to it if necessary. I always make my knives with removable pivots so that the owner can disassemble the blade and washers if the need for heroic cleaning measures should be presented. When taking down any

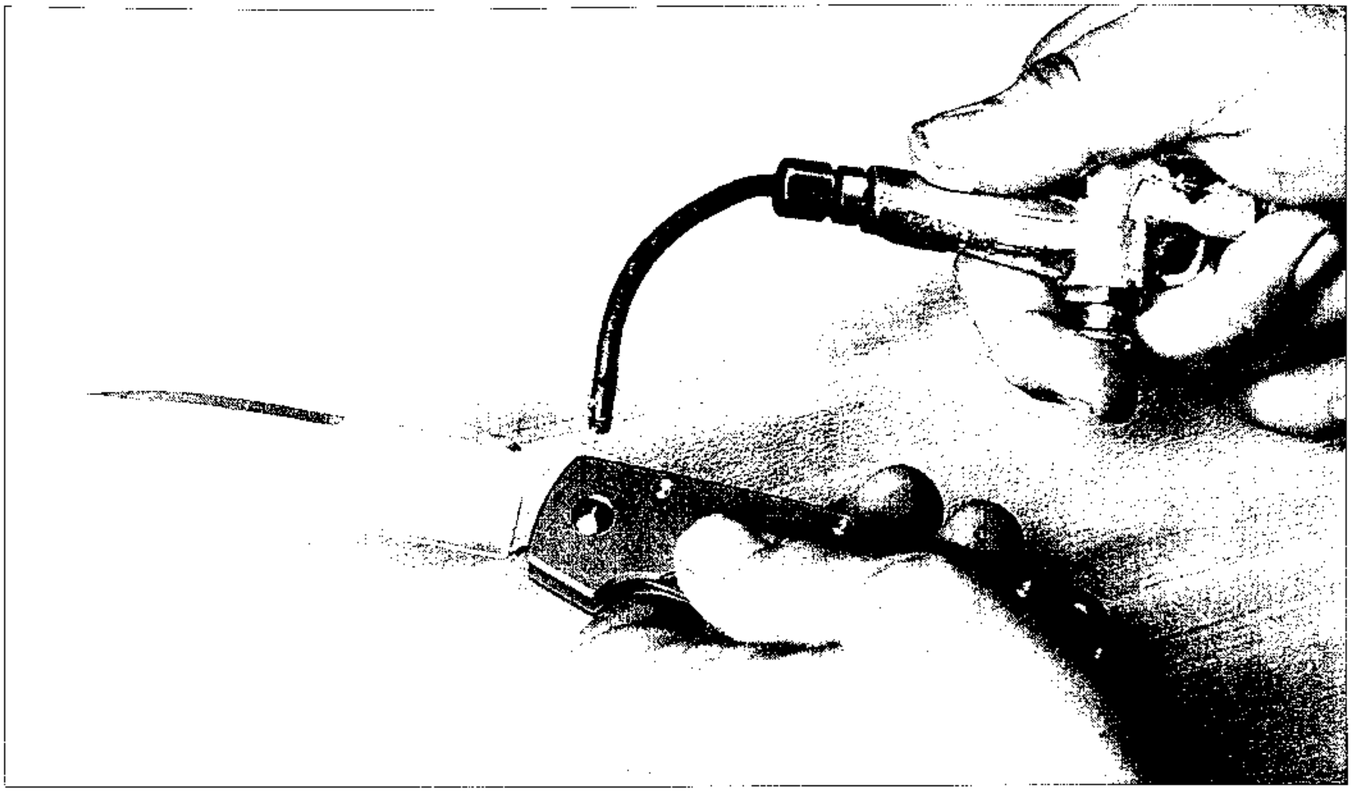


Fig. 206: If possible, blow out the collected gunk with compressed air.

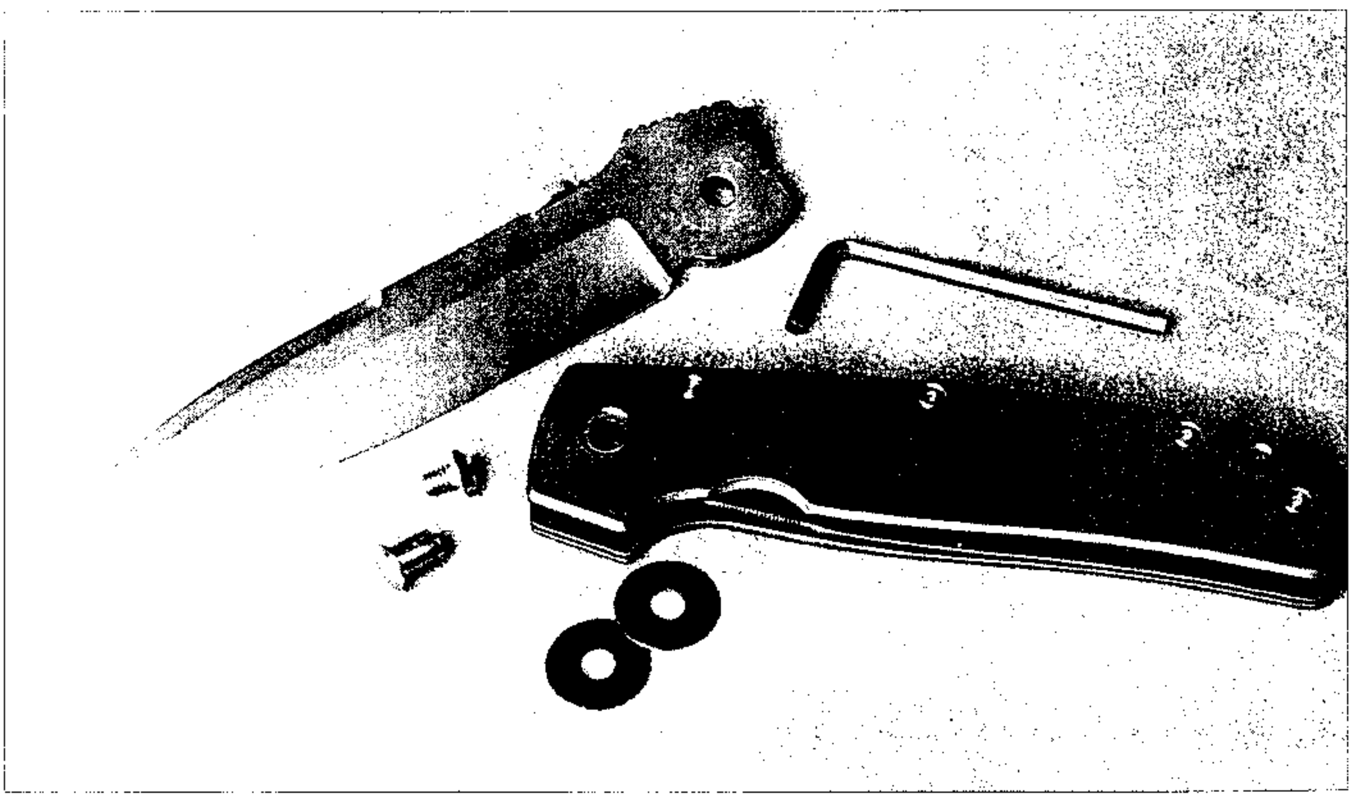


Fig. 207: The end user should be able to disassemble the knife for cleaning and minor adjustments.

Fig. 208: Just a drop of a good oil is sufficient for modern knives. Don't overdo it!

knife, be sure to note which part goes where so that you can avoid an embarrassing phone call to the maker when it doesn't seem to go back together again as it should!

If the knife is made with natural materials such as wood, stag or ivory, avoid heavy soaking or rinsing as these and other like materials will absorb water and possibly change shape or crack as they dry out.

If the knife has been subjected to corrosive elements such as sea water, blood or fruit juices (especially tomatoes), rinse it thoroughly in running, clear water from the tap or a stream as soon as possible, then dry it off thoroughly. All blade steels, even the exotic stainless steels are subject to corrosion from these liquids if left unattended. Blades of stellite and ceramic are, of course, exempted from this rule but their fittings, (screws, pivots, thumb studs) are not.

OIL, GREASE AND WAX

One of my pet peeves is to have a knife returned to me for servicing and find that it has been over oiled, sometimes to the point of soaking. Modern knives require far less oil than most folks think and tons of the stuff are not going to make the blade open up any faster. To the contrary, free oil or grease on the inside of the knife will tend to collect and trap dust, grit and pocket fluff. The Nylatron washers that many knife makers use today are self-lubricating and require very little, if any, maintenance.

If needed, a single drop of 3-in- oil, Breakfree, Triflon or any of the gun or clock oils should be applied with a toothpick right at the joint. Then, wipe off any excess (Fig. 208).

Non stainless Damascus should be protected periodically with a paste wax or rubbed down with gun oil.

Fig. 209: Brush some oil onto the scales from time to time. Then wipe off the excess.

Handles of natural material should also be rubbed down periodically with a mineral based oil or wax. G10, Micarta and carbon fiber can also be rubbed down with the same type of mineral oil but this is more for looks than for protection. Any part of a knife that has been sandblasted (including G10) will have a bare and lighter colored surface after this process. Fingerprints and naturals skin oils will immediately show up if these surfaces are touched, so knife makers automatically brush them down with oil to evenly coat the surface. If the knife is washed with soap, acetone or commercial de-greasers, the bare surface will again appear but can be quickly restored with a toothbrush and a little oil (Fig. 209). This is true also for anodized titanium surfaces. The colors will change if the anodized area is wiped clean of all oil. Just wipe some back on with a soft cloth.

Finally, as I have counseled all of my customers in my brochures since I started in this most satisfying of crafts:

Fondle your knife often!

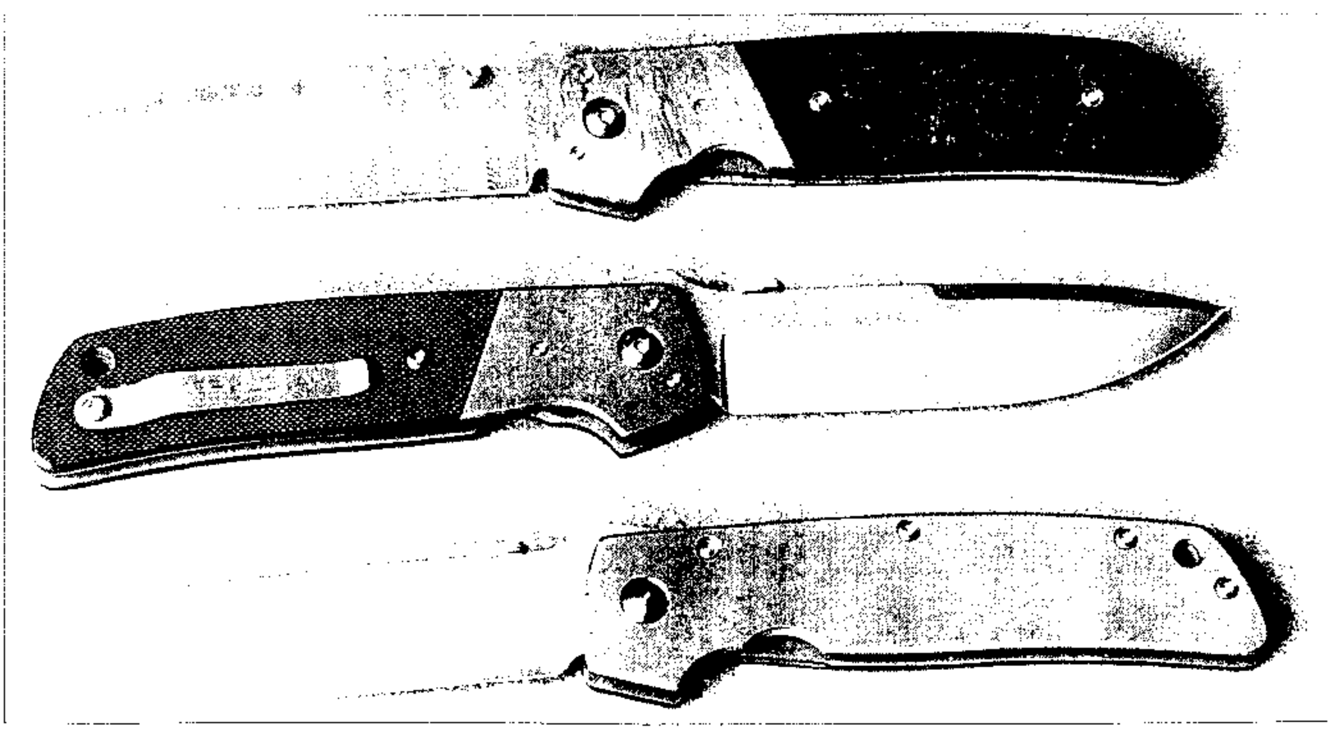


Fig. 210: Take care of your knives and they will take care of you.

Chapter 11

The Fail-Safe Linerlock

The linerlock has, without doubt, become one of the most popular folding knife locks in the industry today, both with custom knife maker as well as with factories. Although many other locks are constantly appearing on the scene and are quickly patented by their creators in the hopes of striking it rich, none, to date, have matched the linerlocks' exquisite simplicity and few have exceeded its standard of strength and reliability. The caveat implied here is that the lock be made correctly. As I have described in previous chapters the linerlock is forgiving in many aspects of construction but does require certain design parameters to be followed.

The linerlock options detailed in Chapters 4, 5 and 7 with the straight or slightly curved bevel ground onto the blade tang are perfectly functional and, if the steps are followed correctly, will produce a strong and dependable lock (Fig. 211).

There is another option, however, which I consider to be a great improvement and, although requiring a bit more precision and a milling machine, I believe is well worth the effort in the final product. Technically, this is known as the "offset-radius" lock but I call it the "fail-safe" linerlock. The technique for creating this lock on the blade tang was developed by Vince Ford and was first used on the Spyderco "Military" and "Starmate" knives.

Essentially, a certain size milling cutter (instead of a belt grinder) is used to create the blade's lock bevel. This cutter is offset from the edge of the blade. (Offset, in this case, refers to the distance that the CENTER LINE of the cutter

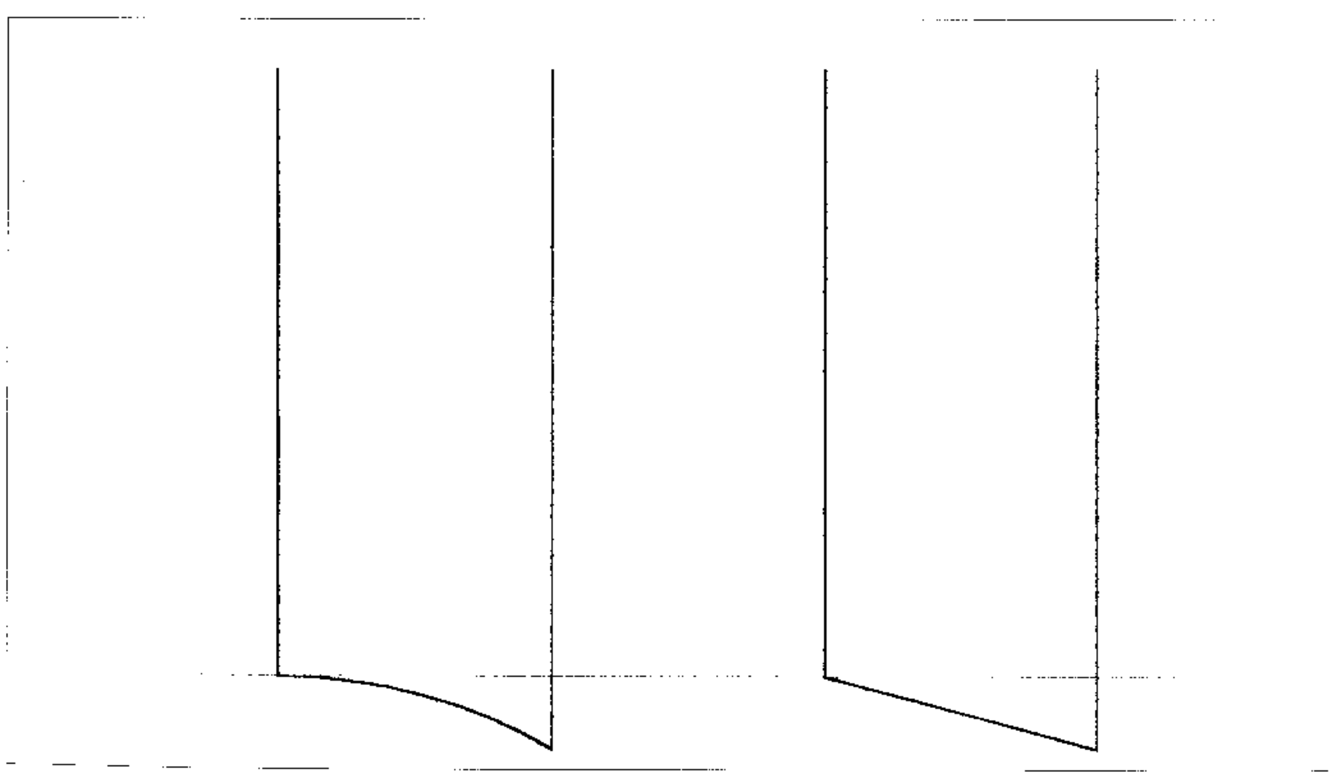


Fig. 211: Two types of blade lock bevels as described in previous chapters: the radius and the straight bevel. Both will produce a strong and dependable blade lock-up if made correctly.

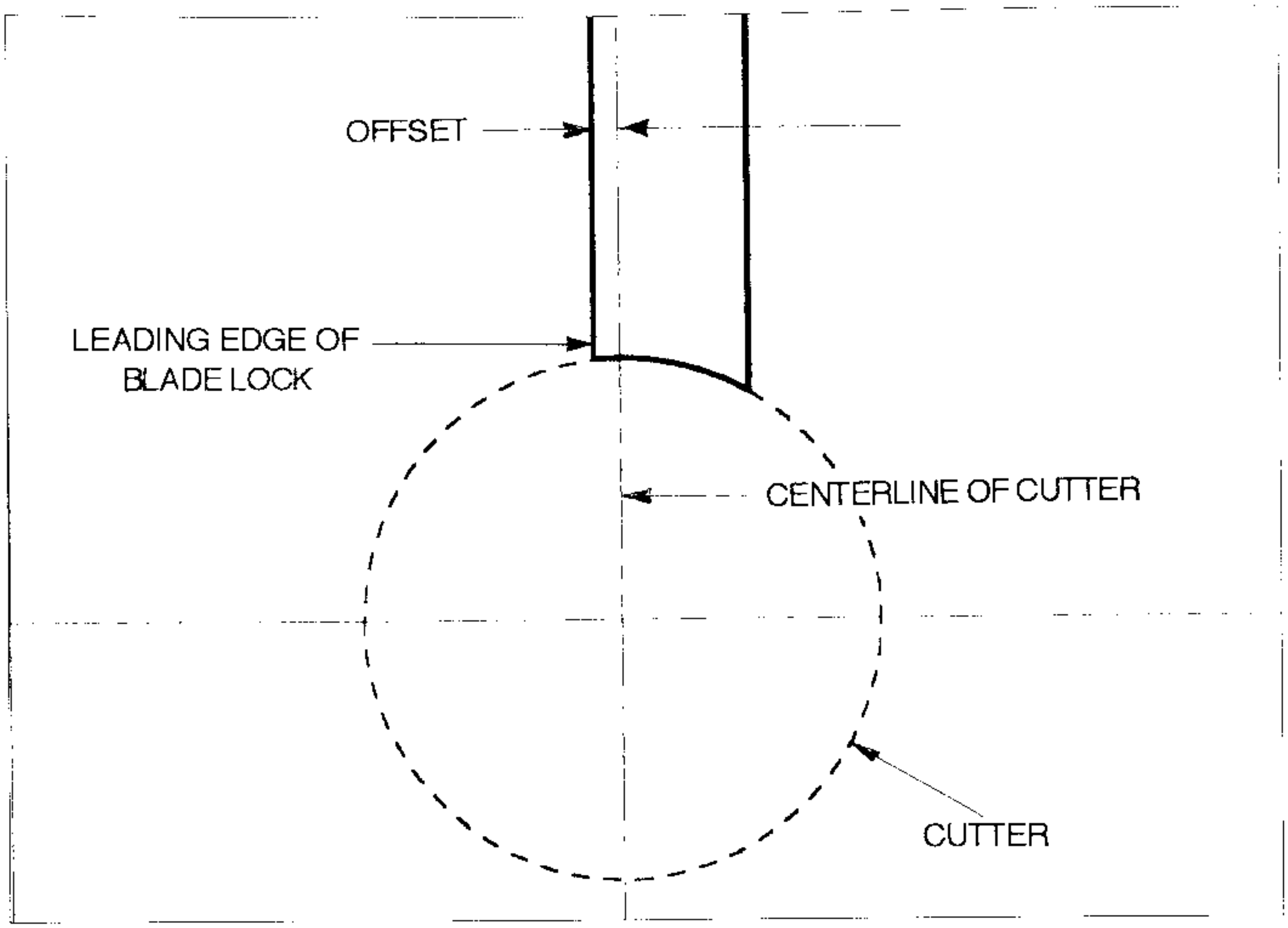


Fig. 212: Positioning of the milling cutter, with a small offset from the blade's leading edge, is critical.

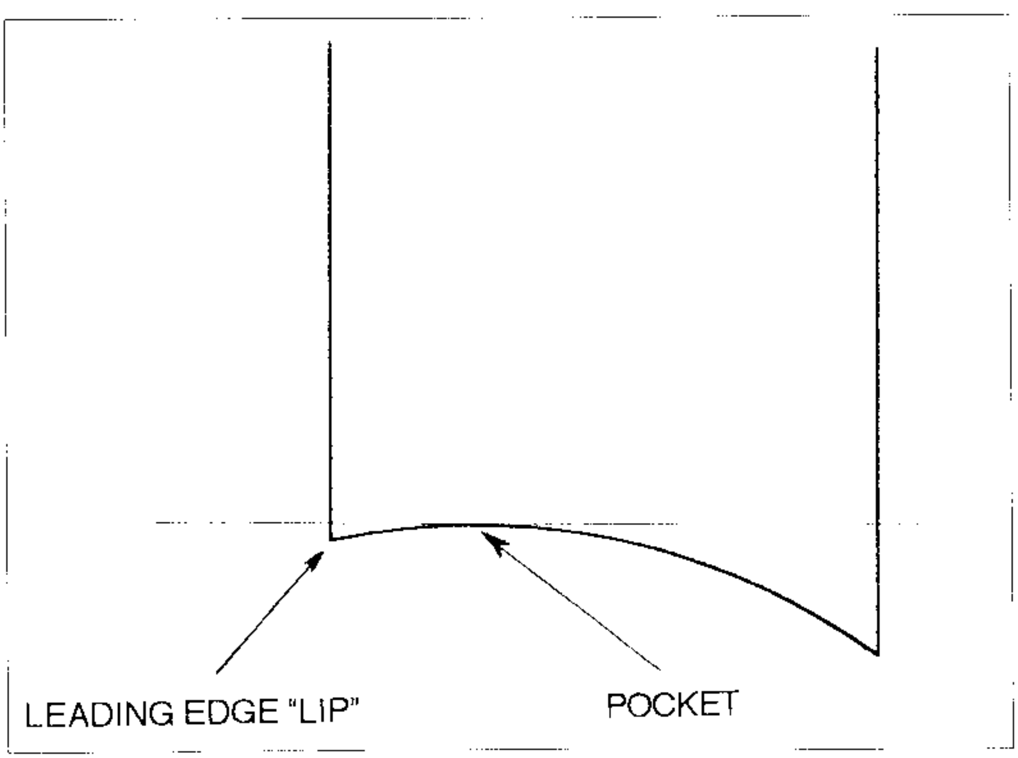


Fig. 213: An improvement to the linerlock bevel is the machining of a small "lip" at the leading edge of the bevel over which the spring must pass.

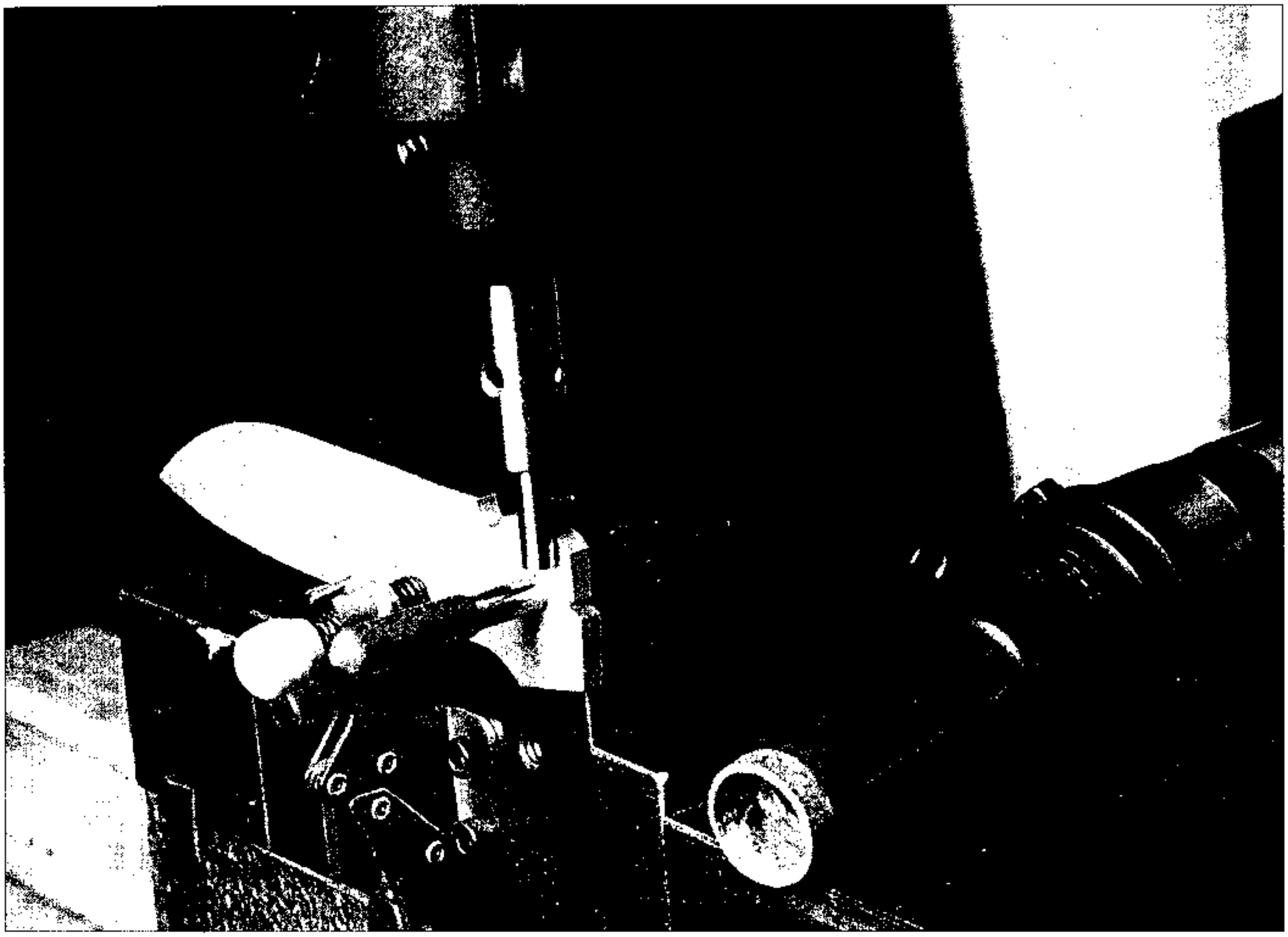


Fig. 214: The blade set up in the milling fixture with the edge finder in place at its starting point.

is moved in relation to the leading edge of the blade's lock bevel) (Fig. 212). This is done so as to produce a "lip" at the leading edge of the bevel which the spring must jump over in order to engage the bevel and therefore lock the knife (Fig. 213). Even if the spring were to be forced away from the bevel by applying enormous pressure on the back of the open blade, the spring remains trapped in the lipped "pocket" of the blade created by the milling cutter. The spring can only be released, and the blade unlocked, if pressure is taken off the blade and the spring manually moved back over the lip.

For those who choose to use this option, I describe below the steps I use in my shop to make the fail-safe linerlock.

Important Note: Since I work all of my blades in the hardened state, I do not use a milling cutter to create the offset radius. Instead I use hollow, diamond core drills to grind the radius into the blade tang. All of the photographs depicting the milling setup, therefore show these core drills, but, if you are working the blade in the annealed state, a milling cutter can be substituted. Diamond core drills are commonly found where lapidary supplies are sold and seem to last forever (almost). See Sources.

First, it is important to understand that different blade thicknesses require different diameter cutters and different offsets. Trial and error have provided me with the following table of dimensions which I use (but do not hold sacred).

Different offsets may be suitable for special applications.

Blade Thickness	Cutter Diameter	Offset
5/32"	3/4"	.008"
1/8"	5/8"	.006"
3/32"	1/2"	.004"

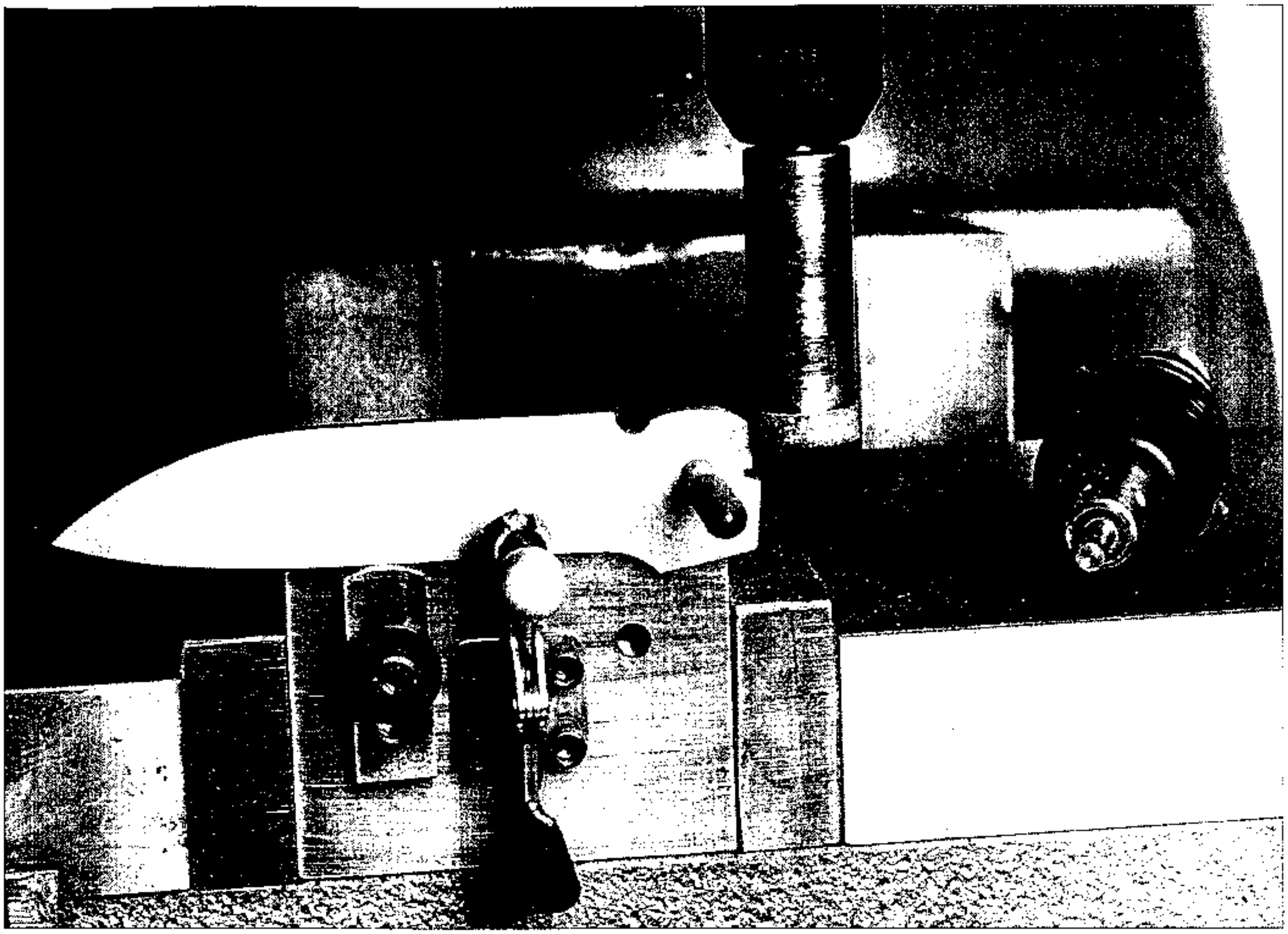


Fig. 215: Plunge cutting the bevel using a diamond core drill. For blades in the annealed state, a carbide milling cutter may be used.

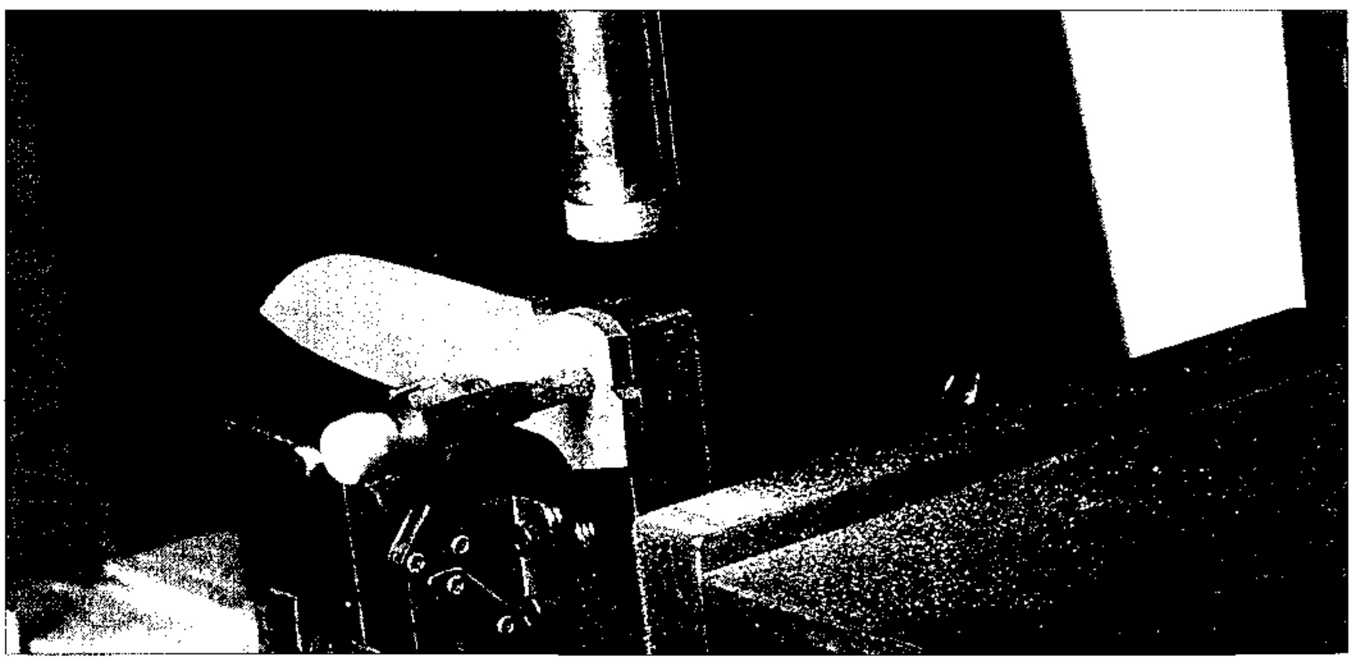
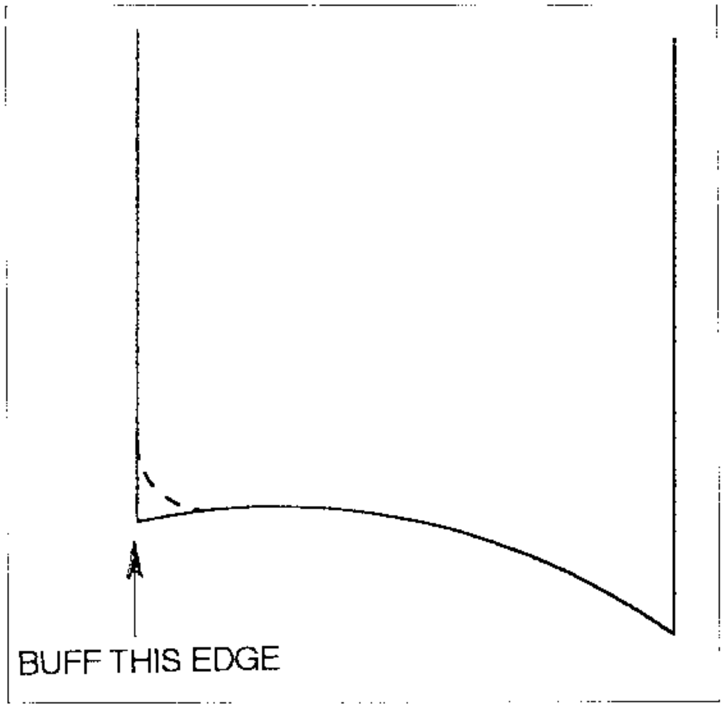


Fig. 216: The finished bevel.

Fig. 217: Lightly buff off the sharp leading edge of the blade's lock bevel.



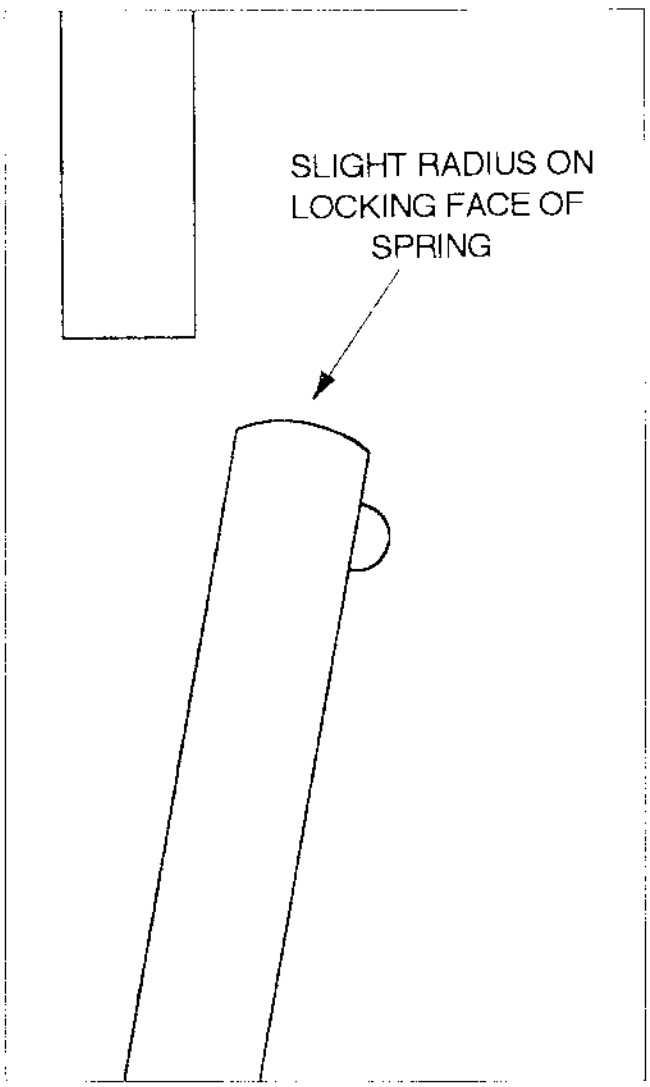


Fig. 218: A slight radius on the locking face of the spring seems to work best with the offset radius bevel.

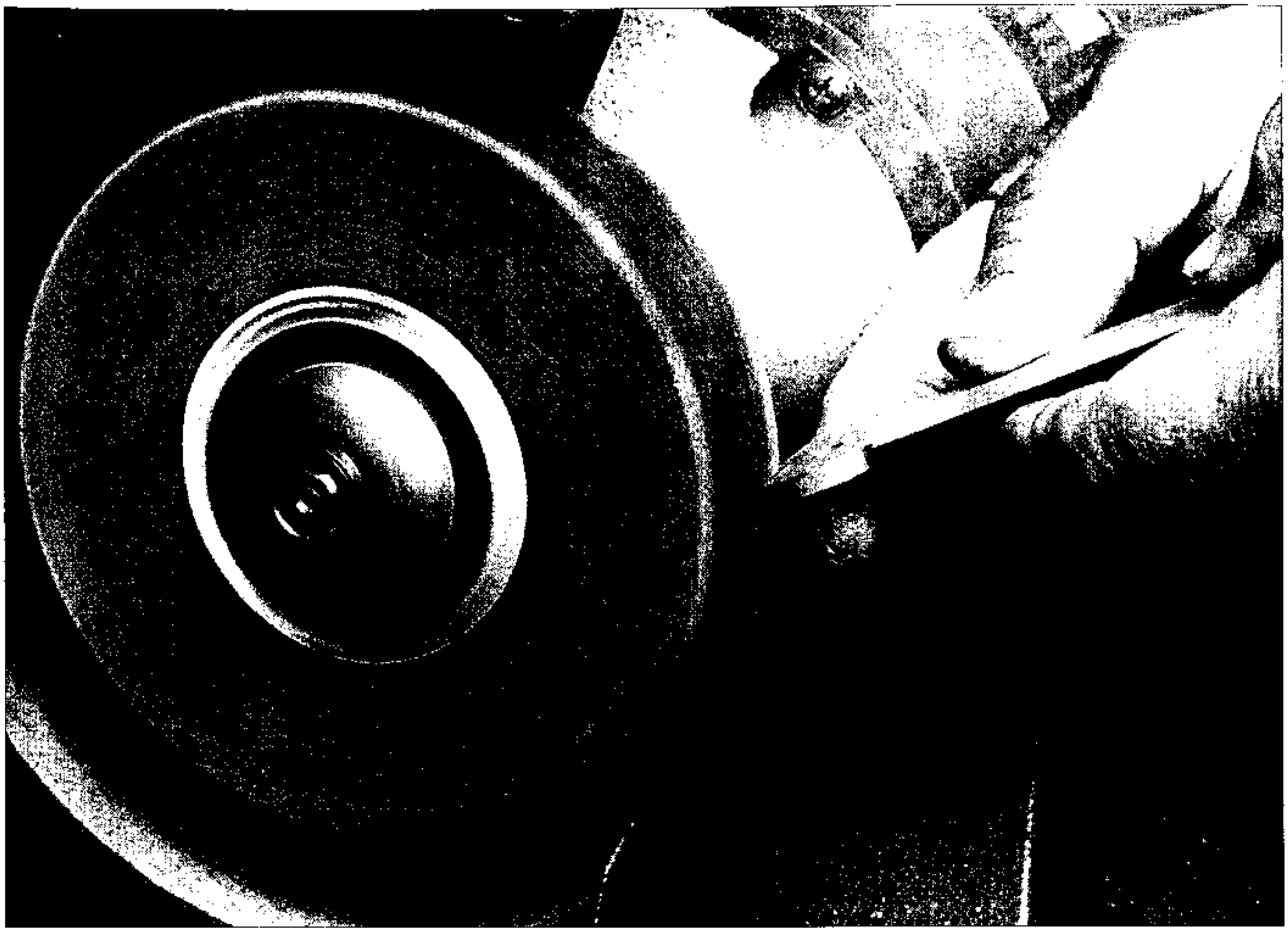


Fig. 219: Buffing the lock's edge with a fine Scotchbrite wheel.

Since I am describing the construction of my ATCF knife, the blade thickness is 5/32" and I am using a 3/4" cutter (core drill) and an .008" offset.

1. Set the blade in a holder which locks it in place securely in the milling vise and keeps the cutting edge uppermost and parallel to the table (perpendicular to the cutting tool.

I use a cast iron angle plate which registers the blades by their pivot holes, and an adjustable stop near the blade point to insure repeatability. The blade is then locked in place with a dedicated clamp. There are a matching pair of holes on the opposite edge of the plate (covered by the point end of the blade in the photo), which allow me to reverse a blade and grind a left-handed lock bevel.

2. Use an edge finder to align the precise center of the milling machine's spindle with the edge of the blade tang (Fig. 214). This edge will be the leading edge of the lock over which the spring must pass.

I have a lighted edge finder which is accurate and easy to use. When the probe touches the steel blade, it completes a circuit and a small, battery operated light turns on. Since the probe is precisely .200" in diameter, I then move the edge finder off the end of the tang and advance the cross slide along the "Y"axis exactly .100". The edge of the blade tang is now aligned with the exact center of the spindle (and therefore the center of the cutter).

3. Offset the cutter according to the notes above (in this case .008"), by continuing to advance the cross slide in the same direction along the "Y" axis as when aligning the edge and spindle center.

4. Advance the blade along the "X" axis until it just barely touches the cutter, raise the cutter out of the way and advance the blade a little more, about .010" - .020". Make a plunge cut down the back of the blade either with the milling cutter or, as shown, the diamond core drill (Fig. 215). Con-

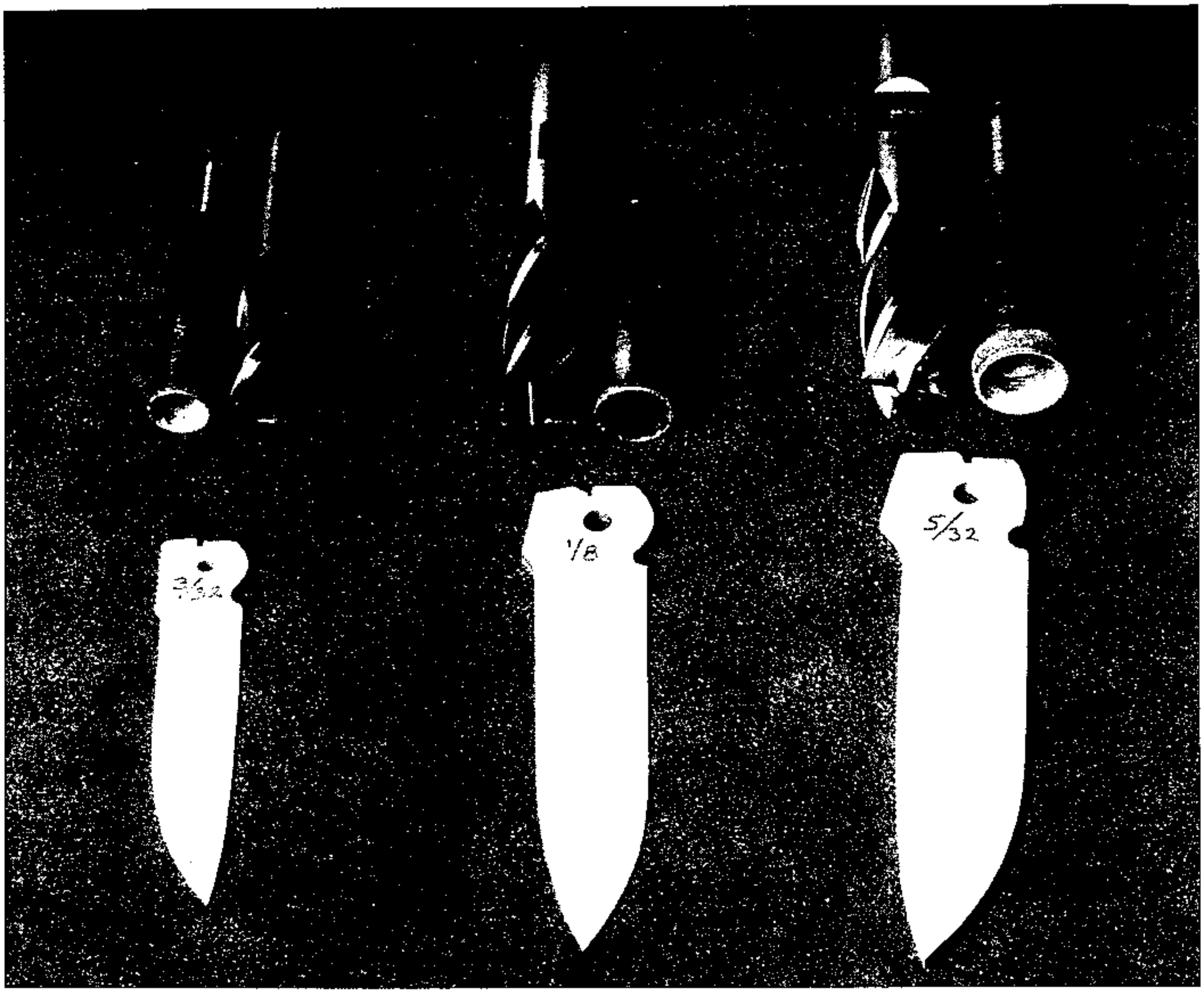


Fig. 220: The diameter of the cutter or core drill will vary according to the thickness of the blade as will the amount of offset used.

tinue advancing and plunging cutting until the lock bevel radius extends completely from one edge of the blade tang to the other (Fig. 216).

5. Remove the blade from the mill and buff off the leading sharp edge of the lock with a Scotch-brite wheel. This will allow the spring to pass more easily onto the lock bevel without being shaved down by the hardened steel blade (Figs. 217, 219).

6. The locking end of the spring may be configured in any of the shapes described in Chapter 4, but I have found that with the offset radius lock a slightly radiused spring face works best (Fig. 218).

Because this type of linerlock requires a milling machine and some specialized equipment, not all custom knife makers will opt for this solution. As I mentioned above, it is an improvement but not the only way to make a strong, safe linerlock.

SOURCES

I remember the days, living in Guatemala, when materials were very hard to come by. Even back in the States, in the early 1980s, one still had to do some searching for certain supplies. For example, the only place I could find titanium at a reasonable price was Boeing's scrap metal yard, and they don't ship the stuff! You have to go up there, to Kent, Washington, and pick it out yourself and then carry it back on the plane.

Today, things are different, thank goodness, and there is a plentiful supply of all materials including the ultra hi-tech stuff like CPM steel and carbon fiber laminates.

I have listed here some of the sources for materials that I use often and find them all to be honest and reliable. Many of these suppliers visit or display at knife shows around the country, where they sell their wares. This gives the knife maker a good opportunity to handle and select just the right material for the knife he wants to build.

There just isn't space enough to be comprehensive in this list but I think the following sources will pretty much cover all the bases. I have a file cabinet full of catalogs and brochures and I offer up here a selection from those files:

General Supplies:

Micarta, steels, handle materials, tools, machines, fasteners, abrasives, etc.

KNIFE & GUN FINISHING SUPPLIES P.O.BOX 458
LAKESIDE, AZ 85929
520 -537-8877 FAX: 520 -537-8066

KOVAL KNIVES
P.O.BOX 492
NEW ALBANY, OH 43054
614-855-0777 FAX: 614-855-0945

SHEFFIELD KNIFEMAKERS SUPPLY, INC.
P.O.BOX 741107
ORANGE CITY, FL 32774-1107
904-775-6453 FAX:904-774-5754

TEXAS KNIFEMAKERS SUPPLY
10649 HADDINGTON, SUITE 180
HOUSTON, TX 77043
713-461-8632 FAX:713-461-8221

Specialty Tools, Machines, Supplies:

BROWNELLS, INC.
200 S.FRONT ST.
MONTEZUMA, IA 50171
515-623-5401 FAX:515-623-3896

PARAGON INDUSTRIES (FURNACES)
2011 S.TOWN EAST BLVD.
MESQUITE, TX 75149
972-288 7557 FAX:972-222-0646

TIP TOOLS AND EQUIPMENT (SANDBLASTING)
P.O.BOX 649
CANFIELD, OH 44406
800 321-9260 FAX:330-533 2876

REACTIVE METALS STUDIO (TITANIUM ANODIZER)
P.O. BOX 890
CLARKDALE, AZ 86324
(800) 876-3434

MARKING METHODS (ELECTRO ETCH, STENCILS)
301 S. RAYMOND AVE
ALHAMBRA, CA 91803-1531
626 282-8823 FAX:626-576-7564

Steel

FRY STEEL COMPANY
P.O. BOX 3585
SANTA FE SPRINGS, CA 90670-1585
800 423-6651

Damascus Steel / Mokume

DEVIN THOMAS
P.O.BOX 568, PANACA, NV 89042
775-728 4363

MIKE NORRIS
35925 CITY LAKE DR
ALBEMARLE, NC 28001
704-982-8445

DARYL MEIER
75 FORGE RD.
CARBONDALE, IL 62901
618-549-3234

Grinders, Abrasives

STEPHEN BADER & CO.
P.O. BOX 297
VALLEY FALLS, NY 12185
518 753-4456 FAX:518-753 4962

TRU - GRIT, INC.
760 EAST FRANCIS #N
ONTARIO, CA 91761
909-923-4116 FAX: 909 923-4116

Heat Treating

PAUL BOS
2320 YUCCA HILL DR., ALPINE, CA 92001
619-445-4740

Handle Materials

CULPEPPER MOTHER OF PEARL CO.
P.O. BOX 445
FRANKLIN, NC 28744-0445
828-524-6842 FAX:828-369-7809

WILDWOODS
9808 MONCLOVA RD.
MONCLOVA, OH 43542
419-866-0435 FAX:419-867-0656

MASECRAFT SUPPLY CO.
P.O. BOX 423
MERIDEN, CT 06450
203-238-3049 FAX:203 238 2373

NATURAL PRODUCTS CO.
29 MAIN AVE
WALLINGTON, NJ 07057
973-773-5508 FAX: 973-773-4055

SANDY TUDOR (DESERT IRONWOOD)
BOX 92
VAIL AZ 85641
602-762-5745 FAX: 602-762-5745

Ivory, Mastodon

RICK FIELDS
26401 SANDWICH PL.
MT. PLYMOUTH, FL 32776
352 383 6270 FAX: 352-383-6270

ROLAND QUIMBY
P.O. BOX 350
ESTER, AK 99725
907-479-9335

Titanium

GEMINI METALS
1185 CALLE SUERTE
CAMARILLO, CA 93010
805-482-4670 FAX:805-987-6492

HALPERN TITANIUM (ALSO G10) AND CARBON FIBER
14 MAXWELL RD.
MONSON, MA 01057
888 283 8627 TEL / FAX

Laser Cutting

LYNNDALE STAINLESS
5302 W. MOHAVE
PHOENIX, AZ 85043
602-269-5070 FAX:602 269 9556

Water Jet Cutting

CUTTING EDGE MFG.
7498 EAST MONTECRISTO AVE. SUITE 102
SCOTTSDALE, AZ 85260
(480) 609-7233 FAX (480) 315-9713

SUGGESTED READING

Here are some other books that the reader may find useful in exploring different approaches to knives and knifemaking:

CUSTOM KNIFEMAKING: 10 PROJECTS FROM A MASTER CRAFTSMAN, BY TIM MCCREIGHT, STACKPOLE BOOKS

ED FOWLER'S KNIFE TALK: THE ART AND SCIENCE OF KNIFEMAKING, BY ED FOWLER, KRAUSE PUBLICATIONS

HOW TO MAKE FOLDING KNIVES, BY RON LAKE, FRANK CENTOFANTE AND WAYNE CLAY, KRAUSE PUBLICATIONS

HOW TO MAKE KNIVES, BY RICHARD BARNEY AND ROBERT LOVELESS, KRAUSE PUBLICATIONS

HOW TO MAKE MULTI-BLADE FOLDING KNIVES, BY TERRY DAVIS, KRAUSE PUBLICATIONS

KNIFE MAKING: A COMPLETE GUIDE TO CRAFTING KNIVES, HANDLES AND SHEATHS, BY BO BERGMAN AND HOLLY BOSWELL, LARK BOOKS

MAKING FOLDING KNIVES, BY HAROLD HOFFMAN, H&P PUBLISHING

SHARPENING AND KNIFE MAKING, BY JIM WATSON, SCHIFFER PUBLISHING LTD

THE COMPLETE BLADESMITH: FORGING YOUR WAY TO PERFECTION, BY JIM HRISOULAS, PALADIN PRESS

THE COMPLETE BOOK OF POCKETKNIFE REPAIR: A CUTLER'S MANUAL, BY BEN KELLEY, KRAUSE PUBLICATIONS

THE HAND-CRAFTED FOLDING KNIFE: MAKING A LOCKBACK KNIFE WITH SIMPLE HAND TOOLS, BY MARK MALMROS, TAMARAX PRESS

THE WONDER OF KNIFEMAKING, BY WAYNE GODDARD, KRAUSE PUBLICATIONS

ABOUT THE AUTHOR

Bob Terzuola is flanked by his two sons, Matthew (right) and Daniel in front of the workbench that put them through college. Bob has been making knives professionally since 1980. He started full-time in 1984 when he moved his family from Guatemala where he had worked as a government consultant on education and mass media research projects. During his last five years in Central America. Bob was the general manager and factotum of a jade carving factory where he honed his skills as a gem carver and developed many of the techniques he now uses in knife making.

Bob is best known, in the knife making world, for his functional and rugged defense knives, developed against the background of civil unrest in Central America, in cooperation with many professional soldiers and adventurers.

In the genre of tactical folding knives, Bob is responsible for many innovations in design and use of materials which uniquely qualifies him as a respected name in the field.

PHOTOGRAPHERS

Tony Vinella (right) has earned a world-class reputation for his commercial and art photography over many years. His work is frequently on display in galleries throughout the United States and often seen in magazines and trade publications. Jody Blagden, a professional photographer in his own right, assisted in the photo shoots and helped create the composition and lighting.