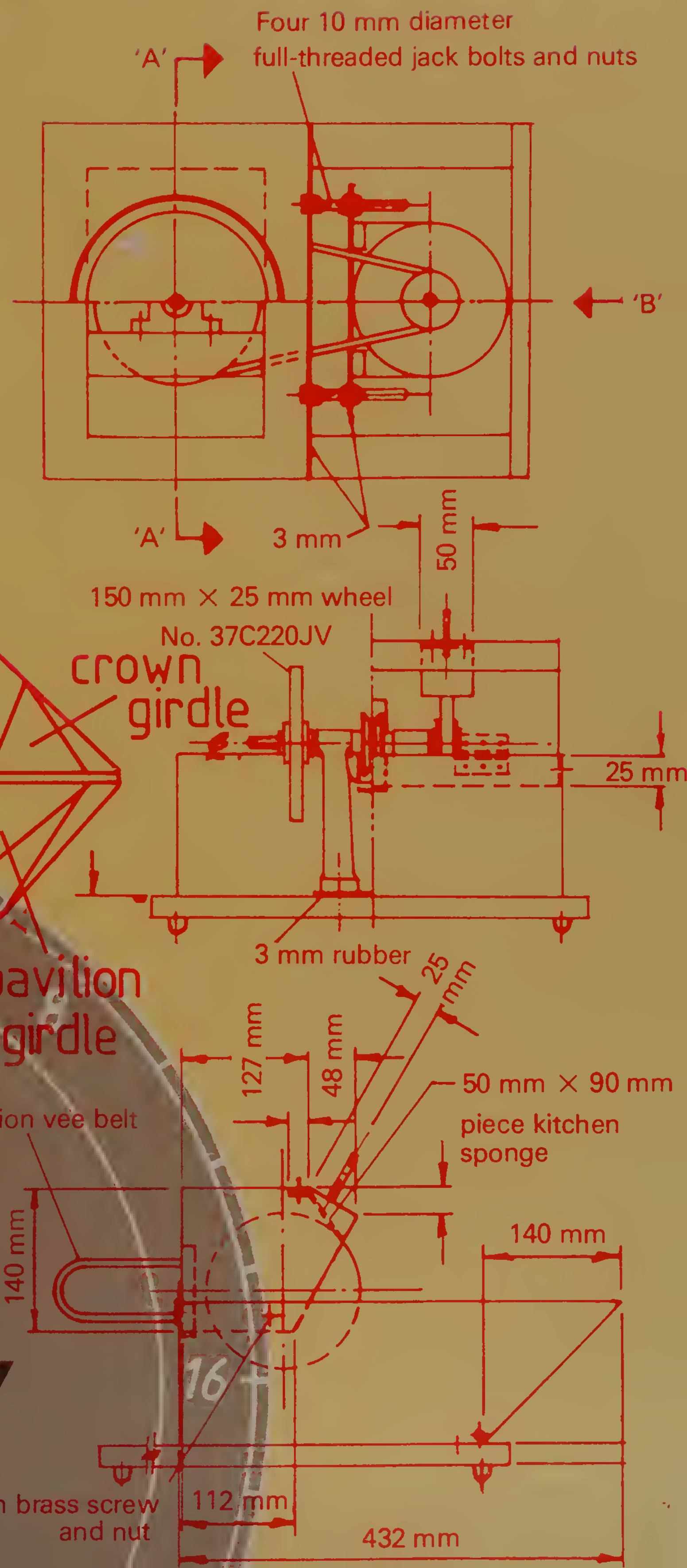
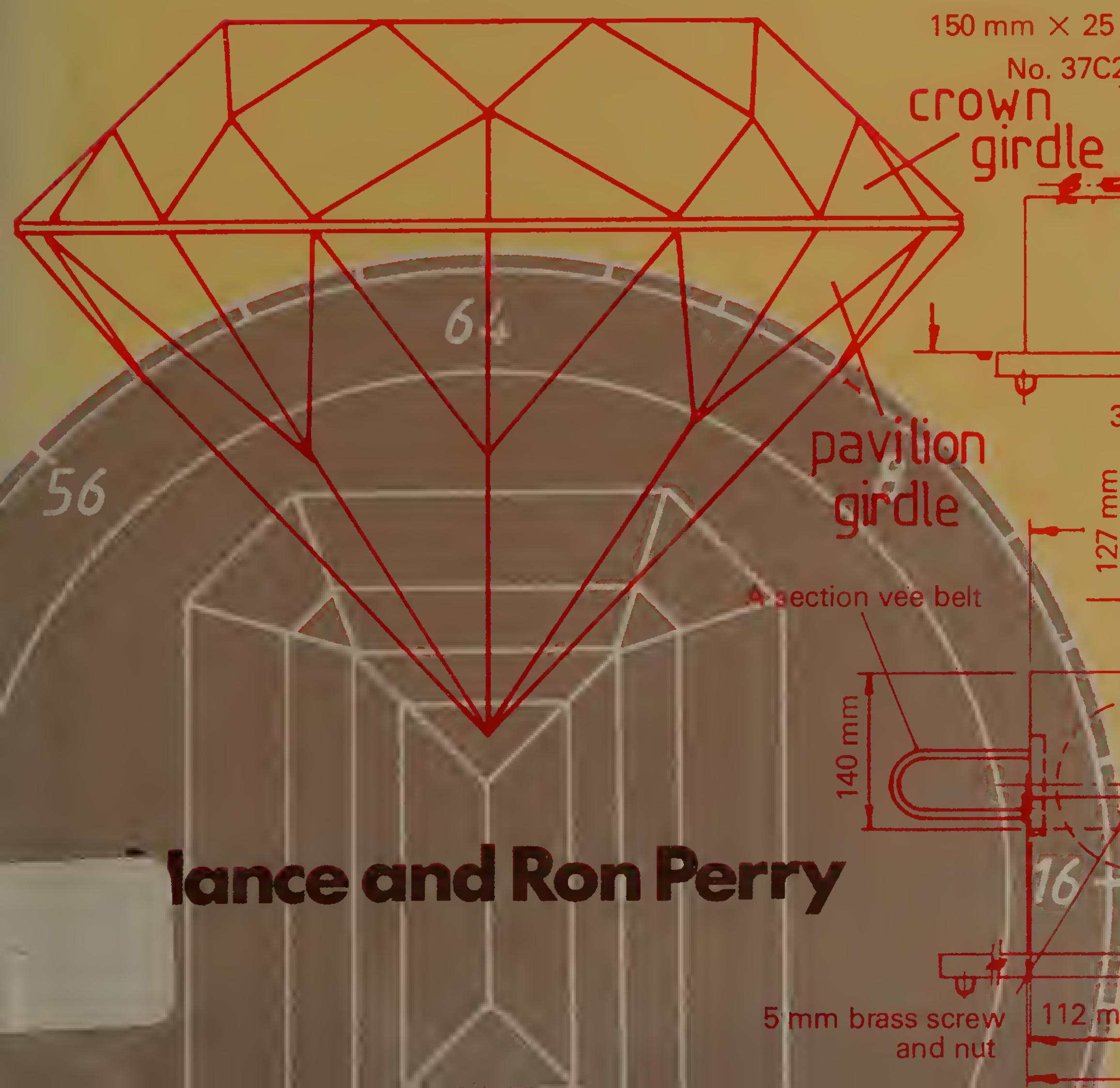
# PRACTICAL GEMCUTTING

## A guide to shaping and polishing gemstones




lance and Ron Perry

$11.95

PRACTICAL GEMCUTTING

Nance and Ron Perry

This authoritative and comprehensive guide by two widely-experienced gemmologists allows you to share in the techniques and skills they have acquired over many years of practical and professional gemcutting.
The authors use straightforward language to take you through the basic tools, equipment and techniques of gemcutting to the advanced treatment and processing of stones. In particular, they explain clearly how to use both the simple and complex machinery that is manufactured today for the use of the lapidary, as well as provide instructions on how to build some of your own workshop equipment.
Included you will find:

- detailed basics of abrasives and polishes, which allow you to understand not only *what* to use for special purposes but *why* it is used.
- information on the use of tumbling machines, and advice on their purchase to suit different needs
- a practical guide to the essential skill of dopping
- instructions on cutting and polishing gems by hand
- explanations of special techniques, including a detailed treatment of cutting and polishing opals
- guidance on how to facet a standard round brilliant
- suggestions for gemstone carving and beadmaking

In drawing on their wealth of time-tested experience, the authors provide something new for everyone, whether hobbyist or practising professional.

*Printed in Singapore*

**Arco Publishing, Inc.**
**New York**

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**A guide to shaping and polishing gemstones**

NANCE and RON PERRY

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**New York**

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# CONTENTS

# INTRODUCTION

The ever-popular hobby of gemcutting continues to flourish and grow as it approaches the end of a half-century of existence. Young and old alike are attracted by its fascinating image, the young because of its 'down-to-earth' fact-finding nature and the older person because it offers an answer to the search for a rewarding interest which can be shared by all members of the family. This does not take into account the financially self-supporting nature of the hobby which can be realised with a little application and practice.

Gemcutting and polishing is a very ancient craft, the basics of which were probably those practised by the citizens of France in 11 000 BC who occupied or visited the Laugerie-Basses Cave, Les Eylies, Dordogne. While their scratched outlines on reindeer antler would not strictly be called gemcutting, the urge of humans to shape things about them as records or into ornaments is shown through their efforts to have emerged very early in man's history. This primitive urge still persists and will continue to do so while man is compelled to investigate the limitless wonders of nature.

Many people of more mature age take up gemcutting in their retirement years and the satisfaction gained from their new-found, all-absorbing hobby, with its wealth of communication with others sharing the same interests, invariably evokes the same regretful response, 'Why haven't I heard of this before'.

This book is offered to the lapidary and those interested in gems in the hope that it will solve at least one problem for some, encourage others to try their hand at the art and stimulate and inspire all to greater heights of endeavour.

# Abrasives and Polishes

GEMSTONE CUTTING requires an ability to wear away or abrade unwanted parts or areas of a stone to produce a particular shape. An agent which is harder than the gemstone is required to do this work and such agents are known as abrasives.

There are four abrasives of significance to the lapidary: diamond, silicon carbide, aluminium oxide and pumice. They are available in grain or grit form as well as in manufactured shapes. The shapes include wheels, laps, cups, points, saws, sticks, drills, wheel dressers and special-purpose tools.

*Diamond*

Diamond as powder is the premier abrasive used by the lapidary. It is produced from boart, inferior-grade rough diamond and broken pieces from manufacturing processes, industrial diamond, diamond recovered from worn-out tools and man-made diamond, using ball and hammer mills. The man-made material may be controlled during manufacture, to a certain degree, as to particle size, shape and crystal character, which is of advantage in some applications.

*Diamond powder sizes*

Powder size control is maintained by manufacturers within very close internationally set limits. Undersize or oversize particles in a batch of nominated grade can cause a great variation in the speed and final excellence of finish in cutting and polishing.

Coarser sizes, termed sieve sizes, are passed through sieves which have from sixteen to 400 holes and wires to 2.5 cm, while finer ones are graded by floating the powder in air or water, in a process called 'elutriation'. They are known as micron grades. For example, the sieve size powder 16/18 contains particles which are between those two sieve sizes and contains 100 particles to the metric carat, while the finest of the sieve sizes 350/400 has 1 300 000 to the metric carat. Micron grade powder, on the other hand, is described by quoting in microns (1 micron = 0.001 mm) the average diameter of a hole through which a particle would pass, as its grade. These sizes vary from 40/60 as the coarsest to 0/½ as the finest. There are many grades inbetween which are international standards but manufacturers adjust these to suit their customers' requirements.

In the past, descriptions of diamond-powder sizes and grades have been given as sieve sizes only and this has been confusing for some, but now international producers have rationalised all systems by supplying powder to packers in micron sizes. A scale showing old sizes compared with micron grades follows. This cannot by fully comprehensive but those sizes of interest to the lapidary are shown.

| Sieve size | | Micron grade | Sieve size | | Micron grade |
|---|---|---|---|---|---|
| 400-600 | = | 20-40 | to 8000 | = | 2-4 |
| 600-1000 | = | 8-25 | to 14 000 | = | 0-2 |
| 1000-1600 | = | 6-12 | to 50 000 | = | 0-1 |
| 1600-2800 | = | 4-8 | to 100 000 | = | 0-½ |

*Diamond powder uses*

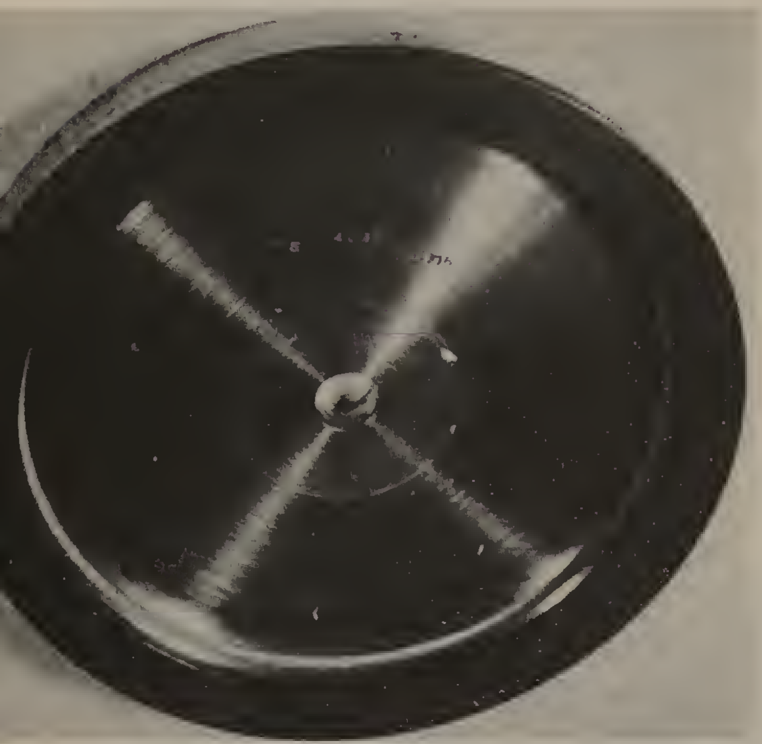
The larger sizes are used in rough grinding and preforming processes. They vary between 100/120 sieve size (coarsest) and 300/400 (finest). Fine grinding and prepolishing makes use of micron grades 8/25 (coarse and fast) down to 4/8 (finer and slower). Polishing grades are all in the micron grade range but are subject to personal preference for any particular choice. Micron grade ½/3 is an excellent, fast polishing powder for all work. It is useful for 'polishing in' small facets without grinding or prepolishing. A medium-speed fine polish is 0/2, while 0/1 and 0/½ are both very fine polish grades, the latter being used as a super-fine second polish stage with large stones.

The above grades are all suitable for cabochon and star stone-cutting and polishing, particularly for the harder varieties. They are applied in compound form (see later in this Chapter) by means of grooved laps, wheels and cups of metal, plastic or wood. The medium of the compound in which the diamond is incorporated for this work serves to lubricate, cool and restrict undue movement and possible loss of the diamond at work.

*Diamond compound*

This useful formulation of diamond powder consists of definite grades of diamond mixed with a medium, each in prescribed proportions by weight. The compound is sometimes colour-coded. The lapidary may mix his own using petroleum jelly (Vaseline) as a medium (see the section on lap hand charging in Chapter 9).

Diamond compound is packed in hypodermic-syringe-type dispensers which make accurate placement a simple operation. Waste is eliminated and there is very little possibility of contamination of one grade by another. Coarser grades cost more than finer ones due to their higher weight of diamond content.



**A sintered metal bond diamond cup wheel or lap. This type of unit is suitable for all lapidary purposes, particularly faceting. The diamond impregnation is in the outer raised rim and is 15 mm wide by 2 mm thick. Well maintained, such a lap will give long and consistent wear.**

*Diamond powder in tools*

Diamond is a very versatile material. It consists of crystallised elemental carbon but may be heated, soldered, coated and bonded and sintered. It lends itself admirably to the manufacture of tools which include laps, wheels, drills, dressers, files, saws and points. This is accomplished by sintering, moulding, electroplating, electroforming and impregnating. Sintered tools encountered in lapidary work are made by mixing an amount of the correct grade of diamond powder with a suitable amount of a special metal powder mix. The mixture is pressed into the required shape, either as a separate piece or in position on the tool base, after which it is heated to the point where the metal powder just fuses, bonding the tool base and diamond into a single solid entity. A final dressing to shape and tensioning if needed completes the job. Special bonds other than metal are sometimes used and these include plastics, plastic/metal powder and vitreous clay bonds.

Diamond may be bonded to the surface of saws, laps, drills and wheels by electroplating, and solid burrs etc. are built up by electroforming while soft metal laps and saw blades are hand-impregnated.

*Concentration*

Tools manufactured from diamond powder carry a description on them stating the amount of diamond contained as a percentage. The reference 100% level contains 4.4 carats of diamond per cubic centimetre of diamond-containing body. The average sintered rim lapidary saw blade, for instance, would show a diamond concentration of between 50% and 25%.

*Use of diamond tools*

All tools containing diamond must be used under conditions dictated by their make-up and physical character. These conditions must be known and understood by their user to the point of instinct, if they are to prefrom efficiently and have a long life expectancy. The conditions are:

1. Diamond tools must be kept cool in use. Any cooling medium may be used: water, oil, water/soluble oil, kerosene, kerosene/oil, kerosene/dieselene or compressed air. All provide the necessary heat-reduction function. Excessive heat will eventually destroy any diamond tool.
2. Grinding, and working in general, must be carried out across the full active face of a tool. Destructive and wasteful grooving or uneven wear will result from the neglect of this point (see the section on safety, care and maintenance in Chapter 14).
3. Machine shafts on which diamond tools are mounted must run accurately and true within close limits (0.05 mm maximum runout). Shaft overhang outside the bearings must be kept to a minimum.
4. Small tools, eg. burrs, small saws etc., must not be expected to perform tasks outside their design capacity. Attention must be paid to the correct surface speed of the tool (see section on lapidary cutting blades in Chapter 3).

*Silicon carbide*

This abrasive was developed in 1891 and is, by comparison, a very pure material of high hardness (9½) manufactured from silica sand, coke, sawdust and salt under controlled conditions. There are two grades, both of which are available in many grit sizes. The green variety is used mainly in metal-working while the black is the mainstay of the gemcutting workshop. Wheels and other shapes are manufacturered from grain mixed with a bond, which in lapidary-type wheels is a clay material. The mixture is pressed to shape and heated to fuse the bond and grain into a whole which is known as a vitrified product. The wheel or whatever is dressed to size and tested before becoming available for sale. Rubber, shellac and various plastics are also used as special-purpose bonds.

*Coated abrasives*

Silicon carbide is attached to the surface of paper and cloth, often by methods which render it suitable for use 'wet or dry'. This familiar type of abrasive form is eminently suitable to lapidary work. Belts, discs, sheets and strips for hand or machine use are cut from such coated abrasives and give the lapidary sterling service when combined with pads, inflatable wheels and laps.

*Aluminium oxide*

Aluminium oxide abrasive grain is produced by the combining of bauxite, coke and iron at high temperatures. Vitrified wheels made from this material are not often found as regular lapidary equipment but are very useful for carving and shaping, especially the softer stones.

Superfine-grade aluminium oxide is the component of some stone polish powders. A very specialised fine-grade Linde A, named for its manufacturer, is much favoured by lapidaries as a polish on its own or in combination with other agents for certain less easy-to-polish stones.

*Pumice powder*

Pumice is a natural product of volcanic origin which has a high silica content. It is milled to produce grades of powder which are very useful in lapidary work. Cab cutters use it in a slurry with water on felt or other wheels for prepolishing. Tumbling makes use of it as a prepolish agent, but its use in the treatment of stones which undercut should be avoided (see section on dopping and cab cutting in Chapter 7).

*Polishes*

The polish on a stone's surface comes about when that surface fuses to a glass-like polish under the influence of localised heat. This is a molecular fusion and the surface freezes instantly with crystal reconstitution upon the removal of the heating influence. Various polishing media are used in combination with wheels and buffs to obtain this necessary condition and a description of them follows.

*Diamond* This polish has been described above.

*Tin oxide or 'putty powder'*

Tin oxide is probably the most familiar and most used of all of the polishes. It may be combined with all or any of the others, including diamond, and is suitable for the majority of stones polished by lapidaries. The addition of tiny quantities of oxalic acid to it for calcite varieties and hydrochloric acid for peridot makes the polishing of these otherwise difficult materials most satisfying.

*Tripoli powder*

Tripoli is the result of the weathering of chert deposits and is approximately 98% silicon dioxide — the material of silica sand. It is extremely fine in grain size, so much so, that it is graded by elutriation, an air-floating process. Tripoli has been used extensively for metal polishing and many lapidary polishes contain some proportion of it. Before accurately-sized diamond-polishing powders became generally available, tripoli was the principle polish for sapphire and hard stones and is still used for that purpose in some shops.

It is used as a slurry mixed with water on laps and buffs.

*Cerium oxide (ceripol, cerium)*

This popular polish is a combination of rare earth oxides, the major one of which is cerium. It is derived from the beach sand minerals mined on Australia's east and west coasts. It is used in slurry with water form or from a suspension in water/methylated spirits, 50:50, and on leather for opal and other stones. It also finds an application in faceting.

*Rouge*

Rouge is an oxide of iron, hematite, the powder of which is blood red, hence the name. It has been the traditional polish for gold for many years, and while opal cutters use it, the general run of lapidaries do not know its efficiency as a stone polish.

*Green chrome oxide*

This beautiful green-coloured powder is a fine polish for gemstone and despite its rather unattractive staining character (which can be offset to a large degree by the wearing of rubber gloves) it is excellent for polishing involved surfaces as well as regular formal shapes. Carvers are often the most dedicated users. It has tremendous penetrating and staining powers and will mark faces, hands and floorcoverings, indeed, all it comes in contact with, but should be tried by every lapidary at least once.

# Grinding Wheels and Grinders

GRINDING WHEELS are available in many shapes and sizes but all contain abrasive grains which may be fixed or expendable.

*Diamond wheels*

These wheels are of the fixed-grain type and have the abrasive embedded in metal, plastic or other bond. Metal-bonded wheels and laps are very popular with gemcutters as they show little wear and thus have a very long life. The other bonds provide very good special-purpose tools such as plastic for girdle polishing laps as used with hard stones. Grit sizes used in wheels and laps are the same as those of the diamond powders (speeds for diamond wheels are discussed under the section on blades, machines and sawing practice in Chapter 3).

*Silicon carbide wheels*

Silicon carbide abrasive wheels are of the expendable type. The abrasive grains are fixed in the wheel by the bond fused to them and, as they become blunted in use, they drop away and are replaced by the new ones thus exposed. Movement of the work across the full face of the wheel is therefore most necessary to maintain an even working wheel face.

A grinding wheel must be the correct one for the job in hand. Two main items govern the work capability of any wheel: grit size and hardness of bond. The grit size recommended for lapidary work varies between 100, wheel identification 37C100MKV, and 320, 37C320KV. A good all-purpose combination for the home lapidary is the first mentioned with a second, 37C240KV, as a fine grinder. These two could well be mounted on a common shaft as in a double combination machine of the type mentioned below.

The 'V' at the end of the number indicates a vitrified wheel while the 'K' shows the hardness.

*Speed*

The design speed of a wheel is that speed at which it is most efficient. At no time should a wheel be run at a speed in excess of the maximum noted on the side blotters fixed to it. Higher speeds cause a wheel to behave as one of a higher hardness while under speed, such as comes about with one which is reduced in diameter by wear, gives the reversc.

*Wheel size*

The lapidary who handles stones of all shapes, sizes and hardness should endeavour to use a wheel with as large a face as possible. An ideal would be one with a diameter of 200 mm and a face width of 38 mm; but smaller wheels, such as the 150 mm x 25 mm that are fitted to smaller combination machines are capable of every bit as good a job as the larger ones.

*Handling*

Wheels of the vitrified kind are used wet in stone grinding and must always be regarded as being as fragile as glass. A bump or drop can cause them to break, or, what is potentially more dangerous, crack. Before mounting any new or old wheel on a machine it must be suspended by the arbor hole and tapped on one side with a solid piece of wood, as a test for soundness. If a ringing sound is not forthcoming, the wheel is suspect and should not be used. A dull thud indicates a cracked wheel. It should be consigned to the box destined for breaking up and use in the tumbler.

Under no circumstances whatever must a shaft be packed up to fit the arbor hole of a wheel except by the use of proper bushes. Disaster, preceded by great vibration, is the inevitable result of such an action. Bushes are available from the supplier in all sizes at very nominal cost.

*Flanges*

Always use correct, hollow-section flanges when mounting wheels. Flat washers can, and probably will, dish in use, placing undue and improper stresses on the wheel, and this could cause it to fail.

Correct blotters must be fitted between the flanges and the wheel sides to provide even pressure from the clamping nut which must not be overtightened.

*Grinding*

The particles of abrasive which comprise a wheel, abrade the surface of the work by a chipping action rather than a cutting one. This process must be allowed to proceed according to the design of the wheel. Undue pressure applied to the work will 'crowd' the wheel and cause removed particles to jam in the interstices of the wheel face which will, in turn, impair the further removal of material. The only remedy for this 'glazing' of the wheel face is for the whole face to be cleaned by dressing (see the section on safety, care and maintenance).

*Wet wheels*

Stone grinding is carried out in a wet state. The application of water to absorbent wheels, such as those of silicon carbide, requires two very important rules to be observed:

1. The *machine* must be switched on before the water is applied.
2. The *water* must be turned off before the machine is switched off.

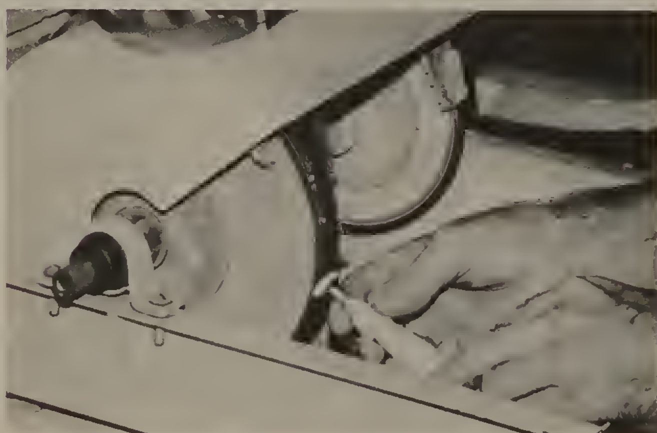
The smooth, vibrationless rotation of a grinding wheel is entirely dependent on it being perfectly balanced, but if the water is left running after the machine comes to a standstill, the lower half of the grinding wheel will become saturated. When the machine is again switched on, the by now, very unbalanced wheel could disintegrate or the machine spindle be put out of line. It is a very good procedure to allow the machine to run for a minute or so after the water is shut off to fully dry the wheel, before finally switching off.

*Grinding machines*

Wet grinding machines come in many configurations and sizes: simple single-place assemblies which are suitable for a saw blade, grinding wheels, sanding disc(s) and then prepolish and polishing discs to be fitted consecutively, two-wheel types with or without provision for the attachment of sanding, polishing and in some instances sawing facilities, and the horizontal and inclined all-purpose machines — all these have dedicated users. Some even have provision for other attachments such as facet heads or vibrating laps. The combination machines are very suitable for the family with lapidary and cutting interests as they are self-contained and portable, ideal to carry on safari in the wagon or caravan.

Many 'do-it-yourself' lapidaries assemble or construct their own equipment and for those so inclined, plans for four basic machines are included (see Appendix II).


**A horizontal-type 'gemmaker' all-purpose machine. The swinging arm fitted to the post on the side of the bowl is the holding device for sawing with a diamond blade on the vertical spindle. Attachments are supplied by the manufacturer which convert the base unit into a very good faceting machine.**



**A two-place wet grinder fitted with a 38-mm-face silicon carbide and a 15-mm-face metal-bonded diamond wheel. This setup is used for the treatment of opal.**

# Lapidary Cutting Blades and Sawing Machines

## Lapidary Cutting Blades

THERE ARE many types and sizes of blades for sawing gemstone. An early form which was used by the ancient Chinese to cut jade was the wire saw. This primitive implement consisted of a twisted strand of two wires tensioned in a hand-held frame and was used in the same manner as a wood saw, with the exception that a mud of abrasive and water was applied to the wire as it moved back and forth. A modern evolution from this prototype is the diamond wire saw. It is often incorporated as the active member of special band saw machines used in the lapidary workshop for cutting inlays and other irregular shapes.

An extension of the wire saw concept is the mud saw. It consists of a sheet of iron or other metal of circular or rectangular shape mounted so that it may be rotated or oscillated against the workpiece while a slurry of abrasive is fed to the cutting edge. Great improvements in the construction of the mud saw now make it suitable for the reduction of large masses of stone in the field as well as in the workshop. In its most sophisticated form it consists of the same rectangular-shaped metal base but with diamond containing segments fixed into the cutting edge. A big commerical demand for sawn stone cladding for architectural purposes had prompted great advancement in the design of such saws.

*Diamond cut-off blades*

Circular diamond cut-off wheels, familiarly referred to as diamond saws, are produced in three main forms, the first of which is the notched rim. It is made by forming 2-mm-deep slots around the periphery of a special steel blank into which a mixture of diamond and metal matrix powder is forced under great pressure. The filled slots and the adjacent edge of the blank are then heated to the point where the metal powder fuses to the blank and the diamond-powder particles, producing a solid single unit.

An edge rolling process is then applied which forms the perimeter into a 'T' cross-section. This shape is a feature of all diamond blades and is necessary to allow the blade edge, which is actually a very thin grinding wheel, to grind a slot in the material which will provide free passage to the body of the saw. The blade is then dressed to size and tensioned before packaging.

The notched-rim blade cuts at a moderate speed, is reasonably quiet in operation, has a fairly long life expectancy and provides an excellent, low-cost means for breaking down large pieces of rough.

*The segmental blade*

This type of blade has the same special steel blank as a base that the previous blade has but the diamond is inserted in metal matrix diamond block segments into machined spaces around its edge. The gaps between these blocks act as clearing slots and allow the cooling fluid to circulate to maximum effect. Some segmental blades have deep gullets cut into the blade body between the segments. Such blades are used for cutting softer stones and concrete.

The segmental blade contains more diamond for its diameter than the notched rim and so is higher in first cost; however its superior speed and longer life, used under the same conditions, more than compensate.

The ruggedness of the segmental blade makes it very suitable for use in situations where more than one person has access to the saw table, e.g. in schools, clubs, etc.

*The sintered, continuous rim blade*

The sintered blade is produced by fusing a highly compressed ring of diamond and metal powder matrix to and over a shaped sawblank edge with local heat, after which the whole blade is dressed and tensioned. Sintered blades have an advantage over the discontinuous types inasmuch as the cutting edge is a continuous piece, all of which is abrasive. There can be, depending on diamond concentration, (see the section on abrasives and polishes in Chapter 1), as much as nine times as much diamond in a sintered blade as in a notched rim the same size.

It is most necessary to consider the continuous nature of the cutting edge, which consists of metal matrix powder, when replacing a blade of the notched-rim type with a sintered one. The matrix is very much softer than the exposed steel

**The edge of the notched-rim diamond saw blade.**

**A segmental diamond saw blade. This particular blade has deep gullets to aid clearance of debris. It is used on a machine cutting soft materials.**


**A section of a small (150-mm) diameter segmental blade. The diamond-impregnated metal segments can be clearly seen.**

of the notched-rim blank perimeter. This steel edge requires a much higher pressure of feed to successfully grind into the stone than does a sintered edge, and so the feed mechanism must be adjusted to reduce it for the new blade.

The sintered blade is higher again in cost, and again, because of its high diamond content, has a longer life expectancy than either of the other two types. It is ideal for sawing expensive materials because of its ability for production in very thin blades.

*Ultra-thin blades*

Until a few years ago, the cost of very thin diamond blades was very high. Technological advances have now made it possible to manufacture relatively low-cost blades as thin as 0.1 mm. Their life is longer than would be expected and their performance is all that could be required. Edge thicknesses of 0.2 mm and 0.4 mm in diameters of 100 mm and 150 mm are ideal for the faceter and opal cutter. The 0.1 mm edge is also very good for very expensive materials but must be used with great care in the interests of one's fingers.

*Saw-blade thickness*

Confusion is sometimes generated by the measurements given as diamond blade specifications. A notched-rim or segmental blade with stated dimensions of 25.4 cm x 0.102 cm would have a body thickness of 0.102 cm and the edge would be considerably more as would the kerf cut in the stone.

On the other hand, a continuous rim blade with those given dimensions would have an edge thickness precisely as stated. The economy of material removed should therefore be taken into account when deciding on a certain blade. The continuous blade is about one-third more economic of stone ground away than the other two types.


**One of the ultra-thin continuous-rim diamond saw blades which is 100 mm in diameter and 0.2 mm thick. This particular blade is very good for opal cutting or faceting.**

*Speed*

Saw-blade efficiency depends on maintenance of design speed for the particular blade. This in turn depends on two main factors: power and rate of feed. Sufficient power must always be available to maintain an edge speed which produces the ideal grinding (cutting) rate. Any drop in speed when loaded should be minimal. An oversupply of power is preferable for that reason.

The surface or peripheral speed of a blade is expressed as linear distance travelled by a point on the edge of the blade in metres in one second, surface metres per second (smps). Harder materials must have lower speeds, e.g. agate, 25-30 smps, while softer ones have up to five times that speed, e.g. aragonite, 120-135 smps.

It is wise to provide speeds to suit the harder materials which are handled and saw the softer ones with care and attention to prevent jamming of the blade in the kerf.

*Calculation of the ideal speed for diamond-blade machine spindles*

The formula and calculation below is given for a 150 mm-blade cutting stone of hardness 7 and above.

$$\text{Spindle speed (rmp)} = \frac{\text{surface speed (smps)} \times 60}{\text{blade diameter in metres} \times 3.142} = \frac{25 \times 60}{0.150 \times 3.142} = 3183 \text{ (say, 3200 rpm)}$$

An electric motor with a speed of 1425 rpm would need a pulley fitted of 113 mm in diameter driving a saw pulley of 50 mm in diameter to attain this speed.

The corresponding figures for a blade of 100 mm diameter using the same 50 mm saw machine pulley would be 4774 rpm obtainable with a motor pulley 168 mm in diameter. Latitude on the higher speed side is desirable to allow a drop in speed under load.

*Cooling and lubricating*

To conform with the conditions of operation for diamond tools already set out under abrasives, all blades must be operated with a copious supply of coolant/lubricant at all times. Rapid destruction overtakes the dry blade (see section on sawing machines in this chapter).

*Care of blades*

Saw blades must be handled with care both on and off the machine. Bumps and drops could cause damage which could be terminal or at least require the attention of a saw doctor. Blades are designed to cut in straight lines and all equipment should be maintained to provide for this requirement. Hand cutting must observe the same rule.

Blades not in use should not be stored flat where damage could be done by other heavy items placed on them. Original sleeves or boxes should be retained for blade storage and should be placed in a vertical attitude with the blade oiled before insertion to avoid rust.

## Sawing Machines

Saw machines which are designed for mounting of diamond blades must incorporate certain features to ensure the best finish on cut faces, least loss of material as remainders, longest life of expensive blades and least risk of damage to work in progress or injury to the operator.

*Stability*

Solid stability is the keyword with all saw machines. Bearings and their supports must be robust while they should be sealed against the ingress of coolant and grits. The spindles must be solid and of sufficient size and equipped with slingers to prevent travel of coolant into bearings. End play of these spindles should be minimal, vibration nil and 'whip', due to spindle overhang outside bearings, reduced to a safe state.

*Flanges*

A diamond blade can be rapidly ruined by side flexing or stressing outside its plane. To prevent such possible distortions, hollow section stiffening flanges must be accurately fitted to the shaft, preferably the inner one fixed to and machined with it, to clamp the sides of the blade. Flanges should also be of a diameter which complies with blade manufacturers' specifications. In most cases this states that the flange diameter shall be at least one-third blade diameter, but in lapidary practice where commercial pressures do not require high volume production from a machine, this is often reduced to one-quarter. An exception to this rule is the ultra-thin blade where at least three-quarters of the blade diameter must be considered essential. Suitable flanges are often supplied by the manufacturer as part of the purchase price. 'Flutter', where the blade's edge oscillates out of the plane of the blade, will develop without such flanges. This will rapidly destroy a diamond edge.

*Saw tables*

All saw machines are not fitted with a supporting table. Trim and trim/slab saws of the smaller types may have a table and base cast as one piece, with a coolant tank or a vice support slide and tank only. Opal saws are often nothing but a spindle supported in cone bearings. This carries an ultra-thin blade and is belt driven. Coolant is applied directly to the blade edge and is caught in an open tank underneath. Work is hand-held. Considerable skill is required to manipulate such saws.

Slide bar saws are often supplied with an auxiliary table which may be screwed to the bars for trimming operations.

Saw blade spindles may be set above or below the table level. Some tables are fixed while others are designed so the table with the clamped stone moves past the cutting edge.

Provision of a table will reduce the thickness of stone which can be cut with a blade.

*Trim/slab saws*

Stone-cutting saw machines are probably the most varied in design of all sawing devices. The most common is the bench mounting pattern known as the trim/slab saw. Blades may be fitted from 100 mm — 300 mm in diameter. Great strides in improvement of design have occurred since the basic pattern was borrowed from the wood saw. They are moderate in cost and there is some pattern to suit all gemcutters which will last well and handle most work.

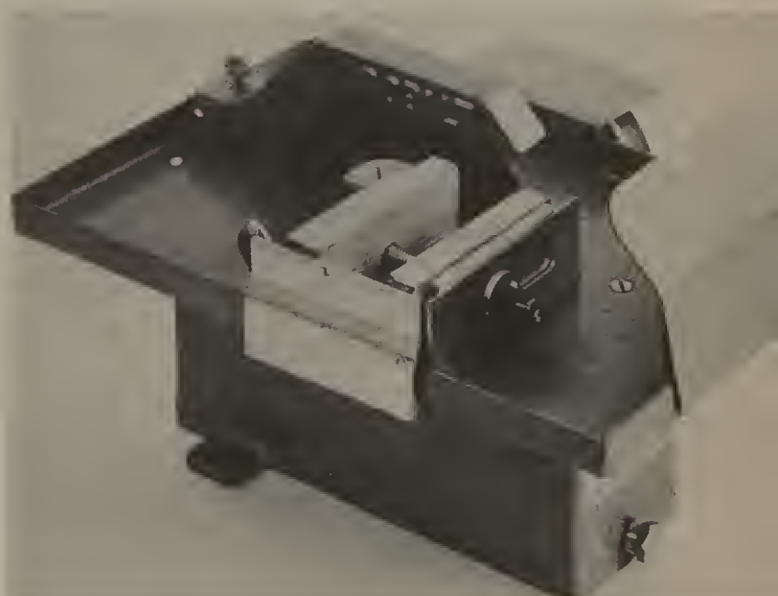
*Holding and feeding*

The method of holding and feeding the stone to the blade is also very varied in different models, however, simple holding systems are fitted to most which secure the stone in a positive way. The feeding devices may be divided into two categories: weight and mechanical.

Both of these feed types incorporate some means of traversing the stone under treatment to allow accurate slab cutting. The weight feed consists simply of a cable which is attached to the vice or clamping device which moves towards the blade, then passes to the rear of the machine over a pulley where it is attached to a weight of suitable and variable mass (see note on sintered-blade feeding pressure in this chapter), which supplies the motive power.

The mechanical feed is a more sophisticated mechanism which consists of a belt drive — from the blade spindle, which provides a slipping clutch facility in case of jamming, driving a gear train which causes the vice and its contents to move towards the blade. It is somewhat less flexible than the weight drive in the case of stone of mixed hardness or where material containing holes is under treatment, as it feeds at a uniform rate.

**A trim/slab saw machine with vice and weight feed. This unit is designed to accept diamond blades from 150 mm to 250 mm in diameter.** *(Photo by courtesy of Halls, Cairns, Queensland).*



**A typical trim saw fitted with a 150-mm-diameter blade and a removable slide vice.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

*Covers*

A cover for the top of the saw is fitted to reduce the loss from splash and spray of the coolant and to prevent contamination of the surrounds and atmosphere in the vicinity of the machine.

Larger saws and special-purpose saws are available, some with blades as large as 1200 mm in diameter, but these are production machines intended for commercial establishments and cost many hundreds of dollars.

*Trim saws*

Smaller machines designed specially as trim saws are made to fine tolerances to suit all fine cutting. Special attachments for these machines are available for many delicate jobs, an example being a thin slicing device for the opal triplet cutter or faceter. Some are supplied with a slide vice, others with a coolant pump and most are fitted with covers which reduce splashing.

*Smaller saws*

All lapidary is not possible with conventional slab or trim saws. Small work such as carving and drilling calls for saws capable of forming delicate and detailed undercuts on figures, entering drilled holes to clean out stubs and small fragments, etc. Blades, some as small as 8 mm in diameter, are put to work on such projects. These tiny saws are mounted on a spindle, which is integral with the blade in the case of the very tiny ones, and clamped into a chuck or work head. It may be bench-mounted or in a hand-held flexible-drive unit.

*Tanks and coolants*

The coolant and the method of its application is probably one of the most important aspects of diamond sawing which prolongs blade life.

*Coolant mixtures*

The universal coolant is water, but as a sole cooling medium for all stone it falls a little short of the ideal. A lubricant is needed to lubricate the diamond cutting points and the passage of the metal bond through the stone. Special emulsifying oils (soluble oil) are manufactured for use with diamond blades. They form a milky emulsion with water and perform the lubricating role while the water does the cooling.

Other mixtures in popular use are kerosene 75 parts, to dieselene 25 parts, kerosene 90 parts, to 10 parts lubricating oil, and straight kerosene. These mineral oils are somewhat oppressive in use as they permeate the atmosphere; however, in spite of this, their efficiency as coolant/lubricants weighs heavily in their favour.

*Cleaning of slabs*

Coolants may be removed from cut slabs by immersion in a hot-water bath containing some liquid detergent with air drying afterwards.

*Absorbent stones*

It is not recommended that any coolant containing oil be used when sawing such absorbent stones as opal, turquoise or chrysocilla, as they will be discoloured by it.

*Application of the coolant*

Some machines are fitted with a pump which directs a stream of coolant at the point of cutting. Others make use of the blade as a pick-up device to deliver coolant from the tank below to the work area. The 'up-and-over' action of the blade combined with the usual blade guard makes this a very successful method. The coolant must be maintained at a level where the blade edge just dips below its surface. Dipping too deep produces an over-supply of coolant above the table. A foam plastic wiper fitted around the blade under the table at the point where it passes to the top reduces this surplus considerably. Further assistance in this regard is provided if a cloth is draped over the blade guard and stone piece while cutting proceeds.

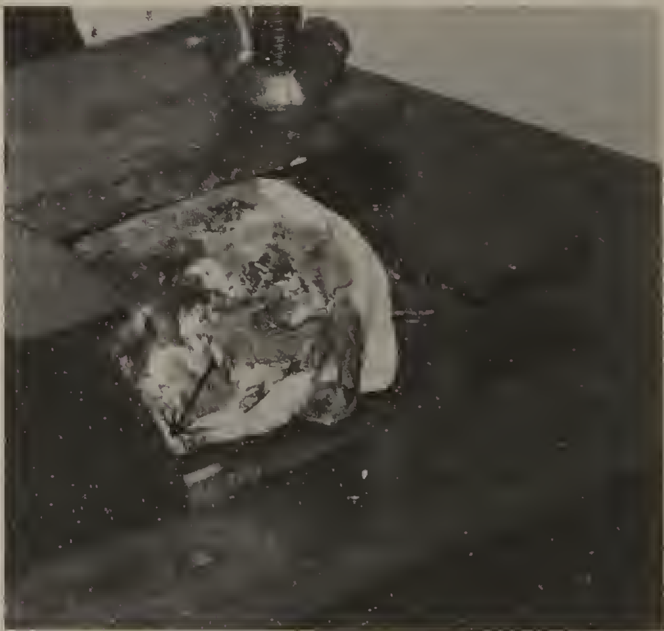
Good blade cooling requires that the coolant be applied to as much of the blade area as possible. The blade feed system adequately cools the above-table section of the blade while the underside turmoil takes care of the rest.

*Sawing practice*

*Preparation:* Before commencing, a few simple rules must be understood.

1. Never attempt to saw a stone which would take more than two minutes to cut — unless it is clamped firmly.

2. Material of an obviously friable or cracked appearance should never be clamped in a vice. It could disintegrate under sawing stresses and destroy the blade.



**A locked-up agate piece ready for sawing. Note particularly the land which has been carefully cut on the stone to ensure that the blade enters the cut straight without deflection. The slope of the face of the stone would cause a destructive situation to develop without this precaution.**

**Small slabs of Agate Creek agate sawn with a 250 mm trim/slab saw while set into a pudding.**

3. Take particular care with stones of a poisonous nature, as sawing debris could be carried to the mouth, e.g. malachite, some beryls.
4. Never run the saw without checking the coolant level, and seeing that it is being delivered to the right plate in sufficient quantity.

All that remains to begin a sawing session is to clamp the stone to the slide. The piece should be inspected to determine correct placement in respect of pattern or shape. Rounder pieces without flat areas must be packed up on each clamping side with plywood or masonite as a non-slip grip. These packing pieces should be allowed to soak in coolant before being used in a set-up.

Care must also be taken when beginning a cut to see that the stone face presented to the blade is at right angles to it. In the event that this is not the case, the vice and stone must be held back against the feed mechanism and advanced to enable the blade to just contact the stone, thereby grinding a small flat on it. Only then is it safe to let the feed drive take over. Left free to cut against an inclined face, the blade would be deflected to cut at an angle and, once begun, the blade would jam, assume a permanent dish shape or it could be destroyed.

*Puddings*

When small pieces, such as small agate geodes, are to be cut, they may be incorporated in a 'pudding' which will remove many of the hazards involved with small-piece sawing.

Take a cardboard box, or something similar, of a dimension which will fit into the vice; into the bottom place a close-fitting sheet of lightweight chopped-strand fibre glass. Mix plaster of paris in the proportions of 60/40 plaster to water, calculating by weight. Sprinkle the plaster into the water and allow it to stand for three minutes before mixing. Place a shallow layer of the liquid plaster over the fibre glass and immerse the stones in the balance of the plaster. Fill the box with the plaster-covered stones, packing as uniformly as possible. Top up the box with plaster to a level surface and place a second piece of fibre glass reinforcement on the surface and work it well into the plaster. Note: one end of the box should be left free of stone for a distance of twenty-five millimetres or so to provide a substantial hold for the vice. This obviates the loss of any stone. Allow the block to set and cool which will take about two hours, after which it may be sawn as if a solid piece. Use only moderate feed pressure when sawing.

The stones used in making a 'pudding' must all be free of grease or dirt and washed in hot water with detergent before placing into the plaster.

*Finishing*

It is necessary that as the end of a cut comes close, the rate of feed be reduced. This will prevent the feed pressure acting on the remaining thin stone section from breaking the slab away from the block which often leaves a sharp spur on the clamped remainder. The feed mechanism continues to advance the vice and, in the case of the weight feed, will propel it rapidly past the blade edge. This could damage the diamond edge, even to the point of breakage.

*Trim sawing*

Trim sawing must be undertaken with the same principles in mind which apply to the larger saws. The smaller blade is much thinner than the slabbing blade and appears to cut more quickly because of the smaller amount of material removed in the kerf. Theory has it that a diamond blade will only cut materials that resist it but the very thin trimming blade, travelling at speed, makes a mockery of theory when it encounters a careless finger or thumb. Care in every respect is necessary when sawing to safeguard blade life, but in trim-sawing personal safety is also a very real thing.

**Slabs of cobra agate, Mexican crazy lace agate and chrysoprase show fine pattern and colour combinations which make excellent cabs.**

# Gemstone Rough, Machines and Tumbling



*The selection of gemstone rough*

Perfection in a cut or polished stone can only come from rough of the best quality, but that perfection is always only found in the eye and mind of the beholder.

*Collecting*

The fossicker who ranges out of doors has a great deal of choice when it comes to selecting pieces to take home and polish. Many collect large quantities of 'junk' in their initial enthusiasm but it is always a sound practice, at a day's end, in the interest of maintaining high quality in the bag, to empty out the day's collection onto a groundsheet or something similar and cull, rejecting all but the best and most suitable pieces. Always leave some for those who follow.

*Size*

Select only pieces of suitable size for the equipment with which they will be processed. Large boulders and chunks which are barely able to be handled are obvious rejects. So too are pieces which cannot conveniently be split or fitted into the saw vice jaws. Smaller ones are much more practical to handle and some of the small to very small pieces may not need to be sawn at all. Smaller pieces are also more apt to be more perfect and flaw-free.

*Soundness*

The outside of a piece of rough should not show obvious signs of serious damage sustained from natural transportation processes. Inspect a large piece closely and pry away any loose pieces from the main body, or tap gently with the rock hammer to remove defective areas. Take care during this operation as pieces of rock are liable to fly from it (see the section on tumbling practice in Chapter 5).

*Transparent or opaque*

Transparent specimens are best inspected wet, particularly if the outer layer is clouded or water-worn. Check for internal cracks or larger, obvious defects, keeping in mind that, as transparent stones are to be used for faceting and the stones so treated are smaller than in cab cutting, smaller pieces could be obtained from clearer areas between defects.

Opaque stones like agate must be taken on face value rather than on absolute knowledge. Obvious holes in the surface of agate geodes, for instance, are often a piece of misinformation on the contents. Some very fine and spectacular material has come from such mysteries. The heft or relative weight of geodes can be a good guide to their internal make-up. A solid agate is very easily discernible from one with a hollow, crystal-lined cavity at its centre, but both are attractive when cut for different reasons and for different people.

*Broken agate*

Broken agate pieces are often discarded at first encounter by the novice lapidary. Part patterns very often cut into most effective stones and should be very seriously considered before rejection.

*Rough massive gemstone*

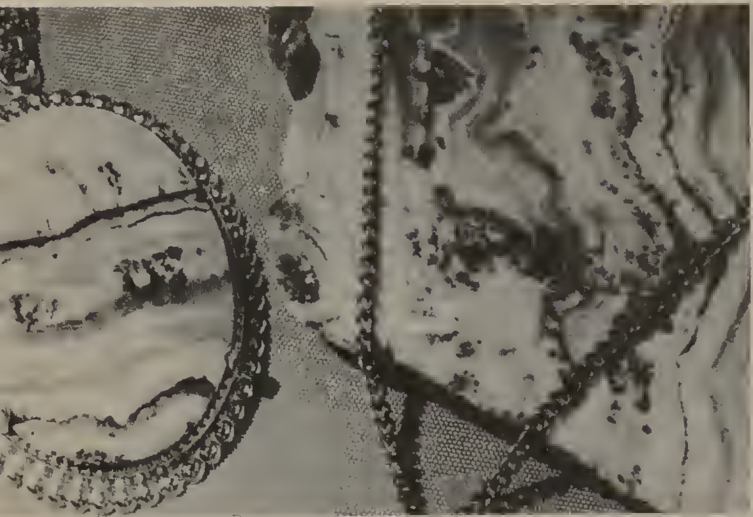
The selection of massive material is the same both in outdoor and indoor fossicking and the remarks below apply equally.

*Indoor fossicking*

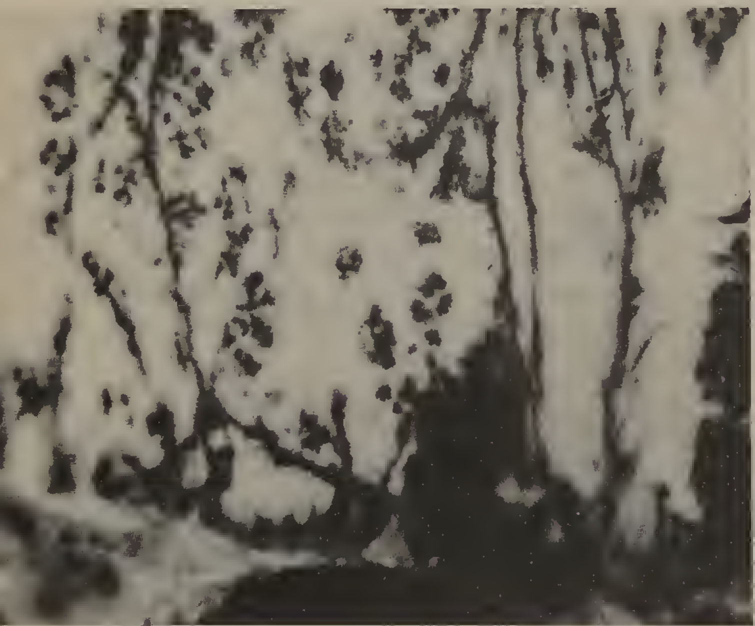
Many lapidaries have neither the time or inclination to go on fossicking trips to distant parts to personally prospect and find raw gemstone for their own use. These enthusiasts can often collect every bit as much (and often more) as the outdoor collector by the expenditure of a little time and as much cash as can be allotted to the hobby, by visiting one of the many rock shops around the country. The stock on view often represents collected rough from every part of the globe, including Australia, and many varieties and types are, for the average lapidary, beyond the faintest hope of encounter in any other place.

*Size*

The size of rough offered represents average demand and does not suffer quite so often from oversize as field rocks do. Tumbling chips are a good prospect as quite often they contain excel-



**Slab and cut and set cab of scenic 'onyx'. The material is really a form of marble but it serves to show the tremendous potential of such stone.**



**Blue moss opalite from Western Australia. This very decorative common opal with dendrites makes most spectacular cabs.**

lent pieces for cab cutting with a minimum of sawing or no sawing at all. Chips are obtained by crushing and while this produces a great deal of perfect pieces for tumble polishing there is always a proportion of rejects.

*Cost*

Larger pieces of slabbing rough are invariably more expensive than tumbling grades, faceting rough is higher in cost than both and rarer and larger pieces of top-grade faceting rough are as costly as one is prepared to go. Some, such as opal and sapphire, in top grades and large sizes must be regarded as investment pieces. It is well to realise that the price of such rough is often much higher per piece if purchased individually than if bought as part of a 'parcel'. The value of a parcel is spread over a number of pieces which, while they may vary in quality and size one from the other, represent better value than one piece bought out of context. 'Mine run' parcels, on the other hand, which may be a better buy per unit weight, often miss out being good value for the cutter as there is invariably a great deal of unusable material included. This latter fact is particularly applicable to sapphire.

Carving rough is most often the least expensive, with the exception of rarer varieties such as emerald, sapphire, amethyst, opal and chrysoprase. It often contains many imperfections but these are often so placed that they may be used to advantage in the projected pattern. An inspiration may even come to mind upon seeing a certain shape or defect in a rough piece.

*Slabs*

Much rough gemstone is prepared by slabbing prior to exposure for sale. All sizes and varieties are available; some of larger size or rarer variety may be limited in quantity from time to time due to international supply problems, but the requirements of the routine cutter or the avid collector of the rare or unusual are well catered for. Some rock shop proprietors issue newsletters and flyers, setting out the latest stocks available. These often contain opportunities not to be repeated.

Select slabs with the same care and attention as would be taken with rough in the field but particular attention is needed here to ensure that the piece selected suits the project. Material for a number of matching pieces such as buttons or a set of matching jewellery would require a larger or thicker slab to ensure a reasonable match of pattern or colour while an agate transparency would require a slab very much thinner than average. The dedicated proprietor will often supply such special requirements to order.

*Faceting rough*

Mention of the higher cost of faceting rough has been made above. This cost arises from several causes. Firstly, the stone is most often a part of a crystal. This is the rarest form of a gemstone and, as the faceted stone is, as a general rule, a much smaller piece than the cabochon, the rough must be as immaculate and perfect as possible in every respect. Price is a sure index of excellence or rarity or a combination of both. Secondly, there is excellence of colour and size. Clarity may also be coupled with this factor. The cost of a small piece of light-coloured amethyst, for instance, suitable for cutting a 10-mm brilliant, would be very modest when compared with a top quality piece of red-purple material of the same size, which could cost up to 100 times as much. This is only a single instance which illustrates the difference between grades.

The care and attention used in selecting and grading facet rough at the mine has been going on for generations. All low-grade or faulty material is clipped or chipped away to the point where the remaining piece represents the highest grade and the largest size obtainable.

*Flaws and feathers*

Apparent imperfections in faceting rough must be inspected with great care with a magnifying glass. Too often a would-be purchaser rejects a fine piece because he sees what appears, to his eye, to be a crack or inclusion which is unacceptable. Closer inspection would probably show that while the piece had been reduced to its minimum for the grade, the defect was in such a position that it was not impossible to cut it out by correct positioning of the pattern. It is useless to try to cut an emerald shape from a piece which is square without great loss. A round or a square is the obvious answer. An apparent crack can turn out to be a reflection of an irregular face in the opposite side of the piece. A hand lens of at least 10 power is necessary to prevent such a misjudgment of a piece, or a costly mistake.

It is most important to keep economy in mind, economy both of stone and dollars, when selecting facet rough. A gem of 5 mm in diameter for a tiny finger does not warrant a fine large crystal piece which would comfortably yield a stone twice that size.

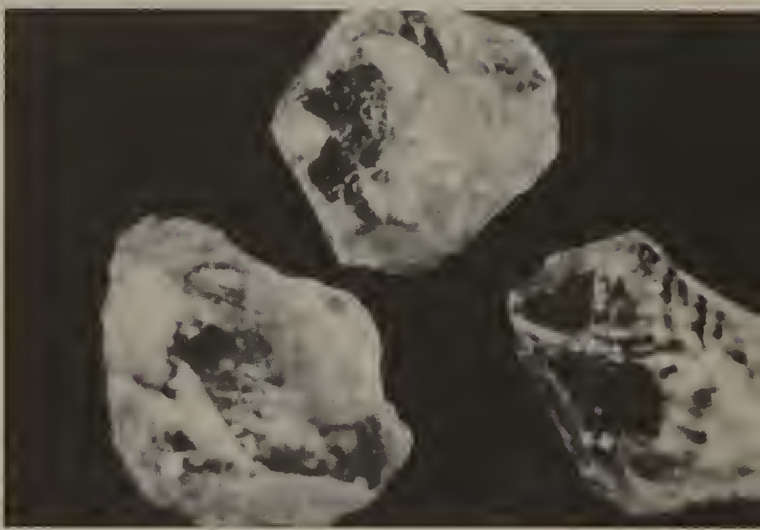
*Small pieces*

Tiny fragments of rough are often an attractive buy. They are frequently inexpensive, even in rarer types, and offer great opportunities for the faceter to gain much practice in small stone cutting or for the ring-maker/faceter to produce small matched shoulder stones.

*Synthetics*

Many lapidaries choose to ignore man-made gemstones or synthetics. They often regard such materials as spurious, false or imitations. In the first place, many synthetic stones do not occur naturally as prototypes, which cancels the contention that these are false. Others are the product of man's great urge to emulate nature, which cannot be dismissed lightly.

Cutters who disregard synthetics lose an opportunity to experience the satisfaction of cutt-



**Faceting rough of two types, water-worn and miner-graded. The first is topaz crystal from which natural transportation wear has removed most of the characteristics of the crystal shape, while the second is golden beryl which has been reduced to perfect cutting pieces by the miner.**

**Typical synthetic boules. The left-hand one is a half-boule of clear corundum and that on the right is a full boule of white spinel.**

ing and polishing such magnificent stones as a 10 carat (or larger) golden sapphire of perfect colour. One of natural origin of the same size would call for the investment of many hundreds or even thousands of dollars — presuming of course that such a large piece of rough was available. Practice with such a gem would not occur in the life of the average amateur lapidary. The multitudinous synthetics available today offer such an increase in experience opportunities for the faceter that no one should regard his collection as complete without a representative of at least one specimen of each.

Synthetics are constantly being improved upon by the emergence of new types and colours but the most numerous at the moment are those of the corundum and spinel group. These are available in over 100 colours and are made in sizes from 100 carat halves up to 300 or 400 carats. Other naturally occurring stones which are synthesised are emerald, opal, turquoise, lapis lazuli and rutile, quartz, garnet and star stones. The man-originated gem materials include YAG, strontium titanate, cubic zirconia and several others rarely seen because of deficiences such as hardness. Boules of these types vary from 5000 to 30 carats. Parts, sections and preformed sections of boules are sometimes available also.

*Mail order*

Mail-order houses specialising in the supply of gemstone rough are constant advertisers in both local and overseas lapidary journals and magazines. They are, for the greater part, establishments of long standing and can be relied on for fair dealing and they know the best when they see it. Some price variations between suppliers for the same material are inevitable but is a minority occurrence. Many offer inspection parcels which means that the purchaser can return unwanted original parcels out of a shipment for credit. This procedure is a very long-established operation and is built on full trust and mutual co-operation between supplier and client.

**A horizontal-bar-type tumbling machine with two 4-litre plastic jars as containers.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

# Tumbling Machines and Practice

TUMBLING MAY be defined as the production of a high polish on the surface of gemstone pieces without individual handwork. From a practical angle this is achieved by abrasion of rough stone pieces in a rotating container with subsequent polishing in a similar manner.

### *Tumbling Machines*

The most basic and simple machinc is the roller type. It has many variations, all of which embody the prime requirements for successful tumbling. Two motor-driven rods which are set parallel to one another cause containers to rotate when set upon them. These containers are charged with abrasive grits, water and stone pieces or polish powder, water and the part-ground stones for a number of hours, days or even weeks, depending on certain variables, when the polishing process is complete. The capacity of the roller machine is almost limitless so long as the machine parts are heavy enough and the driving power sufficient for the intended load.

Water wheels have been used to power tumblers as have windmills, both of which have limitations which restrict their general use.

A second tumbler with a container driven with its axis at an angle of approximately 45° is known as the inclined tumbler. It has the advantage of being operable without any sealing of the container being necessary. This, it will be seen, is a decided advantage.

The third tumbler type to be considered is the vibrating machine. This ingenious unit causes the stone charge to move in a certain way by vibration produced by mechanical or electronic means. Vibrating tumblers are fast machines but they are not suitable to very large production. The vibration frequency is of the order of 1200 cycles per minute and a specially contoured container for the stones vibrating through a very small orbit at this freqency causes its contents to circulate so that the necessary grinding or polishing action takes place.

#### *Tumbling machine types*

A summary of the main types of tumbling machines is set out below and shows some of the advantages and/or disadvantages of each.

*1. Roller type*

(Simple double rod, driven by small electric motor or equivalent)

| | |
|---|---|
| capacity | From 500 g to tonnes. |
| speed | Slow. Dimensions govern speed of process. |
| containers | Steel drums, plastic, rubber or plastic-lined steel, specially moulded containers. |
| first cost | Low for smaller types. |
| noise | Low to medium, depending on material of container. |
| advantages | Ample capacity, economic first cost, easily built by handyman (see Appendix II). |
| disadvantages | Space consuming, requires regular supervision. |

*2. (Better roller type)*

| | |
|---|---|
| capacity | Up to 25 kg in three or four containers. |
| speed | Larger containers with larger diameters make process faster than '1'. |
| containers | High-grade plastic, steel, aluminium or rubber, or plastic-lined octagonal or hexagonal ditto. |
| cost | Medium. |
| noise | Much less than '1'. |
| advantages | Higher efficiency than '1'. |
| disadvantages | Higher initial cost than '1'. |

*3. Miniature roller type*

| | |
|---|---|
| capacity | Up to 1.2 kg per barrel. This machine may be set to drive five barrels in all with only one powered unit. Machines may be interconnected to produce various speeds suitable for grinding or polishing. |
| speed | Fast. |
| containers | Plastic with special liners. The periphery of the barrels |


**Convenient self-contained roller-type tumbling machine with a 4-litre octagonal rubber-lined barrel.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

**An ingenious tiny tumbler which has gear teeth formed on both edges of the barrel. These can be engaged with other barrels to enable up to five batches to be processed with a single powered unit. The capacity of such a string is approximately 500 g per barrel.**

| | |
|---|---|
| | is profiled in the form of gears used for driving as above. |
| cost | Medium. |
| noise | Very low. Good for indoor operation. |
| advantages | Space-saving, fast, integral motor gives long life, low power cost. |
| disadvantages | Small capacity. Unsuitable for individual stones in a batch over 25 g in weight. |

*4. Inclined tumbler*

| | |
|---|---|
| capacity | Varies with design and container size from 50 g up to 100 kg or more. |
| speed | Medium. |
| containers | Specially fabricated for larger models, standard heavy plastic jars for smaller ones. |
| cost | Low to high, depending on model. |
| noise | Minimal. |
| advantages | Requires virtually no supervision except visual. |
| disadvantages | Slower in operation in smaller capacity units, higher first cost. |

*5. Vibrator type*

| | |
|---|---|
| capacity | Up to 15 kg. |
| speed | Very fast. |
| containers | Specially fabricated, profiled with close-fitting flexible covers. |
| cost | High. |
| noise | Minimal. |
| advantages | Very fast, economical of space. |
| disadvantages | High first cost, limited capacity. |

*Points for consideration before purchasing a tumbler.*

What do you want your machine to do? Are you a new starter with a great enthusiasm and a garage full of tumbling material? If so, a medium-sized roller type would be best. Of course the machine does not always have to be operated at full capacity. Only one or some smaller barrels can be run with equal success (see note on container dimensions in Chapter 5). It would be a mistake to settle for a smaller unit in the hope that it will handle more than recommended by the manufacturer. Do not expect to obtain quality stones, produced in a trouble-free process, from an overloaded tumbler.

If your requirements are to occasionally treat a kilo or so of stones for the bazaar or your own amusement, one of the smaller inclined or self-contained units would be ideal.

For the commercial or semi-commercial producer where time is of the essence, and smaller formal or preformed stones are required on a regular basis, the vibrator type is indicated.

All smaller machines are ideally suited to the final stages of prepolish and polish for pre-shaped (hand) stones or small amounts of baroques which have been extracted from larger grinding batches part-completed in other machines.

## *Tumbling practice*

### *Rough*

Gemstone pieces of suitable size for tumble polishing may be obtained by two major means, fossicking and from the local rock shop. Tumbling mixes are available from the latter and would be the best start for a first attempt.

### *Precautions*

Breaking larger pieces of stone by hand requires a deal of care as injury from flying fragments is a very real possibility. Gloves and goggles or a face shield should be worn during the operation. A breaking area should be set up by covering a light wooden frame about 900 mm square by 30 mm high with hessian or heavy building plastic. The frame is left open at top and bottom but it is advantageous to provide a loose piece of hessian or heavy cloth as a floor to catch the broken pieces. A heavy piece of wood, such as a section of railway sleeper or even a piece of heavy boiler plate or something similar is placed under the floor hessian on which to place the stone. A knapping blow rather than a straight smashing blow is delivered with a lump hammer to the piece. The latter type of blow induces shatter marks through the more brittle types of stone. A second bag placed over the stone will prevent many flying chips from being lost.

Bought tumbling chips often contain an oversupply of larger pieces but these should be reduced to suitable size with the hammer. Do not discard the very small scraps which accumulate when breaking as they are very useful pieces in the first grinding stage (see below).

### *Stone sizes*

Beautifully polished baroque stones are often seen in rock shops and appear to come in every size and shape. Polished large 'fidget' stones, so called because of their alleged calming effect when handled, of 100 g and larger, need a special mention as such large sizes are not easily polished except in very large batches — 1-500 kilos. For example, an average 4-litre container of rough, ready for first grind, should be in about the following proportions by weight:

- 50% of pieces less than 12 mm average diameter.
- 25% of pieces over 12 mm but under 18 mm.
- 12½% of pieces over 18 mm but under 20 mm.
- 7½% of pieces up to 25 mm.
- 5% of pieces between 25 mm and 30 mm, including one or at most two of up to 35 mm average diameter.

The smallest category could, and should, contain more smaller stones than the maximum (see Chapter 5).

### *Flat-faced stones*

Sawn pieces and stones which have been ground to some degree are often included in grinding batches but, due to their tendency to stick together, should be in a minority.

### *The importance of smalls*

There is a reason for the apparent oversupply requirement of smalls in a batch. A batch of freshly broken stone in a barrel may be compared to a crowd of people which stands with hands on hips. The space they occupy will be considerably larger than if they were to place their hands at their sides. The new stone with its sharp points and edges is the hands-on-hips crowd. Not much contact is possible. As grinding reduces points and edges, the hands-by-sides analogy becomes applicable. A very large piece in a batch of all similar-sized pieces would take an unseemly long time to grind and round out. Contact would be very long in coming and as contact with abrasive between stones is the required active grinding action, smaller stones or smaller stones in conjunction with larger ones gives much greater contact and come more rapidly into grinding state.

### *Preground stones*

Formally shaped cabochons and other ground pieces are often finished in a batch of rough stones, where they are included in the fine grind, prepolish and polish stages of the process.

### *Hardness and tumble polishing*

A German mineralogist, F. Mohs, devised a scale of relative hardness for gemstones which derives from a series of minerals divided into 10 degrees of hardness in relation to their resistance to scratching. It is in no way linear but is universally used in gemmology and gemcutting. The hardest with a number given as 10 is diamond, with corundum 9, topaz 8, quartz 7, feldspar 6, apatite 5, fluorite 4, calcite 3, gypsum 2 and talc 1.

Hardness must be considered when preparing stones for tumble polishing as stones of similar hardness must be processed together if softer ones are not to be reduced unduly in size over the longer periods of grinding needed to shape harder ones.

A mixture of hardnesses is permissible but close and frequent inspection of progress is then most necessary (see the stone hardness division table at the end of this Chapter).

*The process*

Stage one: first grind
Machine used: Roller type. Container: 4-litre steel drum.

Load prepared broken stone into the container until about three-quarters full. Add water to barely cover the charge. Add 300 g of silicon carbide grit of 32-46 mesh.

Add an additional 25 g of 220-mesh grit which will serve to keep the coarser silicon carbide in circulation in the early stages of grinding.

Close the container securely and check for leaks. Take particular care to thoroughly clean the mouth of the container and its surrounds before closing. Grit left in its vicinity will cause wear and eventual leakage. A wide funnel is a very useful accessory for charging purposes.

Place on the rollers and switch on.

Run for twenty-four hours and only then open and inspect the container and its contents, particularly the water level. When the grinding action begins, the debris produced mixes with the water and silicon carbide to produce a slurry. When this becomes appreciable, additional water may be needed to maintain the cream-like consistency required to coat all stones.

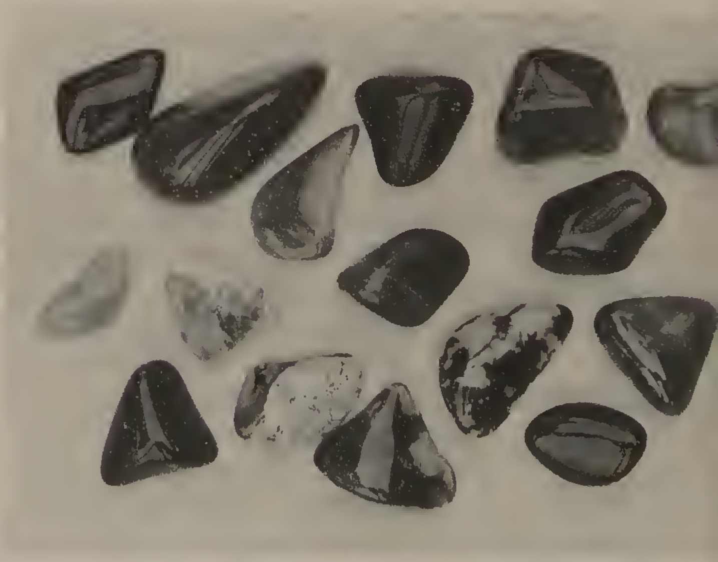
Re-close the container when all is satisfactory and continue for another forty-eight hours. Again check when closing for a clean closure area.

Open at the end of the period and at regular twelve-hourly intervals until the stage is completed. If the container is fitted with a degassing valve opening will not be necessary for another 100 hours. Plastic or rubber-lined containers may be regarded as having degassing valves but regular fifty-hour inspections are recommended.

The development of gas in the container is a product of grinding and should not be allowed to build up to an excessive degree. There will only be one burst due to gas build up in any tumbler's life! The mess and damage resulting from such a happening can only be seen to be believed. Careful supervision of the whole process is the only preventative.

After a total of approximately 200 hours, depending on the state of the original stone and its hardness, open and check for progress by rubbing some of the slurry between thumb and forefinger. Any residual grittiness indicates that the abrasive is still active. Should there be no such grittiness, add a further 50-100 g of grit. Before doing this, however, wash off and examine several stones for state of rounding. All sharp edges and points should be rounding nicely. With softer stones this may be the point where second grinding is indicated. The first grind is where the final shape of a stone is produced. Do not expect the stone to change shape radically in second grind or later processes.
Add water sparingly, if considered necessary, before closing once more, and continuing the run until inspection shows no signs of chips, nicks, indents and large scratches. This is essential as the following grinding and prepolishing only refine and do not remove radical defects.

Place the total charge into a sieve and wash out into a large drum which can be used until debris makes cleaning out essential. Do not wash out into plumbing or onto lawns or gardens as the products of grinding block plumbing and kill plant life. Secondary washing may be carried out anywhere as it is a relatively clean process.



**Baroque tumble-polished stones showing the high polish attainable by this method.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

*Second grind*

Clean all stones with running water, warm in the final stages if possible, and remove any broken or obviously unsound pieces for inclusion in a later first grind. Clean the container and replace the charge in it. Add 250 g of 220 grit silicon carbide with sufficient water to only half-cover the stones, clean the opening and close.

Continue grinding for about 100 hours with twelve-hourly inspections. This stage produces more gas than the previous one and inspections must be regular. When all samples inspected are smooth and defect-free wash out once more.

The duration of second grind is very variable due to machine speed, stone hardness, size of container, etc.; so the only certain way to assess progress is by inspection.

*Prepolish*

Again clean out thoroughly and add 100 g of 600 grit silicon carbide with about one-quarter of a container full of water. The exact amount may be arrived at only after a preliminary run on the rollers with a first amount of water less than is considered necessary. Too much water can slow the process down so it is better to add rather than be obliged to wait for the grit to settle so that some water may be removed. After a first experience a more definite quantity will be known.

Clean and close securely. Run for 100-200 hours with very regular degassing. Prepolish has the highest gas production of all. A sticky slurry is desirable throughout this stage.

The prepolishing may be considered complete when samples show no scratches of any description and have a glistening appearance when dry. The amount of grit required for prepolish may vary from the amount stated but more can be added if required. Insufficient first grind time is indicated if much more than 100 g is used.

*Polish*

Wash out most thoroughly and put the grind/prepolish container aside for the next batch.

Take a clean container which will be kept only for the polish stage. Wash the charge with warm water and detergent and rinse off with warm water only and place wet into the polish container. No sign of the darker silicon carbide can be allowed into the polish container. One speck of it can ruin a whole polish batch. Absolute cleanliness is imperative.

Place 100 g of polish powder together with about 500 g of plastic granules and two teaspoonsful of yellow soap chips (Lux flakes are suitable) on to the wet stones in the container. Do not add water at this stage. Close.

Run the closed container on the rollers for about five minutes. Open and add only sufficient water to form a slow moving 'mud'. Every stone should be covered with a coating of the slurry and should move in the rotating container with a minimum of noise. Avoid a too 'loose' charge. Continue rolling for from 100-150 hours, depending on prepolish excellence, then open and inspect with a critical eye. The polish on every stone should be impeccable and will be so if the previous operations have been faithfully carried out. Accidents are bound to happen from time to time. A stone may break in the final stage and spread an unsightly rash of scratches on the other stones. Plastic granule packing will help to reduce this possibility but careful rough selection is the surest preventative.

Stones such as rhodonite, amethyst, opal varieties, goldstone and feldspar varieties may suffer impact damage when treated in a mixed batch and the addition of plastic-granule padding to the container will reduce, if not eliminate, damage to the stones. Very high plastic-to-stone ratios are sometimes necessary to obtain maximum protection. Some experimenting can be advantageous in this regard. It is advisable if possible to treat batches of the same stone types individually (see the group tumbling table at end of this Chapter).

*Finally*

When the final polish is considered satisfactory wash out in a sieve. The polish powder may be recovered by retaining the wash water and allowing it to settle before decanting the clear water from the top. The plastic granules are easily removed by placing the charge of stones with the wash water into a plastic bucket. Swirl the water above the stones and scoop out the plastic with a smaller sieve. Store the granules and polish slurry in a clean container for future use. The slurry may be used for three or four batches but the plastic is never discarded as it is non-deteriorating.

Rinse the finished stones with hot water and detergent and dry on a soft towel. The use of hot water ensures that the stones dry without water marks.

*Tips and hints*

An aid to faster processing is found in the very small stones (fines) which accumulate after a few batches have been treated. They are not much used in jewellery although they may be used in mosaic work. A few handfuls added to a new batch of broken stones in first grind will appreciably speed up the total process. The small size of the pieces allows them to fit between the larger pieces and this, in conjunction with the abrasive, brings the required grinding action more quickly into being. They are left in the charge throughout the grinding, prepolish and polish stages and will ultimately wear away entirely, but to a very good purpose.

*Containers*

One of the most important factors governing speedy and efficient first grinding, the slowest of the separate tumbling processes, is the shape of the container.

The ideal movement of a charge of stone water and abrasive in a container is one where the rotating side rises, carrying with it the charge to a point where weight causes a folding over in the manner of a breaker on the beach. The topmost stones proceed to slide down the slope formed by other rising material. The longer this slope the more friction and abrasion. The speed of rotation of the container, and the shape and water content of the charge influence the 'wave' behaviour. The speed of rotation must be adjusted so that the wall of rising stone attains the highest point possible and folds over with no throwing of the topmost stones. Throwing is indicated in practice by an audible clicking sound. Too slow a rotational speed causes the charge to slide first up, as the container carries it upwards, and then the whole body of the charge slides down. No folding over or friction between stones takes place. A regular swishing sound indicates too slow a speed. Manufacturers' recommendations as to speed should be followed for individual machines. Patterns of containers vary from round to hexagonal and octagonal, metal, plastic or lined with plastic or rubber, all of which have advantages, but excessive speed can still cause stone damage.

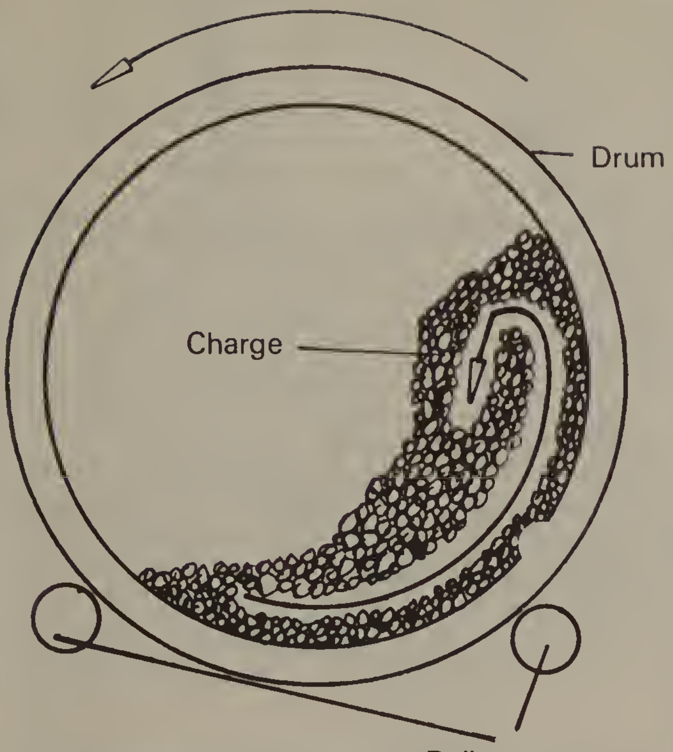
**Tumbling drum for roller-type tumbling machines.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

The principle of efficient grinding in a tumbler container is one of pressure. This comes from the height of a charge above a stone at the bottom of the moving mass. In experiments with a 200-mm-diameter metal round drum the first grind took seven weeks to complete with broken agate as the subject. The length of the drum was 175 mm. A similar charge in a narrow drum 300 mm in diameter by 100 mm in length arrived at the same stage in four weeks, while a very large rubber-lined drum, 1300 mm in diameter and 750 mm in length took just five days. The weight of this charge was just on two tonnes. The use of a large diameter compared to length is therefore suggested as the ideal container. A resilient lining is also desirable as it inhibits chipping as well as noise. Such drums may cost a little more initially but their life is almost indefinite.

*Partial or intermittent tumbling*

It may not be possible for tumbling to be carried on twenty-four hours a day. In this situation it is recommended that the container be removed from the rollers when switching off for the day. It should be stood up so that the charge settles at one end. If the container were to remain stationary on the rollers for a time, the charge would settle and become solid at the bottom. This would make the restarting next day all but impossible. On the other hand, the charge, when settled at the end of the drum, being symmetrical and balanced, requires only a short period before the required movement of the charge is resumed.

Removal of the container from the rollers is required to reduce indentation of roller covers by containers and their runners where fitted. This indentaton can cause deterioration of both covers and runners.




**The tumbling principle**

*Vibrator tumblers*

These excellent machines are dependent, for their successful operation, to a very large degree on maintenance of a good stone/abrasive/water balance. Sufficient water must be available at all times to keep the mix fluid. Too dry a mix and the mass sets solid, too wet and much splashing and undue movement takes place which could damage stones.

*Group tumbling table*

Gemstones which may be tumble-polished together can be grouped into four divisions.

*Division one*

Partly rounded beach pebbles (These should not be coarse-grained but of fine, close-grained texture)

| | |
|---|---|
| Petrified wood | chert |
| bloodstone | beryl |
| carnelian | chalcedony |
| jade (jadeite) | garnet |
| | |
| ribbonstone | rhyolite |
| jade (nephrite) | jasper (all types) |
| agate | chrysoprase |

*Division two*

| | |
|---|---|
| rhodonite | prehnite |
| aventurine (green and blue) | |
| crystal quartz | rose quartz |
| green quartz | canary quartz |
| sheen obsidian (gold and silver) | |
| snowflake obsidian | sodalite quartz |
| amazonite | moonstone |
| obsidian | peacock obsidian |
| rutitated quartz | tourmaline quartz |
| smoky quartz | milky quartz |
| rainbow obsidian | tiger's eye |
| impregnated chrysocolla | |

The use of plastic-granule packing with all of this division is recommended to minimise bruising or impact cracks.

*Division three*

| | |
|---|---|
| opalised wood | aragonite |
| blue moss opalite | jaspilite |
| | |
| psilomelane | yellow moss opalite |

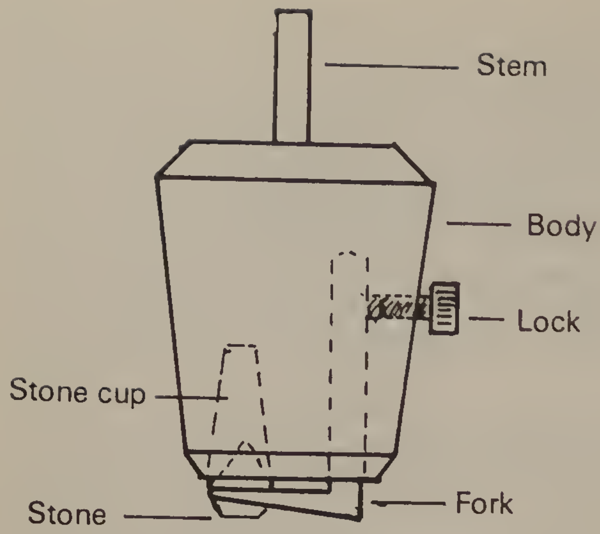
These stones should all be closely supervised during the process. Differences in hardnes contained in the same stone can result in undercutting. Heavy plastic padding (up to three-to-one) will help minimise this action.

*Division four*

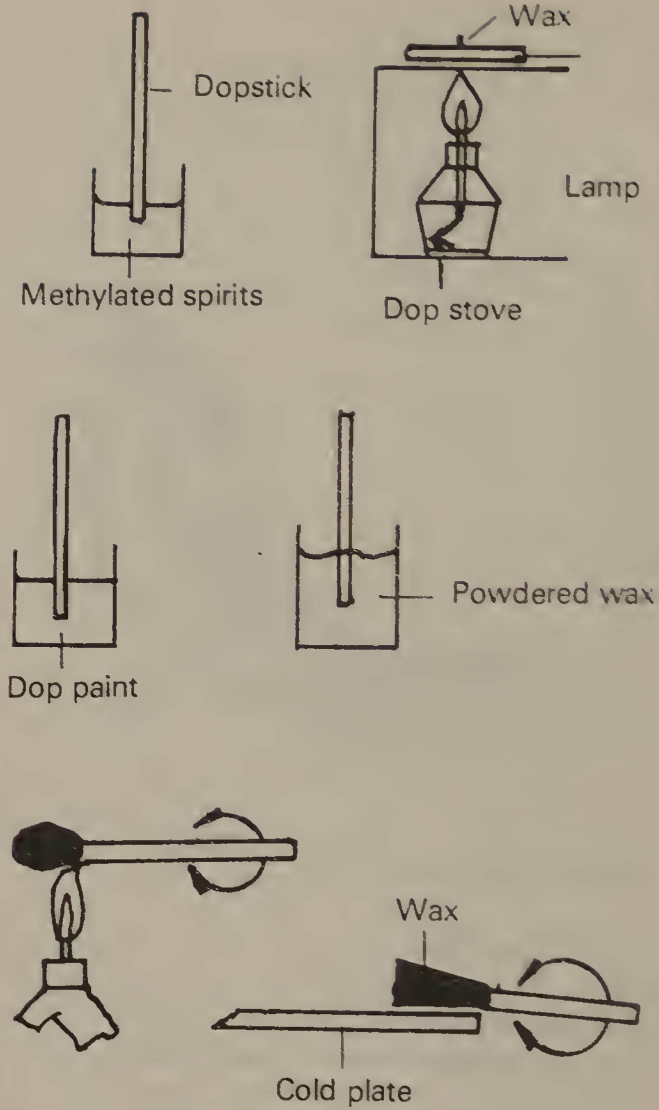
The following stones must be regarded as special-treatment subjects. They are best treated separately but if necessary should be grouped as indexed. Heavy padding is required in every case.

| | |
|---|---|
| + goldstone (all colours) | Øopal |
| + rhodochrosite | Øturquoise |
| Øamethyst | Ømalachite |
| * abalone shell pieces | * mother of pearl |
| Ølapis lazuli | * Øtrue chrysocolla |

Chrysocolla, marked *Ø, is true chrysocolla. It differs from chrysocolla in quartz (see Division two), in that its hardness varies from 2 to 4. Chrysocolla in quartz, on the other hand, assumes the hardness of quartz and polishes very well. True chrysocolla takes a glazed surface at best.



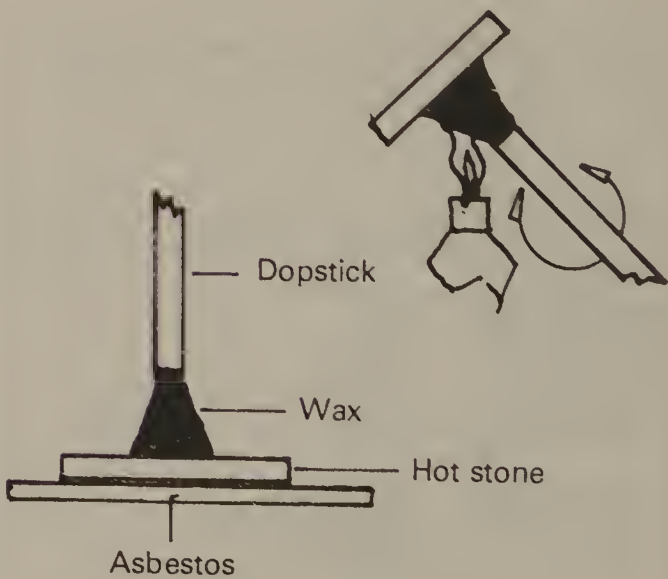

**Mechanical dopstick**




**Dopping procedure — 1**

**Dopping equipment: dop stove, powdered and stick wax and a metal spirit lamp.**

**Metal dopsticks and holder suitable for all jobs but with particular suitability for opal.**




**Dopping procedure — 2**

# Dopping

THE DEFINITION of the word 'dop' as 'a small cup affixed to a long stem used to attach a gem in cutting and polishing' was originally applied to diamond cutting and has been retained to cover all handling attachments for stone and lapidary treatment.

The beginner in lapidary often fails to understand the necessity for dopping. Fingers appear to be eminently suitable for holding a stone blank, that is until the heat generated in sanding or polishing causes a relaxation of grip and the stone is flung to destruction or at least to the floor. This quickly convinces anyone of the absolutely compulsory need for dopping.

*Dopsticks*

Dopsticks come in all shapes, sizes, materials and forms. Wooden sticks from extra large 20-mm-diameter ones down to matchstick sizes are used for holding a piece for carving or tiny opals; metal ones with precision-locating devices to suit faceting machines and metal sticks made to fit insulating or metal handles — all have a place in gemcutting. A mechanical type used in diamond cutting has been modified to suit hard stone cutting, e.g. sapphire, but this is a tool for the very experienced craftsman. No wax, glue or other fixative is used with it.

In order that a stone which is dopped onto a dopstick remains attached for the whole period of treatment and does not detach before being required to, certain rules must be observed.

*Materials*

The following materials and tools are required for successful dopping:

*Dopping wax* Powder or stick, or cold dopping cement, epoxy or cellulose type.

*Methylated spirits* Solvent for wax-type dopping and as fuel for heating.

*Dop paint* A solution of 25 g shellac in 100 ml methylated spirits. A precoating for wax dopping.

*Cement solvent* Eposolve or acetone.

*Spirit lamp* Methylated-spirit type, or

*Hot plate* Special low-heat type.

*Dop stove* For use with lamp only.

*Cold plate* A 100-mm square of steel sheet used to form the wax on a dopstick.

*Asbestos mat* A 100-mm square of asbestos millboard 1½-3 mm thick.

*Dopsticks* Wooden dowels of 5, 6, 8, 10 and 12 mm in diameter, 100 mm long, *or* metal sticks to suit projected sizes.

*Dop holder* An adjustable handle of metal or insulating material.

*Dop rack* Any plate or board drilled with blind holes spaced to suit stone and dopstick diameters.

*Tweezers* 150 mm long, blunt end, to handle hot stones.

*Dopping practice*

*Basic rules*

*Cleanliness* This must always be observed. The face of any stone and all dopsticks must be free of old wax, dirt, cement or grease before dopping can commence.

*Temperature* The stone surface and that of the stick must be at the same temperature and above that of melted wax for satisfactory adhesion.

*Changes of temperature* Avoid rapid changes of temperature (thermal shock). Stones must be heated or cooled gradually and gently. They should be preheated, that is, partly heated before being raised to wax melting point. Stones are placed on a pad of steel wool and brought to a lower temperature with a desk lamp (see section on contact dopping later in this Chapter).

*Procedure*

1. Take the shaped or preformed stone and select a dopstick to match its size. Clean thoroughly with methylated spirits, paying particular attention to the dopping face of the stone and the end of the stick. *Caution:* acetone and methylated spirits are highly inflammable and must be kept away from open flame, used cloths or tissues containing such solvents. A 'safe' area should be set aside for cleaning purposes.

2. Preheat the stone blank by means of the spirit lamp or hotplate or as above for heat-sensitive stones. A simple dop stove made from a strip of galvanised steel 75 mm wide and 300 mm long bent into a square 'U' shape is invaluable. The

'U' is placed on its side with the lamp standing on one of the arms. Stones may be placed on the upper arm at the farthest extremity away from the flame and gradually advanced towards it as needed. Place a small splinter of wax on the back face of the stone as a heat indicator.

3. While the stone is heating, take a dopstick and warm the end in the flame, rotating to ensure even heating. Dip into the powdered wax, collect melted wax from a heated stick, or dip into the wax well on the hotplate as applicable to the type of heat and wax used. Rotate the stick to form a blob of wax at its end. Reheat in the flame as needed to form a uniform shape and until the wax is seen to 'wet' onto the stick. This is when the wax is seen to run onto the wood with no sharp standout point between wax and wood. The wax splinter on the stone should have melted by this time and, if so, remove with the tweezers and place it on the asbestos.

Roll the wax blob on the cold plate so that an inverted cone shape of wax is formed with its wide end at the outer end of the stick.

4. Place the formed cone onto the centre of the heated stone on the asbestos. The heat in the stone should be sufficient to melt the wax on contact. Use moistened fingers to press and shape the wax as a supporting cone for the stone.

When the wax firms, lift stick and stone and rotate in the flame with the junction of wax and stone at the point of the flame. Rotate steadily until the wax is glistening in appearance. Avoid ignition of the wax. Overheating at this point could cause the stone to slide off the stick. Place back on the asbestos and allow to cool. When firm and set, with the stick truly vertical, upend and set into the dop rack to cool completely.

*Removal of stone*

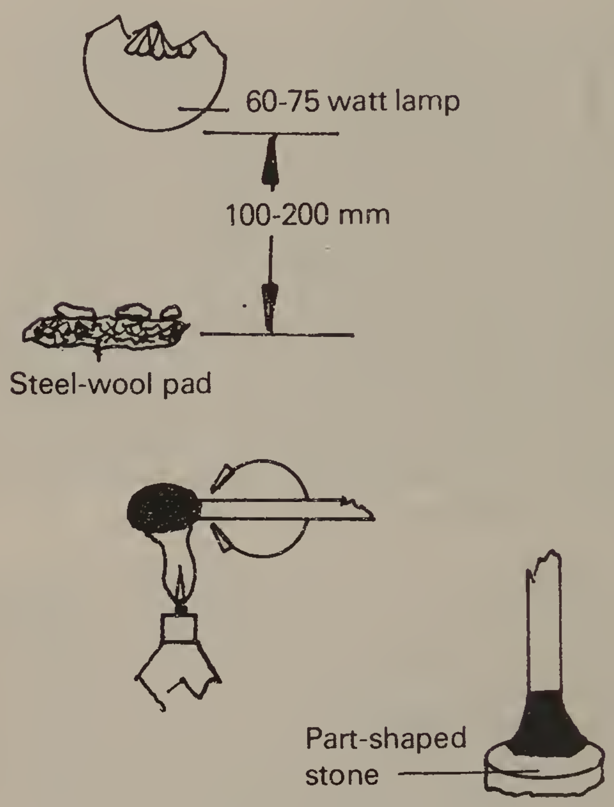
5. *a.* A thermal shock can cause undopping of a stone from a stick and use is made of this fact for the removal of stones from dopsticks when completed. A short period in the refrigerator freezer will separate stone and stick cleanly. The stone should be at room temperature before placing it to separate.

*b.* The wax may be reheated to detach a stone. A short soak in methylated spirits will facilitate cleaning of the stone.

*c.* A sharp blow to the stone with a wooden stick while the waxed end is supported will separate stick and stone but this procedure can be hazardous for the stone.

*Contact dopping*

This is a special method for opal and other stones which will not tolerate excessive heat and which has been found in practice to be both quick and safe. Dopsticks of aluminium or brass are best for this method as it depends to a large degree on heat conduction through metal.




**Contact dopping**

*Preheat*

A flexible gooseneck-type table lamp fitted with an incandescent lamp of 60-75 watts is set over a pad of unsoaped steel wool at a distance from it of 200 mm. The stones to be dopped are placed on the pad and the distance from the lamp gradually reduced to 100 mm, when the temperature of the stones will be found about right for the process to begin. A preheat period of five to ten minutes is sufficient.

*Dopping*

Clean and wax the end of the dopstick in the regular manner as already described. While still soft, proceed as follows.

Place the waxed end of the stick into contact with the warmed stone. Apply briefly at first so that the wax takes on the shape of the stone. Heat the wax in the flame once more and repeat. Continue this routine until the wax adheres to the stone. Once adhesion takes place, briefly heat the dopstick *shank only* in the flame and hold it in a vertical attitude, stone up. The heat will flow upwards and if it is sufficient it will securely bond stick and stone. A repetition of the last procedure may be found necessary until experience is gained.

*Cold dopping*

Stones which have no tolerance to heat, or a stone which a cutter has misgivings about as to its heat tolerance, may be cold dopped. Epoxy cements or cellulose based glues offer a rapid and satisfactory alternative to heat. The latter need a filler such as cornflour to give strength to the bond.

To remove such dopping bonds, the cellulose glues require the use of acetone. Please note the inflammability caution when using it.

On the other hand epoxy cements have no solvents but are removed in some instances by heat, or where this is not possible, by solvents which render them peelable, such as 'Eposolve'. When in use, this substance must be regarded as toxic as the trichloroethylene content is anaesthetic and toxic as well as the cause of skin problems. Handle it with care.

The use of 'Eposolve' and similar products in conjunction with composite stones using epoxy cements in their make-up must also be approached with care. To soak the stones for any time could cause the cement between the parts of the stone to swell and, as the solvent has not got access to all parts of the cement layer at the same time, the swelling which characterises the effect of solvent on cement will destroy the stone. The solvent must be applied with a swab only to the local area of the dopping.

Some brands of epoxy cement soften under heat and quickly release the stones. The 'UHU' brand of epoxy has been found to be very good for tiny stones for this reason.

*Physical removal*

A sharp small knife or a scriber may sometimes be used to separate stone and stick, but care must always be taken to avoid scratching.

*Facet dopping*

The foregoing remarks on dopping apply equally to dopping for faceting. Wax powder is preferable as the melting point is usually considered higher than that of the wax supplied for cab cutting. In practice a precoating with dop paint will collect sufficient wax powder to ensure intimate 'wetting on' to the stick with heat.

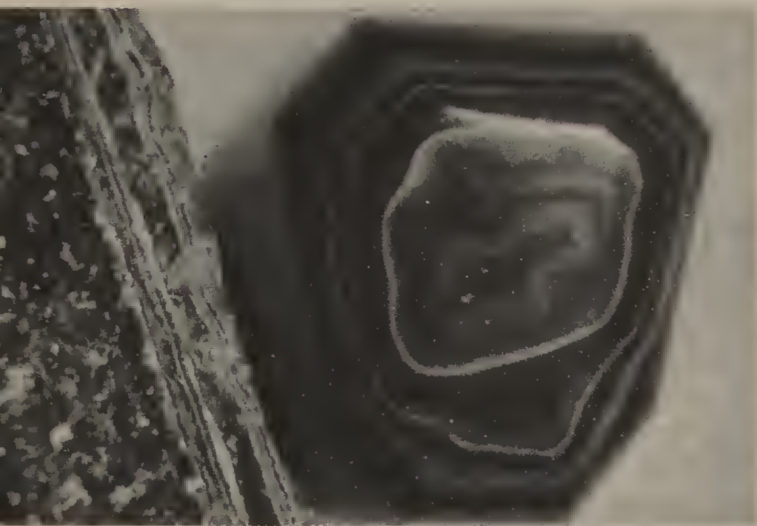
*Variations on dopping procedures*

As the lapidary becomes practised in the art there will be many calls for special dopping procedures to be undertaken to achieve certain results.

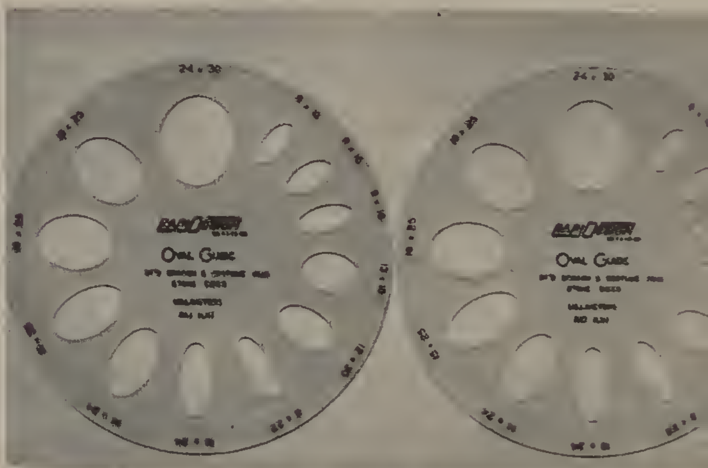
Diamond sawing often calls for the dopping of gemstone flats remaining after slab sawing a particularly good piece where there is no hold left for the vice. Dopped to a substantial piece of wood, the final cut is simplified. Carving sometimes requires that a piece be immobilised while being shaped. Again, dopping is the answer. Bead production is simplified by its use when cutting preforms, and drilling fine holes or large-cavity boring both use its benefits. The brief resume given here is a mere introduction.

**An informal shape in pink rhodonite which has made the most of the material in a slab. Such shapes are ideal for inclusion in gemstone collections and displays.**

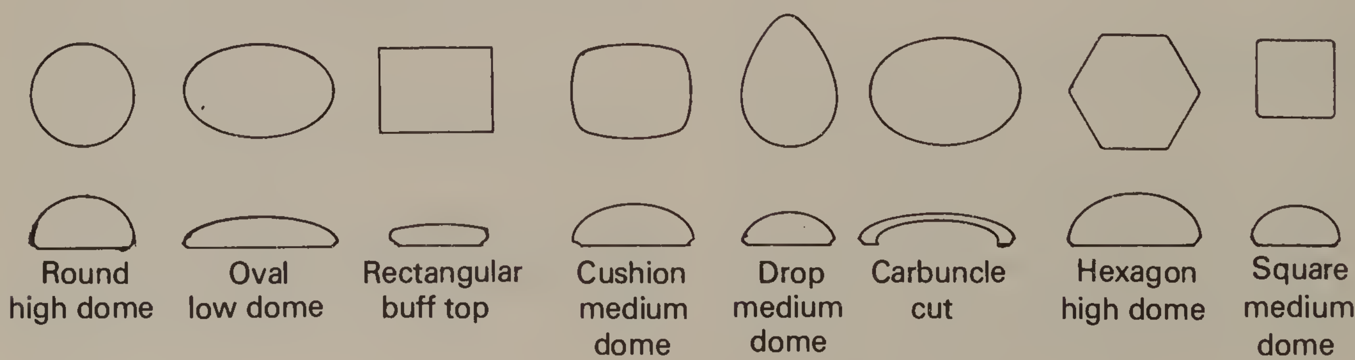
**An assortment of free-form, non-standard cabs cut in Agate Creek 'fire agate' by the late Hap Wheely. The infinite variation of patterns within a stone is well shown.**



**A cut stone in malachite together with its parent rough. The pattern resulting from cutting with the face of the stone parallel to the banding of the rough is clearly shown. If cut at right angles to this, the banding would be stripes across the face.**



**Two examples of the many standard gem templates available. Shapes other than oval are also procurable from rock shops.**




**Cabochon shapes and profiles**

# Forms Used in Gemcutting

GEMS ARE traditionally cut in two forms: faceted and cabochoned. The second of these two is further divided into formal and informal divisions. The formal cabochon is of an oval or round shape with a domed upper profile, although this rather restrictive rule is often extended to cover any regular shape with upper surfaces varying from almost flat to very short radius curves. Cabochons may be also single- or double-sided, have a high or low profile, or be high on one side with a hollowed back which is called the carbuncle. The cabochon may also be a solid piece of two or more pieces fixed together and cut as one, when it is described as a composite stone. The traditional two-part doublet which is used with opal, sapphire, ruby, and, of more recent times, the synthetics, has been extended to encompass three-part stones or triplets. These developments have received a great boost in popularity from the rise in stone values and the world increase in demand for popular jewellery.

The informal cabochon is the polished gem resulting from the use of all, or the major part, of a piece of gemstone rough. The handcrafting of jewellery by hobbyists and others has created a great demand for these individual informal creations in gemstone.

*Faceted stone shapes*

The pattern of a faceted stone is designed to take advantage of the optical character of the mineral of the gem, to refract, reflect and disperse light passing through it and to return as much of it to the eye of the observer as possible. This is achieved by grinding and polishing to a high finish flat facets on the stone surface at precise places and angles.

Composite stones are also produced in faceted form but in many cases they are made by those intent on deception.

Whatever the inclination of the gemcutter, there is no limit to the possibilities which his or her imagination or dedication can bring into being as a fine gem.

*Templates*

The form and shape of any gem is only useful for jewellery-making where standard commercially-produced mounts or settings are used if its dimensions are a good fit. To this end, templates are available which have openings in them which are accurate representations of standard jewellery findings, settings and mounts. They are cut with allowance for a tracing pencil to give guidelines for subsequent shaping. These standard sizes are international, but there are templates on the market which are only shapes of varying dimension and bear no relation to the standard ones. Care should be taken when using a template to ensure that the selected shape is indeed a standard one which will match the jewellery mount required. It is advisable to obtain the mount before beginning any cutting as it may then be used to test progress accuracy from time to time.

*Cabochon Cutting*

The lapidary involved with tumble polishing comes to the point where wider experience with gemstones becomes attractive; the cutting and polishing of individual pieces by hand fills this ambition very well.

A small cash outlay will provide the necessary machine which is almost as easy to handle as the familiar tumbler. The processes involved are the same, with the method of application the only difference.

Let it be said at the outset that the method to be described is one which has been found to be successful in practice over many years, but it is in no way the only one. Experience is always the best teacher and after a short experience of practical hand gemcutting, methods will suggest themselves to the lapidary which might suit him better or produce better or faster results. The end result is always the vindication of the method. Stay with a method only until another produces better results.

*Preparation*

Rough gemstones for cab cutting, as it is affectionately called, are prepared by slabbing with a diamond saw into slices of approximately 7-mm thickness. Of course, any thickness may be used but this depends on the size of the projected cab (see Chapter 4).

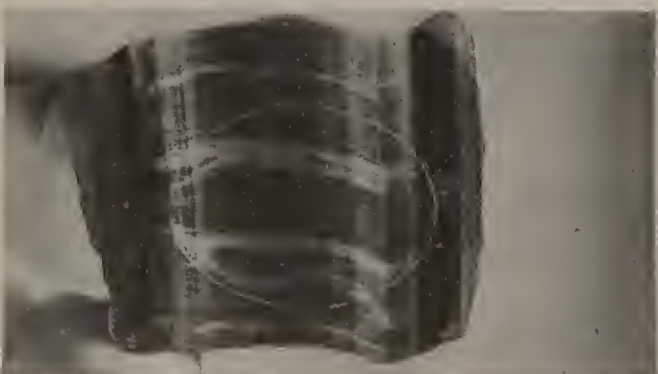
Small pieces suitable for the first attempt are available for a modest amount from the local rock shop.

*Marking out*

Select a piece suitable for the purpose envisaged or, if it is to be purely a practice piece, one which will cut a cab of an oval shape about 25 mm x 18 mm. This is a readily handleable size and allows cutting down if any accident should spoil this first attempt.

Place the template outline on the slab face selected as the front, positioning to take advantage of the pattern, if any. Mark around the outline with the aluminium pencil, which should be sharpened with the grinder to a chisel shape. Keep a flat side of the pencil accurately against the outline edge. This will ensure that the size is maintained in the marking. It may be necessary to take the pencil several times around the shape to produce a clearly visible mark.

**The metal pencil must be kept closely against the template opening to ensure accurate marking out.**



**A fine slab of blue/gold tiger's eye marked with an aluminium pencil and template in preparation for trim sawing and cabbing.**

*Trim sawing*

Trim around the outline with the saw (see Chapter 3). Cut only in straight lines. Blades containing diamond are not designed to cut curved lines. Be as economical of stone as possible by not cutting deep into areas of the piece not involved with this particular job. Several short cuts rather than one long one will often save another smaller stone from the discard because of the freedom from an intruding sawcut from a previous trimming.

When the trimmed outline is free of the surrounding stone, go to the rough grinding wheel.

**Trimsaw the cab blank from the slab with care and concentration. Cut close to the template marking to avoid waste.**

*Rough grinding*

Switch on the machine and then the water supply, in that order. Adjust the water until the face of the wheel is just wet without any splashing. Too much water will quickly saturate the operator and will not cool or remove grinding any more efficiently.

Hold the stone, marked side up, with thumb and forefinger of both hands, so that the face is horizontal and at right angles to the vertical plane of the wheel. Do not clutch it fiercely. Grip firmly enough to prevent the wheel moving it in the hands and yet still to allow its movement by the operator.

Apply the stone edge to the face of the wheel, just below centre, firmly but gently enough to prevent the wheel's rotation from pushing the stone away. A rest for the stone may be used. Move the stone constantly across the wheel face, slowly rotating about itself while grinding proceeds. Grind the edge away right around the stone until the mark on the face is approximately 0.5 mm from the ground edge. Never allow the movement to cease while the stone is in contact with the wheel. Hesitation with the stone in contact will produce a flat which will ruin the projected shape and make reduction of size necessary. The stone should now be a perfect replica of the mark on its face, larger by a small amount.

**A very firm hold on the slab and a position just below centre front is necessary for trouble-free grinding.**

**A cab preform being edge-ground on a silicon carbide wheel. The hold on the stone must be secure and the position of the fingers is shown.**

*Special grinding method for stones with a tendency to chip*

Chippable and softer stones which crumble or chip when ground in the above manner should be held to the wheel face with the plane of the slab tilted downwards in the direction of the rotation of the wheel, rear end up. Grind cautiously as described above and when the shape is completed, turn over and repeat with the other side up. These procedures will produce an edge composed of two separately ground areas, even in size and completely around the stone.

Turn the newly ground edges so that the slab is parallel with the wheel and, holding firmly between two thumbs while manipulating with the other fingers of either hand, reduce this double area to a single one at right angles to the marked face.

Stones which may require this treatment are opal, opalised wood, opalite, some chert, obsidian, softer stones between hardness of 5-6½, and sometimes crystal quartz with inclusions.

*Setting bevel*

Grind a small bevel around the back corner of the blank at 45° to the face. It should be about 2 mm wide as a maximum. Smaller stones such as the 25 mm x 18 mm one mentioned above will require a bevel of about 1 mm in width. The purpose of this bevel is to provide clearance for a fillet of metal which is often found as a join between side and back of a jewellery mount. It also prevents chipping when handling.

*Dopping*

The ground blank must now be dopped in the manner set out under the section on dopping. It should be a secure and accurately centred dopping on the back of the stone, with the dopstick vertical.

*Rough grinding*

When it is thoroughly cool, take the stone and switch on the fine grinder. Adjust the water flow and grind a 45° bevel around the front edge of the stone in the same manner as the setting bevel. Keep grinding this bevel more deeply until the lower edge reaches within about 1 mm of the edge of the back bevel. The edge should be parallel right around the stone. Now grind another bevel, this time around the upper edge of the one just completed. Continue this grinding of the top edge of the bevel until it is about 5 mm wide. Form another at the top and continue repeating until the whole upper surface of the stone resembles a contour map with evenly spaced contours. This 'apple peeling' technique is repeated on each of the junctions of the contours until the top of the stone is covered with many very narrow ground paths and the curving profile is seen to be even in all directions.

**A profiled grinding wheel in use to shape the upper curve of a dopped stone. Note the position of the hands when holding the dopstick.**

*Fine grinding*

Move to the fine grinder and proceed to remove all traces of the contours. This is achieved by holding the dopstick by the waxed end with one hand and the outer end with the other. Move this outer end up and down and vary the path sideways so that the whole of the stone's surface is covered by the wheel face. Turn the stone from time to time so that no spot is overground. Special care must be taken to prevent overgrinding of the narrower portions of the stone. Proceed slowly and with care. Let the wheel do the work and err on the light rather than heavy pressure side.

Pass the stone under the ball of the thumb from time to time and test with this sensitive area for irregularities which may remain. If any are encountered check further by inspecting with a lamp looking across the stone towards it. When located, reduce the area to match in with the surrounding area. When finished, the fine-ground stone should be perfectly smooth and uniform in appearance. It is now ready for sanding.

*Sanding*

Sanding is the process whereby any slight scratches which remain from the fine grinding are brought to the point where no sign of them or any other irregularity is visible.

Mount a 400 grit silicon carbide cloth disc on to the rubber backing of the sander. Wet the disc thoroughly. Apply the stone to the rotating disc gently at first, particularly if the disc is a new one. The comparatively rough new disc is very aggressive until worn a little. It will be difficult to wet also, so use plenty of water from the squirt bottle until it becomes broken in. Turn the stone against the disc with pressure. It will wrap itself around the stone to a certain degree which achieves the intended purpose as it smooths away the rougher texture left by the fine sander. Grinding is achieved by a flat wheel face which is inflexible. To generate a true curve by this means is difficult, to say the least, and the resilient sanding face is the first stage where a true curve is developed. Keep sufficient water up to the disc, as much friction and heat are developed. It also serves to wash away the debris and keep the cutting face open.

Inspect the face of the stone most regularly to ensure that no area is being neglected. Particular attention must be directed to the outer edge where the back setting bevel and the top curve meet. An otherwise perfect stone can be spoilt by inattention in this area. Continue sanding until no obvious defect remains.

**Sanding on a coated abrasive cloth disc (silicon carbide). This operation is carried out wet. The abrasive disc is attached to the supporting rubber back with a special disc cement.**

*Prepolish*

Scrub the dopstick, stone and hands thoroughly before proceeding. Mount a silicon carbide disc of 600 grit and wet it well. The alternative method would require a soft felt wheel mounted on a disc plate charged with pumice powder in water or with 600 grit in water. The felt wheel is not recommended for undercutters (see Chapter 8). Abrasive on felt tends to cut away softer areas while polishing the harder ones of mixed mineral stones. A squirt bottle is the best to use for the application of pumice slurry in prepolishing, in the interest of accidental contamination. Brush application is much more prone to introduce foreign particles.

Prepolish with considerable pressure, covering all areas of the stone evenly. Regular inspection with attention to the sides is still very important. It is time to polish when the surface is even in appearance and has a fine satiny glow. It cannot be stressed enough that the prepolish must be immaculate. The final excellence of polish attainable is entirely dependent on the perfection of prepolish. Polishing can never remove obvious scratching or irregularly sanded areas.

**Prepolishing with pumice on a felt wheel.**

*Polish*

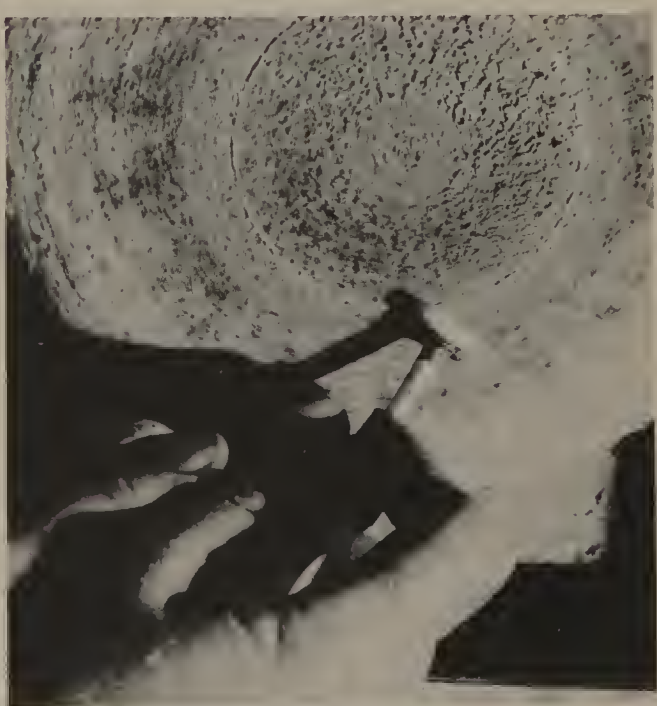
The stick, stone and hands must again be scrubbed scrupulously clean. One speck of remaining abrasive introduced to the polish buff not only ruins the stone's polish but contaminates the buff for following work.

Wet the polish buff of leather or hard felt with the polish mixture, again using a squirt bottle. The mixture is made from 25 g of tin oxide, cerium oxide or any other preferred powder in 100 ml of water containing a drop of liquid household detergent (wash-up detergent is ideal).

The polish is developed in two distinct stages, the first wet and the second dry. Apply the stone to the face of the buff with considerable pressure, turning in all directions to cover the entire face of the stone. Some stones benefit from a swiping motion from the edge to the centre of the buff.

The buff will tend to dry out after the first few passes and, if on inspection it is seen that the desired gloss is beginning to appear, continue in brief sessions to spread this gloss over the whole surface. Care must be taken to avoid overheating when dry polishing, this could melt the dopping wax and loosen the stone. Periodic rests, or the polishing of several stones in sequence (sequence processing), will allow the stone to keep cool.

When the polish is everything which is desired in all areas, allow it to cool, refrigerate to separate, clean up with methylated spirits and admire.



**Polishing an opal on a domed leather buff.**

*Back polishing*

It is usual to polish the back of a cab but there are those who do not consider it necessary or, alternatively, the stone may be destined for a closed back setting, in which case it may be omitted.

It is necessary to redop the stone with the polished face to the stick and then go through the fine grinding, sanding and prepolish/polish stages as before. Take care with the junction of the back setting bevel and the top. There must be no sharp junction here, rather there should be a softly rounded blending of top into back. Setting over claws of jewellery settings requires considerable pressure to be exerted on the stone and any fine or delicate sections could be damaged.

Make a habit of testing the stone in the setting for fit as each stage is completed or begun, as each removes some amount of stone, however small it may be.

*The double cabochon*

The cutting of a double-sided cab is a simple matter of duplicating the shape and profile on both upper and lower surfaces of the stone. One may be cut higher than the other or both may be identical.

The slab for a double cab must be thicker than normal by the amount required to yield the desired profiles.

The junction of the two cabs must be maintained as a regular and even straight line. Any waviness or variation in thickness will present problems when setting the stone into jewellery.

*Finally*

Remove the stone from the dopstick, wash free of wax with methylated spirits and then warm water and detergent, before drying.

# Special Cutting and Polishing Techniques

ONCE CABOCHON cutting is learned, it rapidly becomes a matter of simple routine with the usual run of gemstones. However, special techniques are found to be necessary when the stone does not respond to those procedures. Inability to gain a high polish, unexpected spontaneous chipping, undercutting and selective erosion in general can cause much frustration and waste of time. Soft stones also offer problems.

*Opal cutting*

Much has been written and rewritten on the subject of opal cutting but, as with all subjects, much has been omitted or mis-stated. It is a simple process, as simple indeed as any cab cutting, but with the difference that an intimate knowledge of the physical nature of the stone must be known by the lapidary to achieve good results.

Opal is a substance of complex physical make-up which contains water in varying amounts. Not all opal is the same. Opal from one field (or country) may vary greatly from opal from another which is similar in appearance. It all consists of silicon dioxide in the form of tiny spheres and has no crystal form (amorphous). (For greater details see our book, *Australian Opals in Colour,* Reed, 1969.) Its hardness varies between 5-6½ on Mohs' scale. Its lack of crystal structure would seem to indicate that it can be cut without regard for orientation. This is not so in every case.

Opal is formed in many ways. Seam opal is laid down in cavities formed when cracks, faults and slips occur and has a direction of best colour. Some seam may be extremely thin and apparently useless as gemcutting material. Fine doublets and triplets may be cut from seam (see below). Thicker opal pieces originate in 'nobbies', 'kernels', 'pipes' and 'seam', as well as fossil replacements. Most of these require no orientation, but there is always the exception to the rule. 'Four-faced opal' in which the 'lights never go out' is the ideal of all opal cutters. This fine (and usually top-grade) material may be rotated a full 360° and show fine colour, often changing, throughout the movement. It only remains for the cutter to pick the best of all colour which is considered to suit the taste of the purchaser. This type of opal may call its own price.

Seam opal may be composed of layers of differing colours with bands and patches of greys or transparent colourless opal dispersed through the whole body of the mass. This is problem material when it is desired to cut larger stones, as the emergence of a colourless or grey patch on the surface of an otherwise colourful stone would depreciate its value. Careful examination before sawing is most necessary to determine the most suitable path for the saw blade with least loss of colour. Solid colour opal of this description may occur as thick and thin seam, black (or dark grey), milk (or white), jelly, crystal and fossil types. The last of these is most often found as opalised shells, either as the whole animal and shell, or just as the shell with the animal long gone. Solid shells often are of fine, top-grade stone. Skin shells are also often of good colour but much thinner. Much of the triplet production makes use of this colourful material. Of course both types may be of very low grade potch also.

Other replacement opal is found in the Lightning Ridge 'nobbies', but this is considered to be of mineral origin rather than of animal or vegetable. They may contain the elusive black opal for which the field is world-famous, but black opal is sometimes seen in seam from some other fields. The 'Yowah nuts' from Queensland may contain a central 'kernel' which is sometimes of extremely high-grade opal. The concretion make-up of the 'nuts' is composed of opal-saturated porous iron-rich sandstone with some jasperisation. This is polishable in some cases but it too can present some problems. Its very variability makes it a subject for much experimentation.

Pipe opal, formed in the holes remaining after the decay of roots and similar tubular structures, is often of crystal quality with fine colour. It presents very little difficulty in polishing except when it contains a central hollow core.

*Orientation*

The cutting of opal, with the best possible use being made of the existing colour, requires that close and discerning examination be made before proceeding. A mirror-backed table lamp is used as illumination for the stone which is viewed wet. The piece should be turned in one plane while watching for areas of good colour. A mark is made at the centre of any area of colour and the stone turned through 90° and examined in that plane, marking as before. When the stone has been viewed in all planes, each colour area is compared and the best of all marked as the probable cutting face.

It is often necessary to grind and/or saw away potch, greys and other sandy, dark or colourless material to enable a clear view to be obtained, but any such action should be carried out with great care and only after close scrutiny of the wet stone. When the area to be cut as the stone is decided, mark out the proposed shape and carefully saw or grind it free of the rough piece. Limit cuts so that remaining cuttable material is not rendered useless. Finish roughing out on the fine grinding wheel. Preliminary shaping of the upper and lower faces may be advanced freehand at this stage (see the special method for stones with a tendency to chip in Chapter 7). When the shape is suitable, dry and dop by the contact dopping method.

*Grinding*

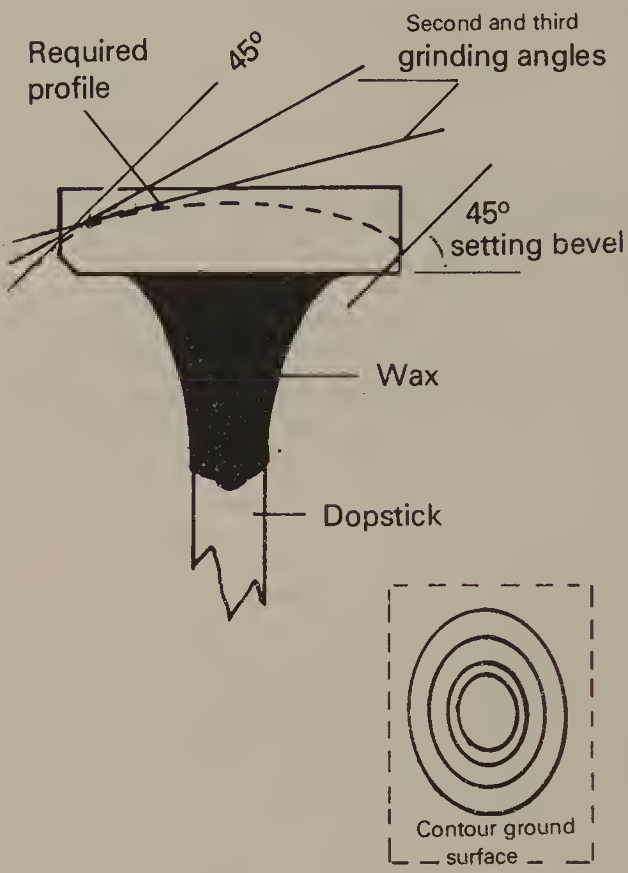
When it is cool, finish shaping the stone on the fine grinder, which may be a silicon carbide or diamond wheel 220-240 or 320 grit size. The silicon carbide wheel must be well dressed to a smooth and bump-free state before beginning any work on opal. Pay particular attention to the area being ground as the softness of opal allows very rapid removal of the material. Do not allow the stone to heat. Keep the water supply constant and adequate at all times.

*Dry Grinding*

Opal cutters with long experience sometimes adopt a procedure which is contrary to what is suggested in that last statement, for they make use of a garnet paper coated abrasive disc, in a dry state, to shape smaller solid opals. Great skill is needed and a great number of stones must be in process at the same time to allow cooling rests sufficient to prevent stone damage. An intimate knowledge of opal is essential for accident-free opal shaping to be successful by this method. It is not recommended for the beginner.

*Sanding*

Wet sand in the usual cab-cutting manner and prepolish on a very well worn 600 disc. New discs should be 'broken in' with a series of passes across the face with a piece of agate before putting them to work on opal. It is not recommended that pumice be used for sanding opal.




**Cabochon grinding**

*Final polish*

This stage is the only one of the series where some heat is allowed but it must be kept to a minimum. Dopping uses heat but this is developed very gradually and not as quickly as is the case with polishing.

A domed buff with a leather-over-rubber polishing surface has been found by the authors to excel all others for opal polishing. Instructions for making such a buff are given later in this section, as no commercial unit is available at time of writing.

*Polish mixture*

Mix 15 g of cerium oxide (or its equivalent) in 100 ml of a 50/50 mixture of water and methylated spirits and place in a plastic squeeze bottle. Shake thoroughly and wet the centre 50 mm of the buff with the machine running.

Apply the well-scrubbed opal to the buff with pressure using a quick swiping motion from the outside edge to the centre. Do not dwell in one place as this generates great heat very quickly.

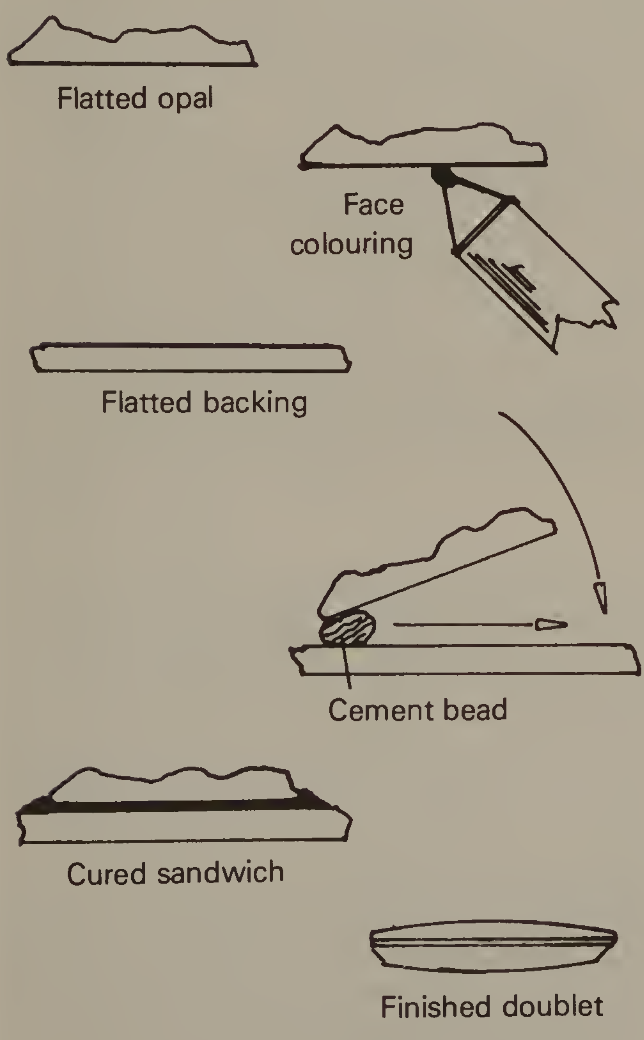
Test for temperature rise after each series of passes with the ball of the thumb.

If the prepolish has been well done the stone will 'grab' into the buff face in a very short time. Inspect frequently. A high gloss should develop with two or three passes in each of three surface-covering directions across the stone.

Should the polish not develop as quickly as described, recharge the buff with more polish and repeat the action, this time with a little more pressure. Continue inspection at intervals until the surface is uniformly bright and clear of all uneven marks. Place aside to cool thoroughly, when it may be undopped in the freezer.

*Back polishing*

Clean the undopped stone with methylated spirits and again redop on the front face. Use a thin coat of dopping paint to ensure complete attachment when contact dopping. Develop the finished shape required — flat, slight or high dome as the material or design allows. A slight dome on the back of an opal is more aesthetically pleasing than a dead flat.




**Opal doublets and triplets**

*Opal doublets and triplets*

Opal of good colour which is too thin to cut into solid stones, or top-grade high colour rough which has been cut into thin slices, may be made into very beautiful doublets or triplets.

Select the rough with due regard to size and excellence of colour, using the same procedure as for solids. Medium to poor colour opal will not make good doublets or triplets.

Mark out and saw the rough to an approximate outline and flat on a fine lap the side which shows *the very best colour.* This side is to be placed *against the backing* and not to the front as would first seem to be logical. Clean off the ground face, which must be perfectly even and smooth. There is no need to polish the surface.

Apply a black colouring to this best colour surface with an oil felt-tipped pen and set aside to dry.

Saw a 1-1½-mm-thick piece of potch. A dark colour is preferred; if it is not available use a piece of black glass known as 'opalite' which may be obtained from your rock shop. Flat one face on the flat lap to the same fine finish as the opal and clean off.

*Cementing*

Thoroughly mix a quantity of epoxy cement of the twenty-four-hour-cure type (five-minute epoxy is not recommended) with a small quantity of lamp black. This may be obtained by holding the blade of a carving knife in the flame of a candle — it will be deposited on the cold surface.

Place a small bead of the mix at one end of the ground face of the backing. Set the edge of the blackened, ground face of the opal piece onto the cement bead and lower it onto the backing so that the bead is pressed forward and across the backing between it and the opal. Avoid trapping any air — this should be simple if sufficient cement is available in the bead. If it is suspected that any air bubbles are trapped, separate and repeat. Squeeze the sandwich gently between the forefinger and thumb with gentle pressure and place it on a level surface to cure. The gentle heat of the inspection lamp will speed things a little but periodic inspection is needed to check if the pieces are still in position, as heat will cause the cement to become less viscous and the sandwich could slide apart.

If a number of pieces are treated at the same time it will be found more convenient and speedy to warm them in a batch in the kitchen oven which has been preheated to 50°C. *Do not* put any opal in the oven with the power switched on.

Use a piece of heavy card or light plywood to support the stones. The cement will cure in twenty minutes or so under these conditions.

Dop when cool and fine-grind the stone to the required outline.

*Doublets: the top*

Dome the front of the stone to as high a curve as the opal thickness will allow. Do not thin the opal section to less than 0.5 mm at the edge or there will be a definite possibility of damage in use.

*Doublets: the back*

Carefully grind away the backing at an angle of 60° which will produce an outline of the back face which is smaller than the full stone.

Undop, redop on the polished face and fine grind, sand and polish to a suitable curve for the setting. It is usual to just soften the sharp-ground edges of the back before polishing as doublets are set in closed settings, as a rule. Claw setting could be hazardous for the opal edge.

*Two-piece doublets*

Doublets may be constructed from two pieces of high-colour precious opal, neither of which is thick enough on its own to cut a solid. Large flat pieces are very natural candidates for this treatment. The colour/pattern should be similar in both pieces and the girdle line of the finished stone should be the junction point for the two pieces. Such pieces are often very valuable due to their large size.

*Natural doublets*

Precious opal of good colour sometimes occurs as a thin layer on the surface of lower-grade stone or colourless potch. Fine stones may be cut from this type of opal and are called natural doublets. Some of the Lightning Ridge natural doublets are outstanding stones, particularly if the underlying lesser stone is of a black or dark grey type.

The cutting of these stones requires great care and observation to maintain the colour band as parallel as possible to the top face. Any dip away from the face by the colour causes a diminution of the intensity at that point with a commensurate decrease in colour quality. The natural doublet is a solid stone and must be cut and polished as such.

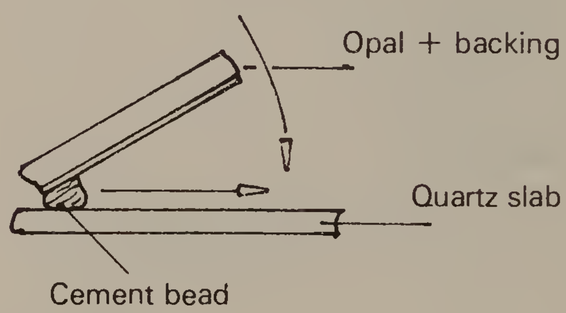
*Triplets*

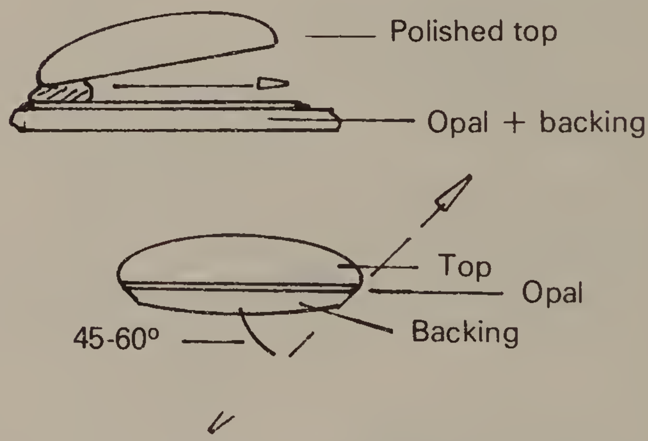
Make a doublet as just described but do not proceed to shape or polish; instead, when cemented and cured, flat the upper face of the opal piece parallel to the backing face on the flat lap. Thin to the point where the colour is very evident when wet. Opal pieces have been reduced to as little as 0.2 mm in thickness and have still showed very good colour. Wash up and rinse with methylated spirits.

Saw a slice of good crystal quartz about 3-4 mm thick, depending on the size of the stone, and flat one side to a fine finish. Cement to the clean flatted opal-backing sandwich in the same manner as was used to make the doublet but *with no black pigment in the cement.* Check most carefully for bubbles in the cement layer before setting to cure.

Grind, sand and polish the crystal top to cab profile but with the girdle line formed in the quartz and not in the opal. This gives a harder edge to the finished stone than would be the case if it were to be in the opal. The polished top acts as a lens which spreads the colour as well as protects the opal from wear.

Undop, redop on the polished surface and finish the back as before.




Triplets

*Precut quartz-crystal tops*

Prefinished quartz-crystal triplet tops are available in standard sizes from lapidary supply houses and rock shops. These are factory shaped and polished to a very fine finish and so profiled that the upper polished dome extends from the top, over the girdle line to a point where the opal should join, just below. Plastic and glass tops are sometimes available at cheaper prices, but these are a bad investment.

To use these tops, the procedure of triplet production must be modified from that given above.

Do not shape the sandwich beyond a superficial outline. Incline the cleaned top on to a blob of de-aired epoxy cement, again of the twenty-four-hour-cure type *without pigment*, placed at one end of the cleaned opal face of the sandwich as before. Apply slight pressure and inspect for bubbles and to see that the cement layer is parallel. Position the top to gain the best colour show. There is no need to polish either opal or the underface of the top which, it will be seen, is fine ground also. This provides a good cementing 'key'. Place it level and allow it to cure.

*Special note*

If any heat is used to accelerate the cure of the cement, make sure that it is very slight, as some brands of epoxy cement soften with heat.

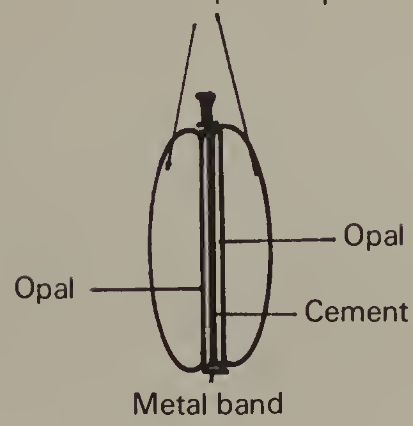
*Back finishing*

When it is cooled, grind away the projecting parts of the opal/backing sandwich. Where more than one top is set on a sandwich, separate them with a fine-bladed saw before edge grinding.

Great care must be exercised during the process to avoid touching the polished face of the quartz top with the wheel, as such spots will show through as white blemishes which must be polished out. An angle of from 45-60° is suitable for the rear slope of the edge. The use of a metal bond, sintered grinding wheel 240 diamond grit leaves a ground edge which is very acceptable. However, if it is desired, the full polishing sequence can be carried out.

*Double triplets*

A novelty use for the triplet method is the construction of a double triplet. An opal sandwich is constructed from two pieces of good colour opal rough, flatted and cemented best colour to best colour side with pigmented cement and black applied to both faces. Two identical polished quartz tops are then cemented to the outer faces which have been flatted parallel. Great care must be used to keep these tops concentric during the curing period. It is sometimes advisable to grind the double opal sandwich to the correct outline, which is the outer perimeter of the quartz tops. After cementing, a piece of cellulose tape may be placed around the four-piece stone to prevent movement of the component pieces. Care is needed to prevent included




**The double triplet (side view)**

bubbles from appearing in the cement layer. A concealing band of silver or gold complete with suspending ring fixed around the joint layer completes this unusual jewellery piece.

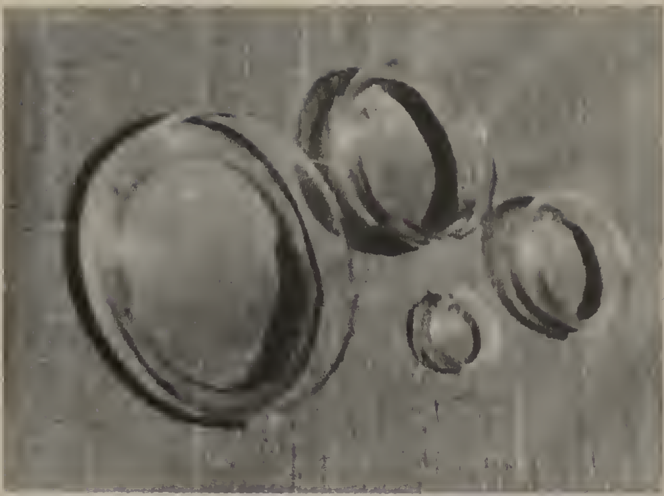
*Opal mosaic*

Opal chips of high colour may be utilised by flatting and cementing into a mosaic on a backing. When these closely fitted chips have their upper faces ground flat, the resulting composite is sawn into strips of uniform width. These strips are then sawn into perfectly square pieces which are then refitted to form a chequerboard pattern on a second thin supporting piece. The whole is then flatted and polished or covered with a polished quartz crystal piece and finished to the required shape.

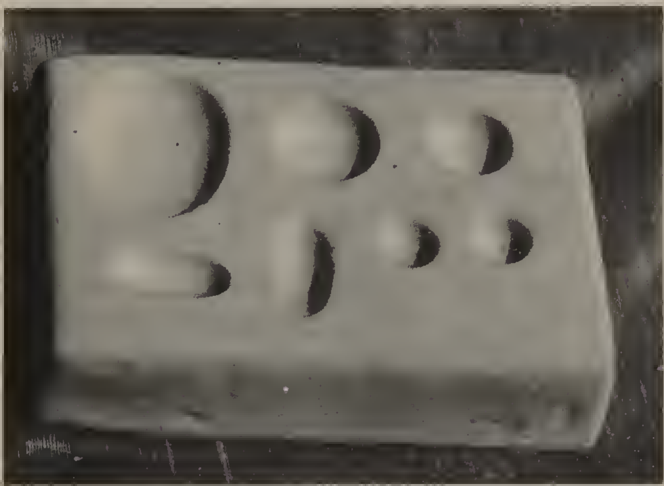
Representational mosaics are produced by painting a design in negative on the back of a quartz slab in black pigmented resin. The clear pattern areas are then covered with high-colour opal chips set in clear cement. The whole is covered from the back with pigmented cement and a cover backing which show up the colourful design sections when viewed from the front. Artists in this opal-picture painting make some very outstanding pieces and for those so inclined, further investigation and experimentation is recommended.

*Opal chip cabs*

The opal chip cab is not a cut stone. It is moulded from plastic of the polyester variety and is a very good use for the tiny chips of good colour which are sometimes collected by the 'noodler' of the mullock heaps on the opal fields and the purchaser who gains his from the rock shop. Plastic shells in standard sizes are sometimes available from the rock shops, together with the necessary plastic in liquid form to make opal chip stones.



**Plastic shells in various sizes for making opal-chip cabs.**



**A ceramic mould used in producing full-moulded opal-chip cabs.**

*Method*

The full moulding technique is begun by obtaining suitable moulds for the stones supplied by lapidary supply houses in ceramic or polythene, the latter being preferred due to its flexibility. The opal chips are selected for best colour, washed in acetone and dried. Sufficient liquid plastic is catalysed and a small portion placed into each mould cavity. The mould should be lifted and tilted to spread plastic over the whole inside face of the cab-to-be. Cover from dust and allow to gel. Mix another small amount of the plastic and place the chips into it. With tweezers, select and place several chips, depending on cavity size, on the gelled plastic in the moulds. Add a small amount of plastic to just cover the chips and eliminate any bubbles with a toothpick or something similar. Leave sufficient room in the mould to take another layer of plastic. Again cover and allow to gel. Mix the final portion of plastic with only sufficient black pigment to colour and then catalyse. Pour a layer on the gelled surface of the second pour, cover, and allow to cure. Do not be premature in pouring this last layer or it will penetrate between the mould and the already set plastic or into the second pour, which will ruin the stone.

When it is completely cured by leaving overnight, remove the stones from the mould and trim any overpour with wet-and-dry paper of about 150 grit.

Premoulded shells are used in the same way, with the exception of the first pour which the shell provides. When using shells, great care must be taken to place them so that they do not tilt out of the strict horizontal position, spilling plastic out and over the side, and ruining the high polish of the top face. Plasticine or electricians' sealing compound may be used to provide a bed on a piece of plywood into which the empty shells may be pressed; this will assist in rendering them immovable.

*Opal balls*

Another use for tiny chips is the so called 'floating opal balls'. Small balls are manufactured, together with special cementable closure pieces, which are suitable for personal adornment after a quantity of glycerine and a very small amount of bright opal chips have been sealed into them. Care must be taken not to overfill with the glycerine, otherwise variations in atmospheric temperature, to say nothing of personal warmth supplied by a wearer, could cause the ball to leak. Some patterns of ball are so shaped as to allow hermetic sealing with a flame after being filled. A hanging cap is cemented to the top for attachment to a chain or to ear-rings.

The bright finished ball owes its appearance to the optical merging of the opal and glycerine, as they both have similar refractive characteristics.

*Mixed hardness and undercutters*

Gemstones with mixed hardness minerals in their make-up or uneven hardness directions in their form are often disregarded by lapidaries because of their difficulty in polishing. They can be treated very successfully. A term applied to these materials is 'undercutters'. The polished surface of undercutters is often marred by an uneven, eggshell-like appearance and lacks the uniform and glossy finish desired. This pattern is the result of differing erosion rates of the surface due to variations in the mineral make-up. Rhodonite, nephrite, jadeite, prehnite, ironstone matrix opal, 'hard' turquoise (without spiderweb) and aragonite are a few of those stones which may be treated by the following method.

*Method A*

This procedure closely resembles that described under opal polishing. The dopped stone is rough-and-fine ground, first-and-second sanded, all in a wet state without heating of any kind. Second sanding should be carried out using a very worn 600 disc, very wet, until the surface is in a state of glaze. Final polishing is carried out preferably on a domed leather buff, or on the side of a hard felt wheel. Avoid this for rhodonite or ironstone opal.

The polish mix is composed of 25 g tin oxide, in 100 ml water, or 20 g tin oxide and 5 g Linde A in the same amount of water. A drop or two of liquid detergent is added and the mix shaken in a plastic squirt bottle. In the first instance add this to the centre section of the buff or wheel only. Apply the well scrubbed and cleaned stone to the centre of the buff at first, and then proceed to work it exactly as described for polishing opal. Use the same swiping motion, outer edge to centre, with considerable pressure. Great heat can be developed in a very short time here and spells for cooling should be allowed if a quick polish is not forthcoming. Lack of polish could be due to insufficient second sanding (prepolish) and, if in doubt, return to that stage and work up the fine gloss required. Any prolonged heating when polishing can, and will, cause selective erosion which should be avoided at all costs.

*Soft stones*

Where some stones of the softer varieties may resist all attempts to polish them with Method 'A', the following method will probably succeed.

*Method B*

Shape the problem stone using a silicon carbide wheel with a grit size of 240 or 320, or alternatively a diamond-impregnated wheel of 240 grit. First sand with a 600 grit disc and second prepolish using a very worn 600, or with diamond powder on leather 6-12 micron grade. Both should be kept very cool. The second sanded, prepolished surface should be so fine that further polishing should almost be unnecessary.

A polish buff of leather over rubber on a domed base with or without a knitted nylon fabric cover, or a hard felt wheel running at 400-500 revolutions per minute should be used. (See the following section for details of construction.)

A polish slurry of 25 g tin oxide in 100 ml water with a few drops of liquid detergent or 20 g tin oxide with 5 g Linde A in the same detergent-water mixture is placed in a squirt bottle. An alternative polish of 15 g green chrome oxide in 100 ml detergent-water mixture may also be used but the comments made before on its staining powers should be taken into consideration when deciding on its use. It is recommended that it be used on an unstitched swansdown buff 150 mm in diameter. Malachite responds particularly well to this polish. Rubber gloves are recommended for its use.

The stone under treatment is well scrubbed together with the hands and/or the gloves after the second sand/prepolish is complete. The buff is liberally wetted with the chosen polish or, in the case of the swansdown buff, gradually loaded with polish. If too much is applied too quickly the buff will not load but will throw most of it by centrifugal force. Wet the leather or felt buff beginning at the centre with the machine running.

The stone is now used to gather polish rather than being put through the regular polishing motions. The aim is to collect as much polish on the surface of the stone as possible. A very slight warming which will result from the friction helps to evaporate some of the water from the polish slurry and the loading usually proceeds quite quickly. Lay the collected polish over the stone's surface as evenly as possible and do not allow any excessive heating. Series polishing, where more than one stone is treated in sequence, will avoid overheating, as that way one is rested while the next is taken up.

Rotate the stone deliberately against the buff so that all parts are treated equally. Do not attempt to develop a polish before the stone is completely covered with the polish.

The buff will have dried out somewhat by this time. Do not rewet it with polish when the stone is coated but proceed as follows.

Begin a cautious removal of the coating using the centre of the buff at first and, with very methodical movements, treat every part of the surface, trying to cover each in one treatment. A high gloss should appear from under the coating. Do not rework any surface or the fine gloss will be eroded. If this happens recoat and repeat until the desired polish is obtained.

Do not be disappointed if the first attempt is not successful. Recharge the buff and repeat as often as it takes. Once the feel of a particular buff is experienced, it will be a fast and simple process to polish soft stones such as rhodochrosite, malachite, lapis lazuli and spiderweb turquoise.

*How to make a domed polish buff*

Obtain a metal plate 150 mm in diameter with a centre boss to fit the spindle of the polishing machine. The screw-on-type plate supplied with combination grinder-polish machines will suit admirably. As an alternative, a vee pulley of 100-mm diameter will be satisfactory.

A wooden dome of 200-mm diameter by 20 mm in thickness at its centre may be ordered from your local friendly woodturner or it may be made at home by the following method.

Take a piece of waterproof plywood of suitable dimensions and saw out a square measuring 160 mm at each side. Scribe a circle on it and drill a 3-mm hole through the centre. Saw away the wood outside the line and centre the metal disc or vee pulley on the wood block. Drill three holes through the metal disc or pulley at 120° to one another and fix the disc/pulley and wood together using 25-mm 8-gauge steel self-tapping screws. Mark the disc and the metal with indexing marks so that they may be reassembled in the same position.

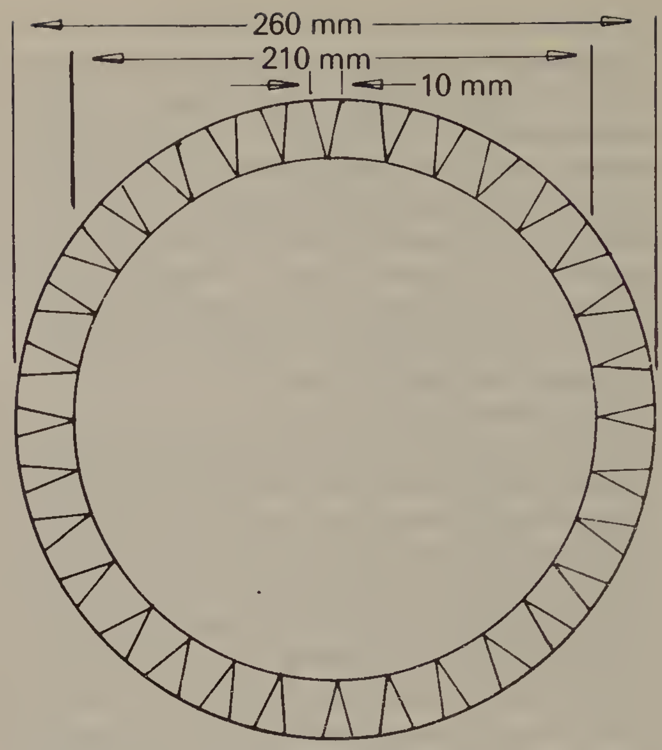
Mount the unit on the polisher shaft and set a block in front which comes to the centre of the disc. Switch on the machine and with a sharp 20-mm wood chisel, securely held and resting on the support block, gradually cut away the remaining wood outside the scribed line. Do not be in a hurry but cut away a little at a time until the circle outline is perfect. Now cut away the surface face of the disc so that a smooth, gradual, domed curve is generated. Full thickness at the centre is reduced to no less than 6 mm at the edge. When the curve is satisfactory, smooth the surface with sandpaper on a flat block held against it. When completed, switch off and remove from the shaft.

Unscrew the backing from the wood and coat the latter with two coats of shellac. Set aside to dry.

Spread a coating of rubber cement over the curved face of the wood and set aside to dry once more.

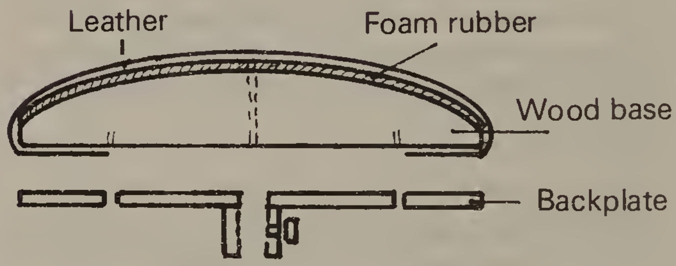
Cut a circle of 6-mm-thick foam-rubber sheet the same diameter as the wood block (10-mm plastic foam may be substituted) and coat with rubber cement and set to dry. When both cemented surfaces are touch-dry, carefully centre the rubber on the curved, cemented wood face and press a locating cut tack through its centre. Attach the two cemented faces working in a circular pattern, a little at a time, stretching the rubber as needed to obtain a wrinkle-free rubber surface. When fully attached, hammer all over to secure firmly. Remove the locating tack.

Describe two circles on a piece of 1.5-mm-thick leather (roan or split) 260 mm and 210 mm in diameter. Cut a series of vee notches 10 mm wide at the outer circle reaching to the inner. These notches must be symmetrical around the circle and to this end should be placed on diameters drawn across the circles.




Split-leather facing for domed lap

**(a) How to make a domed polished lap**




Domed polish buff (cross-section)

**(b) How to make a domed polishing buff**

Have a supply of cut tacks and a hammer at hand.

Thoroughly wet the leather and place it over the rubber-covered dome *with the flesh side out.* Centre it then press a locating tack through the top.

Stretch the leather diametrically by pulling opposite tabs around to the back of the wood and tack, lightly at first. Secure two other tabs at right angles to the first and then at 45° to those in such a manner that all are eventually fixed. Check for smoothness of the leather and if any wrinkling or loose patches are found, untack and restretch before securing again. When all is correct hammer home all tacks. Remove centring tack. Do not overlap any tabs when fixing. Try to maintain a perfectly flat back to the wood dome.

Align the index marks and fix the metal back with the screws. This operation must be carried out on a clean sheet of paper or on some place where there is no chance of contaminating what is a polishing surface. Mount on the polisher shaft.

*Fabric facings*

If it is required to use fabric surfaces for polishing, a bonnet of knitted nylon or terylene should be made by hemming a circle, making a provision for a drawstring. The material should be double or triple thickness and is used over the leather surface of the buff with the drawstrings pulled up tight and tucked away behind the disc in such a way that they cannot become loose and tangled in the shaft. It is advisable to have more than one such bonnet as they are prone to develop holes when used with diamond powder, and a standby is a must.

*Cork buffs*

Polishing of flat surfaces sometimes calls for a flat polisher and a cork-covered one will often fill the bill. Cork-compound sheet 2-3 mm thick is cemented with rubber cement to a metal disc such as that used for the domed buff construction or on the face of a Laminex-faced wood disc screwed to a vee pulley, also as above.

Other facings have been used for special purposes and lapidaries who use them report good results. Vinyl, waxed parchment and pigskin leather are among those suggested.

### *Stars and cat's eyes*

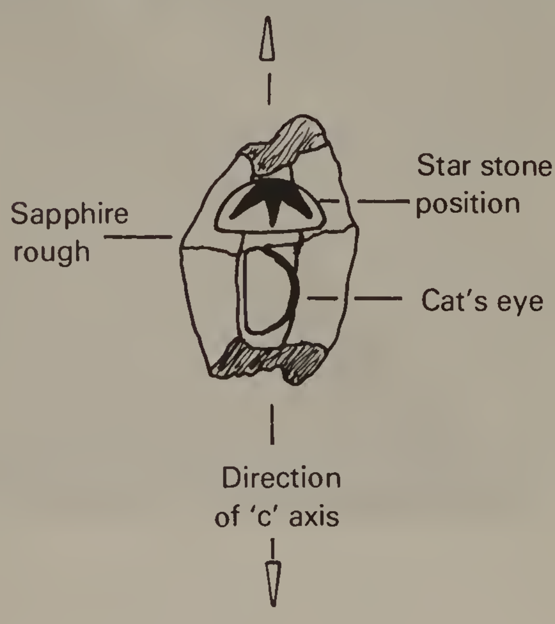
Star and cat's-eye stone-cutting and polishing require more of a special technique than a separate method. Orientation of the rough holds the secret of success or failure and practice and experience is needed to become adept.

The cause of the star and cat's-eye effect in stones is those inclusions in the crystal which reflect light. These are laid down in a particular manner in each stone type and must be first located and then placed in the correct position in the finished stone to obtain the desired effect. A little knowledge of the nature of crystal structures in gemstones is necessary for a good rate of success but a study of the diagram will give a basic understanding sufficient for practical purposes.

At first sight the inclusions may not appear to be in any order, but when closely studied under an incandescent inspection lamp, a rough stone piece oiled with baby oil will, when turned this way and that, show signs of reflections. When observed, the piece must be more closely studied to see where the best, most distinct reflection is centred. If a definite area is found, the centre must be marked with an oil pen. A turn of the stone through 180° should show a similar pattern which must also be marked. After deciding if these are primary star areas, the area should be ground to a smooth, slightly curving surface. If a star is required, take care that the reflection is not a straight line. From the diagram, it can be seen that such a show would indicate that the stone is being viewed at right angles to the one required. The piece must be turned through 90° and a fresh orientation carried out. A precaution against incorrect orientation is to observe the movement of the pattern. If it is an all-over one and it widens when turned either side of centre, a star is indicated, although some of the bronze patterned material will show no distinct rays unless domed rather high. A line pattern which moves from side to side without any widening beyond a superficial one, indicates a cat's eye.

Sapphire, garnet and quartz are rather more difficult to orient correctly than is ruby, which is more often supplied in pieces with definite crystal shape. Tiger's eye, on the other hand, needs no such crystal indication, as the eye is very obvious. For very formal eyes, straight-fibred rough should be selected, but material with crinkly fibres can give very impressive stones, particularly the blue (falcon's eye).

The star or cat's-eye stone must be cabbed with a higher dome than with regular cab cutting as the extent of the rays of the star and the




**Stars and cat's eyes**

eye slit is extended thereby. All cutting and polishing processes are the same as for regular stones. Dished diamond laps or special star cups are very quick and are designed specially for the purpose.

*Gemstone mosaic*

Tumbling and cab cutting often leave tiny pieces of unused gemstone, either from the polish barrel or the saw bench. These are often stored away in a jar for some future unknown purpose but they may be used in a most unusual way: gemstone mosaic. Embedded in plastic, they are mouldable into legs for gemstone slab-table tops or, even more unusually, they are made into gemstone pictures or mosaics.

It was the authors' privilege to receive from Roberta Herrick of Colorado, USA, an artist in mosaic gemstone, two examples of her work. Made in standard 40 mm x 30 mm oval size, they have included in their make-up, pyrite, chalcedony, agate, jasper, rose, green and milky quartz, chrysocolla in quartz, garnet and obsidian. The rose quartz, which is very pale in small pieces, is the only stone which has its colour assisted by having colour applied on the back support. This support bears the basic design and the stone builds up the picture with this as a guide. The finished pieces are surrounded with a gold foil strand.

Such creations could equally well be laid up in a metal cup of the size required, which would make them wearable as attractive jewellery.

**Hand lapping a sawn agate geode half on a large cast-iron flat lap using silicon carbide abrasive and water. This process is followed by fine grinding and then polishing on the vibrating lap.**

# The Flat Lap Machine and Lapping; hand-charging of Metal Laps

## *The Flat Lap Machine and Lapping*

A FLAT lap machine consists of a motor-driven plate which rotates or oscillates. The attitude of the plate may be either vertical or horizontal. Plates are made from many materials, among which are aluminium, cast iron, mild steel, copper, brass, gunmetal, lead, tin, tin alloys, copper alloys, wood, leather, parchment, wax, glass, felt, plastics, cloth and other combinations of these and other materials. They are used unsupported, as in the case of the metals, or mounted on another as a supporting substrate.

### *Uses*

Jobs for the flat lap vary from the roughest of grinding, such as facing a rough sawn agate, down to the super-polishing of the smallest facet on a tiny stone.

The harder metals such as cast iron, mild steel, copper, gunmetal brass and other alloys of copper are generally used for the preliminary grinding or cutting of harder gemstones (see earlier chapters).

Softer metals, tin and tin alloyed with lead and antimony (type metal), are extensively used for the manufacture of polishing laps, especially useful with sapphire but indispensable as general polishing laps.

Unscored laps of plastic are used for topaz polishing in faceting while waxed parchment is used for problem polish work on very soft faceted gems.

Grinding and facet cutting use special diamond-charged laps of copper (see following section) or commercially-produced metal-bonded types (see Chapter 1).

### *Speed*

A lap gives a very fast means of removing material from a flat face. The speed of rotation must be adjusted to the point where applied abrasive and coolant is not thrown off by centrifugal force. Of course this is not a problem with the lap with its abrasive fixed into the surface.

The freehand method of lapping where there is no mechanical means of holding the stone is very suitable for larger pieces, while in the other extreme case, faceting, the stone must be very firmly secured against undue movement. A dopped-on handle, however, is very useful for added control of even the largest pieces. Faceting, as it incorporates lapping, is considered in a later chapter.

### *Direction of rotation*

A lap may be used with the rotation towards or away from the operator. Finer control is generally found with the latter direction. Abrasive can then be fed ahead of the stone and a minimum is thrown off before it can be used.

The coolant/abrasive is fed to the lap and the stone held firmly against the rotating face. Even hand pressure is needed to prevent overcutting at the trailing edge of the stone which seems to receive more abrasion than the leading one unless extra pressure is applied here. Another characteristic which often escapes notice is that of uneven wear due to speed variation across a lap. This is particularly noticeable in larger laps. The circumference of a 250-mm-diameter lap is about 786 mm while a 150-mm circle on that lap has a circumference of about 471 mm. As the lap rotates, both of these circles rotate together and it will be quickly realised that the abrasion effected by the larger circle will be much greater than that of the smaller. A stone which covers both of these circles will be very unevenly abraded unless it is kept in constant motion across the lap face. This effect occurs with all lap sizes so the constant movement message remains for even the smallest of laps. The wear between lap and workpiece abrades both to a greater or lesser degree and, as the efficiency of the lap is dependent on its face remaining flat, any wear produced in working must be evenly distributed across the whole lap face to maintain this condition. If uneven wear occurs the lap face will have to be reconditioned (see the section on safety, care and maintenance in Chapter 14).

Rough and fine grinding laps are both the same in nature, but those for prepolishing and polishing are separate and distinct. Diligent cleaning of the machine and its surrounds must precede the fitting of any of the latter after a session of grinding. Some advantage may be gained by using foil inserts around grinding laps which are removed, with their collected abrasive, as a prelude to total cleaning before polish laps are fitted.

Large polish laps, which are sometimes of leather, are mostly slightly domed rather than flat. This allows very high polishing pressures to be applied to obtain much quicker results. The speed of polishing still rests with the preparatory work, as always, and fine sanding and pre-polishing is the key.

*The vibrator lap*

A flat lap which rotates is subject to many problems, more even than have been shown here. There is a lap which moves in a very small orbit at high frequency, which avoids some of those difficulties. It is termed a vibrating lap. Any point on its surface is caused to describe a circle of the order of 4 mm in diameter, which attempts to move stone faces resting on the lap synchronously with it. Inertia causes the stone to lag behind and abrasive slurry on the lap acts between lap plate and stone to abrade their surfaces. The metal of the lap is abraded less, being ductile, and the desired effect is obtained. Some lap plates are cut into segments on the face to facilitate abrasive movement, but the latest trend is for plain flat surfaces.

*Operation*

Sawn stone pieces are placed on the lap surface together with a water abrasive slurry of a consistency which neither splashes in operation nor sticks the pieces to the plate. Larger pieces are sometimes fitted with plastic or rubber guard rings to prevent damage between neighbours, very small pieces with little weight are set into added weight plaster 'puddings', similar to that used in sawing practice. This time the faces of the pieces are set on a plate-glass surface with petroleum jelly and the plaster is poured around and above. The faces are later cleared of plaster by cutting a shallow groove around their perimeter into the plaster. A rubber buffer band is placed around the plaster at plate level, again to prevent impact damage and deterioration of the plaster matrix.

The vibrating lap is considered faster than hand work because many pieces may be treated at the same time with a minimum of attention.

A little experience of the particular machine is necessary to obtain best results as the water/abrasive balance is quite critical and different stones react differently to lapping, just as they do to vibrator tumbling.

**A vibrating lap attachment for the 'gemmaker' horizontal-type all-purpose machine to which it is shown fitted. The dark disc below is the polishing pad.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

The vibrator lap is ideal for finishing those very large pieces such as book ends, monolithic modern gemstone sculptures and the like.

*Hand-charging of Metal Laps*

The process of charging a metal lap with diamond powder should be known and understood by the lapidary. It is a fairly simple undertaking which, once carried out, will become almost instinctive. The major aim is to obtain satisfactory impregnation, evenly distributed over the lap's surface, plus a total absence of contamination. This last problem is the biggest obstacle for the newcomer to hand charging to overcome. Hospital cleanliness is needed to eliminate the possibility of any foreign larger particles contacting a lap when charging; the realisation of the importance of this fact puts the operator well along the way to success. Failure requires that the contaminated lap be relegated to a coarser grade or the surface be machined off, both of which are wasteful and expensive.

*Charging*

*Equipment required:*

A 300-mm steel ruler or straight-edge.

A very sharp knife such as a trimming or snap-blade knife.

Spare blades.

Two tumble-polished agates about 25-mm diameter.

A piece of clean glass or mirror for each grade of diamond to be charged.

A square of chamois leather of approximately 75 mm (side measurement) for each grade.

Petroleum jelly.

A new hypodermic syringe, without needle, of 2-ml capacity. (This is obtainable from the local chemist. Avoid the rigid type, as it will split if petroleum jelly is stored in it. The more flexible polythene type is suitable. One is required for each diamond grade.)

One carat of each diamond grade.

*Method*

Cover a section of the charging table with clean newspaper and place a piece of plywood or wallboard, also covered with a few thicknesses of clean newspaper, in its centre.

Begin by charging the finest lap first. Do not have any other diamond powder on the table than the one in use. Any possibility of a speck of coarser diamond coming within the vicinity of the lap when charging is a risk for contamination.

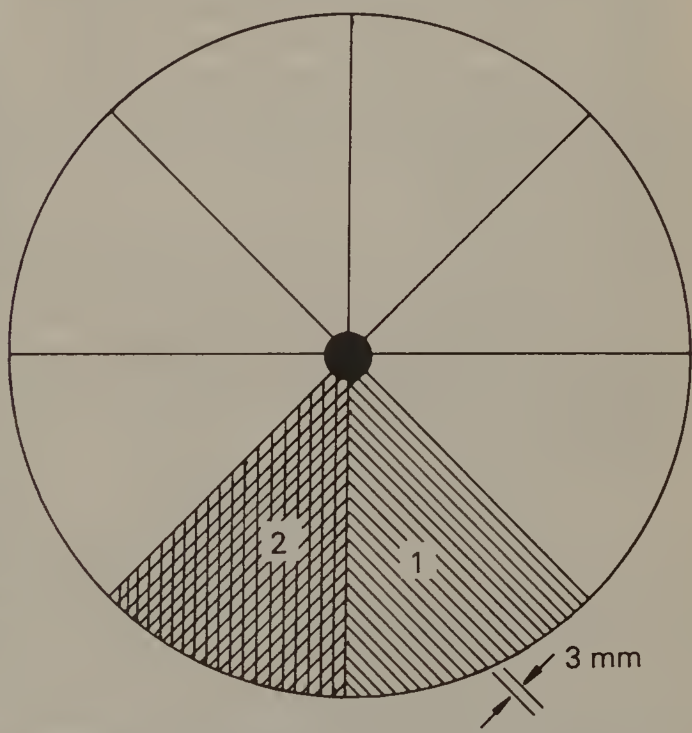
*Scoring*

Place the lap blank on the covered ply and score with the knife along the straight-edge across the diameters at right angles to one another (see diagram). Now score two more diameters, this time at 45° to the first two. Score heavily with the knife held at about 45° to the horizontal. Run the knife off the blank into the ply underneath to carry the score over the edge.

Score more lines parallel to one side of each segment in turn, progressing in a clockwise direction around the blank until all eight are filled (1). Do not extend the scoring of one segment into the adjoining one.

Now place another set of scoring parallel to the other boundary of each segment, this time moving in an anti-clockwise direction (2). The pattern should now be even all over each segment and each segment should be identical with its neighbour. Scoring is a laborious job, but it should not be done hurriedly as uniformity of depth and spacing of the scoring will make it a very easy lap to use.

**Lap scoring. An alternative method of preparing the soft metal lap for charging is by the use of a stippling wheel. A typical tin-type metal lap ready for its diamond charge is shown together with the wheel.**




Scoring of metal lap for diamond charging

*Charging*

*N.B.* The quantities quoted here are for a 150-mm lap. Laps of 200 mm should have double quantity. Draw a quantity of petroleum jelly into the syringe to the 2-ml mark and press this out onto the cleaned glass. Place one carat of diamond powder alongside it and mix thoroughly with a flexible knife or a painter's palette knife. Replace the mix into the syringe with the knife-blade tip. Insert the plunger end and expel excess air. Mark the grade clearly on the syringe barrel with an oil pen. Avoid water-soluble pens as if the syringe is often handled with wet hands they will obliterate the identification.

Thoroughly clean off the glass surface, finishing with methylated spirits. Store in a clean plastic bag, marked for identification.

Warm the lap briefly on a hotplate or over a flame and replace it on the plywood.

Press out about 0.2 ml of the compound into the centre of each of the eight segments and then, with the leather, spread it over its own segment area with a circular motion. Resist the urge to do this work with the fingertips, which would seem to be simpler, as the scored metal is extremely sharp. Ensure that the scoring of all segments is filled with compound.

Take a polished agate and, beginning at the outer edge, burnish the whole lap surface so that the scored lines are closed over the diamond compound. Use only moderate pressure as the aim is to leave a slightly raised edge to each scored line. Place the lap on the machine and switch on at low speed. Continue the burnishing again from the outer edge to the centre. Wipe off the lap with the leather, then store. The leather and the burnishing stone should be stored in a clean plastic bag for future use.

*A word of warning*

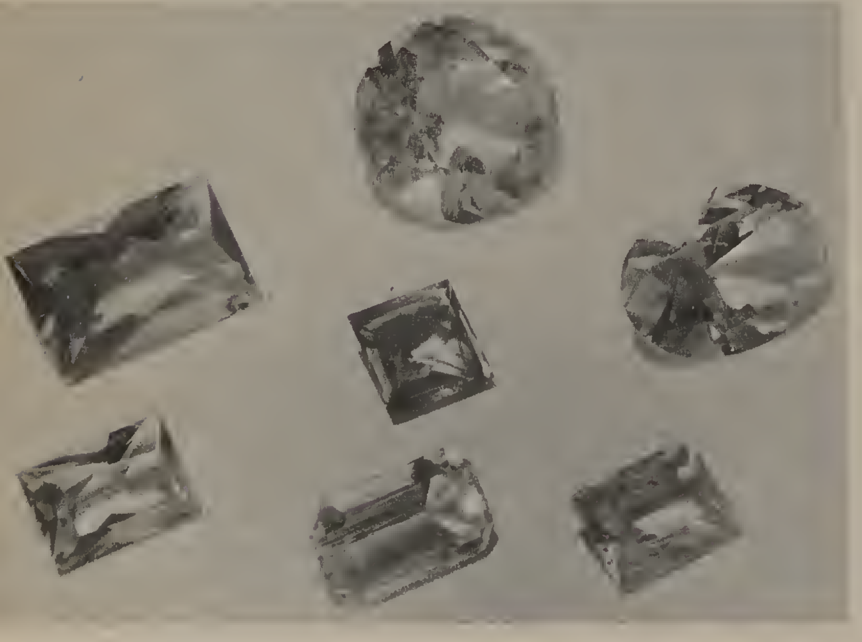
Burnishing of laps may be carried out by the use of steel rollers or ball races. Diamond will embed itself in any metal to a certain degree and it has been found in practice that an appreciable amount of the diamond used to charge a lap is lost to steel rollers. If such rollers are used, it is essential that they be segregated and kept for the charging of only one grade of diamond. A separate one is necessary for each grade handled. Agate, on the other hand, does not retain any powder except that which sticks to its surface, but even it should be kept only to its own grade.

The charged lap is now ready for use.

When a series of laps is to be charged, the paper table and scoring-board covers must be discarded and replaced before proceeding from one lap to the next.

*Soft metal laps*

Tin and tin alloy laps (type metal) are easily deformed by excessive burnishing pressures. The largest burnisher area is desirable for an even polishing surface. A large, sawn, flat agate piece about 35 mm x 15 mm on the face, which has had its corners rounded on the fine grinder before fine sanding, or a full half-boule of synthetic corundum, makes an ideal burnisher. The polishing surface should be kept as flat as possible as any slight irregularity could develop into the start of a 'tracking' defect which will mar any polish. 'Tracking' is evidenced by lines in the polish suddenly appearing just when optimum surface is reached. Correction of the lap is the only way to eliminate this annoying happening and reburnishing will do this. Left uncorrected, it will require the lap to be rescored and charged or, if very bad, the surface of the lap may have to be skimmed in a lathe and recharged as a new one.



**Left: Some of the shapes and patterns of cut which may be executed with the faceting machine.** *(Photo by courtesy of Rytime Robilt Pty Ltd, Melbourne.)*

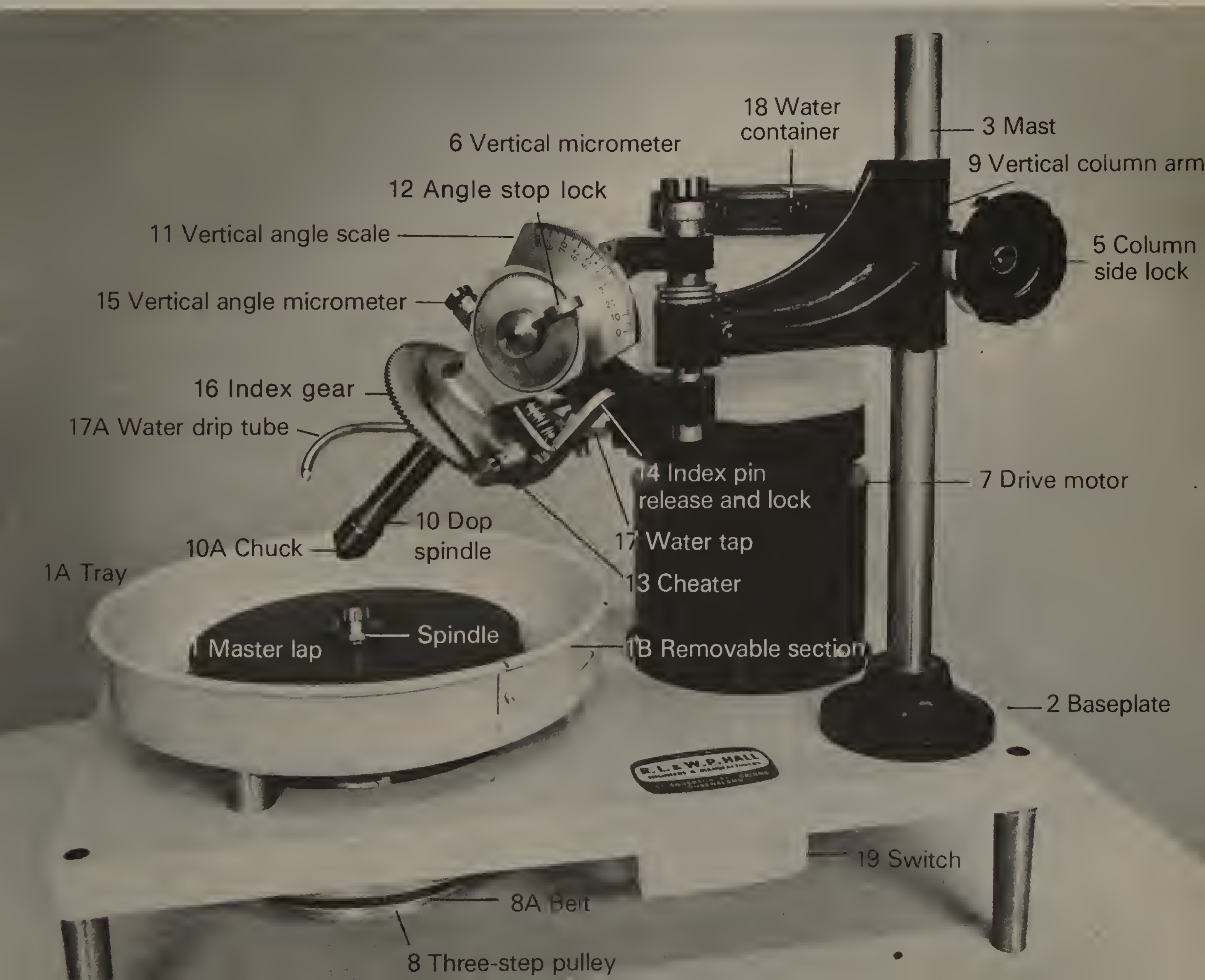
**Right: A typical modern faceting unit with all parts labelled. The various features of this particular machine are to be found on most others although they may be applied in slightly different ways or places.** *(Photo by courtesy of Halls, Cairns, Queensland.)*

# Faceting

SYMMETRICAL FACETING of gems began during the sixteenth century and since that time more ways and means have evolved to aid the lapidary. Commercial faceting has been purely a matter of expertise and personal skill and has been handed down over the generations until today. Methods of the past still persist in professional circles, but the emergence of the needs of the hobby gemcutter who has no task-master in the shape of commercial demand, has brought forth an eruption of technical and technological development to enable him to gain greater use from his leisure time. Evidence of this development is visible in the great assortment of fine machines in rockshops and lapidary supply houses.

Some of the faceting machines offered are based on the old hand-work concepts, while others are very accurate mechanical dividing heads which give fine results to the most inexperienced, so long as they follow certain rules. This built-in skill can be developed to enable the dedicated cutter to become as much of an expert as his professional counterpart. The illustration shown here is of a typical machine of the indexed dividing head variety and while it may not strictly conform to the layout of all others, it has those parts necessary for ease of working and delivery of fine professional work.

The faceting machine consists of a substantial baseplate (2) which has a vertical spindle carrying the master lap (1) set in it truly at right



angles. The lap/spindle is surrounded by a drained tray (1A) which has a removable section (1B) in its rim to allow access for preforming and girdle polishing. The baseplate also carries the motor drive (7) which projects through it and the control switch (19) which is underneath, away from possible splashes. The motor shaft is fitted with a three-step pulley (8) which drives an identical one at the end of the lower end of the vertical spindle by a drive belt (8A). A container for coolant (18) with its control cock (17) and drip tube (17A) is mounted above the motor in such a manner as to allow coolant to be used anywhere on the lap surface. A vertical mast (3) is fixed on the baseplate precisely at right angles and parallel to the vertical spindle. A vertical column arm (9) and column slide lock (5) slide up or down the mast to set the head assembly at approximate height while fine height control is obtained by means of the vertical micrometer (6). Fine, repeatable settings are possible by means of the micrometer drum which is calibrated.

The head assembly consists of the following individual parts and controls:

The dop spindle, or quill (10). Keyed dopsticks fit into the spindle and are secured by the locking chuck (10A).

The vertical angle scale (11) and angle stop and lock (12).

The vertical angle is set and locked by these two and the final fine adjustment obtained with the micrometer (15).

The index gear (16) is a wheel with a number of teeth around the rim. This number may be a multiple of two, three, five or in some cases, specific numbers to suit a particular pattern.

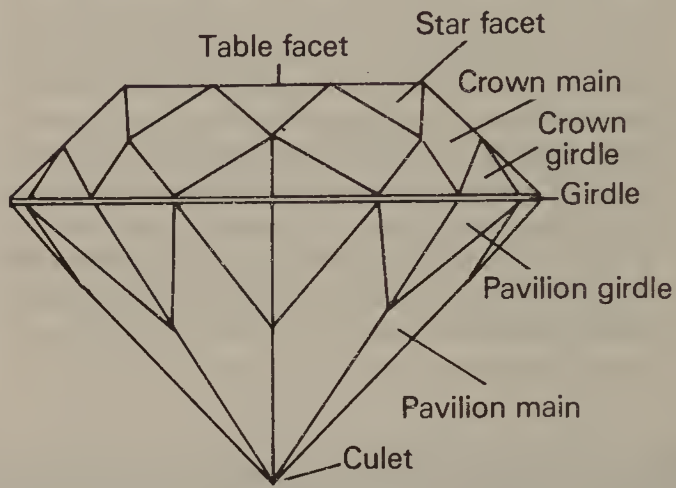
It controls the horizontal rotation position of the stone at any time and is set by the index pin (14) which is mounted on the release and lock lever. The index pin may be locked out when disengaged from the index gear. This allows the spindle to rotate freely (freewheel) for preforming, girdle cutting and polishing.

The cheater (13) gives fine horizontal control to the index gear. It is calibrated to allow repeat settings to be made. A dial gauge is sometimes fitted to the vertical angle movement which makes facet matching and accurate repetition very easy.

### *Faceting a Standard Round Brilliant*

#### *Recording*

It is necessary in all facet cutting and polishing to make a written record of the angles, indexing and settings to allow correct repetition on subsequent processing. Do not use abbreviations or depend on memory. Many a half-faceted gem has been redesigned because of unintelligible shorthand or a lapse of memory. Work out a convenient progress sheet which is easy for you as a lapidary to use. Do not include unnecessary details, just note the height micrometer, the vertical angle and indexing. Draw out a number of standard sheets once the procedure has been established by cutting and polishing a few stones. These sheets will gradually accumulate to become very good references for occasions when similar-size stones are required.

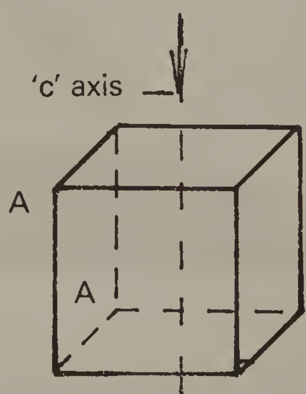



**Parts of the standard brilliant**

#### *Preforming*

Select a perfect piece of crystal quartz, having an eye to clarity, size and absence of inclusions. Examine it carefully with a glass 10X, both externally and internally, and decide whether the size of the desired gem will fit. Use calipers for this purpose as 'guesstimation' can cause disappointment later on.

For the purpose of this exercise it is proposed that the stone finish as a 10-mm-diameter round standard brilliant, so the blank preform piece must be approximately 12 mm cubed. Saw the piece to this size and flat off the future table




Oriented rough sawn to shape

**Preforming**

facet on the grinding lap which may be of cast iron or copper without scoring, or of diamond-impregnated copper or a similar sintered one. If the first type is used, apply 240 grit silicon carbide in water as abrasive. This flatted area is the plane about which the stone will be cut. Lap it to a fine and uniform finish.

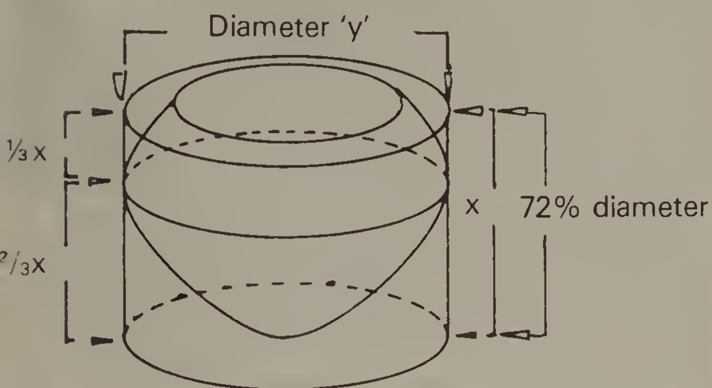
### *Proportions*

Before proceeding to final rounding and calibrating, we must examine proportions.

The total depth of a stone cut from quartz — table to culet — is approximately 72% of its diameter. The depth/diameter of various stones varies as does the refractive index of their substance. Angles for cutting set down in the tables in Appendix I are arrived at by consideration of these constants.

The height of the crown above the girdle line varies between 20-30% of the total height of the stone. A line to define the proposed girdle line is drawn around the preform when it is rounded out. This gives guidance when cutting the facets.

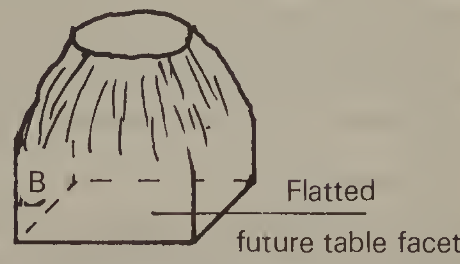
A round brilliant of our dimensions requires the preform to be 10.5 mm in diameter. Its height will therefore need to be approximately 8 mm (72% of the diameter). The girdle line will be marked at 2.5 mm down from the table flat (33%).



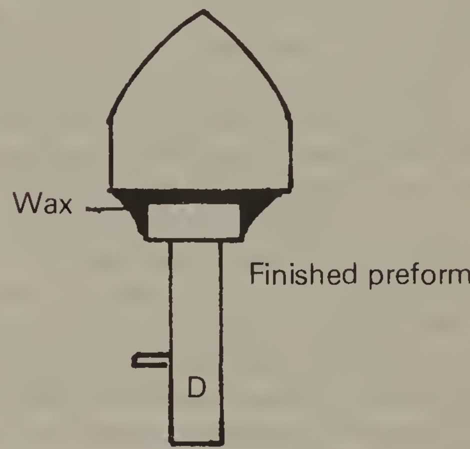

Proportions

### *Shaping and calibrating*

Shape the flatted blank corners to a preliminary outline by means of the trim saw and/or grinder 'B'. The final back preform outline is required to be similar to 'D' in the diagram. The preform for a round brilliant has been described as a prosperous turnip-shape with curving sides. An aid to obtaining this shape very rapidly can be found in one of the battery-powered, slow-revving portable drills. The roughly shaped preform is dopped on the table flat when it becomes recognisable as roughly cylindrical. The dopstick is chucked in the drill and, with the grinder switched on, the drill and stone are applied to the wheel face at a suitable angle to develop the desired outline, 'C'.




Sawn or rough crystal section




Shaping

### *Special note*

When dopping for faceting, be very thorough and do not skip stages or shortcut any operation. Faceting requires good attachment of the stone

**Dopping gear for faceting. Left to right: powder wax, dop stove and lamp with stick and stones heating, insulated dopstick handle and dopsticks in stand.**

and dopstick as the processes are much more prolonged than in cabbing and stresses not encountered before are routine happenings. Pay particular attention to the close fitting of the dopstick and stone faces. A minimum of wax is required to ensure a good joint. Both should be parallel and there must be a filet of wax around the perimeter of the stick and stone joint.

*Final shaping*

If this stage is to be carried out on the faceting machine, chuck up the dopped stone in the spindle and lock.

Lower the head with the vertical angle set at 90°. Adjust the height so that the stone just touches the lap and turn on. Set the index at 64 and grind a small flat on the stone. Continue this action, grinding at all principal index points around the stone, noting that every index setting causes some grinding to take place. If it does not, lower the head a little and repeat. This is the slowest of the preforming stages.

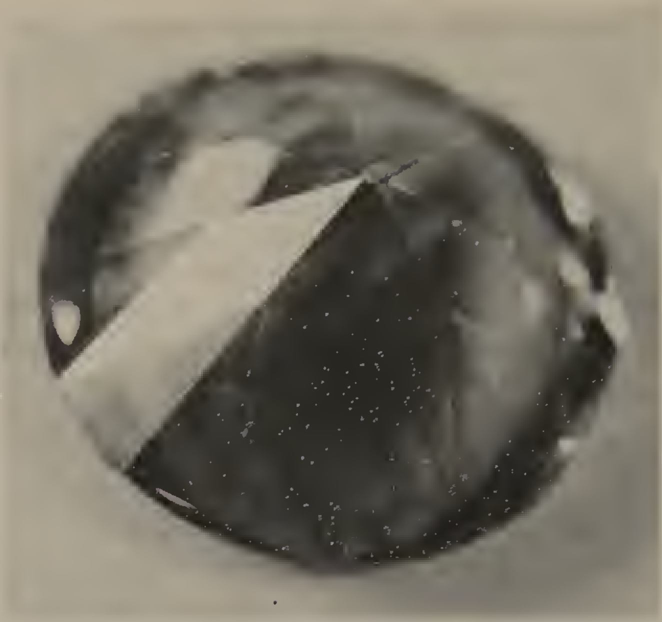
When there is a continuance of flats around the stone, release the index pin and lock it out. Now, with the spindle 'freewheeling', rotate the stone on the running lap with copious coolant until the stone is perfectly round without any girdle imperfections.

Mark the girdle line with a metal pencil at the required 2.5 mm from the table and continue it around the stone.

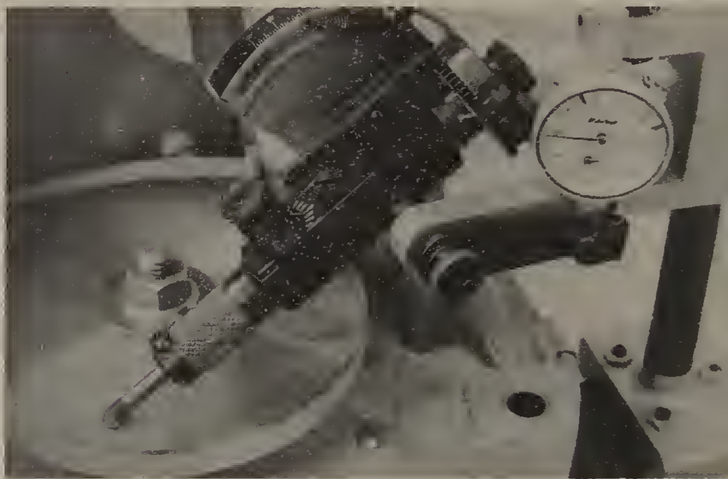
*Pavilion mains*

Raise the head on the mast to a point where the stone just touches the lap, with the vertical angle set at 43°. Release the index-pin lock and set at 64. Set the machine-speed range to medium, switch on and adjust the water drip. Lower the stone by means of the vertical height micrometer until the stone is grinding. Hold the dopstick close to the stone and exert only as much pressure as is needed to obtain a smooth grinding action. Do not press down on the stone to an excessive degree as this will cause 'loading' of the lap surface which is similar to 'crowding' (see Chapter 2). A short period of practice will familiarise the lapidary with the amount of pressure required.

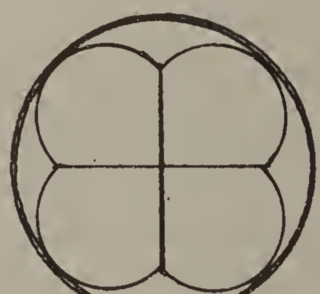
Downward adjustment will be necessary as grinding proceeds and should be continued until the first facet approaches the marked line. When just to the line, check the vertical angle for accuracy and then set the index to 32 and repeat the process on the other side of the stone. The upper junction of these first two facets will be the culet or back extremity of the stone. When completed, reindex and grind at 16 and



**A completed pavilion main formed between two girdle facets which must meet at a point equidistant from the girdle.**



**A preformed stone dopped on to a metal dopstick and fitted into a typical facet head. The vertical angle scale may be seen at top centre. The dial gauge gives extremely fine control on degree of cut. The index wheel and release and lock lever controls the rotational position of the stone. The cheater knob is at the centre of picture.**



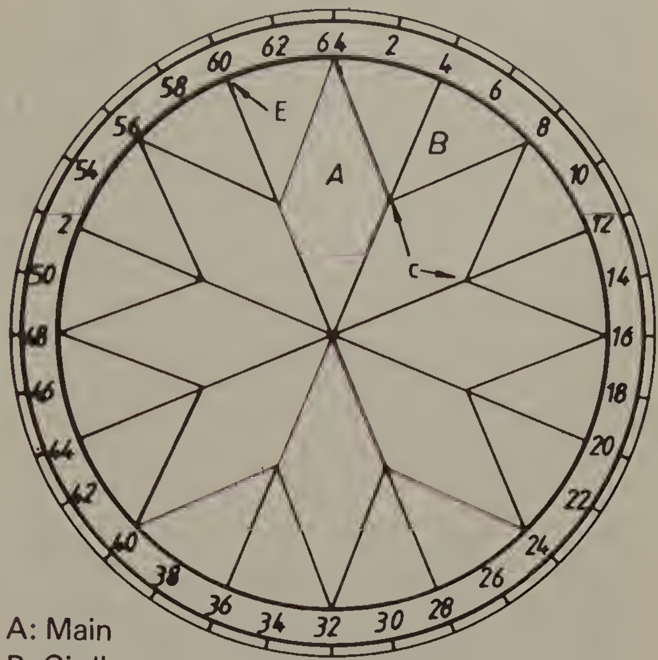
Four first facets

Pavilion mains (first cuts)

then at 48, cutting down to the line in each case. The stone pavilion is now quartered.

Repeat this procedure, this time with indexing at 8 and 40, 24 and 56. These eight facets are the pavilion mains. Remember to record all height, angle and index settings.

Girdle and main facet indexing and junctions




*Pavilion girdle facets*

Reset the vertical angle to 45 and the index to 62. All facets must be uniform in size and evenly ground to meet at the same distance from the girdle line, point C.

The first facet is ground so that it extends along the girdle line to a point halfway across the already ground main at E. When the second facet is grinding, a line will develop between the first and second facet at one end while the other will come to the centre of the other adjoining main, or slightly over that point. This second facet is cut with an index of 2.

All girdle facets are cut with an index setting each side of the main index thus: 62-2, 6-10, 14-18, 22-26, 30-34, 38-42, 46-50, 54-58.

All facets of a group must be identical and a simple way to achieve this is to practise a counting routine when cutting or polishing. Begin a slow count when placing the stone down and end on lift off. In this way a reasonably accurate lap contact period will be allowed each and every facet in turn.

**Pavilion girdle facets of a cut stone showing overcut on the right-hand one.**

**The overcut corrected to bring the junction between the two facets to a point.**

A thorough clean-up of stone and machine surrounds is now essential before proceeding to the next step.

*Prepolish and polish*

Grinding the facets with a sintered-metal diamond lap will make a prepolish stage unnecessary, as it produces a very fine finish when used at the correct speed with a good coolant containing soluble oil. A polishing lap of tin/type metal hand-charged with diamond of ½/3 grade will rapidly produce a fine polish on most stones straight from the grinding lap.

Regular prepolishing will be described, as the polish stage is identical whether executed after or without a prepolish.

Replace the grinding lap with one charged with diamond powder 8/12 micron grade. Reverse the procedure used for grinding and prepolish all facets, indexing according to the recorded settings.

Check most carefully that the level of the lap will allow the facet to be treated to make a full-faced parallel contact before switching on. Any slight difference in thickness of laps will require a slight adjustment up or down with the vertical micrometer. Put petroleum jelly on the facet and set down on the stationary lap where the imprint left will show how the facet contacts it.

*Polishing*

Remove the prepolish lap and clean up. Place the polish lap in place. If prepolishing has been faithfully carried out, all facets in each group should be even in size and glazed in appearance. This appearance will require a minimum of polishing. Polishing allows the adjustment to the junctions of facets with each other or the girdle, should this be necessary. If other than diamond is used as polish, it must be applied to the lap at regular intervals — but sparingly. An oversupply can cause 'tracking' (see Chapter 9).

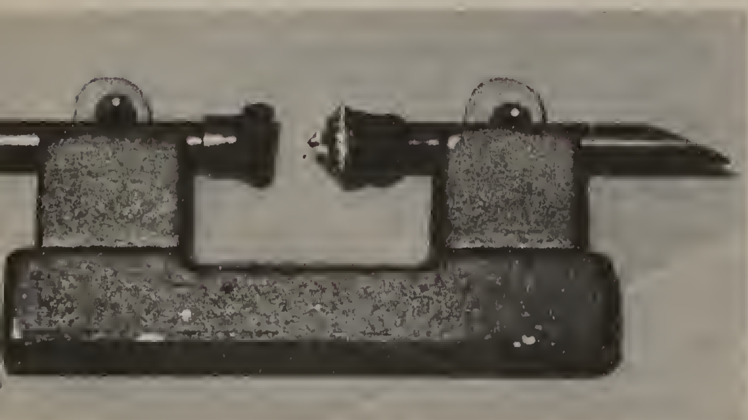
When making first contact with the polish lap with a facet, just touch the facet to the lap and instantly lift off. Too high is indicated if the culet end of the facet shows polish while the other end indicates too low. Adjust, index the next facet in line and test again. Adopt a policy of '1% cut, 99% look' in all faceting operations. No small facet can stand repeated testing without being overcut. Those facets with partially polished areas can be corrected when all others are satisfactory. When the two groups of facets are fully polished, it is time to transfer.

*Transferring*

Transferring the half-finished gem to a second dopstick is probably one of the two most critical operations in faceting, the other being the first dopping. It is a dopping process, but it is not included under dopping as it is peculiarly reserved to the faceted stone. Accurate transferring guarantees correct shape in the gem with no taper in the girdle line and consequent lean in the gem.

Meticulous attention to every step is also most necessary to eliminate any possibility of the stone moving out of position during transferring or detaching during later stages.

Remove the stone and stick from the chuck and thoroughly clean the polished face and surrounds with methylated spirits.



**A half-finished stone with all pavilion facets polished, set in the jig ready for transfer.**

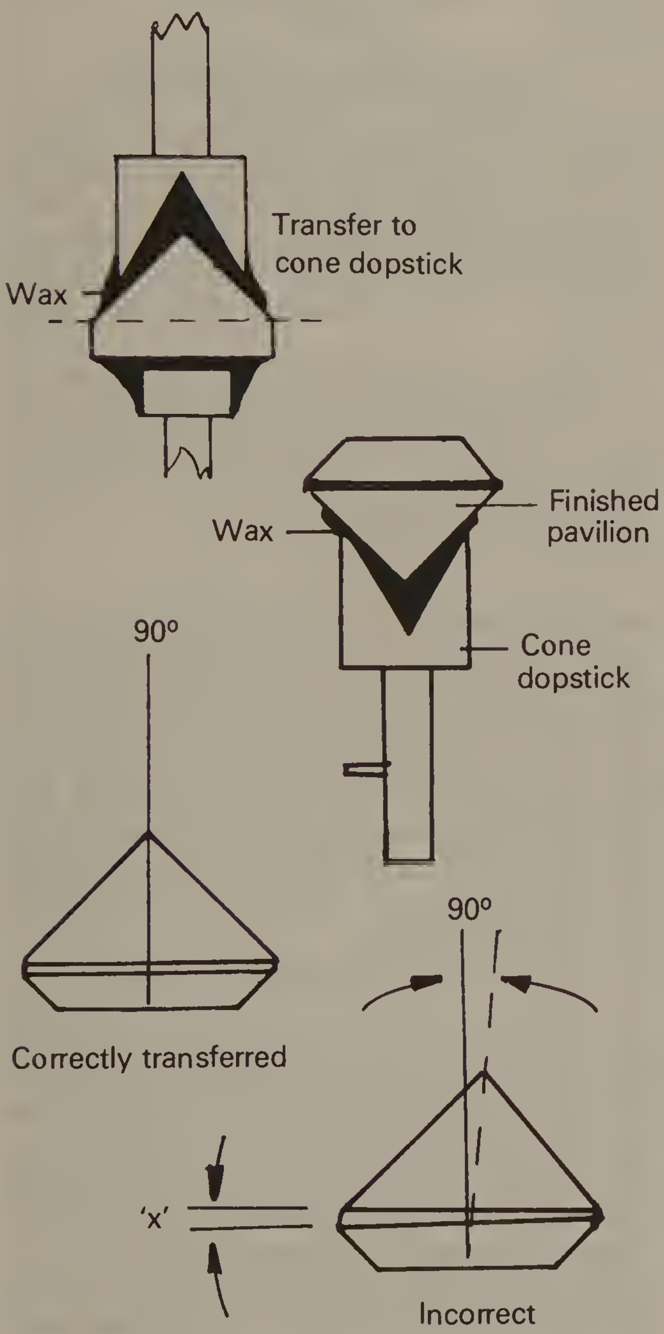
**The waxed dopstick pressed into contact with the finished face of the stone in preparation for redopping. Note the angled end of the stick which ensures correct orientation of the stone when replaced in the head of this particular faceting machine.**

The transfer block or (jig) consists basically of two slotted blocks aligned correctly with one another, set on a common base. Clamp the stone and stick into one of the slotted blocks. Take a cone dopstick of 8-mm diameter and clean it thoroughly with methylated spirits. It is advisable to clean even brand-new sticks, as there may be a film of oil on the surface which would impair the bond of wax and stick. Dip briefly into dop paint and then into powdered wax. See that the wax covers well and then heat until the wax 'wets' on without any gaps of bare metal. Check for penetration by the wax to the very bottom of the cone by probing with a sharp point. Lightly clamp into the second block and press into contact with the polished face of the stone. Now withdraw it from contact with the stone and reheat by manipulating in the flame of the lamp until the wax is fluid once more. Press back to contact the stone and lock up tightly. Continue heating the new stick head until the wax 'wets' on the surface of the stone and stick. Undue heating of the original dopping may be minimised by holding the block with the new cone stick uppermost in a vertical attitude. The heat will concentrate in it while still allowing the stone to receive enough heat for good adhesion.

When all appears as required, set aside to cool. Now take the stone, complete with the two dopsticks, out of the block and slightly warm the old dopstick in the flame until it can be 'bent' away from the table surface of the stone. Do not heat too much or the second dopping may also come away which would ruin the transfer. Caution with all heat!

Clean any adhering wax from the top of the stone with a sharp knife, taking care not to chip the stone edge. Check for correct alignment of the stone by inspecting through the wet table where a clear ring of metal, the top edge of the cone, should be visible, concentric with the stone's outline. If this ring is out of place, it will be necessary to reheat and correct it. Place the stone and stick back in the block and with a large flat dopstick in the other end, heat while pressing the two sticks together. As soon as the wax softens, the stone should assume the correct position. Maintain pressure until cool and again inspect.

In transferring procedures the use of a tiny hand torch, available from rock shops, is preferable in the delicate transferring operation to the regular spirit lamp; however, it is in no way essential. The author has an old lamp which has done good service for just on twenty years and still works well.




**Transferring**

*Crown cutting*

Reinsert the new stick and stone into the chuck and lock up. A locating method to ensure correct alignment of the stone is fitted to most machines but, should this not be the case, an orienting mark should be made on the girdle of the stone to allow correct positioning.

*Special note*

Much is written and many devices made and sold for the purpose of crown and pavilion alignment, but once the faceter has fully grasped and practised the conventional cutting and polishing rules he may find it interesting to flout the conventions and experiment by cutting a stone with top and back out of 'correct' alignment by a ¼-½ of a girdle facet. This may take a little application on the part of the faceter to achieve if the transfer block makes it impossible. Indexing must be adjusted to obtain the required rotation. Many brilliant stones, particularly those in material with high dispersion, e.g. YAG, have come from the authors' workshop, cut with this deliberate 'error'.

*Crown mains*

Begin by setting the vertical angle stop at 42 and the index at 64. Lower the stone to contact the rotating lap and make a preliminary cut. Stop within a millimetre or so of the line and inspect. Continue cutting down, adjusting the vertical micrometer as necessary until the facet is 0.75 mm from the line. Proceed around the stone with opposite cuts at 64-32, 16-48, 8-40 and 24-56. This opposite method of cutting should be practised until proficiency is gained to

**A part-completed crown main facet. When finished, the girdle end of the facet will be extended right to the girdle.**

the point where all facets are uniform in size. Then, and only then, should continuous 'around the stone' cutting be attempted. The latter method of cutting saves a great deal of time and, as the grinding of facets is only a preliminary process, it should not become an unduly irksome one by consuming important time.

All main facets must be uniform in size and when this is so, proceed to the girdles.

*Crown girdles*

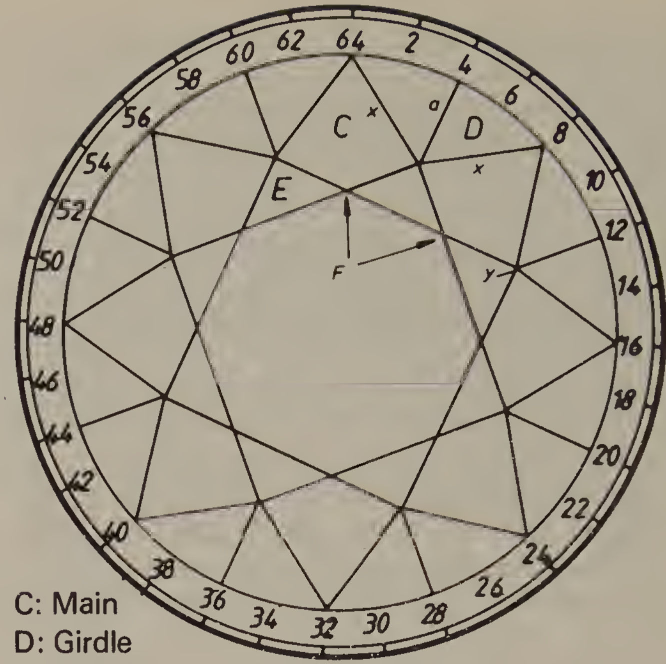
Increase the vertical angle to 46 and set the index at 2.

Girdle facet-cutting on the crown is probably the most critical and detailed of all processes on the stone. Great attention must be paid to the placement and extent of the first of each pair of facets, but the degree of cut of it is most important.

Lower the stone to just touch the lap and inspect. The facet should be showing from the girdle up towards the table. When fully cut the facet should extend slightly more than halfway across the adjoining main at the girdle.

Index 6 and repeat the operation. The intersection of the two facets must be the straight line (a) shown on the diagram and the length of the common sides of main and girdle facets (x) equal. The girdle thickness, that is the distance between crown and pavilion girdle facets, should now be no less than 0.5 mm. This is ideal for a 10-mm stone, and will allow polishing of the girdle without fear of crumbling or chipping. If it is more than required, lower the vertical

**Another crown facet in a semi-finished state. With the final polishing of the main facets, the girdle facet will lose its four-sided appearance and assume its required three-sided shape.**




**Crown indexing and junctions**

micrometer and recut very carefully. If too thin, it will be necessary to recalibrate the stone by cutting the outline ever so slightly at vertical angle 90 until the necessary width is obtained. Very little cutting will be necessary but it should be done before proceeding with the facet cutting.

Continue generation of the girdle facets around the stone, indexing at 10-14, 18-22, 26-30, 34-38, 42-46, 50-54 and 58-62. Inspect the girdle for uniformity and touch up any facets which may be out of line.

*Star facets*

Star facets are of such a small area when compared with mains and girdles that the author has often 'polished' them in rather than having cut and then polished. This is a time-saving and practical procedure so long as star angles are known and no experimenting is necessary. Remove the cutting lap, clean up generally and put the prepolish lap in place. This is a hand-charged diamond lap made with micron grade 8-12 powder in copper.

Set the vertical angle to 27 and the index at 4.

*Special note*

The actual angle of the star facets will need to be adjusted to obtain a satisfactory shape. This angle depends on the ratio of the crown to the overall height of the stone. A low crown will need a different angle to one which is higher. A little experimentation is both necessary and beneficial when first becoming familiar with faceting procedures. The above figures are suitable for a 33% crown.

Set the stone down on the lap with caution and immediately lift and inspect. The facet must not extend beyond the halfway mark along the table facet/main junction (F) or more than one-third down the main junction line towards the girdle (y). Proceed with caution and if the machine is fitted with a dial gauge, set the indicator just short of the required point to allow for later polishing.

Index 4-36, 20-52, 12-44 and 28-60. Now go over the mains and girdles using the recording settings.

When prepolishing the mains a slight undercut of facets can be allowed. This will show as short 'joint lines' between girdle facets at the girdle end. These will be eliminated with the final polishing.

*Final polishing*

Clean up the lap and remove it to store. Clean stone dopstick and the surrounds of the machine before fitting the polish lap. Adjust the vertical micrometer if needed to place the first facet precisely flat and in allover contact with the lap (see section 'polishing' for contact test). The facets are polished in reverse order to that in which they are cut and prepolished, i.e. girdles, mains and then stars.

If other than a diamond polish lap is used it will be necessary to feed polish as a slurry to the surface from time to time by placing a small quantity on the inner area of the lap from where it can be picked up with the stone. Movement of the stone across the polishing face in an irregular manner is essential to obviate any possibility of 'tracking' (see Chapter 9). Carry out the counting procedure suggested in the section 'Pavilion girdle facets' earlier in this Chapter to keep facets uniform.

Polish girdles using recorded settings and then the mains. With these facets, continue polishing until the 'joint lines' mentioned above recede to the girdle edge and perfect junctions show all round.

*Table facet polishing*

Remove stick and stone from the chuck and replace with the 45° angle holder. Insert the stone and stick into it and adjust as necessary to achieve perfect parallel contact with the lap as in section 'polishing', with the vertical angle set accurately at 45.

In all processes of prepolish and polish, a small amount of material is removed and the height of the facet face is raised above the lap. Some adjustment is therefore most necessary if the facet under treatment is to be maintained with a perfectly flat face. Polish the table facet until perfect in every regard. Experience is the only teacher of 'how much' and 'when' adjustment of the micrometer is required.

*The cheater*

This adjustment facility is sometimes required to assist in obtaining a perfect contact between lap and facet, but in stones of less than 10 mm in diameter, its use should be kept to a minimum. The action of the cheater is a micro-adjustment of the index setting.

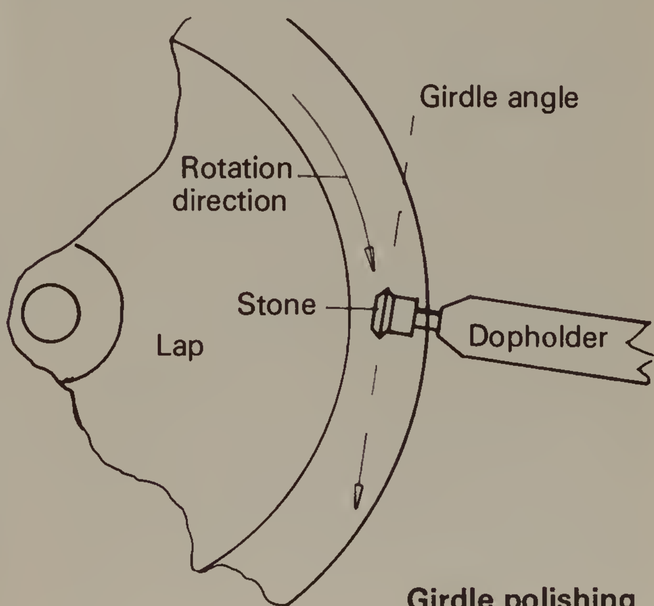
*Star facet polishing*

If the star facets have been left until now for 'polishing in' as previously suggested, they can be developed and polished in one operation by means of a lap charged with diamond powder ½/3 micron grade. This has a far greater stock-removing power than finer grades, but still produces a fine and commercially acceptable finish. Its use also gives greater control over star facet shape and removes the possibility of overcutting to a significant degree.

*Finishing*

All of the facets of the brilliant have now been fully treated and the only remaining procedure is an optional one — girdle polishing. It is not considered necessary by some lapidaries but from the point of view of an exhibition stone it should be carried out. Coloured stones demand it.

The still-dopped stone, set in an insulated handle, is held with the dopstick held parallel to the plane of the lap and the girdle edge just touching the outer charged surface of it, but with the plane of the girdle at a tangent to the perimeter of the lap. The active surface of the




**Girdle polishing**

lap approaches the stone slightly from one side and not parallel to the girdle. A prepolish lap 8-12 grade, or a plastic-bonded diamond 800 mesh lap are both very good for the purpose.

Rotate the stone during girdle polishing in a very steady manner. Do not leave it in contact with the lap, which continues to polish, while a new grip is sought. Develop a hold on the stick which will allow a steady sweeping motion which will cover the full perimeter in two or three movements. Use only such pressure as is necessary to develop a polish in one or two revolutions of the stone.

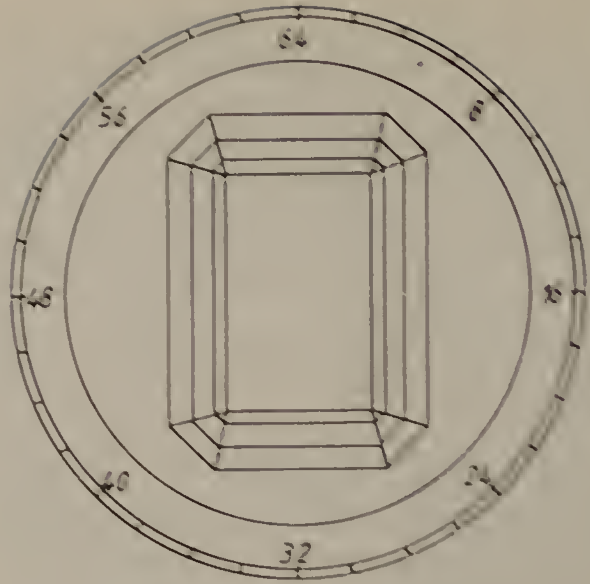
*Alternate treatment of the girdle*

Some very complex solutions to girdle polishing have been evolved among which are those calling for the polishing of tiny facets around the periphery of the stone where they are placed at an angle of 90°. The number varies from pattern to pattern and may coincide in size with the girdle facets or be cut to a multiple of their number. It is doubtful if such extra facets add to the look of a gem but they certainly do add to the difficulties of the setter.

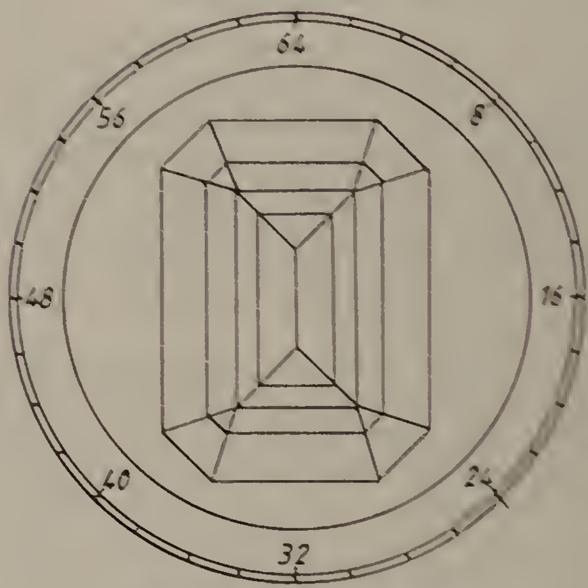
*Other patterns for stones*

The foregoing description will allow the new faceter a reasonable chance to cut and polish his first brilliant. With a little further diligent practice the lapidary will become familiar with the traps for the unwary which abound for the inattentive or careless and how best to avoid them. The finished stone is only as highly finished as the operator requires, so it is entirely in the hands (and eyes) of the lapidary to produce fine, acceptable gems.

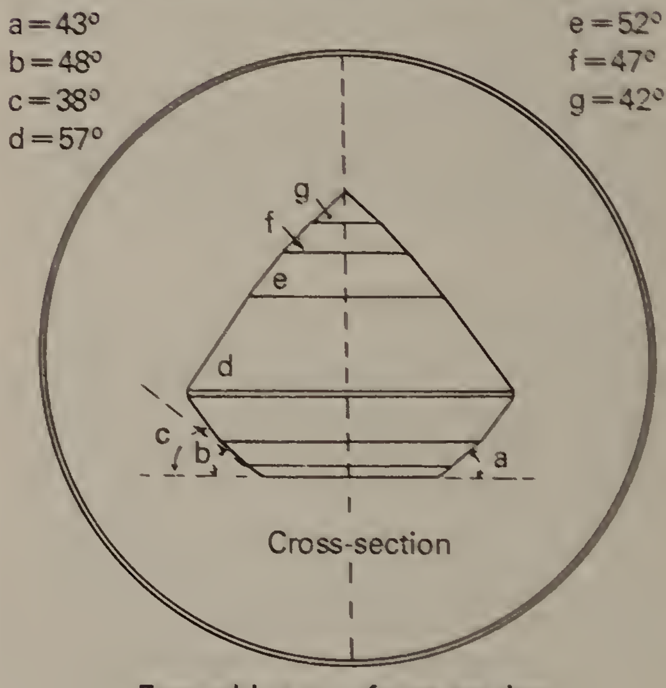
Upon completion of the first stone it will be readily understood that the only difference between the production of a round stone and any other shape or design, is the arrangement of the preform shape and the shape and angles of facets placed on it. Lack of space in this book prevents the inclusion of many stone patterns but the basics for the octagon or emerald cut are included with angles and indexing. This would be a good exercise to pursue once the brilliant is fully familiar. The reader is advised to consult one of the specialised faceting pattern books available from local book or rock shops. The proprietor of a rock shop will probably be a practised and practical faceter in many instances, most happy to advise on which book will suit or even willing to supply practical advice on faceting problems.



Emerald cut — crown



Emerald cut — pavilion



Emerald cut — facet angles

# Gemstone Carving

A vase and cover carved from rock crystal and fitted with gilt bronze mounts. It was probably executed by Ferninando Eusebius Miseroni between 1640 and 1650 in Prague (then Bohemia). It was acquired by the Victoria and Albert Museum, London, in 1977. Its height is 43 cm. *(Photo by courtesy of the Victoria and Albert Museum, London.)*

THE ART of fine gem carving evolved around 4000 BC from the earlier and cruder works which came even before this time. It continued until after the fall of Rome about 476 AD. Resurgence came with the Renaissance and it has waxed and waned until the present day. A more affluent and educated society has increased the demand for fine works of art in the shape of gem carvings, among other things, and amateurs and professionals alike continue to produce inspired examples. One very good example of the possibilities of gemstone carving is shown. It is in fine rock crystal and is in two parts only, body and cover. The fittings are of gilded bronze and it stands 43 cm in height.

*Types of carving*

Carving is a form of sculpture which covers several types of work. Relief carving may be low or high, the first being the development of a pattern above the surface of a background to show three dimensions, while the second carries this idea to the point where the pattern is lifted even further to show full three-dimensional figures. Intaglio, on the other hand, requires the generation of a negative three-dimensional representation in a flat background surface. A good example is the signet ring; not quite so often seen these days, it was in older times the identification impressed into wax sealing on documents and other papers. The coat of arms, so dear to many hearts nowadays, is only one pattern impressed by the signet rings of bygone days.

The cameo, carved in any material with colour difference in a layered structure, is another very familiar carving form. The carving of cameos was originally done in quartz materials and some very complex, finely executed pieces still exist and are on show in museums throughout the world. An eight-layered square cameo carved from agate in Roman times is in the British Museum and is an inspiration to any lapidary interested in carving.

Cameos are more often cut in shell of various kinds where the layered nature of the material allows the required cutting away of one layer to expose one of a contrasting colour beneath. However, the keen lapidary need not confine his efforts to this rather easily worked raw material, as some of the banded agate coming from local sources offers great promise for the creation of very good cameos.

The pattern in all three types so far mentioned is developed by grinding away successive sections of the rough to the depth required by the pattern until the outline in three dimensions is complete. The subsequent treatment of the ground surfaces is carried out using conventional finishing materials as set out in tumbling and cab cutting, but their methods of application would vary as required by the nature of the piece.

**A small cameo cut from gold-lipped pearl shell (*Pinctada maxima*). This piece is cut in three layers and is only 18 mm x 13 mm.**

**A carving in white opal. This piece measures 35 mm from top to bottom and has utilised the best colour area, which is in the hair-garland area.**

*Small carvings*

A very popular type of carving is that carried out in precious gem materials and colourful shell. Tiny leaves and flowers as well as animals, zodiac symbols, religious motifs and an untold assortment of flowers, birds and characters from eastern mythology are carved from sapphire, emerald, ruby, aquamarine, tourmaline, lapis, citrine, bloodstone, moonstone, malachite, agate, carnelian, horn, fish and camel bone, mother of pearl, nacreous shells of various types and ivory. Some of the pieces are so small that they are sold 'so many to the carat', particularly in the more precious (and expensive) gemstone materials. On the other hand, larger carved pieces can be as large as the rough permits. Tiger's eye is one material which lends itself very well to the carving of very small pieces as well as much larger ones. In some cases very large pieces may be made in this stone by carving component pieces separately and assembling them all into one finished carving.

*Carving methods and materials*

The prime abrasive for gemstone carving is diamond powder. It may be used loose, as compound in petroleum jelly or impregnated into metal as tools.

Silicon carbide is probably the most used abrasive for carving, with aluminium oxide as a second string to the carver's bow. Pumice powder is also useful as are the general-purpose polishes which the lapidary uses. Silicon carbide and aluminium oxide are most useful as small wheels or points which are available in many shapes. They are not too expensive to be regarded as expendable as they can only do so much work before losing cutting efficiency because of wear. They are used in motorised hand pieces or bench-mounted work heads which are ideal for smaller works, but in all projects the diamond saw is the primary shaping tool. Careful planning of sawing will reduce the rough piece to the point where subsequent hand work will prepare the outline for final prepolishing and polishing with powered or hand laps and points.

*Practical carving*

Gemstone carving, indeed carving in any medium, can be one of the most soul-satisfying of occupations. To hold in one's hands what was recently a shapeless piece and now, due entirely to the passage of time and a good measure of diligent effort and persistent application on the carver's part, is a thing of permanent beauty, is an experience no lapidary can afford to miss.

The first reaction to a suggestion that such a project should be undertaken is the declaration 'I'm no artist'. An art form is a work which expresses the 'art' of the person, be he a sculptor, painter or gem carver. Carving is not necessarily the production of a 3-m classic 'David' or even a piece of fruit in rose quartz, jade or jasper. Far from it. Some of the most appealing creations in gemstone are those informal variations on the cabochon with patterns incised, ground or ground and polished into their surface by means of the sharp edge of the grinding wheel. Graceful curves as well as more severe patterns in geometric lines and angles can be combined to produce pieces of outstanding merit. For example, a plain, sawn-and-polished monolith of banded jasper, rutilated quartz or snowflake obsidian set about with a flower arrangement or tumble-polished stones makes an attractive and noteworthy centrepiece or collector's item.

Tiny figures are often suggested at first sight of a shape in rough gemstone and may be brought out and clarified with a minimum of work at the grinder and finished with the polisher to bring them to life. Recognisable figures and other items may be faceted from rock crystal very effectively, but this is a job for the expert.

**A finely finished carving in gold tiger's eye. The length, from trunk to tail tip, is approximately 115 mm.**

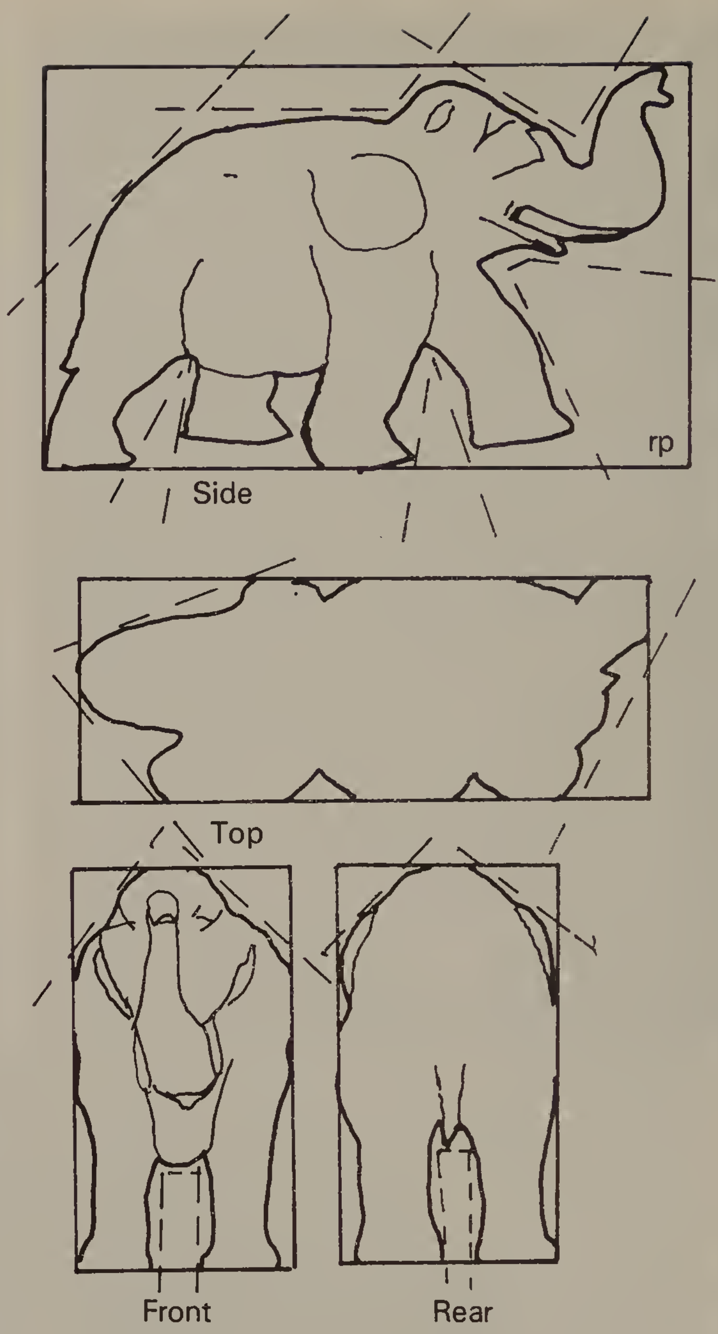
The grinding and shaping of small pieces may be a straightforward process but to begin from scratch, given a large piece of rough gemstone as the workpiece, requires a deal of planning and a definite programme if the result is to be up to expectations. To put aspiration into practice, there follows a project in soapstone which will give outlet to any nascent artist in the lapidary.

Soapstone (talc) has a Mohs' hardness of 1 and is very easily worked.

*Project: elephant carving*

This first exercise shows how to carve an elephant. It is not necessary that the result be realistic enough to trumpet. A stylised representation is all that is needed to gain the experience.

Tools required for the operation are a hacksaw with a coarse blade, a 200-mm round file, a 150-mm round file, both rough cut, a similar pair of square files, a small piece of glass about 60-mm square, a small penknife, and 'OO' glass paper.



Dotted lines show suggested saw cuts

**Carving project**

*Process*

1. Select a sound piece of soapstone of any colour and mark out and saw from it a rectangular block 90 mm x 55 mm x 30 mm. Sawing should be carried out with the hacksaw with the rough clamped in a vice well padded with felt or canite to prevent jaw damage.

A. 2. Trace on the larger side of the block an outline of the diagram using first some carbon paper and a scribe, then, in the interest of clarity, go over with a felt pen and ultimately a steel point or scriber to form a heavy visible line.

B. 3. Clamp up in the vice and saw off the corners in the tail slope area. Cut a small piece out from the under-head-front-of-legs zone and smaller triangular pieces from the forehead-trunk-back-and-front-legs area. Now file the sawn faces and the adjacent incurves to the scribed outline. Maintain the faces at right angles to the large block face.

C, D. 4. Mark the end views (front and rear) one on each end of the block. Make two sawcuts from the bottom of the block upward towards the tummy about 3 mm apart. Break out the thin stub between the cuts with a small screwdriver or the penknife and clean out to the line with a smaller file. Remove the top corners (shoulders and rump) with the large square file. File recesses as a slope of the side (fatter tummy) to the legs and slightly wider feet with the round files.

E. 5. Mark the top plan outline on the top of the block. Saw off the three corners as shown by the dotted lines. File out the smaller triangular indents to the line with a square file.

Round out the whole preform by means of files, the knife and glass scraper, blending and rounding all corners of the piece — top, sides and underparts.

The animal is now formed with the exception of the head. Work around this with the pocket knife until details are considered satisfactory. Detail the ears, eyes and mouth area similarly. Narrow the trunk with the saw or, if desired, a small coping saw may be pressed into service instead.

6. Details of the sides and rear areas require considerable attention although they may be stylised to a simpler representation. All cuts

and applied pressures made with the knife should be controlled and moderate as soapstone will split or flake off if handled roughly.

7. The only operation left to complete before fitting tusks, if they are to be included, is to go over the whole beast with a knife and glass scraper, endeavouring to produce a fine texture and details to suit the individual desire of the carver. This surface may be given a gloss by wiping over with a very small amount of baby oil on a cloth.

8. Tusks may be sawn and scraped from bone or white chalcedony, the former being rather more realistic. Use the fine grinder and glass paper for bone, and grinder and sanders with a final polish for the latter. Drill holes to accommodate the tusks at the appropriate positions on the head. Do not use a power drill for the drilling but rather metal twist drills in a hand chuck. Great caution is needed due to the fragile nature of the material, as mentioned earlier.

*Carving in harder stone*

Once the elephant is successfully completed, the carving of a similar work in harder stone can be undertaken with some confidence. This will require quite a deal more patience, as the knife-and-file procedures used with soapstone will have to be replaced with small silicon carbide wheels and points, as mentioned at the beginning. Major grinding and shaping is carried out very well on as narrow-faced a wheel as is available. Twelve-mm wheels 150 mm in diameter which have their face profiled to an angle of 85-90° are ideal.

Polishing is carried out, together with sanding, by means of flex drive held felt bobs and buffs charged with fine abrasive or polish as required. Cast-iron shapes and points are also useful in shaping difficult areas. They may be charged with silicon carbide or, better still, diamond compound. Rubber-bonded silicon carbide wheels and shapes (Cratex) may be used with success on some stones for fine sanding or prepolishing.

# Gemstone Drilling

PIERCING A gemstone is one problem which will ultimately confront the average active and venturesome lapidary. There will come a time when a cavity is required in a fine specimen of rock crystal to make a small flower vase, or a clock movement has to be mounted at the back of a polished slab. Any operation requiring a hole in a stone, while it may involve more than average expenditure of money, time and effort, is in no way impossible. Drill points and tubes, usually diamond-charged, are available as stock items from rock shops and others may be made by hand to suit a particular purpose. These consist of metal tubes with diamond powder fixed around the perimeter. They are designed to fit a 'water chuck', a perforated spindle which is used in the chuck of a drill press machine. The water chuck allows coolant to be introduced into the drill tube, while it is in contact with the work, which flushes out grinding debris. The drill assembly is moved up and down while working to further assist this process. A circular groove is thus ground into the stone which results in a hole when carried right through the piece.

Small drills of the above description are fairly rapid in operation and, when properly used, will penetrate an average slab in six to seven minutes. Larger drills are available up to about 50 mm in diameter and prices vary from manufacturer to manufacturer, but even larger ones may be obtained to special order. Considerable power is required to drive the larger sizes.

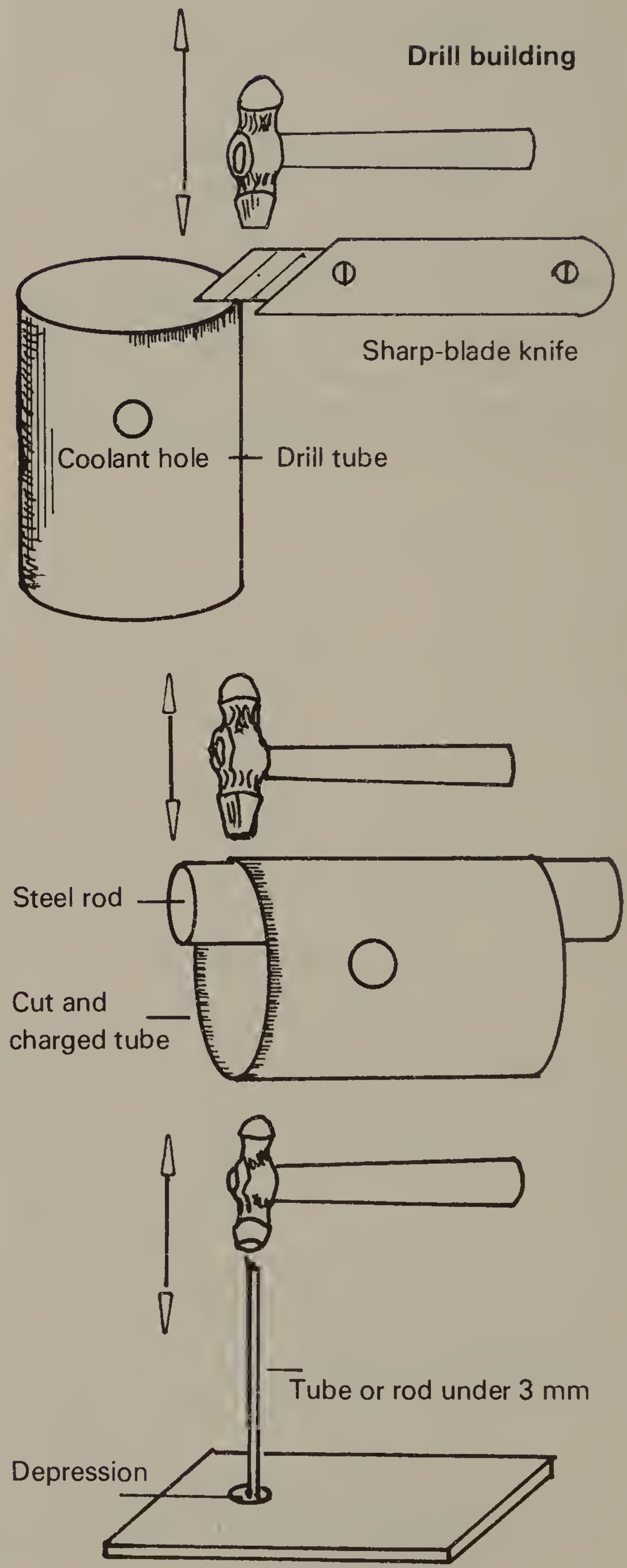
*Drill building*

Take a piece of thin-walled copper tube of suitable size for the job in hand. The wall thickness should be about 1 mm but slightly thinner tube may be used for holes under 6 mm.

A shank to enable the tube to be held in the machine must be fitted to drills over 8 mm in diameter and this may take the form of a piece of mild steel shafting of appropriate diameter, but it is better to have the local machine shop turn one up for the job. A passage should be drilled through the piece to facilitate cleaning.

Drill a small hole in the side of the drill tube to allow free circulation of coolant. Cut the face

Drill building



edge of the tube with a sharp trimming knife to form evenly-spaced slots around the perimeter which are about 0.5-0.75 mm deep. A small hammer applied to the back of the knife will assist cutting slots of uniform depth. Mix a compound of about 2 ml of petroleum jelly and one carat of diamond powder, sieve size 60/72, and press this into the cut slots. Close the slots over the diamond by hammering the tube edge with a piece of steel shafting inside it as an anvil. Gentle tapping is all that will be required for an undistorted tube end.

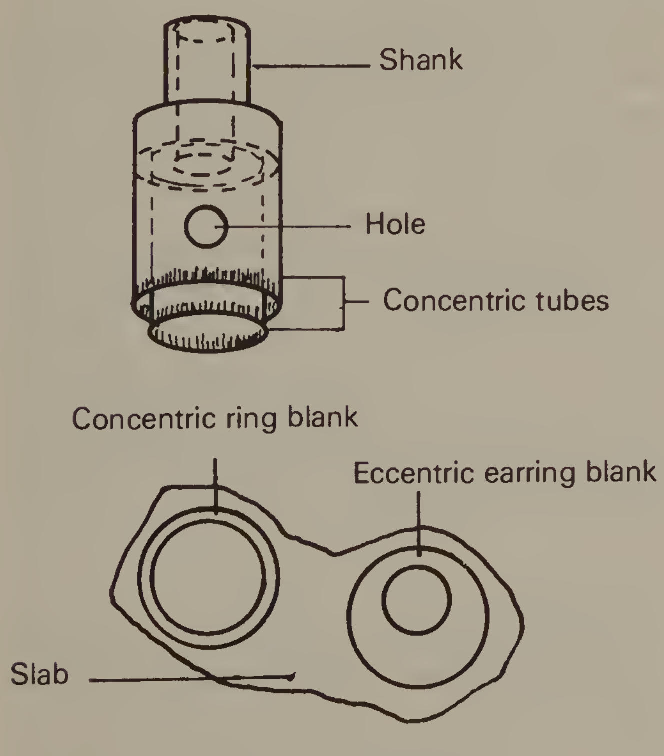
Smaller drills which do not allow insertion of anvil steel through them may be treated by hammering the cut end into an indentation drilled into a flat piece of mild steel in which some of the diamond compound has been placed. Gentle tapping again will result in the slots being closed with compound trapped in them.

Tiny drills too small to cut may be charged in the same manner and, when worn by work, brought back to new condition.

*Uses for drilled cores*

Larger tube-drill cut-gemstone cores are very useful when sliced for the production of identical pieces for buttons or matching jewellery, while diagonally-cut slices make ideal blanks for oval cabochons.

Gemstone finger or ear-ring blanks may be produced by perforating a slab with two concentric tube drills. These are mounted on the same shaft with the inner one ahead of the outer by a small amount. The annulus produced by this assembly makes an ideal finger-ring blank. Consecutive drilling of a blank with one operation slightly offset makes the cutting of attractive ear-ring or pendant pieces a very simple project. Conventional finishing processes are used for later treatment of drilled blanks while special decoration or edge treatment may require the use of smaller abrasive points and buffs.




**Uses for drilled cores**

In all gemstone drilling, the workpiece must be immobilised before work can commence. This is particularly important when two drillings are planned in the one piece, such as in finger-ring production. The piece should be dopped to a backboard of masonite or plywood of the waterproof variety of such a size as to allow fixing under the drill point in any desired position. This dopping removes the possibility of chipping when the drill point breaks through the back of the slab.

*Suitable gemstones for ring production*

Drilled rings may be cut from almost all gemstone materials but some are more suitable than others. Great care is needed in handling gemstone and rings in particular, but while those cut from the jades are almost indestructible, others are very brittle and can easily break if accidentally dropped on a hard surface.

*Very small holes*

Fine single-stone (diamond) drills are good for drilling very small holes and sintered or electroplated types also, but in every case they must be used with full care and understanding of their capabilities. Designed speed and coolant type with reasonable pressure will produce the required hole in time while impatient use will rapidly wear, or even destroy, the drill.

At no time is a diamond drill suitable for casual use. It must always be treated as a delicate and breakable item. Its relatively high cost compared with high-speed drills should impress the lapidary to the point of caring enough to exercise great care when drilling. Masonry drills are not suitable for drilling gemstones. Manufacturers' recommendations for their drills should always be followed without quibble.

*Drill machines*

Machines in which diamond or other gemstone drilling points are mounted should be solid in construction with accurate shafts, chucks and driving gear, all free of vibration and 'wander'. Even very small shaft inaccuracies can cause rapid wear of drill points.

The most sophisticated machine for gemstone drilling is the ultrasonic drill. This plant depends on the principle of electrical transduction, where a metal shape of the desired dimension is caused to literally change dimensions, at a rate in the order of 18 000 times per second. When placed in contact with the surface of the gemstone with abrasive grain between, this friction element very rapidly causes the required hole to come into being. Unfortunately the cost of such a machine is prohibitive except for the commercial producer.

A very much smaller gem drill is available on the market which combines a rotary drill with an automatic vertical oscillation of the drill point. This machine is modest in cost and, because of its semi-automatic action, leaves only the supervision and abrasive supply for the operator's attention.

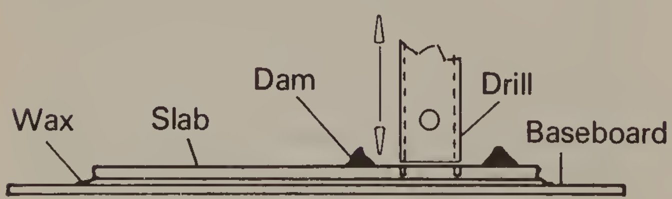
*Drilling practice*

All gemstone drilling requires a certain basic set of processes which, it must be stated from the outset, are essential for all stone drilling if it is to be successful.

1. Drills must be kept cool during all stages of the operation.
2. Drilling pressure applied to a drill point must always be moderate. The drilling action is essentially a grinding one and the grinding element must not be crowded (see Chapter 2).
3. Stone does not drill in the same manner as metal and the process is very much slower. Recognition of this fact will prolong the life of all drills.
4. The workpiece must always be secured in place by dopping or by mechanical means, except in the case of very small pieces which may be drilled, hand-held, with diamond-impregnated drills. A good supply of coolant at the drill point is still essential.

*Drilling method*

The drill point is mounted in a drill press, gem drill or a heavier slow-speed power drill mounted in a steady and accurate drill stand. It may also be used in a hand-held flex drive (as above), or in a work-head chuck which is bench-mounted. The length of the drill shank should be kept to a minimum if used in hand-held flex-drive machines.



**Drilling method**

The selected workpiece or pieces to be drilled are immobilised on the locating baseboard by dopping, etc. and then fixed under the drill point. A dam of Plasticine or modelling clay is formed around the contact point to retain the coolant which may be water, turpentine, kerosene or any of the regular saw coolant/lubrication mixtures (see Chapter 3).

Add coolant to the dam and switch on. Apply the drill point to the stone with slight pressure and observe for grinding action. When this shows any sign of commencing, move the point away from the stone and repeat this action at regular intervals. Continue until the drill emerges into the baseboard or, if the stone is held mechanically, cease the process when the groove is about halfway through the slab. Unclamp and turn the piece over. Re-secure with the groove immediately under the drill point but on the underside of the slab. This is almost impossible to do unless the piece is accurately symmetrical in shape or stops are positioned to allow the very accurate repositioning necessary for the drill to emerge where required. Where large numbers of pieces are drilled this may be a standard set-up. The dopped piece or pieces must now be undopped and cleaned up.

*Silicon carbide drills*

The foregoing remarks have all assumed the use of diamond as the abrasive, but silicon carbide is quite as effective in drilling stone, albeit a little slower in action. The major difference in practice is the necessity to add abrasive as the process proceeds.

Water with detergent added is the usual coolant and silicon carbide on 100 grit is added around the drill tip with the drill running. In the case of larger tube drills, it is sometimes useful to add some portion of the abrasive through the hole in the side of the tube before switching on, but with the drill resting on the work piece. A small brush is used to keep a supply of silicon carbide at the drilling point throughout the process.

*Predrilling*

Delicate, small and complicated shapes should be drilled before shaping is carried out. The making of beads is one such example.

# Bead-making and Sphere-cutting

*Bead-making*

**B**EAD-MAKING COMBINES two processes which have been described previously in Chapters 11 and 12, the only difference now being size. Stone beads and those cut in other materials — bone, ivory, horn, coral, shell, etc. — do not have the mouldable nature of glass, in which a great number of bead types are manufactured from a molten state. Their shape, and particularly the hole through the piece, must all be ground or generated by a grinding means. The shape is simply produced as an out-of-the-ordinary cabochon while the perforation is a stone drilling. The softer materials may be drilled with regular metal drills, but all stone and harder materials are best treated with the drills described in the previous section.

*Shape-making*

Beads other than spherical in shape or of round cross-section must be shaped by regular cab-cutting methods. All should be first drilled through, excepting those which are very small or are of precious materials — for example, opal. These are drilled in a jig specially designed to hold the finished bead accurately in a repeatable position.

Round beads may be produced in small sizes by means of a simple device called a cavity stick. This is a piece of metal rod in which a hemispherical cavity is formed. The size of the rod should be about one-third larger in diameter than the required beads. For work larger than 8 mm in diameter, the stick method is not very practical and hand methods or sphere-cutting must be used.

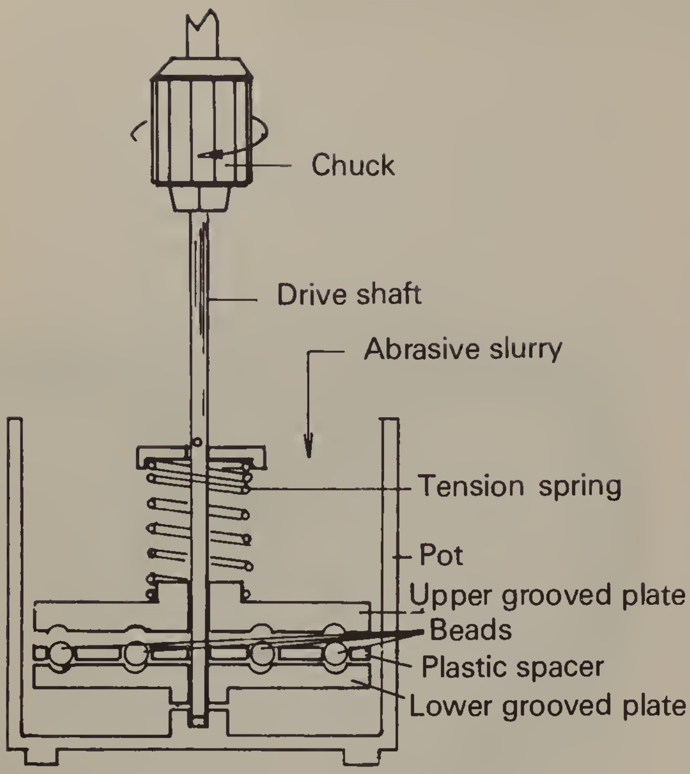
The slow power drill may be used in the making of round section longer beads and, with practice, beads with a fancy longitudinal cross-section. This method, as with most rotary tool production, requires predrilling of the blanks, although this may be undertaken afterwards, in which case the sawn preform must be dopped, end on, to a dopstick, preferably a metal one, which will be accepted by the drill chuck.

The last bead-making method makes use of a production shaping machine aptly called a bead mill. This is a metal pot into which fits a spindle fitted with three plates. The bottom one of these is loose and rests on lugs at the bottom of the pot. The second is of plastic and is perforated to accept the bead blanks and prevent their contact one with the other. The top plate is flexibly coupled to the spindle and is identical to the bottom plate with one exception. Both have bead grooves machined in their surfaces — the bottom of the top plate and the top of the bottom. The blanks are placed in the perforations of the second plate and rest on the groove of the bottom one. Abrasive slurry is added to cover the assembly and the top plate is added. The spindle is chucked in a drill press, the pot secured against rotation and the machine switched on. The action of the active plate on the bead blanks in conjunction with the abrasive loaded bottom plate reduces the blanks to spherical shape fairly rapidly. Subsequent pre-polishing and polishing processes are carried out in the tumbler. The vibrating tumbler is eminently suitable for this job.

**A string of graduated round beads cut from carnelian. It is necessary to cut several blank sizes for this kind of work as the graduation requires at least six sizes of bead.**

*Practice*

The production of any bead requires a deal of practice, as does any gemcutting. The cavity-stick method is no exception and even greater




**Bead mill**

application will be necessary before the knack of rapid rounding is achieved.

The stick is charged with a heavy slurry of silicon carbide 100 grit and the preform, sawn from slabs into very regular blanks and 'de-cornered' as in sphere-cutting with the grinder, placed in it. This is addressed to a silicon carbide wheel 220 grit which has a radial groove formed into its face to suit the bead size.

The stick is held firmly supported by both hands and inclined at an angle which causes the rotation of the wheel to hold the blank in the cavity. This angle will vary slightly with beads of different diameters and experiments must be made to find the one most suitable. The desired state is where the blank rotates and is neither thrown nor jams in the cavity. The rounding is a rather fast operation and should be undertaken in short sessions with inspection between.

As stated above, quite some practice will be needed before expertise is gained at this fascinating operation, so do not be disappointed if the first number of attempts are unsuccessful. Hold the stick firmly but with angle flexibility. Do not crowd the bead into the wheel.

The slow drill method is similar to preforming as described in faceting in Chapter 10. The blank is dopped, and then shaped against the grinder wheel held in the slow drill. It will be realised that many unusual profiles can be developed by this means and the tumble-polishing methods described in tumbling (see Chapter 5) can be put to very good use in their finishing.

*Special bead blank sawing*

The necessity for the blanks from which beads are to be made to be identical makes sawing a very special process for attention. A combination of dopping and accurate sawing is used to attain the desired uniformity. The first sawing of the rough produces slabs of one dimension of the bead. These slabs must be gradually heated and wax-dopped, one upon the other to form a multi-layered 'cake'. When cooled, this cake is again slabbed, this time to form 'pencils' — hopefully still in slabs. These second slabs are now set into a plaster 'pudding' (see section on puddings in Chapter 3) and again slabbed. Care must be taken when setting into the plaster that the wax/stone slabs containing the 'pencils' are positioned so that the 'pencils' are all parallel to one another. To assist in this, it is advisable that the second slabbing should be arranged so that a reference flat side is left for orienting purposes. Alternatively, the waxing up of the first slabs can be carried out in a container which is of such a shape that this necessary orientation of second-sawn slabs is easily carried out, even when they are covered with plaster.

## *Sphere-cutting*

Too many lapidaries look at pictures of spheres in gemstone which appear in magazines from time to time and never think of trying their hand at cutting and polishing one for themselves. Everyone should cut at least one for the experience. The illustration shows the process through all stages with examples of each. It is not recommended that the first attempt should be a large piece, but one of 30 mm in diameter is quite a feasible proposition.

*Tools*

The tools required for the job consist of a vertical shaft, such as the spindle of the flat lap, onto which may be screwed a cup of about 20 mm in diameter. Another of the same diameter is required for the hand-held tool. This has a handle fitted. Both may be improvised from pipe caps obtainable from plumbers' supply houses. The local engineering shop will be able to drill and tap them to enable them to be fitted to the machine and handle. Sets of special cups are obtainable from lapidary machine manufacturers also.

**Spheres cut from petrified wood and agate in four stages. The lower left shows the initial cube, the rear left has all corners removed with the saw, and the two examples in the centre have all square characteristics ground away. The two spheres at the right are finished to a high polish.**

*Method*

Select a sound piece of rough stone like jasper with a colourful pattern — poppy jasper, for example, would be a good choice. Saw it accurately to a cube of 30 mm a side. Then saw off all corner edges equally as accurately. The second example in the illustration shows this finished second sawing. Grind off as much as possible of the remaining non-spherical features of the block with the coarse grinder until the third example in the picture represents the shape developed.

*Grinding*

Now fit the threaded cups to the spindle and handle respectively. Pack both with clean cloth and wet with water with detergent and place half a teaspoonful of 100 grit silicon carbide into the spindle cup. Place the ground preform on it and hold in place with the handle cup. Switch on the machine and hold the handle cup at an angle which retains the rotating stone piece in place. In a comparatively short time grinding of the surface will become evident. If the rough grinding has been well done, the spherical shape will develop. When the shape is satisfactory and the surface clear of indents and defects, wash off, clean out the cups, replace the cloth with fresh and add 400 grit at first and later 600, continuing to grind until the surface is fine, smooth and satiny.

*Polishing*

After cleaning out again, pack once more with cloth and tie two layers of leather (chamois, or thin split) over the mouth of both cups. This is best done by tightly binding the leather with copper wire. It must be tight enough to prevent rotation of the leather independently of the cup. Make up a polish slurry from tin oxide with water in which some pure soap flakes have been dissolved and place a portion of it on both leather surfaces. Place the carefully scrubbed sphere onto the lower one and repeat the action of the grinding process, applying considerable pressure. Additional slurry must be added from time to time to prevent the sphere sticking. The leather should be maintained in a state which enables the sphere to move. As a polish develops, more friction will be felt and heat will be most evident.

When the polish is satisfactory, wash off and inspect very closely.

*Note:* The second-stage grinding must be carried to the point where no defect, however small, is detectable even with a glass. If any indent or defect is passed over at this stage, it will be necessary to return to the same operation when it is found that no amount of polishing can or will remove it.

**A close-up of the cups of a large sphere-cutting machine with a 125-mm, almost-completed sphere between the polishing cups. The polish medium in the tray is constantly fed to the cups as they rotate.**

# Workshop Safety, Care and Maintenance

*Safety*

ACTIVITIES OF a creative nature invlove the use of hands, fingers and eyes, to a greater or lesser degree. The keeping of these in good working order and condition is therefore of the utmost importance.

Motor-driven machines and devices are very widely used in the lapidary craft and an intimate knowledge of their safe handling and maintenance is essential for all who come into contact with them. Proper use is mandatory if accidents to persons or damage to machine or work in progress is to be avoided. An 'airy-fairy' approach to the use of what can be a dangerous machine when handled haphazardly, as is often seen in club cutting rooms, is to invite disaster. Such handling must be replaced by an aware, firm-handed approach coupled with a high degree of concentration if accidents are to be eliminated.

*Speed*

The prime cause of accidents to persons can be attributed to speed. The use of powered tools and machines on a casual basis does not sufficiently acquaint the user with their deadly potential. The grinding capability of a coarse grinding wheel rotating at high speed is very suddenly (and painfully) realised when a finger becomes the 'grindee' in a brief moment of inattention. Likewise, a diamond saw blade of very small diameter, but rotating at up to three times as fast as the grinding wheel, will very neatly slice into a fingertip under similar circumstances. Should the inattention be prolonged even for a second, particularly when using one of the very thin blades, the blade could jam or even tear, with sad results for the operator's fingers as well as the saw.

The most effective technique for the prevention of such calamities is total concentration. When sawing, do just and only that. Never be distracted while a piece is still working. This applies equally to all machine operations.

When sanding and polishing use forthright motions in applying stone to disc or buff. Deliver sufficient pressure with each contact to achieve maximum effect. Light, indefinite passes lead to slow polishing or sanding and this will possibly allow the disc or buff to whisk the stone out of the operator's hands, with dire results.

*Belts and pulleys*

All open moving parts, such as belts and pulleys, should be covered to prevent accidental involvement with clothing or fingers. Trailing articles of clothing, neckties, long sleeves, scarves, etc., are an open invitation for contamination transfer or accident if worn when using powered machinery.

*Cleaning*

All gemcutting machinery must be maintained in a clean state at all times. Every cleaning operation must be undertaken with the machine at rest and with the power disconnected from the supply point. Never be tempted to 'just wipe off that rotating shaft with this cloth' because it would seem to be convenient and easier that way. The grasping power of such a shaft could be very suddenly and painfully realised if the cloth, with fingers tightly enclosed, should become wrapped around it.

The immediate surrounds of a machine being cleaned must be cleared of all work in progress. This will prevent stray contaminating particles from lodging where they should not. Laps and buffs must be put into protective sleeves and bags, each in its own marked container, grinding and polishing media containers put carefully into their correct storage places. Polishes and polish laps must be kept away and separate from grinding or prepolishing gear, the latter on lower shelves than the former. In this way any falling particles will be finer than those fallen upon.

*Maintenance of blades, wheels, laps and buffs*

Cleaning and sharpening, or dressing, of busy cutting, prepolishing and polishing wheels, laps and buffs becomes necessary from time to time. It is an essential maintenance job which should be carried out regularly.

*Saw blades and machines*

All saw blades suffer from gradual erosion of the metal bond which holds the diamond abrasive. This should proceed in a regular and even manner which allows the blade a long and useful life. An accident to the edge of such a blade can cause a centre of deterioration if neglected. Any such happening should result in immediate cessation of work and close inspection of possible

**Safe trimsawing requires a firm hold on the piece and a comfortable attitude for the operator.**

damage. Careful honing, to smooth a nick or cut in the edge, will often keep the blade happily in service. A more serious defect or break in the diamond section can only be repaired by the manufacturer or a specialist diamond-saw repairer.

One very common problem with diamond blades is caused by a lack of straight-line sawing. This is caused, in the case of the slab or trim/slab saws, by inaccurately-set saw-spindle mounts or by slide bars which are not accurately parallel with the blade.

Trim saws which are hand-fed have a problem, particularly if used with a side guide for the stone, as this tends to pull work to that side unless great care is exercised to prevent it happening. This ever-so-slight out-of-line feeding causes uneven wear to the guide side of the blade which will eventually wear off the diamond section on that side of the blade. This removes the 'T' section edge of the blade and changes it to an 'L' which will not grind sufficient clearance for the blade when it becomes chronic, and this could cause a jam. If slight wear of this nature is detected before it becomes too bad the blade should be reversed on the spindle, even though this will cause some loss of diamond. Additional life will be gained by this action but, as in all such wear situations, preventive care is the best insurance.

A glazed or slightly unevenly worn blade may be resharpened by sawing a coarse silicon-carbide dressing stick or a section of a common building clay brick. This will remove some metal enclosing the abrasive grains and will, if used too heavily or too often, reduce the diamond content to an appreciable degree. Lightly, and only when needed, are the watchwords.

*Tables*

The table area immediately around the blade must be kept free of stone chips, offcuts and splinters as a routine. This chore should be done immediately a sawing session is over. Smaller trimsaws are notorious for the debris which accumulates. Tiny chips can be very annoying when one suddenly impedes the progress of a piece at a very critical time by emerging underneath it. Such happenings may be avoided by cleaning the area with a small paint brush kept handy for the purpose. This should be done at each cut or short session. One back corner of the table can be reserved as the recipient of the debris until clean-up time.

*Tanks and coolant.*

A periodical clean-out of the coolant tank is necessary to maintain the coolant in a clean condition. Rock 'sawdust' is very abrasive and will hasten wear of the costly diamond blade if not removed from the tank before it rises to an unsafe level. Condensation inside the tank compounds the problem as it is held in the settlement level of the stone debris. The edge of a diamond blade is bonded to the steel body with metal powder and the water of the condensation will cause rusting or corrosion of this bond area. The level of coolants containing water should be lowered when the machine is unused for long periods for this reason. The authors have seen examples of quite large blades corroding away completely below coolant level when left for a matter of a few weeks. The settlement area of most trim/slab saw machines is rarely of large enough capacity to allow more than a couple of days' sawing before needing a good clean out.

The coolant should be drained out while warm from a session and allowed to stand for a time, after which the clear top fluid may be decanted and kept for future use. Water mixes should be discarded. The sediment left in the tank should be scooped out with a metal tool of some kind. The solid nature of some sediments precludes a plastic tool. Do not be tempted to use the fingers, in a glove or not! The soft powdery nature of the rock dust effectively hides very sharp chips and splinters which can cause extensive lacerations.

Clean up the inside and outside of the tank to new condition with successive waste-clean cloths. This is particularly necessary where the machine is fitted with a coolant pump. All filters on such machines should be washed out with clean coolant before refitting.

Settled rock dust residue may be left to dry out, but it is better left at the local refuse dump.

*Grinding machines and wheels*

The water-catching trays of grinding machines accumulate much abrasive dust and stone debris and should be kept clean by regular attention. A shock pad of kitchen viscose can be placed to cover the bottom of these trays with great advantage. It helps prevent accidents to stones in process which are dropped and has the advantage of being easily removed for rapid cleaning. Water deflectors of the same material may be clipped over the upper wheel faces to prevent undue splashing.

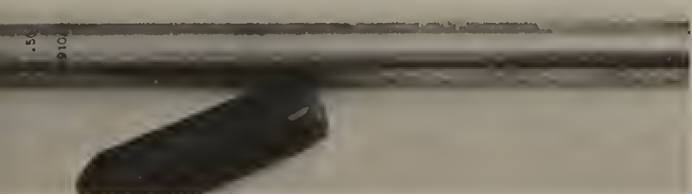
*Wheel shaping and cleaning*

Reshaping and conditioning of the wheel face is a very necessary job which should be done immediately the wheel shows signs of irregular wear, which is evidenced by bumping or uneven grinding noises. Smooth grooves can be utilised quite often for profile grinding of cabochons and should not be confused with the uneven wear which could damage a stone.

All reshaping of wheel faces must be carried out before cleaning is commenced as much splashing is caused in the process. It is advisable that protective shields for the eyes, or at least a face shield, should be worn during the work.

A diamond wheel dresser of the single-stone or multiple-point type may be used, both being equally effective. All dressing is carried out wet. Enough water must be supplied to the wheel face to eliminate free dust from the dressing.

With the machine running and the water adjusted, apply the dresser to the wheel face with a substantial support underneath it. Maintain the dressing point at just below the normal grinding position on the wheel face. Traverse it slowly across and back, taking a series of shallow cuts to arrive at a smooth face, rather than attempting to achieve the desired result with only one or two. If a single-stone dresser is used, hold the



**A diamond dresser and cap. The stone size and serial number are engraved on the shaft.**

shank at a depressed angle of about 15° with the dressing point down. It may be used to shape the face for particular purposes such as cabochon profiling, bead generation, carving, or profiling for special projects.

When the face is as smooth as required the wheel may be put back into service but, if smoother surfaces are required, particularly with fine grinding wheels, the application of a silicon carbide dressing stick will adequately produce a silky surface.

*Discarded and worn-out wheels*

Silicon carbide wheels which have worn to the point where further speed increases no longer make them usable, damaged wheels and others which have met with accidents, can be made into very valuable tumbling pieces by the use of a lump hammer. These wheel pieces are added to first-grind barrels of rough stone. They are removed when second grind is ready to proceed. To break wheels, place them in a hessian bag and place that on a heavy piece of wood or metal before applying the hammer.

*Diamond wheels and laps*

Metal-bonded diamond peripheral wheels can become clogged with stone debris after considerable use. They can be cleaned by the application of a silicon-carbide hand-honing stone to the face with much water, when the diamond points will become cleared of the metal matrix to a slight degree, together with the debris. Should the face be badly dished through uneven wear the wheel should be returned to the manufacturer for regeneration to new condition.

Diamond laps, such as those used for faceting, need constant checking for any signs of dishing. Perfectly flat facets are impossible with a lap face which is other than perfectly flat. Unlike peripheral wheels, sintered-metal laps may be corrected by the lapidary with a minimum of effort and equipment. If the uneven wear is only slight, it may sometimes be corrected by honing the surface with the lap running and copiously wet. Apply the honing stone supplied with the lap at a slight angle to the direction of rotation and flat on the lap surface. Move it around to completely cover the sintered surface. With cup wheels which have a narrow segment of diamond impregnation, take care to keep the stone accurately horizontal to ensure that the surface is truly flat and not inclined. The honed face will become bright and evenly surfaced and should be checked with a steel straight-edge for flatness if any doubts remain as to its correctness.

*Cup wheel and lap regeneration*

Badly worn or dished cup wheels and laps must be regenerated by grinding their face on a plate-glass surface with silicon carbide grit of 46 grade. Place the lap face down on the glass with a slurry of grit, water and detergent. Hold it with the hand and rotate in a circular pattern.

**Hand grinding a sintered diamond cup wheel or lap on a plate-glass surface with silicon carbide. Repeated rotation of the lap after each two or three passes is necessary to ensure even regeneration of the face.**

Change the hand position from time to time by taking a new grip with the fingers after three or four circular movements. The purpose of this hand-position changing is to ensure that no one area of the lap is treated unevenly.

After the lap has been ground and turned through a full 360°, wash off and test for flatness with the straight-edge. Continue until the face is true and bright.

*Facet-head cleaning*

The average facet head is a complicated lodging place for contamination and should be kept clean at all times by means of a small soft paint brush.

*Felt and leather buffs*

Felt or leather buffs and wheels can become unserviceable if coarse scratching particles become lodged on them. They may be reclaimed for continued use by two possible means. The first is to transfer them to a stage earlier in the process which calls for a coarser grit size or, secondly, by skimming the surface. With the wheel running, a supported, very sharp 15-20-mm-wide wood chisel is slowly passed across the face from the outer edge to the centre, removing only the thinnest even layer of the face. If a felt face is impregnated with a fine abrasive, it will be found necessary to resharpen the chisel at frequent intervals.

In the case of leather faces the layer removed must be very thin and the control of the cutting edge absolute to prevent penetration of the leather face.

*Tumbler maintenance*

The humble tumbler is not immune to breakdown despite its apparent robust simplicity. Leakage and spills occur unexpectedly and must be cleaned up instantly. The contents of a grinding barrel are extremely destructive to shafts and bearings. Tumblers should receive a regular wiping down while at rest, with a particular eye to lubrication and wear. Larger machines should have regular checks made of their containers for small leaks, gaskets and sealing rings for tracking which could lead to leaks, and rollers and rubbers for uneven wear or deterioration. All driving rollers must be kept free of spillage, oil and grease which could cause slip. A regular wipe-over with methylated spirits is recommended for all rubber or neoprene rings, buffers, gaskets and rollers.

Replacement of worn tumbler parts is essential in view of their continuous duty role. Belts must be checked for wear, replaced if necessary and treated with anti-slip dressing at regular intervals. Vee pulleys should be inspected for polished appearance which would indicate belt tension problems. Correct belt tension requires approximately 18 mm of play between drive and driven pulleys when tested by pressing the stationary belt with the forefinger.

Pulleys on all shafts must be tested for looseness and tightened where necessary. Bearing and shaft endplay should be kept to a minimum.

*Coolant/solvent maintenance*

Solvents and oils used in coolant/lubricant mixes must be stored with due regard to flammability and affinity for rubber. Spills must be cleaned up immediately and pump lines and tanks kept in a leak-free state. Recovered coolant or drained coolant which is settled in containers should be covered to prevent contamination or accidents. Mixes containing kerosene or dieselene are inflammable, if not flashable. Prevention is still the best cure.

Settlement with possible filtration through paper towels or cloths is all the maintenance required by most coolant mixes but those containing water and soluble oil must be regarded as expendable and discarded once the oil emulsion breaks down.

*Dopstick cleaning*

The cleaning of metal dopsticks used in faceting and other processes often presents a distasteful task for the busy lapidary. If partially cleaned dopsticks are put back into service, they can be the direct cause of the loss of a valuable or important stone due to undopping in work. If a cleaning procedure is established and faithfully followed, it can be almost a guarantee that such accidents will be avoided. A soaking pot of polythene (one of the well-sealed refrigerator containers is ideal), a final wash container of smaller dimensions and a small tumbling machine are almost all that is necessary for such a procedure. A small quantity of ceramic abrasive triangles, of 5-mm size, obtainable from electroplating suppliers, is necessary also.

All dopsticks are placed to soak in the pot immediately they are detached from the stone. Those used with epoxy cements must have a separate container for soaking with eposolve or the appropriate solvent. Those used with cellulose cements must also have their separate acetone soaking pot.

After a preliminary soak (overnight is preferable), the sticks are placed into the tumbler with the triangles and a quantity of methylated spirits and water and run for up to five hours, depending on the state of the sticks. It may be necessary to renew the methylated spirits.

A rinse, again with methylated spirits, and a swift brushing with a wire scratch (brass) brush will usually bring them to almost new condition ready for the 'clean' box.

Cone and vee sticks should be checked closely for tightly impacted wax in close corners and cone points. These may need the attention of a sharp point for maximum cleanliness.

If there are not sufficient sticks to warrant the tumbler-cleaning set-up, cleaning may be carried out by following the same soaking procedure but substituting a second rinse in methylated spirits, with brushing substituting for tumbling.

*Finally*

The practical gemcutter's workshop should always be kept in a state of immediate availability for use. Careful cleaning and maintenance combined with adequate safety precautions will ensure that this remains the case.

# APPENDIX I: Table of Gemstone Constants and Cutting Angles.

| Stone | Colour | Mode of cut | Hardness | Specific gravity | Refractive Index | Refraction | Crown Main | Crown Star | Crown Girdle | Pavilion Main | Pavilion Girdle |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Abalone | multi | cab, carve | 3½ | | | | | | | | |
| Agate | all | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Alexandrite | red/green | facet | 8½ | 3.68-3.78 | 1.742-1.757 | D | 37 | 22 | 41/43 | 42 | 44 |
| Amazonite | blue, green | cab, carve | 6-6½ | 2.54-2.57 | 1.52-1.53 | D | | | | | |
| Amber | brown, yellow, black, red | cab, carve | 2-2½ | 1.03 | 1.54 | A | | | | | |
| Amethyst | pink to purple | cab, carve, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/47 | 43 | 45 |
| Andalusite | pink/green | facet | 7½ | 3.1-3.2 | 1.63-1.64 | D | 43 | 28 | 47/49 | 39 | 41 |
| Apache Tears | brown | tumble, cab, facet | 5½ | 2.3-2.5 | 1.5 | S | 42 | 27 | 46/48 | 43 | 45 |
| Apatite | yellow, blue, green | cab, facet | 5 | 3.15-3.22 | 1.63-1.66 | D | 43 | 28 | 47/49 | 39 | 41 |
| Aquamarine | blue, green | facet | 7½-8 | 2.65-2.85 | 1.56-1.59 | D | 42 | 27 | 46/48 | 43 | 45 |
| Aragonite | cream, white | cab, carve | 3-3½ | 2.93 | 1.53-1.68 | D | | | | | |
| Australite | brown | cab, facet | 5½ | 2.3-2.5 | 1.5 (av.) | S | 42 | 27 | 46/48 | 43 | 45 |
| Aventurine Feldspar | red-brown, | cab, carve | 6-6½ | 2.54-2.57 | 1.52-1.53 | D | | | | | |
| Aventurine Quartz | green, red, blue-white | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Azurite | deep blue | cab, facet | 3½ | 3.8 | 1.73-1.80 | D | 40 | 25 | 45 | 40 | 42 |
| Beryl *(See Aquamarine, Emerald, Goshenite, Heliodor, and Morganite* | | | | | | | | | | | |
| Black Coral | black | cab | 3½ | 1.34 | | | | | | | |
| Black Opal | black base with colours | cab | 5-6½ | 1.95-2.2 | 1.44-1.47 | S | | *(See Opal)* | | | |
| Blue Moss | | | | | | | | | | | |
| Opalite | green with red | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | *(See Opalite)* | | | |
| Bloodstone | spots | | | | | | | | | | |
| Bowenite | green | cab, carve | 5 | 2.54 | 1.56 | D | | | | | |
| Cacoxenite in Quartz | gold needles in amethyst | cab, tumble | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Cairngorm | brown | cab, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/49 | 43 | 45 |
| Calcite | all colours | cab, carve, facet | 3 | 2.71 | 1.48-1.65 | D | 42 | 27 | 46/49 | 43 | 45 |
| Cameo *(Chalcedony or shell-carving)* | | | | | | | | | | | |
| Carnelian | red | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Cat's Eye Chrysoberyl | yellow to gold | cab | 8½ | 3.68-3.72 | 1.74-1.75 | D | | | | | |
| Cat's Eye Quartz | grey to bronze | cab | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Chalcedony | all colours | cab, carve | 7 | 2.65-2.66 | 1.54 | D | *(See other Quartz varieties)* | | | | |
| Chert | cream to red | cab, carve | 7 | 2.65-2.66 | 1.54 | | | | | | |
| Chiastolite | black/white | cab (crosses) | 7½ | 3.1-3.2 | 1.63-1.64 | D | | | | | |
| Chrysoberyl | yellow, green | facet | 8½ | 3.68-3.72 | 1.74-1.75 | D | 37 | 22 | 41/43 | 42 | 44 |
| Chrysocolla | blue | cab | 2-4 | 2.1 | 1.5 | A | | | | | |
| Chrysoprase | green/white | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Citrine | gold, yellow | facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/49 | 43 | 45 |
| Coral | white, pink, red, black | cab, carve | 3½ | 2.65 | 2.6-2.7 | | | | | | |
| Corundum *(See Sapphire and Ruby)* | | | | | | | | | | | |
| Cubic Zirconia *(See Zirconia)* | | | | | | | | | | | |
| Danburite | colourless yellow | facet | 7 | 3 | 1.63-1.636 | D | 43 | 28 | 47/49 | 39 | 41 |
| Diopside | green to violet | facet, cab | 5-6 | 3.2-3.32 | 1.67-1.70 | D | 43 | 28 | 47/49 | 39 | 41 |
| Dumortierite in Quartz | blue | cab | 7 | 2.65-2.66 | 1.54 | | | *(Constants as quartz)* | | | |
| Emerald | grass-green | cab, facet | 7½-8 | 2.69-2.75 | 1.56-1.59 | D | 42 | 27 | 46/48 | 43 | 45 |
| Emerald (Synthetic, Chatham) | green | facet | 7½-8 | 2.65 | 1.564-1.567 | D | 42 | 27 | 46/48 | 43 | 45 |
| Emerald (Synthetic, (Gilson) | green | facet | 7½-8 | 2.65-2.67 | 1.561-1.565 | D | | *(Rough stone not available)* | | | |
| Epidote | green, brown | facet | 6-7 | 3.25-3.5 | 1.735-1.765 | D | 37 | 22 | 41/43 | 42 | 44 |
| Euclase | colourless, blue, yellow, green | facet | 7½ | 3.05-3.1 | 1.65-1.67 | D | 43 | 28 | 47/49 | 39 | 41 |
| Fabulite *(See Strontium Titanate)* | | | | | | | | | | | |
| Feldspar *(See Amazonite, Labradorite, Moonstone and Sunstone)* | | | | | | | | | | | |
| Fluorite (Fluorspar) | all colours and brown | cab, facet | 4 | 3.17-3.19 | 1.43 | S | 41 | 26 | 45/47 | 45 | 47 |
| Fossil Wood *(See Chalcedony)* | | | | | | | | | | | |

| Stone | Colour | Mode of cut | Hardness | Specific gravity | Refractive Index | Refraction | Crown Main | Crown Star | Crown Girdle | Pavilion Main | Pavilion Girdle |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Garnet | | | | | | | | | | | |
| Almandine | red, violet-red, black | cab, facet | 7½ | 3.8-4.2 | 1.75-1.82 | S | 37 | 22 | 41/43 | 42 | 44 |
| Almandine Star | red, violet-red, black | cab | 7½ | 3.8-4.2 | 1.75-1.82 | S | | | | | |
| Demantoid | green | facet | 6½ | 3.83-3.85 | 1.88-1.89 | S | 43 | 28 | 45/49 | 40 | 42 |
| Grossular (Transvaal Jade) | green to red | carve, cab | 6½-7 | 3.42-3.73 | 1.742-1.748 | S | | | | | |
| Hessonite | trans., green, red-orange | facet | 6½-7 | 3.55-3.67 | 1.742-1.748 | S | 37 | 22 | 41/43 | 42 | 44 |
| Pyrope | deep red | facet | 7½ | 3.68-3.8 | 1.74-1.75 | S | 37 | 22 | 41/43 | 42 | 44 |
| Rhodolite | violet | facet | 7¼ | 3.84- | 1.76- | S | 37 | 22 | 41/43 | 42 | 44 |
| Spessartite | brown, red | facet | 7¼ | 3.90-4.2 | 1.79-1.81 | S | 37 | 22 | 41/43 | 42 | 44 |
| Goldstone | gold, blue, green, black | cab, carve | 5 | Man-made | | A | | | | | |
| Goshenite | colourless | facet | 7½-8 | 2.65-2.85 | 1.56-1.565 | D | 42 | 27 | 46/48 | 43 | 45 |
| Grass Stone | clear, with rutile needles included | cab, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/47 | 43 | 45 |
| Green Quartz | pale to deep green | facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/47 | 43 | 45 |
| Greenstone | *(See Nephrite)* | | | | | | | | | | |
| Gypsum (Alabaster) | white | cab, carve | 2 | 2.2-2.4 | 1.52-1.53 | D | | | | | |
| Haematite | black | cab, carve, facet | 6½ | 4.9-5.3 | 2.94-3.22 | D | 45 | 30 | 48 | — | — |
| Heliodor | yellow to gold | facet | 7½-8 | 2.65-2.85 | 1.56-1.565 | D | 42 | 27 | 46/48 | 43 | 45 |
| Hiddenite (Spodumene) | green shades | facet | 6½ | 3.17-3.23 | 1.66-1.67 | D | 43 | 28 | 47/49 | 39 | 41 |
| Howlite | white | cab | 3½ | 2.58 | 1.59 | D | | | | | |
| Hyalite | colourless | cab, facet | 5½-6 | 2.1 | 1.44 | S | 41 | 26 | 45/47 | 45 | 47 |
| Idocrase (Vesuvianite) | blue, brown yellow, green | cab | 6½ | 3.4-3.5 | 1.71-1.73 | D | | | | | |
| Iolite (Water Sapphire) | blue | cab, facet | 7-7½ | 2.60-2.66 | 1.53-1.55 | D | 42 | 27 | 46/48 | 43 | 45 |
| Ivory | cream-white | cab, carve | 2½ | 1.8 (average) | 1.54 | A | | | | | |
| Jadeite | white, green, pink, brown | cab, carve | 6½-7 | 3.3-3.5 | 1.65-1.68 | D | | | | | |
| Jasper | all colours and mixed | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Jet | black | cab, carve | 3½ | 1.1-1.4 | 1.64-1.65 | | | *(Fossil Wood)* | | | |
| Kunzite (Spodumene) | violet-pink | facet | 6½-7 | 3.17-3.23 | 1.66-1.67 | D | 43 | 28 | 47/49 | 39 | 41 |
| Labradorite | yellow to gold, transparent | facet | 6-6½ | 2.54-2.57 | 1.52-1.53 | D | 42 | 27 | 46/48 | 43 | 45 |
| Labradorite | grey, with play of colour | cab, carve | 6½ | 2.54-2.57 | 1.52-1.53 | D | | | | | |
| Lapis Lazuli | blue with white-and-gold flecks | cab, carve | 5½ | 2.75-2.9 | 1.5 | S | | | | | |
| Lapis Lazuli (Synthetic Gilson) | blue with gold flecks | cab | 5½-6 | 2.4-3 | 1.50-1.55 | S | | *(Rough stone not available)* | | | |
| Malachite | green | cab, carve | 3½ | 3.74-3.95 | 1.65-1.9 | D | | | | | |
| Marble (Calcite) | all colours | cab, carve | 3 | 2.71 | 1.48-1.65 | D | | | | | |
| Mexican Onyx | *(as Calcite)* | | | | | | | | | | |
| Milky Quartz | opaque white | cab | | | | | | *(Constants, as Rock Crystal)* | | | |
| Mocha Stone | *(Local name for Chalcedony with Dendrites [QV])* | | | | | | | | | | |
| Moonstone (Feldspar) | white, pink, silver, black | cab, carve | 6-6½ | 2.55-2.58 | 1.52-1.53 | D | | | | | |
| Morganite (Pink Beryl) | pink | facet | 7½-8 | 2.65-2.85 | 1.56-1.565 | D | 42 | 27 | 46/48 | 43 | 45 |
| Morion | brown quartz | cab, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/48 | 43 | 45 |
| Moss Agate | many colours with dendrites | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Moss Opalite | blue, white, yellow with dendrites | cab, carve | 5-6½ | 1.95 | 1.47 | S | | | | | |
| Mother of Pearl | white, black, gold | cab, carve | 2½ | 2.65 | | | | | | | |
| Nephrite (Jade) | green, white, black, brown | cab, carve | 6½ | 2.92-3.00 | 1.60-1.65 | D | | | | | |
| Nevada Wonderstone | red with fawn stripes | cab, carve | 7 | 2.53 (app.) | | | | | | | |
| Obsidian | red, black, brown | cab, facet | 5½ | 2.3-2.5 | 1.5 | S | 42 | 27 | 46/48 | 43 | 45 |
| Odotolite | blue | cab, carve | 5 | 3.00-3.25 | 1.58-1.62 | *(Fossil Bone)* | | | | | |
| Olivine (Peridot) | green, yellow, brown | facet | 6½-7 | 3.34 | 1.654-1.689 | D | 43 | 28 | 47/49 | 39 | 41 |

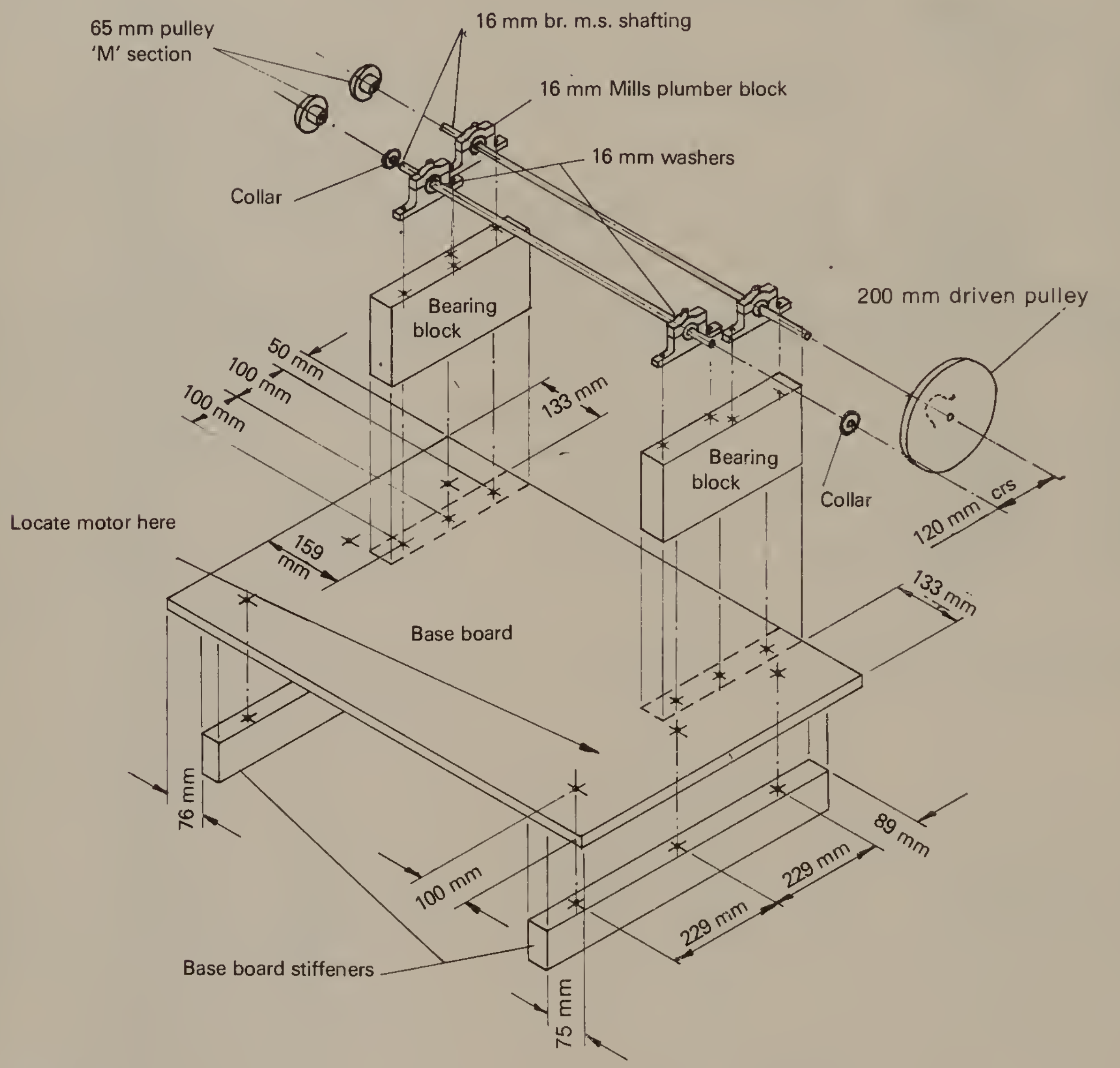
| Stone | Colour | Mode of cut | Hardness | Specific gravity | Refractive Index | Refraction | Crown Main | Crown Star | Crown Girdle | Pavilion Main | Pavilion Girdle |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Onyx (Quartz) | black or brown with white stripes | cab | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Opal | clear white, grey, black with colour play | cab, carve, facet | 5-6½ | 2.1 | 1.44-1.47 | | *(Crystal Opal is best for faceting)* | | | | |
| | | | | | | S | 41 | 26 | 45/47 | 45 | 47 |
| Opal Doublet | all colours | | *(Composite two-part stone; see 'Special cab-cutting techniques')* | | | | | | | | |
| Opal Triplet | all colours | | *(Composite three-part stone; see as above)* | | | | | | | | |
| Opal (Synthetic Gilson) | all colours | | 6-6½ | 2.65-2.67 | 1.561-1.565 | S | *(Rough stone not available)* | | | | |
| Opalite | yellow, white, blue | cab, carve | 5-6½ | 1.95 | 1.47 | S | | | | | |
| Peridot *(See Olivine)* | | | | | | | | | | | |
| Petrified Wood | all colours | *(See Chalcedony)* | | | | | | | | | |
| Petalite | white, pink | cab, carve | 6 | 2.39-2.46 | 1.504-1.516 | D | | | | | |
| Prase (Quartz) | green | *(As Jasper)* | | | | | | | | | |
| Prehnite | white, brown, green, yellow | cab, facet | 6-7 | 2.8-2.95 | 1.62-1.65 | D | 43 | 28 | 47/48 | 39 | 41 |
| Psilomelane | black-banded | cab, carve | 6-7 | | *(Quartz-impregnated black mineral)* | | | | | | |
| Pyrite | metallic, yellow | cab | 6-6½ | 5.02 | | | | | | | |
| Quartz | *(See variety heading: Amethyst, Aventurine Quartz, Cairngorm, Cat's Eye Quartz, Citrine, Grass Stone (rutilated), Green Quartz, Milky Quartz, Morion, Prase, Rock Crystal, Rose Quartz, Smoky Quartz, Tiger's Eye, Tourmaline in Quartz)* | | | | | | | | | | |
| Rhodochrosite | banded pink | cab | 4 | 3.45-3.70 | 1.59-1.80 | D | | | | | |
| Rhodonite | pink, red | cab, facet | 5-6 (tough) | 3.5-3.7 | 1.71-1.75 | D | | | | | |
| Ribbonstone | banded red, brown, yellow, white, | | 7 | 2.65-2.66 | 1.54 | | | | | | |
| Rock Crystal | clear | cab, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/47 | 43 | 45 |
| Rose Quartz | pale to deep pink | cab, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/47 | 43 | 45 |
| Ruby | red, pink | cab | 9 | 3.90-4.00 | 1.75-1.77 | D | 37 | 22 | 41/43 | 42 | 44 |
| Ruby (Star) | red | cab | 9 | 3.90-4.00 | 1.75-1.77 | D | | | | | |
| Ruby (Synthetic) | *(As natural stone)* | | | | | | | | | | |
| Rutile (Synthetic) | clear, pale yellow, red, blue | facet | 6½ | 4.25 | 2.65-2.90 | D | 32 | 15 | 34/36 | 41 | 41½ |
| Sapphire | blue, yellow, clear, gold, green parti | cab, carve, facet | 9 | 3.90-4.00 | 1.75-1.77 | D | 37 | 22 | 41/43 | 42 | 44 |
| Sapphire (Star) | blue shades, bronze | cab | 9 | 3.90-4.00 | 1.75-1.77 | D | | | | | |
| Sard | brown | cab | *(Variety of Chalcedony [QV])* | | | | | | | | |
| Sardonyx | banded-red or brown | cab | *(Variety of Chalcedony [QV])* | | | | | | | | |
| Sinhalite | yellow, brown | facet | 6½ | 3.46-3.52 | 1.68-1.70 | D | 43 | 28 | 47/49 | 39 | 41 |
| Smoky Quartz | brown shades | facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/49 | 43 | 45 |
| Soapstone | cream, white | carve | 1 | 2.6-2.8 | 1.54-1.59 | D | *(Values are approximate)* | | | | |
| Sphalerite | yellow to brown | facet | 4 | 4.07-4.00 | 2.368-2.370 | S | 35 | 20 | 39/41 | 41 | 43 |
| Spessartite *(See Garnet)* | | | | | | | | | | | |
| Sphene | yellow, green, brown | facet | 5-5½ | 3.45-3.56 | 1.88-2.05 | D | 32 | 15 | 34/36 | 41 | 41½ |
| Spinel | red, blue, yellow, green, brown | facet | 8 | 3.5-3.75 | 1.71-1.736 | S | 37 | 22 | 41/43 | 42 | 44 |
| Spinel (Synthetic) | all colours | facet | *(Constants and angles as natural stone)* | | | | | | | | |
| Spodumene | clear, yellowish, lilac, green *(See Kunzite and Hiddenite)* | facet | 6-7 | 3.17-3.23 | 1.66-1.679 | D | 43 | 28 | 47/49 | 39 | 41 |
| Star Garnet *(See Garnet)* | | | | | | | | | | | |
| Stichtite | rose-red to purple | cab, carve | 2½ | 2.15 | 1.53 | D | | | | | |
| Strontium Titanite | white | facet | 6 | 5.13 | 2.41 | S | 30 | 15 | 34/36 | 40 | 41¼-41½ |
| Sunstone | red-brown | cab | 6½ | 2.62-2.65 | 1.54-1.55 | D | | | | | |
| Synthetics *(See separate stone headings)* | | | | | | | | | | | |
| Thulite *(See Zoisite)* | | | | | | | | | | | |
| Tiger's Eye | blue, gold, brown, red | cab, carve | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| 'Tiger Iron' *(Cut as Tiger's Eye)* | | | | | | | | | | | |
| Topaz | colourless, pink, blue, yellow | cab, facet | 8 | 3.5-3.6 | 1.607-1.637 | D | 43 | 28 | 47/49 | 39 | 41 |
| Tourmaline in Quartz | colourless | cab, facet | 7 | 2.65-2.66 | 1.54 | D | 42 | 27 | 46/49 | 43 | 45 |
| Tourmaline Types: | | | | | | | | | | | |
| Achroite | colourless | facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |
| Dravite | brown | facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |
| Indicolite | dark blue | facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |
| Rubelite | red, pink | facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |

| Stone | Colour | Mode of cut | Hardness | Specific gravity | Refractive Index | Refraction | Crown Main | Crown Star | Crown Girdle | Pavilion Main | Pavilion Girdle |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Schorl | black | cab, facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |
| Siberite | yellow, blue, green, violet | facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |
| Tourmaline in Quartz | clear with black needles | cab | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Watermelon | pink/green | facet | 7-7½ | 3.0-3.15 | 1.616-1.652 | D | 43 | 28 | 47/49 | 39 | 41 |
| Zoned Cat's eye | colours with inclusions | cab | 7-7½ | 3.9-3.15 | 1.616-1.652 | D | | | | | |
| Transvaal Jade | *(See Garnet)* | | | | | | | | | | |
| Turquoise | blue | cab, carve | 6 | 2.61-2.84 | 1.61-1.65 | D | | | | | |
| Turquoise (Synthetic, Gilson) | blue | cab, carve | 6 | 2.68-2.75 | 1.59-1.60 | D | | | | | |
| Turritella Agate | brown with included shells | cab | 7 | 2.65-2.66 | 1.54 | D | | | | | |
| Unakite | pink and green | cab, carve | Rock 5 | 3(approx.) | 1.6(approx.) | | | | | | |
| Varicite | blue, green | cab | 4½ | 2.52-2.6 | 1.55-1.56 | D | | | | | |
| Verdite | green with spangles | cab, carve | Rock 3 | 2.82-2.95 | 1.58 | | | | | | |
| Whale Tooth | *(See Ivory)* | | | | | | | | | | |
| YAG (Yttrium Aluminium Garnet) | clear, pink, yellow, blue, blue-white, green | facet | 8-8½ | 4.55 | 1.83 | S | 37 | 22 | 45 | 45 | 44 |
| Zircon (High Type) | clear, red, yellow, green, blue. | facet | 6½-7½ | 4.10-4.70 | 1.79-1.99 | D | 35 | 20 | 39/41 | 41 | 43 |
| Zirconia (Cubic) | clear blue, pink, yellow | facet | 8½ | 5.95 | 2.17 | S | 38 | 21 | 44 | 42 | 42½ |
| Zoisite (Massive) | blue, green, yellow, pink, brown | cab, carve | 6½ | 3.1 | 1.69 | D | | | | | |
| Zoisite (Tanzanite) | blue, green, yellow, pink, brown | facet | 8½ | 3.35 | 1.692-1.70 | D | 43 | 28 | 47/49 | 39 | 41 |

A = amorphous, D = double, S = single.

# APPENDIX II: Drawings for Machine Constructions

**Tumbling machine**



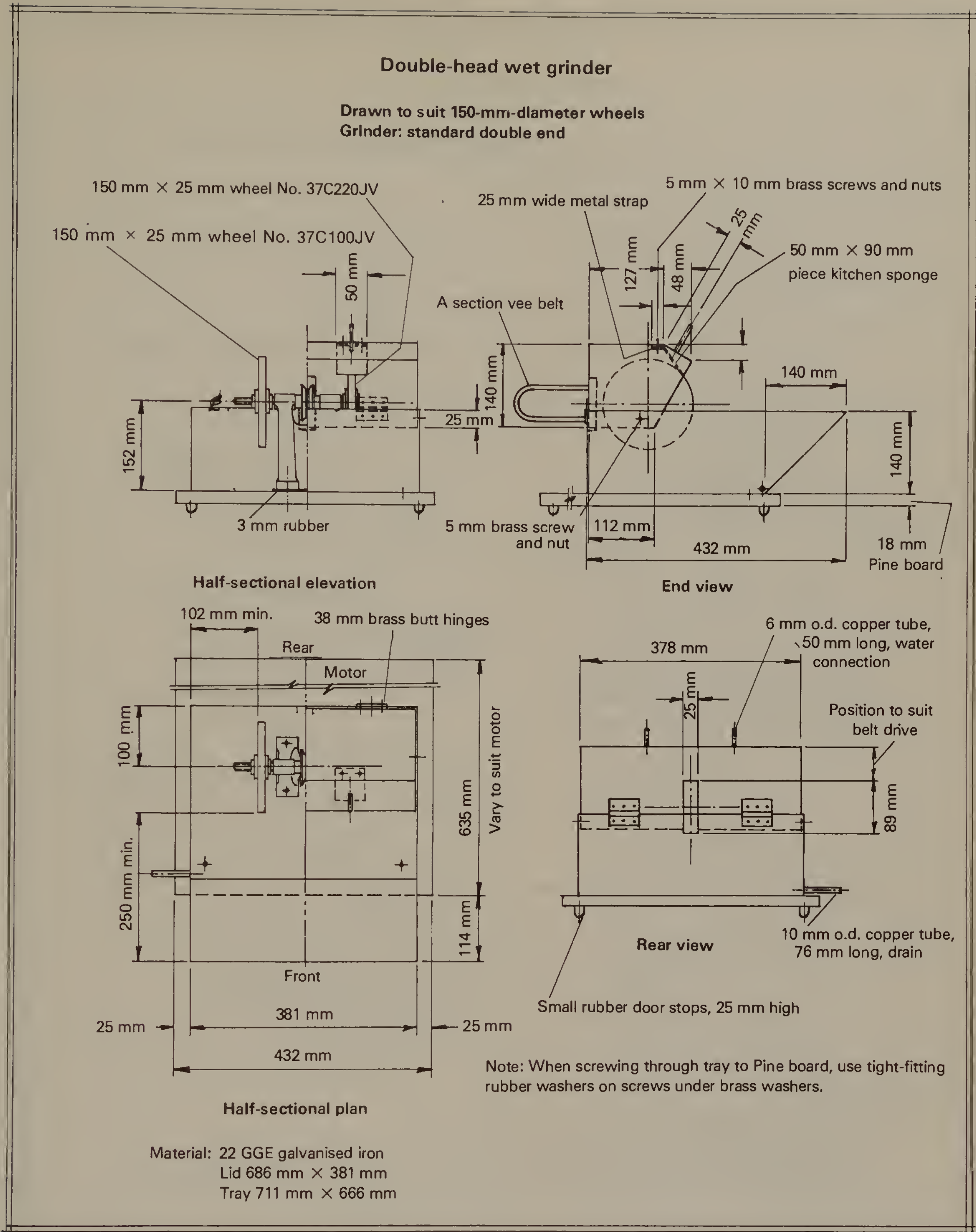

**Material list**

1. Base board: 940 mm × 645 mm × 18 mm Pine board
2. Base board stiffeners: 75 mm × 50 mm D.A.R. Oregon
3. Bearing block: 305 mm × 100 mm × 50 mm D.A.R. Oregon (finished sizes)
4. Four Mills 16 mm plumber blocks
5. Two 16 mm collars
6. Two 16 mm washers (place one against each bearing)
7. Twenty 38 mm × 6 mm coach screws and washers
8. Two 64 mm × 1M section pulleys
9. One 203 mm × 1A section motor pulley
10. One 64 mm × 1A section motor pulley
11. 16 mm d × 826 mm br. m.s. shaft
12. 16 mm D × 762 mm br. m.s. shaft
13. One $\frac{3}{4}$ or $\frac{1}{3}$ h.p. 1425 rpm motor
14. A section Optimat belting
15. 406 mm 'M' section belting and joiner

*A simple tumbling machine* (roller type)

This simplified version of the tumbler may be driven by any motor, electric or petrol, which delivers about one-quarter horse-power.

Vee pulleys, item eight of the materials list, are to be connected together by a suitable length of belting of the adjustable type so the driven shaft transmits the drive to the idler. Allow no more than 15 mm of slack in this belt and 20 mm in the one from motor to driven shaft. Test with the machine *at rest!*

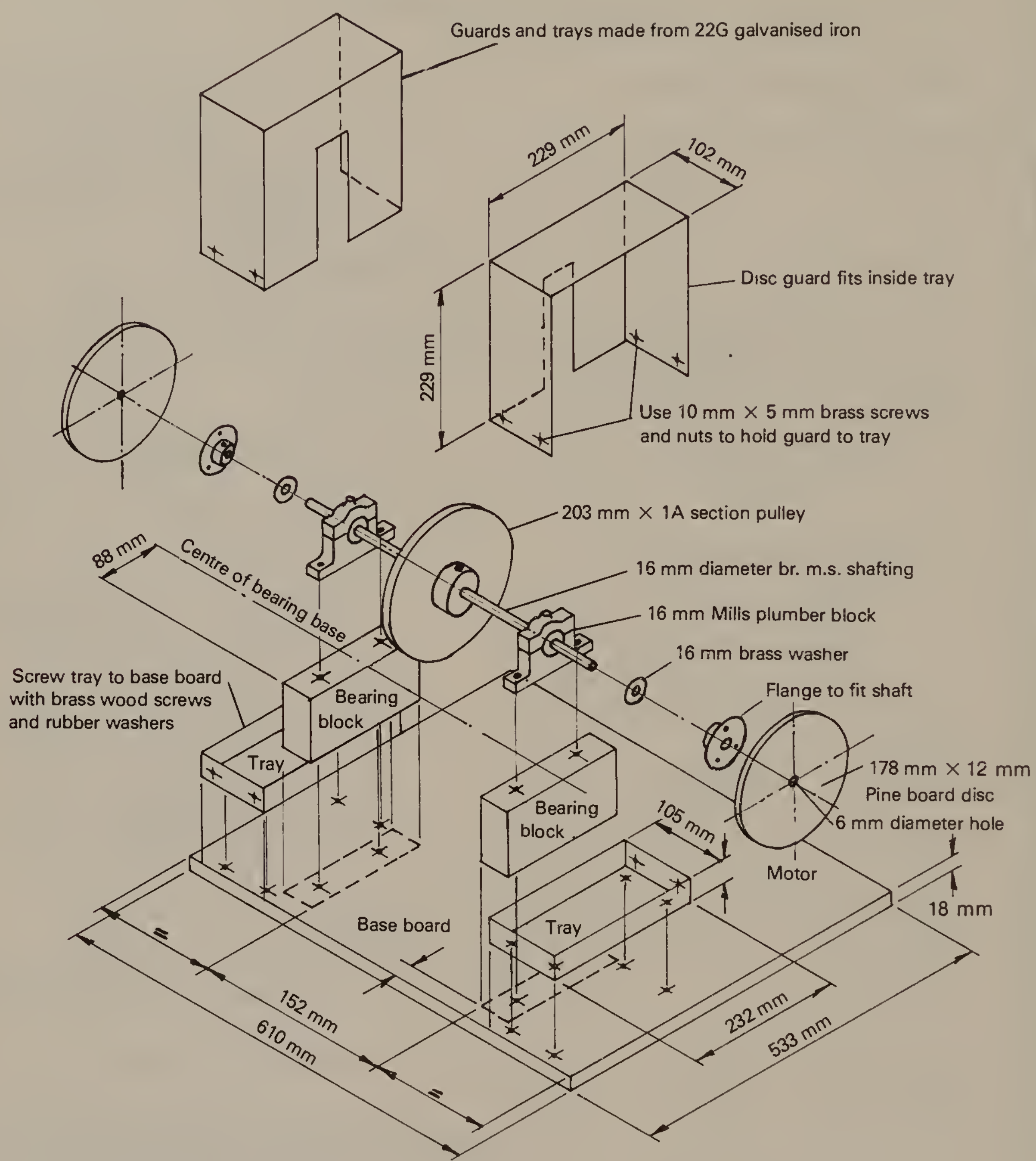



*A double-head wet grinder*

The water supply for this machine should never be derived directly from the town main supply. A bucket set above the machine with a siphon fitted with a control cock is adequate for all general work, but if a lot of work is anticipated a more permanent water supply could be investigated. This could be a ball-cock-and-tank arrangement which will dispense the required low pressure flow to the wheels.

Do not discharge the waste water directly into the sewer but into a settlement bucket or tank where the products of grinding, which would very quickly cause trouble in the household plumbing, can settle before the water is disposed of into the garden or some suitable place.

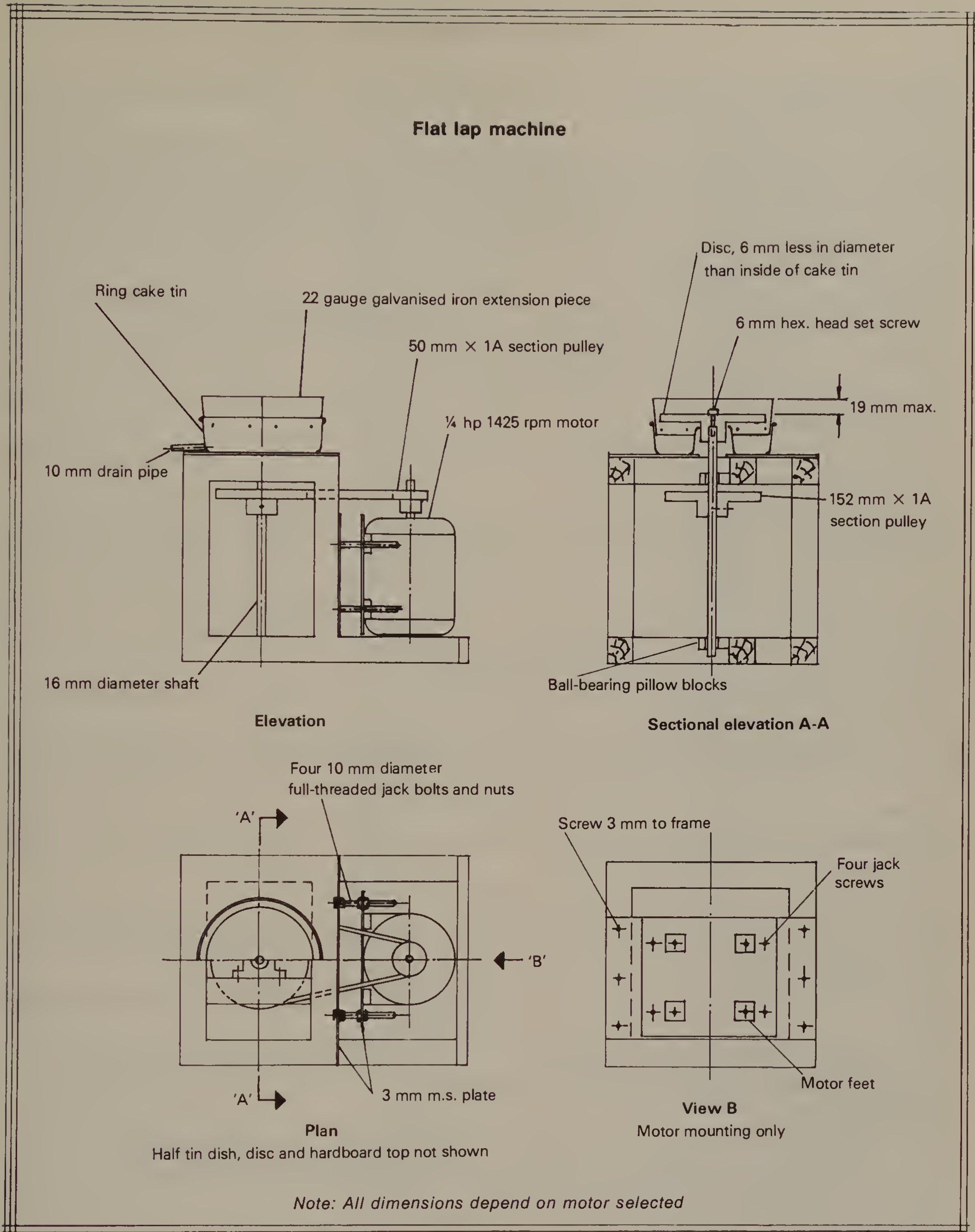
**Sander-polisher**




*Note: 1. Bolt bearing, bearing block and base board together with 140 mm × 10 mm diameter coach bolts, nuts and washers. Nail block to board before marking and drilling.*
*2. Fit one rubber door stop to underside of base board in each corner.*

*A two-place sander-polisher*

The flanges shown in the drawing may be substituted for by vee pulleys 100 mm in diameter. It will be necessary in that instance to drill three screw holes through the web of the pulleys to accept fixing screws.




*A flat lap machine*

This useful little machine is slightly more complex in construction than the previous three and, if intended as a basis for a faceting unit, must be assembled with particular care and accuracy. The position of the shaft bearings to ensure verticality is the most important aspect for attention. Rubber buffer feet should be fixed to the base to reduce vibration and to assure stability.

# Some Suppliers

Aleta's Rock Shop, 1615 Plainfield, N.E., Grand Rapids, MI 49505 *Tumbling and cutting materials, grinding wheels, diamond blades.*

Baskin & Sons, Inc., 732 Union Ave., P.O. Box 9, Middlesex, NJ 08846 *Gold and sterling castings.*

Bourget Bros. Jeweler's Tools and Casting Supplies, 1626 11th St., Santa Monica, CA 90404 *Bor-jay gold and nickel silver in sheet, round wire, half round wire, triangle, square bezel.*

California Crafts Supply, 1096 N. Main St., Orange, CA 92667 *Gemstones, findings, tools, wax patterns. (Pattern catalog $1.00).*

Cotati Rock Shop, P.O. Box 237, Cotati, CA 94928 *Lapidary equipment and supplies.*

Covington, Box 35L3, Redlands, CA 92373 *Combo units, grinders, grinding and buffing heads, gem tumblers, trim saws, build-your-own kits.*

Ebersole Lapidary Supply, Inc. 11417 West Hiway 54, Wichita, KS 67209 *Findings, gemstone material, equipment and tools.*

Fire Mountain Gems, 11274 Ventura Blvd., North Hollywood, CA 91604 *Silver and yellow gold settings, cubic zirconia.*

The Gem Shop, W62 N722A Riveredge Dr., Cedarburg, WI 53012 *Custom cabochons.*

Gem-O-Rama, Inc., 20 Pound Park Rd., South Shore Industrial Park, Hingham, MA 02043 *Gemstones, tools, mountings.*

Greenway Lapidary, P.O. Box 758, Longwood, FL 32750 *Semi-precious cabochons.*

Grieger's, 900 South Arroyo Pkwy., Pasadena, CA 91109 *Gemcutting equipment, tumblers and materials, jewelry making kits, craft supplies, minerals.*

Hong Kong Lapidaries, Inc. P.O. Box 489, Forest Hills, NY 11375 *Cabochons, drilled-through beads, cubic zirconia (white and colors).*

International Import Company, P.O. Box 747, Stone Mountain, GA 30086 *Faceted gems. (Catalog).*

Lapidabrade, Inc., 8 East Eagle Road, Haverton, PA 19083 *Jewelry findings. ($2.00 deposit for catalog).*

Lee Lapidaries, Inc., 3425 West 117th St., Cleveland, OH 44111 *Variable speed facet units, facet cutting laps.*

Lochs, R. D. 1, Center Valley, PA 18036 *Quality and economy facet rough.*

Parser Mineral Corporation, 97 Golden Hill, Danbury, CT 06810 *Cabochon, facet and semi-facet rough. (Catalog $2.00).*

Rocks 'N' Chips, 7952 Lorain Avenue, Cleveland, OH 44102 *Lapidary machines, supplies, findings, silver.*

The Stoneworks, Route 113, Dunstable, MA 01827 *Cubic zirconia facet rough in colors.*

Technicraft Lapidaries Corp., 492 Merrick Rd., Oceanside, NY 11572 *Lapidary and jewelry, hobby and craft supplies.*

Trinity, 5738 Marconi Ave. Suite 6, Carmichael, CA 95608 *Cubic zirconia, diamonds.*

TSI, Inc., 101 Nickerson St., P.O. Box 9266, Seattle, WA 98109 *Casting equipment, tools, wax models, mountings, chains, findings, stones, wire.*

Wright's Rock Shop, Route 4, Box 462, (Highway 270 West), Hot Springs National Park, Arkansas 71901 *Minerals, cutting rough, supplies and equipment.*

Zymex, 900 W. Los Vallecitos, San Marcos, CA 92069 *Stone, tools, mountings and findings.*

NOTE

For suppliers near you, look in your local Yellow Pages under 'Lapidary' or refer to the latest April (Buyers Guide) Edition of *Lapidary Journal*, available from Lapidary Journal Inc., P.O. Box 80937, San Diego, CA 92138.

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Lapidary—the art of cutting and polishing gemstones—is a subject of ever increasing popularity. In this book, the author, Eric Shore, leads the novice through all the stages of this enthralling hobby, from the basic techniques of handling a hacksaw, file and abrasive paper to using both commercial and home-built equipment. Here are the intricacies of sanding, grinding, tumble polishing, lapping and cutting a cabochon, each process described in detail with step-by-step instructions and illustrated with photographs and line drawings. Vivid color plates show the marvelous results of these cutting and polishing operations. No one who sees these rough stones and minerals turned into objects of such beauty that they become the source of eternal fascination will fail to fall under the spell of lapidary.

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