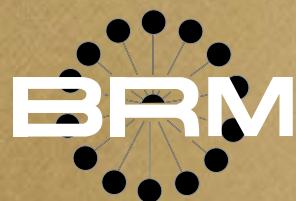


Common Practices In  
**CYLINDER BORING, HONING, AND WALL FINISHING**  
With Suggestions and Recommendations



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**BRUSH RESEARCH MANUFACTURING CO., INC.**

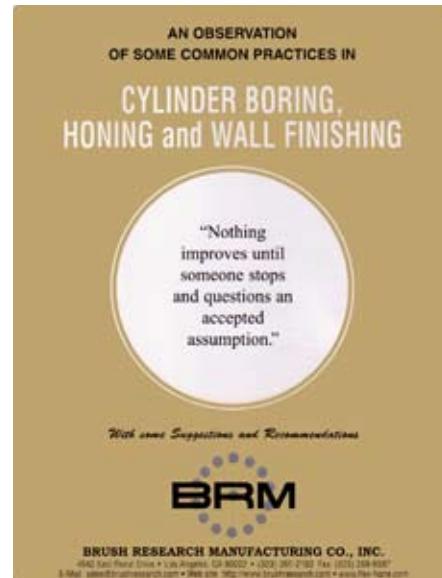
# AN INTRODUCTION TO THE COMPANY, THE FLEX-HONE® TOOL, AND THE FOUNDER

The booklet that you have in your hands is a reprise of Brush Research Manufacturing's original "Gold Book" entitled, "An Observation of Some Common Practices in Cylinder Boring, Honing and Wall Finishing," a piece of literature that essentially became required reading in the industry. The book was translated into fifteen languages. It became a reference book at automotive technical schools.

The Gold Book was written in simple and easy to understand language, while Brush Research's subsequent publications addressed more technical issues. In this reprise we are keeping with the tone of the original and reusing much of the text written by the founder and inventor of the Flex-Hone tool, Steve Rands.

Brush Research has been involved with the problem of finishing cylinder walls and de-burring applications from hundreds of industries and applications since 1958. The Flex-Hone tool was a revolution in the surface finishing industry and we are still the sole manufacturers and patent owners of this tool.

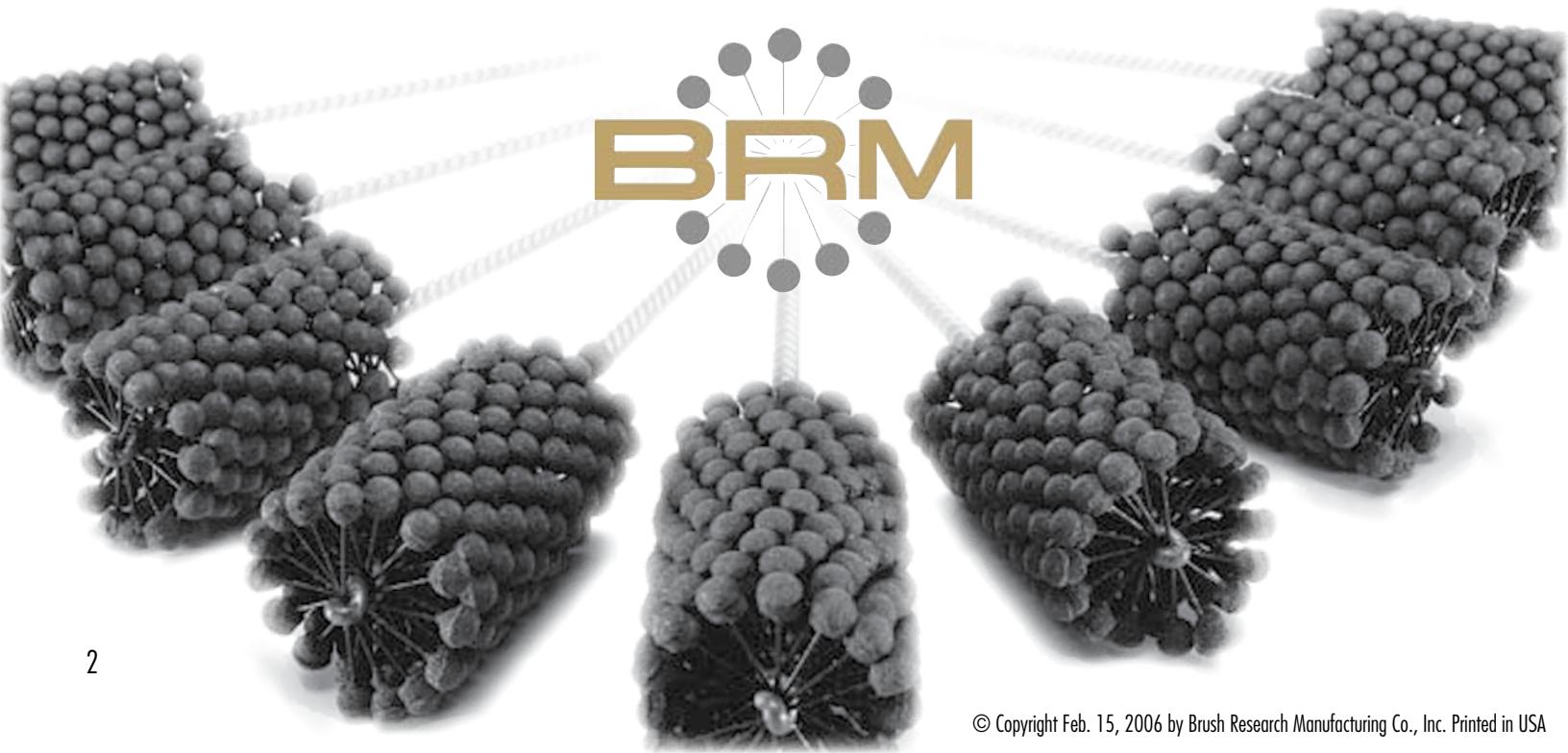
For decades, people have been learning of the incredible benefits of the Flex-Hone tool. In fact, we are constantly uncovering new applications and new benefits of the tool. We are always receiving samples for testing and problem solving from customers, and we undertake these projects wholeheartedly.



## The Original Gold Book

We are proud to know that in our automotive applications, the tool has been found to lower oil consumption resulting in saved energy and reduced pollution. We have assisted the government and the armed forces. Our tools have been used in nuclear power applications, hydraulics, pneumatics, firearms, high performance auto and motorcycle racing, musical instruments, consumer product manufacturing, computer assembly and manufacturing, the list goes on and on and grows everyday. All of our tools are manufactured in the USA. If we don't currently make the tool you need, then we usually can custom design and produce the right tool for the job.

Steve Rands said, "Keep an open mind. Experiment. Nothing improves until someone stops and questions an accepted assumption." We at Brush Research continue this belief and are always striving to raise the bar in engineering and surface finishing standards.

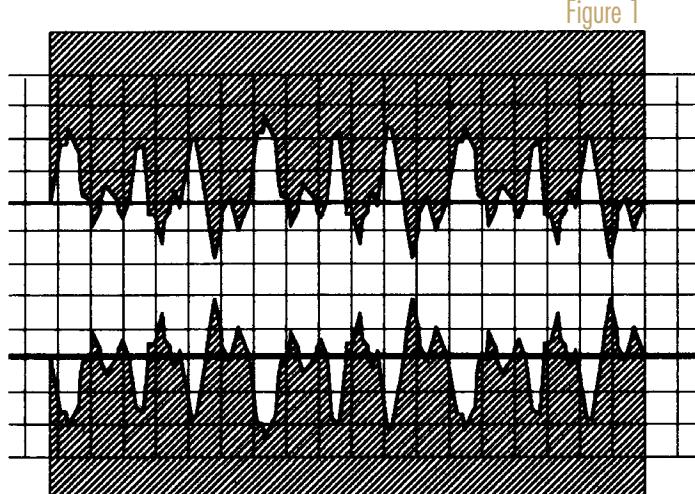


# FLEX-HONE®

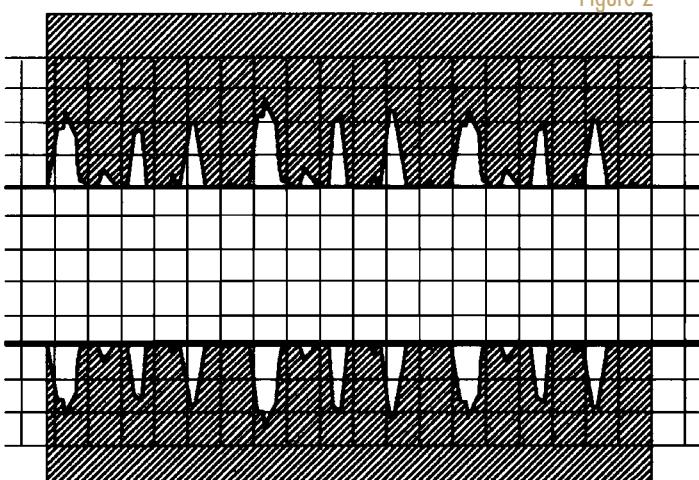
## THE MOST SIGNIFICANT DEVELOPMENT IN BORE FINISHING

### WHAT TYPE OF FINISH ON A CYLINDER DO WE WANT?

1. A plateaued area of from 60% to 80% of the surface to form a bearing surface for the rings and to hold a film of oil.
2. A crosshatch with uniform cuts in both directions of approximately 45 degrees
3. A surface free from cut, torn, and folded metal.
4. A surface finish to fit your needs - for example, a chrome ring needs a coarser finish than a moly. A rubber cup in a hydraulic needs even a finer finish.



AN UNACCEPTABLE FINISH



AN ACCEPTABLE PLATEAUED FINISH

### CROSSHATCH

We say we want a 45 degree crosshatch, which is 20 to 23 degrees from the horizontal. Why? So that the upward motion of the cylinder will spread the oil sideways in both directions and cover the entire wall. Be sure that the grooves are evenly spaced or the rings will have a tendency to rotate or surge in the direction of the groove.

The crosshatch is made by the actuation and rotation of the hone during the honing cycle. Fast rotation and fast actuation up and down will give you a narrow crosshatch. The reverse is also true. A loaded-up rigid stone will give you an uneven crosshatch or a uni-directional one. It is important (with a rigid stone) to have the final half a dozen strokes or so without much pressure to try and plateau the surface and so that you can carry the cross hatch to the top of the cylinder.

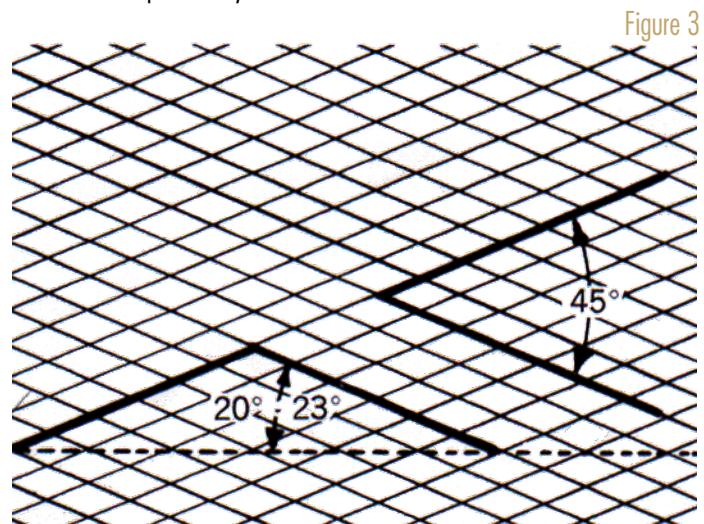
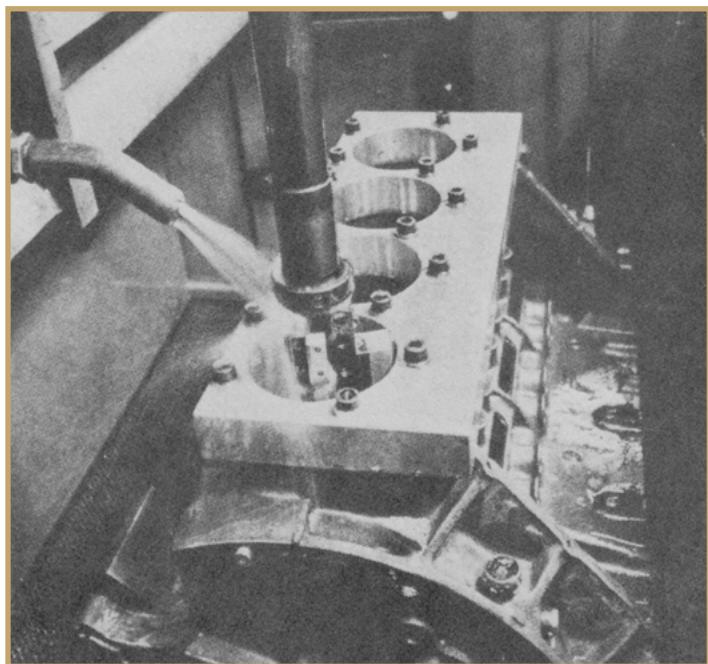


Figure 3 is a drawing that displays marks in the proper degree angles and shows an evenly cut hatch where the cuts are the same in both directions. The areas in between the cuts are the plateaus we need. This grooving is brought about by the thousands of cutting heads of the abrasive gain in the stone itself. With the Flex-Hone, because it is self-centering, the pressure against the walls will be equalized so that you have no need to worry about even cuts in both directions. Also with the Flex-Hone you can and should bring the hone out of the cylinder while it is rotating, thus bringing the finish up and out of the cylinder so that the whole cylinder will look the same and your needed cross hatch will be under the ridge or at the top of the ring travel.

## A COMPARISON OF HONING DEVICES...AND A FEW THINGS TO WATCH FOR

We visited a production engine rebuilding shop in Los Angeles and asked the Supervisor if we could have 4 or 5 replaced stones from their Power Hone machine. The type of machine is shown below. Bear in mind that these stones were worn out and had been replaced. We were told that the set of stones would do about 20 to 22 blocks, depending upon cylinder diameters. When you look at the final measurements in Figure 4, just think what the last few engines' cylinders must have been like in their final honed condition.



You can get one of these machines (pictured above) new for \$18,000 to \$30,000 and they would do an excellent job. With a good dial gauge and a careful and experienced operator you can hone pretty well to size with an excellent finish. However the stones are rigid and are subject to some limitations. Now let us look at the stones taken from the machine like this one:

We marked and measured the five stones that were given to us and labeled them A, B, C, D, and E in three places, bottom (1), middle (2) and top (3). This is something you can try yourself. Pick up 4 and 5 at random as we have done and get a micrometer (measurements at dead centers).

Results from this test are summarized in Figure 4 to the right. There was no stone left on "A". The operator had let it grind right down to the metal base. "B" had a taper of .017 inches (.4318mm) in its length. "C" had a taper of .009 inches (.2286mm). "D" had a taper of .037 inches (.9398mm)...which is quite a lot. It is difficult to imagine these stones doing a very good job on a newly bored cylinder.

Sometimes they ask us, "Will your Flex-Hone straighten out a cylinder?" I quite often reply that a brand new set of stones (rigid, that is) might. But at least our Flex-Hone never gets tapered. It can't. Its flexibility means that the centrifugal action will cause it to self-center and the pressure against the wall will be constant. With a lot of pressure on the rigid stones, a lot of stock will be removed. You can't get much pressure on the walls with the Flex-Hone. The Flex-Hone is just not a stock removal tool. Not if you are in a hurry.

Remember Figures 1 and 2 on page 3, showing the difference in surfaces between a rough, newly bored cylinder and a cylinder that had been Flex-Honed. We had a rough surface to begin with. It would not do that with a glazed cylinder. While evaluating "C" we noticed that the stone is broken off at the top. With the Flex-Hone, the abrasive globules are formed on the ends of high density nylon. Bang it on the top of a work-bench some time. See if you break any. Only if you wrap it up on the crankshaft counterweights will you rip any off. And think what you would do to a rigid stone type.

Pictured to the right is one of the best hand-held hones you can buy. It has been a standard for many years. We measured this one also and found the measurements showed the worn stones to be extremely accurate. It has two rigid stones and two guides. It is easy to adjust the sizes. On the next page are the measurements of the two stones (Fig. 5) taken in 3 places, one on each end and one in the middle.

Each of these stones had a high side and a low side as they naturally would have as they work on a curved surface. So we will show low and high measurements along its length.

Figure 4

Positions	1	2	3
Stone "A"	.202" (5.130 mm)	.190" (4.826 mm)	.176" (4.470 mm)
Stone "B"	.236" (5.994 mm)	.244" (6.198 mm)	.253" (6.426 mm)
Stone "C"	.251" (6.375 mm)	.255" (6.477 mm)	.260" (6.604 mm)
Stone "D"	.245" (6.223 mm)	.261" (6.629 mm)	.282" (7.163 mm)
Stone "E"	.229" (5.817 mm)	.224" (5.690 mm)	.222" (5.639 mm)

I would say that this hone would do a pretty good job of "straightening" out a cylinder, if that is what you were after. I really do not know what to say about the stone being about .010 inches (.254 mm) thicker than the other.

## THIS NEXT ONE IS SOMETHING ELSE...

I traveled to a repair shop that rebuilds and repairs high performance foreign cars and picked up a used three stone hone. Also the owner has his own race car. He apologized for this hone; as well he should. He explained that, "I now use the Flex-Hone." So maybe we can forgive him a little. One stone broken and the other cracked. The faces of the stones were about as flat as a golf-course. It would be a little ridiculous to measure them. But, brother, what they would do to a cylinder wall. It is amazing how many shops use devices just like this one...without a second thought.

(Below) A traditional two stone rigid hone.

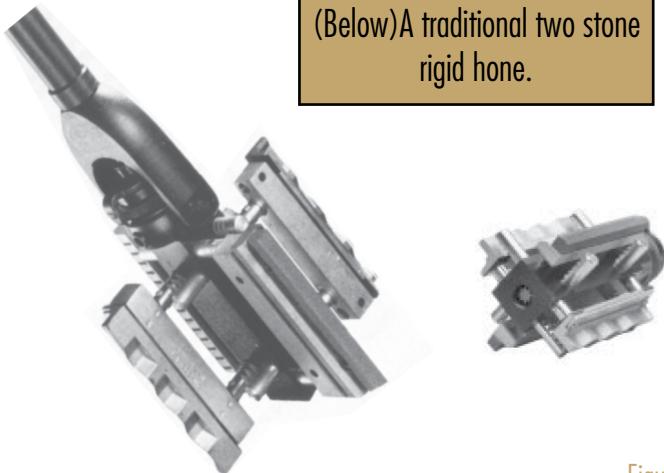
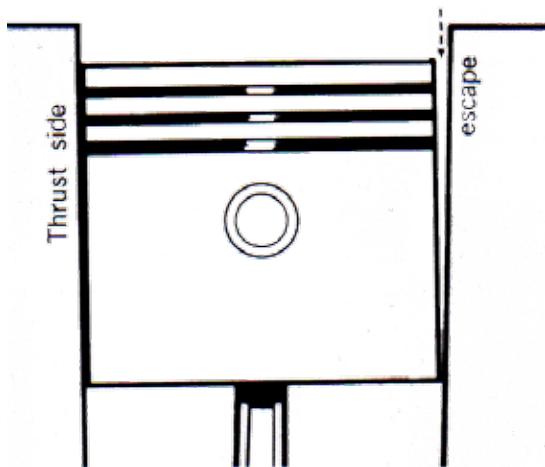


Figure 5

Position	1	2	3
High side of "A" stone	.595" (15.113 mm)	.595" (15.113 mm)	.593" (15.062 mm)
Low side of "A" stone	.552" (14.021 mm)	.552" (14.021 mm)	.552" (14.021 mm)
High side of "B" stone	.606" (15.392 mm)	.605" (15.367 mm)	.602" (14.275 mm)
Low side of "B" stone	.562" (14.275 mm)	.562" (14.275 mm)	.562" (14.275 mm)

## TAPERED CYLINDERS

Figure 6



A worn cylinder. Worn more at the top of course, with the taper GREATLY exaggerated.

A taper of more than .012 (.3048 mm) probably will have oil escape under the rings (opposite the thrust side) and may also have blow-by and will damage the rings.

However, some companies say that if the taper is not more than .007 to .009 that the cylinder walls should be deglazed.

The problem is that if you have a cylinder, glazed and tapered .005" and you use a rigid hone, by the time you have the wall de-glazed you have probably had to remove so much metal so as to make the cylinder unusable. You might have to remove as much as .005". The end result is a cylinder that is dangerously close to having serious problems immediately, and very well could develop them quickly.

The Flex-Hone, however, contours itself to the cylinder and deglazes it, puts in the proper crosshatch with almost no stock removal (.0005"). Furthermore, if you have a carbon, or metal ridge from ring wear which you have to remove with a ridge reamer, the rigid stone will have a difficult time getting your proper finish at this point. The Flex-Hone gets easily "under" the ridge to ensure proper contact between ring and wall.

## RING SEATING

Before we created the Flex-Hone, people would often say that a rough surface of friable material has to be left for the rings to work on or else the rings won't seat.

The need to "break-in" your cylinders arises from the surface finish that is generally accepted at the manufacturing level. The cylinders are usually finished with a very sophisticated diamond hone which cuts extremely well. The problem, however, is that the finish, while precise, leaves a lot of "proud" metal, or small peaks in the finish. The break-in process wears these away until they become the desired plateaued finish. The problem is that the wearing down is done by the piston and ends up wearing the rings and decreasing the life of the engine.

The Flex-Hone does it better and faster. By finishing the cylinder wall with the Flex-hone for 30 seconds, we can do what might take the rings 500-1000 miles (800-1600 km) to do, while saving unnecessary wear on the rings. Our users say that they get "instant ring seating."

We tell them, "Well, almost instant." It does take a few seconds to use the Flex-Hone.

Another benefit of having the Flex-Hone finish the cylinder is lowered oil consumption because of its superior finish.

## PORTED ENGINES: TWO-STROKES

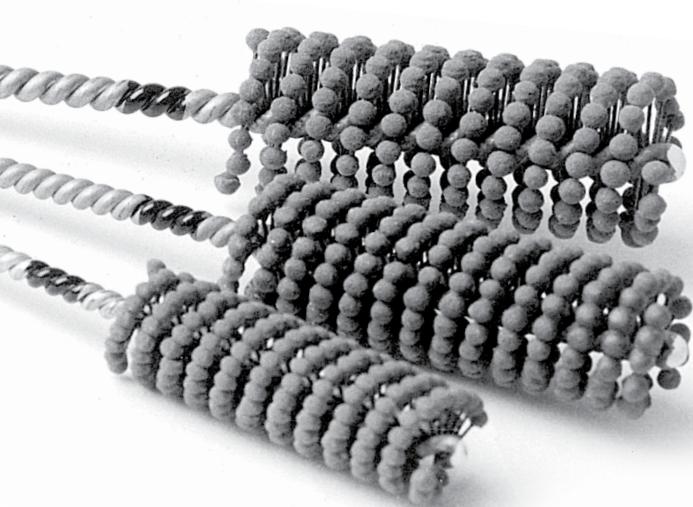
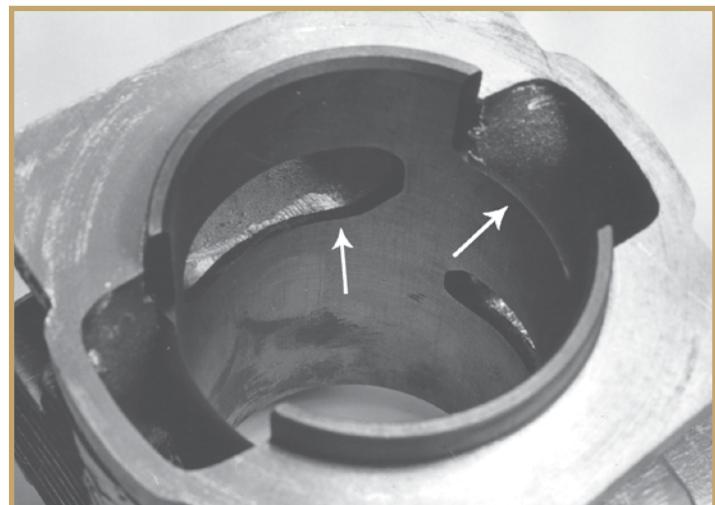
They have more emissions, faster RPM's, less moving parts, but ports present a problem in original manufacture or in rebuilding. They must be deburred, or the sharp edges of the ports do a butchering job on the rings. It is not only the sharp edges, but pressure behind the ring forces it outward against the walls - and when the ring gets into the big void that is the port, you have a shoe-horn effect. The ring bulges somewhat into the port. So, doubly, the port must have a gentle radius. You can do it with a rat-tail file, hand grinders, but with the Flex-Hone it is simple. With a two stroke the Flex-Hone must be the right size (diameter for the bore) or the globules of abrasive will pop into the ports and you will have unnecessary stone wear. That is why we make small graduated sizes for this class of engine. Look at the two photos to the right. One is of a cylinder that has been production bored, AND HONED with a rigid stone. Note the sharp edges (white arrows).

Now look at the second photo (right). THE SAME CYLINDER after 60 seconds with the Flex-Hone.

One U.S. Company who makes small ported engines has constructed a machine to take a group of barrels at a time. The Flex-Hone is rotated and actuated 15 seconds to the left, then 15 seconds to the right. The ports are deburred, and the proper cross hatch is put into their flash-chromed cylinders. Not only do they save a lot of time (money in manufacturing), but they report fast ring seating, and much better performance and longer engine life.

The Flex-Hone is used for a vast variety of deburring jobs.

In the U.K., a manufacturer of hydraulic cylinders has a step-down master cylinder. The Flex-Hone is used as a finishing operation in each one they build. Another U.S. major car manufacturer uses the Flex-Hone before roller burnishing to remove the peaks- and it results in zero rejects.



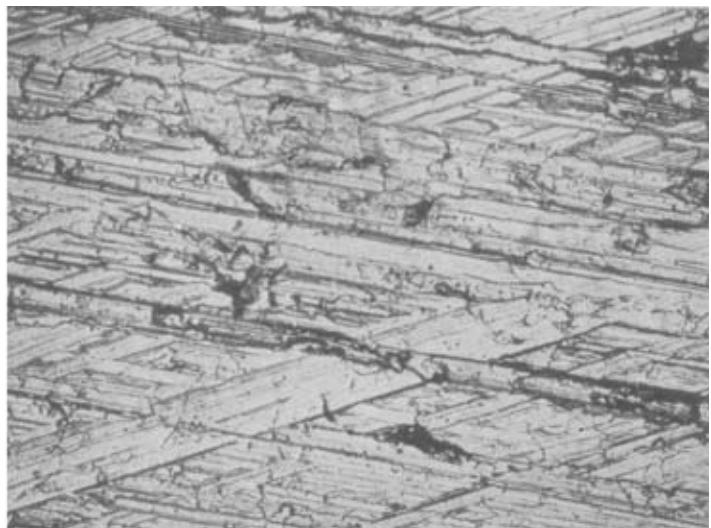
## MONEY (TIME) SAVING OPERATIONS FOR FOUR-STROKES?

We say, "BORE TO SIZE and USE OUR FLEX-HONE TO DE-FEATHER AND CROSSHATCH." But that is not always possible.

If your boring machine is of the best, is well maintained, the cutting tool has the proper face, and the side and back rake angles in a way that it will cut a chip (like a high grade metal turning lathe does), THEN you can bore to size, or within  $\frac{1}{2}$  a thousandths of an inch (.0127mm) and use our Flex-Hone to take off the peaks (defeather) and put in the proper crosshatch. What do you save by using the Flex-Hone? You save yourself a whole big fat rigid honing operation and probably get a much better job.

Let us look on the next page to some less than good boring jobs and some less than desirable rigid honing faults.

Figure 7



Bear in mind that as much as possible we should maintain the original micro-structure of the metal up to and including the cylinder wall surface. Boring bars that do not cut a chip, but plow through the metal deforming it sideways, and inwards while it pries off the metal removed, will undoubtedly deform the sub-surface layer. This is usually many times the depth of the final finish and this "slip-ring" or plastically deformed sub-surface structure will have different characteristics than the original metal of the block or liner. Too heavy a pressure of the boring tool or the heavy hogging hone will also super-heat the surface metal causing work-hardening.

Another undesirable feature is the removal (tearing out) of the carbon particles that are so important to the cast iron structure. Not only are carbon particles important, but their removal often times causes a cavity in the bore surfaces that collapses, leaving a large hole in the surface. This plowing action of the improper boring operation or the heavy pressure of the stock removal honing operation TEARS metal, cuts WIDER grooves than are necessary, and FOLDS over the peaks. All this has to be worn off by the rings in their seating-in operation, if they ever do seat.

It is easy to tell with the naked eye if your groove (cut with your heavy pressured rigid stone) has cut, torn, and folded metal. The groove will have a wavy appearance.

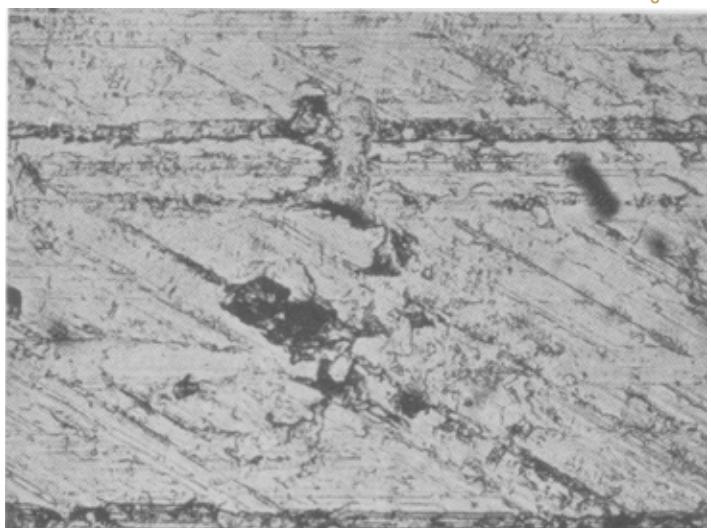
On the right (Fig 7) you can see the smeared metal, the places where the graphite particles have been removed leaving holes in the surface, in which debris can lodge. What sort of surface is this to hold oil, to seat rings, to give compression, to add life to the rings?

Figure 8 shows that the horizontal scratches are boring tool marks. They need to be honed out. This is no job for the Flex-Hone. It is not a metal removal tool. You need the heavy pressure of a rigid hone. An operator with a boring machine that leaves tool marks like these had better bore .002" (.0508mm) or .003" (.0762mm) undersize and rigid hone out the balance. But rough honing it out, fast, with heavy pressure, and not sufficient coolant-lubricant, can only result in a very undesirable finish.

Figure 9 shows a used cylinder wall, like the one just above. Note the wide grooves where the rings had to do the final honing job and had to tear out torn and folded metal leaving wide, deep gorges in the metal. The finish was left so sharp that burrs were put on rings, which is seen by the up and down scratches, where the burrs cut into the wall in the travel of the piston.

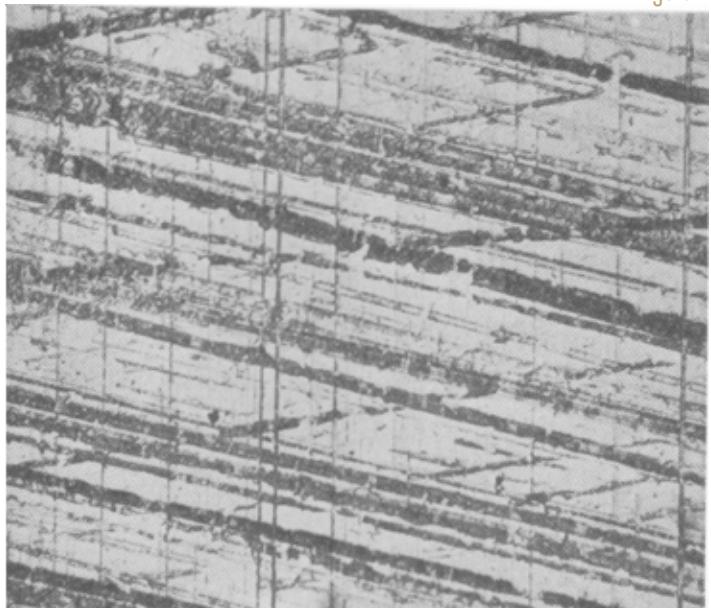
The horizontal boring marks (Fig. 9) form quite a resistance to the rings in their upward or downward travel. Ring breakage...oil usage. In the bottom photo, note the uni-directional original cross hatch. One-way cuts cause your rings to turn, bound, and break

Figure 8



X100

Figure 9

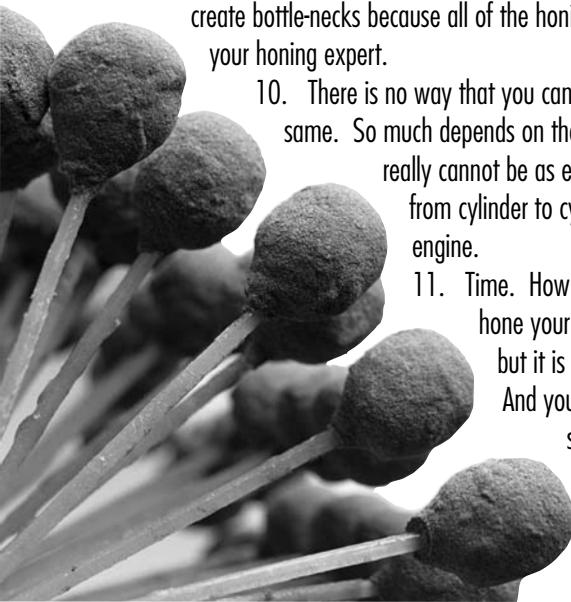


X100

## HOW THE FLEX-HONE® DIFFERS FROM THE RIGID HONE

Let's review some of the disadvantages of using the rigid stone types:

1. A new set of stones are straight and in the initial application can be expected to hone straight. The first cylinder contours them, and each succeeding cylinder adds to the unevenness so that they just do not hone straight any more.
2. In honing a worn cylinder, the rigid stone has to grind out the high spots before it reaches the low spots. Sometimes you have to take out more material than you either want or need to.
3. In order to remove metal the stones must exert enough pressure against the wall. This pressure then often tears the metal, folds it over, cuts deeper grooves than is necessary or desirable.
4. The stones load up. When this happens they must be wire brushed out or the parts of the stone face that are loaded up with cut metal and varnishes will not cut.
5. If your honing device is worn in some of its fittings, then sometimes the hone body will not hold the rigid stone securely and square to the cylinder wall, causing them to cock to one side. This causes the rigid stone to gouge into the metal, so that one stone cuts differently than the other.
6. There is a problem in trying to get even pressures from each of the stones. Some hones have spring-loaded stones which try to equalize the pressure. Others have metal guides or felt pads. The pads certainly carry the honing oil, which helps, but being softer than the stones are not that good as a guide.
7. The stones break and crack which means a replacement. This means not only the cost of the new stones, but also the cost in labor from the time spent replacing them.
8. You really can't run the rigid hone out of both open ends of a cylinder, though you should or you run the risk of creating a bell-mouth at the ends. Also, you should be able to remove the hone while it is still spinning to create the crosshatch finish where you need it - at the top of the ring travel.
9. Most rigid honing in a shop has to be done by the experienced mechanic. It is not an easy job and requires skill and training. This can create bottle-necks because all of the honing jobs have to wait for your honing expert.
10. There is no way that you can hone each cylinder the same. So much depends on the operator, that you really cannot be as exact as you should be from cylinder to cylinder and engine to engine.
11. Time. How long does it take to rigid hone your block? It all depends, but it is quite an undertaking. And you better have a good supply of extra stones lying around.



## THE FLEX-HONE® DIFFERENCE

1. Instead of two or three stones, such as in the rigid hone, we have hundreds of smaller stones that are flexible. You have 360 degrees of cutting medium going for you all the time.
2. It cuts very quickly and easily. No training necessary, no expensive machinery, not to mention any wasted time.
3. There is very little pressure on the walls. Only the pressure created by the modulus of the nylon filaments. This tool cannot gouge out the metal and cause torn or folded over edges.
4. The hone is self-centering and self-aligning thanks to its patented design. You get even pressure from each abrasive.
5. You can cut off the old surface and present a new surface with the proper ring-seating and oil retention WITHOUT a great deal of metal removal. A remarkable achievement.
6. The honing stones are practically unbreakable, and are self-wearing so that you always have abrasive on the outermost edge of the tool.
7. No loading, no wire brush cleaning. Just rinse the tool with water to clean.
8. You can (and should) have the tool rotating before entry into the cylinder. It enters more easily and doesn't put vertical scratches in your upper cylinder. You'll be able to properly create a cross-hatch finish from end to end without any bell-mouthing.
9. A balanced engine because every cylinder will have the same finish. The kind of consistency and quality you can rely on throughout your organization.

Please ask for it by name:

**FLEX-HONE®**

## COARSE V.S. FINE FINISHES

With a high performance engine where the maximum compression is wanted, and the running life is short, perhaps you may want an ultra-fine finish. Possibly with a large diameter bore engine with a slow RPM and a heavy viscosity oil, you may want a coarse finish. Care must be taken with coarse finishes, particularly in new engines. The increased friction causing excessive temperatures may promote scuffing and excessive wear on the rings. The greatest engine friction is the piston-ring/cylinder sliding-bearing interaction. Fine finishes reduce friction and oil retention capabilities.

Today's multi-viscosity high detergent oils do not need the deep finishes that yesterday's paraffin based oils required. A deep (coarse) finish may carry up to ten times the oil needed to lubricate the cylinder wall (if multi-viscosities are used) resulting in excessive oil consumption.

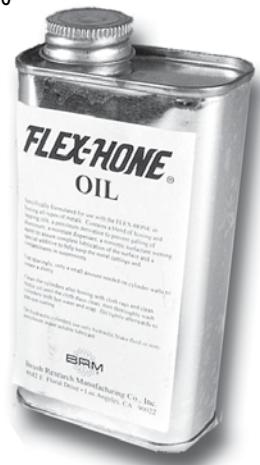
As an example, there happens to be a 1,000 cc twin motorcycle on the market today whose engine style has not changed for many, many years. The thin walled iron sleeve on the new bikes is subject to warpage if the new owner does not exercise great care in the breaking-in process.

There has been a lot of replacement of sleeves. Our local agency has discovered that before delivering the new bike or replacing new sleeves, that Flex-Honing the cylinder has cured this fault. This is perhaps due to the old thinking of a coarse finish to begin with. Excessive friction creating excessive heat between the piston rings and the cylinder wall undoubtedly caused the warpage, and may also have annealed the rings.

## CLEANING WALLS AFTER HONING

If you are going to leave the crankshaft in, then of course be sure to mask off the journals. Some guys even cut an old rubber beach ball in half and push down into the bottom to catch the dirt. But catch it. That is why we recommend a light-weight oil, to lubricate and increase the life of the hone, to absorb the heat and prevent hardening of the metal, and to catch and hold the metal grindings, the abrasives that have chipped and been cast off and the other contaminants. We have compounded a Flex-Hone Processing Oil. It contains cutting oil, lapping oil, a wetting agent, a rust remover, a super lubricant, and the same stuff they would put in toothpaste to pick and hold all the "bread crumbs." A few drops will do. But whatever you use, PLEASE DON'T use a solvent, kerosene, or diesel oil. They penetrate into the

wall finish and will fill the valleys of the finish with all the contaminants you want to get rid of. Also, NOT only should you not use solvents to hone with, you should NOT use them to wash out your cylinder for the same reason. After the honing job, just don't wipe it out with an oily rag and smear the abrasive into the surface. Instead, use a good brush and some (preferably) hot water and some soap or detergent, and wash it out until the foam stays white. Then wipe it with a paper or cloth towel until the cloth or paper towel stays clean and white. Then dry it out so it won't rust, and protect it with a swabbing of light oil.



## QUALITY CONTROL - MANUFACTURING SPECIFICATIONS

When a new engine is being developed, somewhere in design engineering, somebody decides on the cylinder wall finish. It goes on the print, and becomes law. Manufacturing sets it up with the equipment that they have, quality control often checks in the beginning, but when things become routine.....

As an example, we got 9 air-cooled two strokes right off the shelf, single cylinder, aluminum alloy with chromed cylinders. We ran them on a surface analyzer. We could only check the surface finish from the crank end as it was a closed jug and the stylus would not reach up to the top of the cylinder (plug end). The readings were:

Figure 10

Cyl. No.	FINISH		OUT OF ROUND			
			Top		Bottom	
	A A	µm	Inches	mm	Inches	mm
1	5-50	.127-.127	.0008	.0203	.0004	.0102
2	8-15	.203-.381	.0015	.0381	.0005	.0127
3	5-10	.127-.254	.0017	.0432	.0002	.0051
4	7-15	.178-.381	.0005	.0127	.0007	.0178
5	5-50	.127-.127	.0014	.0356	.0005	.0127
6	6-12	.152-.305	.0005	.0127	.0003	.0076
7	5-10	.127-.254	.0025	.0635	.0023	.0584

BEFORE

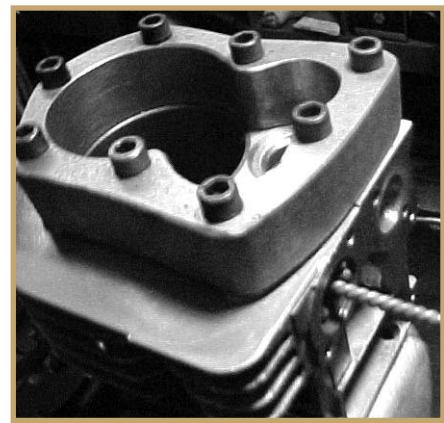


AFTER



Their desired finish was 7-10 (.178-.254 µm Ra).

We sawed the top off the one of the cylinders and found a finish of 1-2 AA at the top of the ring travel.



Assumption: They had used a Micromatic type automatic with a diamond stone. Perhaps the stone was worn unevenly because of the ports and may have "bounced" causing out-of-round, and the stones may have become tapered causing almost no cross hatch or finish at the plug end of the cylinder, where it is needed most.

We had No.1 cylinder professionally honed with a Sunnen Power Hone. Finish was improved 10-45AA and the out-of-round remained .0008" (.0203mm) and .0004" (.0102mm).

We tried No.2 with an 80 grit, No.3 with a 40 grit, No. 4 and 5 with a 120 grit and a No. 6 and 7 with a Flex-Hone 180 grit.

No. 6 used the Flex-Hone 180 grit Silicon Carbide for 30 seconds. Finish 5-12AA. Out-of-round after honing .0007" (.0178mm) and .0004" (.0102mm). Finish remained the same. Out-of-round deteriorated.

No. 7 used the Flex-Hone 180 grit Boron Carbide for 30 seconds. Finish after was 5-12. Out-of-round .0022" (.0559mm) and .0003" (.0076mm). Out-of-round was greatly improved. Rather inconsistent with No. 6?

MicroSurface Engineering Labs conducted the tests with the finest of equipment in a Clean Room atmosphere. Approximately 3 ½ hours EACH was spent on EACH cylinder before and after to check the out-of-round and to make sure the axis was perpendicular. The manufacturer had previously no knowledge that his finishes were different on each cylinder, had no knowledge that the finish deteriorated from the crank end to the plug end until it disappeared into NO finish at all.

#### IF THERE IS MORAL:

Constantly check. Take nothing for granted. One reading does not guarantee a production run any more than one swallow makes a summer. Don't be too sure or too smug about your equipment or your readings. AND—can we really trust the readings given to us? How consistent can we be? After trying to analyze these readings, I began to wonder, "How long is a piece of string?" "How big is a brick?"

## MICRO-FINISHES

Machines that read profiles fall into many categories. Like honing or boring machines, they depend upon price, maintenance and operator skill. Some use a diamond stylus with good accuracy. Others use an electronic reading with better accuracy. Most use a skid which gives you an average finish. We have AA (Arithmetic Average) or RMS (Ratio Mean Square) which is about an 11% higher reading than AA.

Some machines are set on a concrete base, and then set in sand, in an atmosphere-controlled room, and the operators are masked. Some machines sit on a table (work-bench) in the back room of the shop where they are dusty, dirty, and are subject to all the vibrations of the factory.

The section of the cylinder that is tested is usually about 1 ½ " (38.1mm) to 4" (101.6mm) in from one end of the cylinder. The section measured is, at the most, ¼ " (6.35mm) long. Some shops mark their cylinders in 4 parts, (90 degrees apart) at each end of the cylinder and get 8 readings per cylinder. Unfortunately, not many will take the time to do this.

So be cautious of the readings that you are given. Qualify them if you can. No reading given to you is necessarily representative of the finish of the entire cylinder surface. The reading is for the part that was measured. Look back at those pictures of worn cylinder surfaces. Can you imagine a reading from one of these? Can you imagine each reading being different?

## FATHER KNOWS BEST

We heard that expression enough times when we were kids, but we did not always believe it to be true. Later we found some of our beliefs were borne out.

Many engineers echo the beliefs of their company or their supervisor. It makes for better job security to go along and not muddy up the water. If MB wants a coarse finish on their cylinders, then every MB engineer you meet in Europe will tell you sharply that the only finish is a rough finish and

will not listen to any argument. If a young man reads in a magazine that one of his well known racing engine idols uses a fine finish, then that is what his car must have. It is just not so. Or not NECESSARILY so.

Where do I get my qualifications? I don't have any, really. But I have spent many hundreds of hours at Trade Shows in most countries of the world, talking, discussing, and arguing with engineers from every walk of life. I have spent hundreds of hours in Engineering and Service Departments of many, many engine manufacturers, talking, explaining, and asking questions. And I have read every book and engineering paper I could get my hands on written on the subject.

My biggest answer to most generalized questions is "It just depends - it has to be qualified to the situation. There is no stock answer." There isn't any one person who has all the answers. This includes all the guys that think they are experts.

If you have read this far, I thank you for listening to my personal opinions. Keep an open mind. Experiment. Do not be afraid to try something new.

## TO ALL THE OTHER ENGINEERS OF THE INDUSTRY

... Whose only connection with the combustion engine is to drive it back and forth to work: THERE ARE MANY CYLINDERS in automated machines, pneumatics, hydraulics, that need deburring at the cross hole entrances that need finishes to prevent weepage. There are air compressors, shotguns, and air cylinders. There are problems of providing the necessary clearance for valve guide stems, connecting rod pins and bolt holes, bronze shoe pins, cleaning cam follower holes, intake valves of all types and sub-surface oil pumps, tapered tubings that need tapered hones, step-down cylinders that need certain finishes.

Try a Flex-Hone. The principles of finish are not that much different from the sealing process of a piston ring with a cylinder wall. The same basic ideas still apply. We will work with you, and make samples for experimentation. The sample goes with a memo billing. If it does not work out, return it. If it does work out, and you keep it, all we need is a P.O. to cover it.

We say we don't guarantee our product because we do not know when someone will try to use a pocket knife to cut a nail in two, or use a cold chisel to pare an apple. But we do strive to guarantee a satisfied customer.

Although you can get fast service from our factory on any of your needs, be sure you have our Catalog and check our website at [www.brushresearch.com](http://www.brushresearch.com) for more information on the Flex-Hone as well as other available on-line literature. In Europe, Scandinavia, the UK, Middle East, North Africa, South Africa, The Far East, Japan, and Oceania, Australia and New Zealand, we have distributors who carry stock and have competent advisors. We also have distributors in most countries in South America.

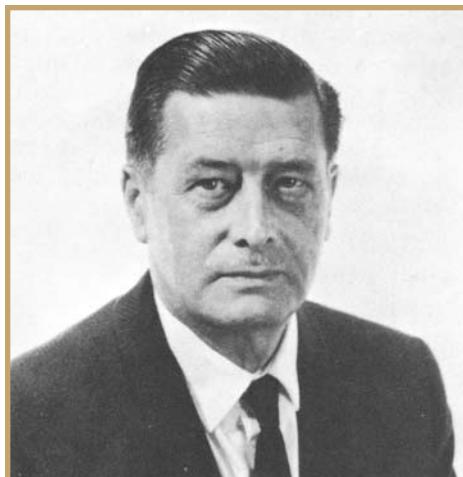
## CHIT-CHAT

Among other things, my Dad was a farmer, and I well remember when farm tractors started to make their appearance. Forward looking farmers, and particularly the young ones, could not wait to get their hands on a Fordson. There were many skeptics. The farm tractor did not look like a team of horses, it cost more, and they were sure that the machine was so heavy that it would pack down their land so hard that nothing would grow on it. The salesmen put on a big community demonstration and had answers for the economy and the performance, but the last excuse they could not counter.

It took many years. The progressive ones had no time to worry about face-saving or that the days of the hay burners, lodged in their barns, were numbered or to admit that they really could not afford a tractor. They got one and plowed new furrows, more of them, deeper and straighter than ever before.

We still have the progressives and the skeptics today. But with the second group it just takes a little longer.

At many, many shows sponsored with the conventions of the Society of Automotive Engineers, Society of Mechanical Engineers, Design Shows, Society of Petroleum Engineers, Automotive Service Industries, etc., we always had the busiest booth at the show. We had something new and we demonstrated. Most times there were from 5 to 20 engineers in front of the booth. And barring interruptions, and if they listened that long, this Booklet is my entire sales pitch. At least a couple of times a day when I had gone through my routine and had finished answering questions as best I could, some guy would pipe up from the edge of the group and say, "What the man says is true. I know. We use them." Such comments were the rewards of the day.

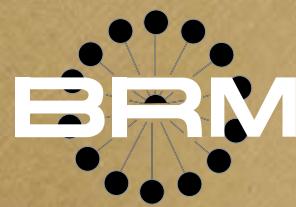


Steve A. Rands Founder of:  
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