TECH Talk



# Master Keying

## MECHANICS

"A master key system is one that provides a magic key that opens all locks." Those of us who are Architectural Hardware Consultants, or who aspire to be consultants, know what a sweeping and inaccurate statement that is. Nevertheless, it is what a great many consumers truly believe and this quote comes from such a consumer. Those who may use the coveted "AHC" after their names represent by so doing that they possess professional competence, dedication and integrity. This means that when they design a keying system they are supposed to know: 1) how to do it; 2) what the owner's requirements are; and 3) that the owner understands and will know how to administer the system.

How I wish I could say truthfully those three conditions were met every time I laid out the keying for a building! How about you? Probably Point 3, which requires that we be educators and teach something to someone is where we fall down the most; yet, if the owner doesn't understand the system or how to use it, what is the point of our taking the time to find out the requirements and establish the system?

Over seven years ago the first hand book was published. Here, at long last, a code system was made available that could be universally used. It would eliminate repetitive writing, provide the opportunity to present to the architect and owner visually, and in simply understood chart form, the entire system. It even assured that if used properly, it would drastically reduce the misunderstandings, correspondence and delay in having keying instructions understood at the factory.

So what happened? Learned AHC's pronounced that their own system was better, the new one too complicated, no one would understand it, and other equally esoteric nonsense, all going to demonstrate that old adage, "You can't teach an old dog new tricks."

Fortunately, there were enough good AHC's around so the system survived and is now alive and well. Unfortunately, it is sometimes abused because some of us rugged individualists can't resist injecting some of our own adaptations into the system. Hopefully, for the reader who has little or no preconceived notions about keying, the following may be of help.

## THE CHANGE KEYFIRST LEVEL OF KEYING

First of all, consider a cylinder that has six pin chambers can be loaded with a "bottom" pin that is available in ten different lengths (called "increments"). This (because some mathematician said so) means that theoretically there are one million possible numeric combinations (called "key changes"). There are two problems. One is called the problem of adjacency. The other is psychological.

An example of the former would be the physical impossibility of cutting a key with the change number 908091. The angle or slope of cuts is such that a key with these depths in the order given is unworkable. Even allowing for differences among manufacturers, the degree of slopes of cuts overlap. Thus the angle of cut sloping up from the first "9" depth would remove adjacent metal so the next depth of "0" could not be made. Illustrated, it would look something like this:

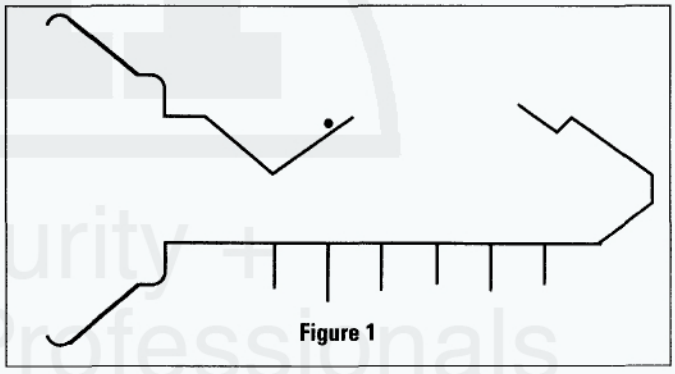

Figure 1

The dot indicates where a number "0" cut would bottom out if there were any metal there to cut into. The lines drawn at the bottom of the key indicate the location of each pin chamber in the cylinders to which the depth cuts in the key must correspond. A good practice then would be to avoid 9-0, 9-1 and 8-0 adjacent cuts. If this is done, the one million possible changes are reduced to 753,754. Another point is the difficulty of inserting a key cut alternately shallow and deep into the cylinder. As the key goes in it raises pins into the pin chambers and these pins fallback into the depth cuts successively until the key is inserted all the way. Steep angles would cause pins to hang up and in some cases, would catch and a pin would not rise. The key then could not be inserted or, if at all, with difficulty. The so-called "psychological" problem can be illustrated by the change number, "222222". The user would be suspicious of the looks of a key cut to this combination, and, of course, if

anyone should try to pick a cylinder which had all the bottom pins the same length, it would be an easy job. If, for example, we decide not to use any keys having more than four cuts the same depth, an additional 1500 combinations would be eliminated. Removing all of the changes creating these problems reduces the one million possible numeric combinations to approximately 752,000. Bear in mind that so far we have not introduced a master key!

## THE MASTER KEY SECOND LEVEL OF KEYING

By providing a single master key, the number of possible numeric combinations is reduced again. The illustrations show a cutaway cylinder containing pins to allow a master key (687846) and a change key (455221) to operate the cylinder. All increments shown are two or more. The reason for this is that the difference in successive pin lengths is only 0.015" (sometimes less.) A master pin that is only 0.015" is not long enough to afford security and can also easily turn in the pin chamber. Keys cut only one increment from each other in one or more depth positions can sometimes operate cylinders (especially worn ones) for which they were not intended.

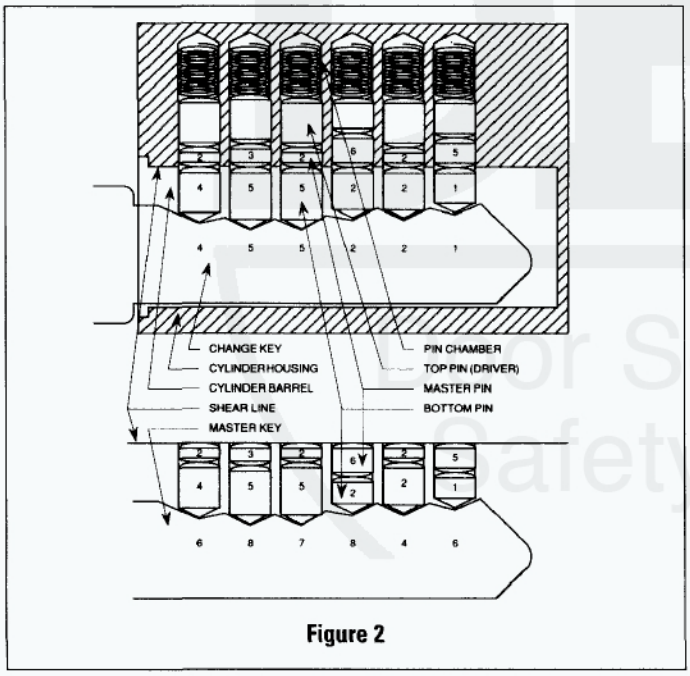


**Figure 2**

The following are all the key changes that will operate this same cylinder. Try it for yourself by working out the depth cuts of any of these changes and comparing them with the combinations possible as shown in the drawing.

| | | | |
|---|---|---|---|
| *455221 | 485221 | 655221 | 685221 |
| 455226 | 485226 | 655226 | 685226 |
| 455241 | 485241 | 655241 | 685241 |
| 455246 | 485246 | 655246 | 685246 |
| 455821 | 485821 | 655821 | 685821 |
| 455826 | 485826 | 655826 | 685826 |
| 455841 | 485841 | 655841 | 685841 |
| 455846 | 485846 | 655846 | 685846 |
| 457221 | 487221 | 657221 | 687221 |
| 457226 | 487226 | 657226 | 687226 |
| 457241 | 487241 | 657241 | 687241 |
| 457246 | 487246 | 657246 | 687246 |
| 457821 | 487821 | 657821 | 687821 |
| 457826 | 487826 | 657826 | 687826 |
| 457841 | 487841 | 657841 | 687841 |
| 457846 | 487846 | 657846 | **687846 |

* = change key; ** = master key

Note there are 64 different keys that can operate this cylinder, although all that is wanted is one change key and one master key to do the job. This means that when all 6 chambers contain master pins for every change key established under one master key, 62 others (64 minus 2) are eliminated!

As will be explained later, the maximum number of theoretical changes possible under a single master key is 4,096. This requires master pins in each chamber, however, and it is good security practice to leave at least one pin chamber "pure".

By this it is meant no master pins should be used in one pin chamber, only a bottom pin and the driver. If this practice is observed, and it should be, there are only 1,024 key changes available. Carrying this logic another step, if two pin chambers are left pure, therefore creating still a higher level of security, there are only 256 change combinations available. We now can understand why it is so important to allow for any desired extensions of the system at its inception. It naturally is to the owner's best interests for the system to have the maximum amount of security possible under the scope of the building(s).

To explain the above, work from the other direction and leave all the pin chambers but one pure. Remembering that 0.015" is the average increment between pins and that this is not sufficient, there are 5 positions that can be used (i.e., pin numbers 0, 2, 4, 6 and 8 or 1, 3, 5, 7 and 9.) Using only 5 pin lengths per chamber gives a theoretical total of 15,625 combinations. One of these positions, however, must establish the master key sheer line. An example of this would be:

| | | | |
|---|---|---|---|
| Master key | 045678 | | |
| | | 8 | master pin |
| Change #1 | 245678 | 245678 | bottom pins |
| | | 6 | master pin |
| Change #2 | 445678 | 445678 | bottom pins |
| | | 4 | master pin |
| Change #3 | 645678 | 645678 | bottom pins |
| | | 2 | master pin |
| Change #4 | 845678 | 845678 | bottom pins |

Therefore as seen in the example above, a numeric relationship in master keying is 1 to 4. If a family of more than 4 changes under a master key is desired, an additional pin chamber must contain master pins. Using two pin chambers provides 4x4 or 16 changes. Employing three gives 16 x 4 or 64, four pin chambers 64 x 4 or 256, five pin chambers 256 x 4 or 1024 and finally, by using all six, we are back to where we started with 1024 x4 or 4096. That same mathematician calls this four to the sixth power.

Recall that theoretically there were 752,000 possible stock or non-master keyed cylinders available and then by introducing a master key with which only five pin lengths per chamber are used, the possible number of combinations was reduced to 15,625 (5 to the 6TH power.) The difference between 15,625 and 4,096, namely 11,529, represents keys that "interchange" or include both master key levels and change levels as illustrated in the chart of key changes following Figure 2. Actually, these, too, are theoretical figures. Just as we had to reduce the one million combinations to 752,000 stock keys because of adjacency problems and psychologically poor cuts, it is necessary to reduce the 4,096 figure. A conservative reduction is 10% or 3,686.

## THE GRAND MASTER KEY AND GREAT GRAND MASTER KEY THIRD AND FOURTH LEVELS OF KEYING

Now let's talk about the grand master key, that status symbol second only to the great grand master key. At this point it becomes mind-boggling to consider the number of combinations eliminated everytime one master key is established. Suffice to say that when using standard cylinders, the available number of change keys is reduced drastically.

To get around this problem, different "key sections" are employed. This means that two or more master keys can be used which are of different configurations fitting cylinder barrels which have been "broached" to accommodate the keys. Master key "AA" or change keys under it, for example, won't fit into a cylinder which is operated by master key "AB" and its change keys and vice versa. But grand master key "A" will fit into and operate either cylinder. Thus, the same changes can be repeated under different master keys because even though the combinations are the same, the change keys will not fit into cylinders operated by a different master key. This is called a "Multiple Key System."

Some manufacturers have developed their own unique methods of being able to supply a greater number of secure changes under various levels of master keying. Since their methods are proprietary, it is not appropriate to describe them here. It is hoped that this will alert the student and consultant alike to at least some of the mechanical dangers of going overboard in establishing intricate and unnecessarily hard to understand-keying systems. They do become exhausted, thus limiting future extensions. And, when the building is completed, control of the system and its maintenance passes from the consultant to the owner; and it is the owner who makes the decisions as to the disposition of keys. We should remember this everytime we are tempted to establish a tricky keying "gimmick" that does nothing, really, except flatter our own egos.

## SYMBOLS

In the first part of this "Tech Talk" we considered the mechanics of master keying, now to the symbols. There is no purpose to be served by simply paraphrasing the handbook "Keying Systems and Nomenclature". Readers are urged to secure a copy of this document and, if necessary, learn it by heart! (At least study it until understood.)

A schematic drawing of the system should be prepared and the key symbols used should be transferred to the door openings on the floor plan of the building. This is the manner in which the keying proposal can be shown graphically to the owner and/or architect on the occasion of the presentation and decided changes can be made on the spot.

Now a caution — please, let's not invent symbols! Al, A2 and A3, for example, are not symbols for masterkeys under GMK-A.

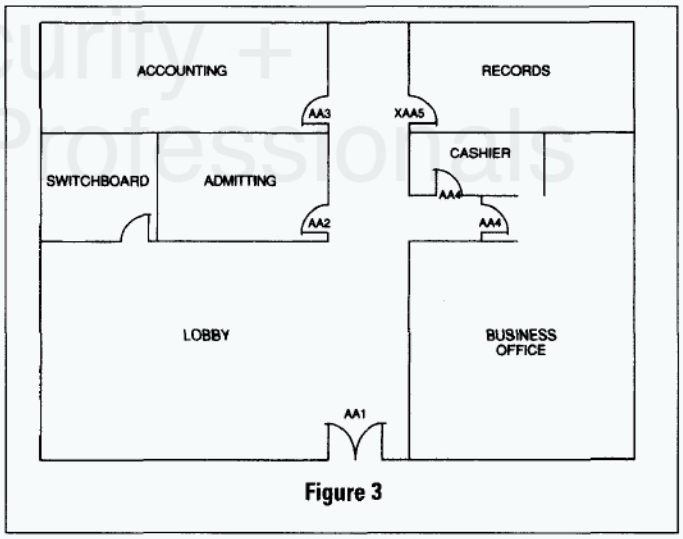


**Figure 3**

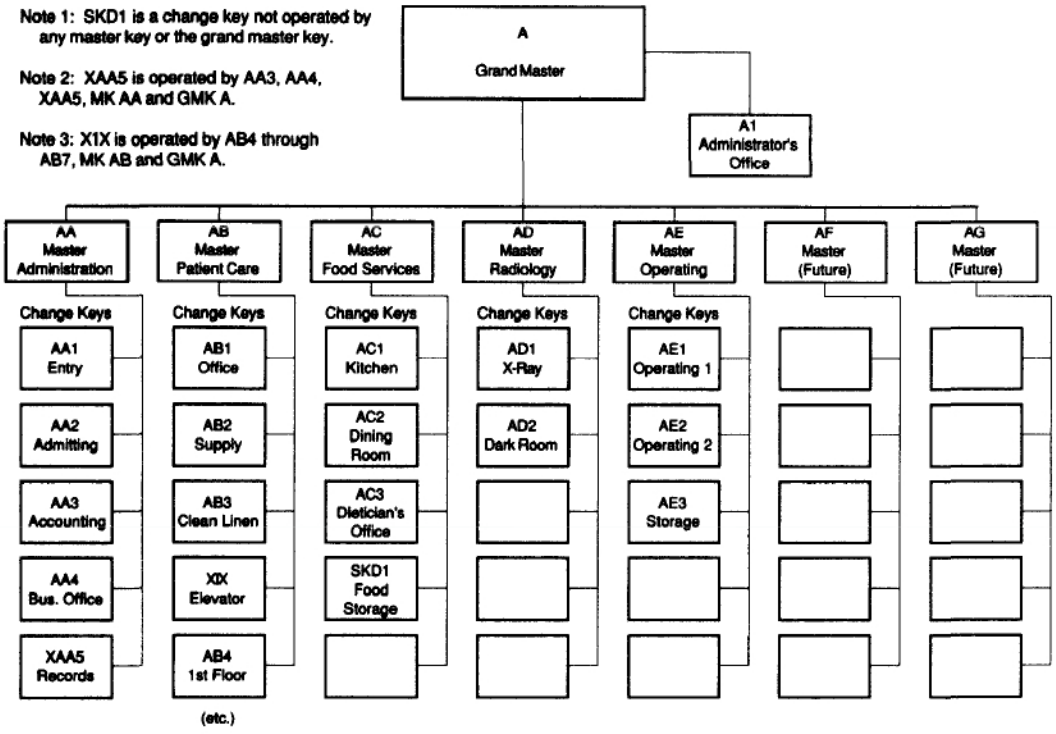


**Figure 4**

They are change keys under the GMK-A only, regardless of articles that have appeared in other hardware publications stating otherwise.

One of the virtues of this system is that in keying instructions to the factory, most symbols can be used without any accompanying explanation, because they mean one thing and one thing only. So please let's follow the system and we won't get a letter back from the factory saying, "What are you talking about?"

After all that preaching, it now is necessary to admit that there are some symbols which must be explained. The symbol for cross keying, "X", must have further instructions because the "X" tells us that cylinders so identified are operated by other keys. This is good because by requiring an explanation, the fact that cross keying is being done is highlighted every time it occurs. Cross keying virtually destroys the security of the cylinder and should be used for convenience only, and when security is not a factor. Crosskeying is achieved by the insertion of additional master pins which create added shear lines, making the cylinder relatively easy to pick. "Carrying two keys won't wear a hole in a pocket any faster than carrying one" is good advice to the owner who wants to do lots of cross keying. Figures 3 and 4 are a partial floor plan of a building with keying symbols

inserted in each locked opening, and the schematic layout which recaps the keying proposal. The cross keying shown is for example only, and is not necessarily recommended.

When the keying system has been approved finally, it is time (possibly even past the time) to enter the order with the lock manufacturer. Each lock ordered from the factory will have its keying identified by the symbols used on the chart. If a lock keyed to AB1, for example, is ordered once, this automatically means that it is a keyed different lock operated by change key AB1, the AB master and A grand master. If eight locks are ordered keyed to AA1, this automatically means that it is a keyed alike group of eight operated by change AA1, master AA and grand master A. None of this explanatory information needs to be written down, however, because the symbol says it all.

The following statements might comprise the total keying instructions attached for this job to a purchase order:

1. This is a visual control system. Mark the keying symbol on all key bows and on the face of all cylinder barrels.

2. Construction master key all designated cylinders and stamp all construction master keys "Construction Master."

3. Pack all locks and cylinders less keys.

4. Ship all change keys to: Ship all Construction Master Keys to: Ship Master and Grand Master Keys by registered mail to:

5. XAA5 is operated by AA3, AA4, XAA5 and GMK A. Note: XAA5 is a change number.

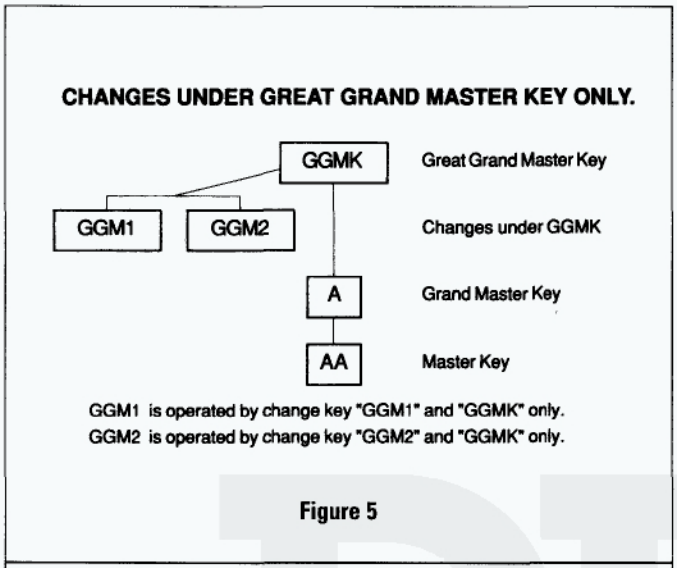


Figure 5

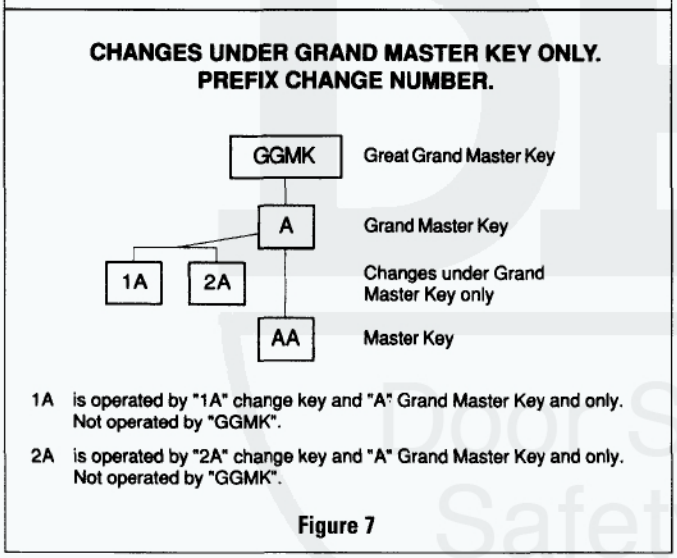


Figure 7

6. X1X is operated by AB4 through AB10, MK AB and GMK A. Note: X1X is not a change number.

7. Establish master keys AF and AG each with 24 change numbers for future expansion. Reserve 12 each additional change numbers under master keys AA through AE.

These instructions would be followed by the purchase order which should begin with a quantity order of the Grand Master Keys, Master Keys, Construction Master Keys and key blanks, if any. This would be followed by the number of keys per cylinder (or change) desired.

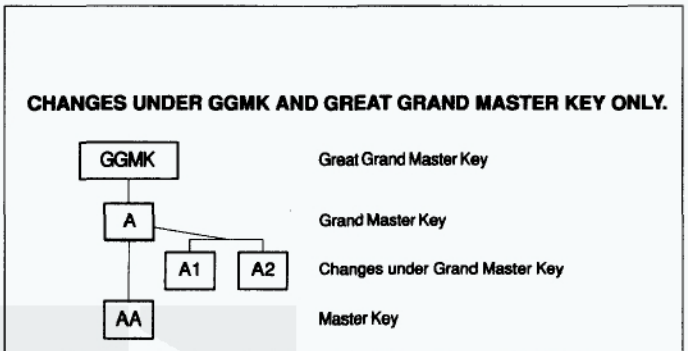


Figure 6

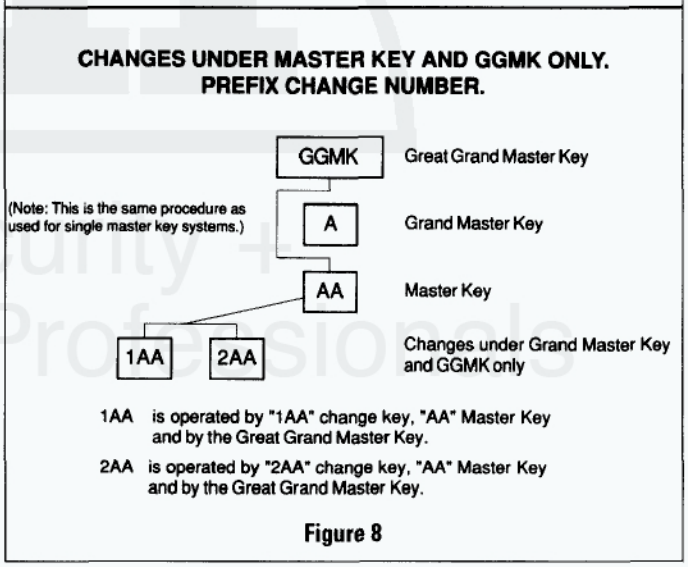


Figure 8

These notes to the factory probably should also be included in the hardware schedule, but this a subject for a different "Tech Talk". In the manual "Keying Systems and Nomenclature," there is a heading, "Exceptions". There described are symbols which can be used when a cylinder is to be operated by something different from the usual levels established (i.e. the change key, the master key, the grand master, etc.) These exceptions can be a little hard to understand and it is hoped the schematics shown in Figures 5 through 8 will be helpful.