MANUAL OF MASTER KEYING

FROM BASIC TO ADVANCED

FORWARD

This is a "HOW TO DO IT" manual and not a listing of ready to use Master Key charts. I believe that each system should be an original one and designed to fullfill the clients requirements. The contents go from BASIC to the more advanced systems and are arranged in that order. If there is any particular area of Master Keying that you would like to see covered write me and I will try to include it in future chapters. Additional chapters will be added and made available to all for a nominal fee as the need for them arises.

This manual is dedicated to all who freely give of their time and knowledge to aid their fellow men to obtain the skills and knowledge which leads to a higher degree of professionalism which in turn leads to a more satisfying and profitable passage through this life.

I can only present you with the knowledge and techniques of Master Keying. Like all skills, how proficient you become will depend entirely upon the amount of effort and time you are willing to invest. Skill and ability come from a thorough study of the subject and long hours of practice. MAY YOU BE WILLING TO INVEST THESE. My very best wishes go with this manual and may you profit greatly from your investment in it.

G.L."Gerry" FINCH
P.O. Box 28
Terryville, Ct
06786

MANUAL OF MASTER KEYING

Title..... Page/Chapter

CHAPTER ONE

The Language of Master Keying

This unit of instruction is designed for those individuals who will be setting up master key charts based on the Hardware Schedules provided by the Architectural Hardware Consultant (A.H.C.), Locksmith or whoever designs the system.

This section deals with terminology, keying symbols, and levels of master keying. Here you will learn the language of the A.H.C. The terminology along with the symbols used in master keying are totally foreign to the uninitiated, so they must be learned first.

A thorough understanding of the terms and symbols that follow is a must. **DO NOT** skip or rush through this section; to do so will make further study unnecessarily difficult. This is the foundation on which to build your expertise.

Terminology

Change Key (CK) A key which generally operates one lock only in a master key system.

Master Key (MK) A key which operates all the locks in a group, each lock in the group having its own Change Key.

Grand Master Key (GMK) A key which will operate all the locks in two or more groups of locks, each of the groups having its own master key.

Great Grand Master Key (GGMK) A key which will operate all the locks operated by the Master Keys and Grand Master Keys in the system.

Shut Out Key A key which will make the lock inoperative to all other keys in the system, except the Emergency Key.

Display Key A key which permits the occupant of a room to lock the door from outside against all keys except the Emergency Key.

Emergency Key A special master key which will operate all the locks in a system at all times. An Emergency key will open a lock that has been placed in the Shut Out mode by a Shut Out or Display key. With some locks the Emergency Key will also act as a Shut Out Key.

Key Interchange A very undesirable situation, where the Change Key in a Master Key system unintentionally opens one or more locks in the system that it was not specifically designed to operate.

Cross Keying This refers to the situation where two or more Change Keys in a Master Key system intentionally operate the same lock. There are two types of cross keying:

Controlled Cross Keying Where two or more Change keys under the same Master Key intentionally operate the same lock.

Uncontrolled Cross Keying Where two or more Change keys under different Master Keys intentionally operate the same cylinder.

Construction Master Key A key that operates all locks subject to it during construction, but becomes inoperative when the owner's individual Change Key is first used or a key designed especially to cancel it out is used.

Key Changes The total number of different keys available in a system. In a master key system it is used to mean the number of Change Keys available under a Master Key.

Key Section(s) The cross-sectional shape or configuration of the blade of a key. The key section is generally shown as a cross section viewed from the bow towards the tip of the key.

Sectional Master Keying Also known as Multiplex Master Keying. A method of enlarging Master Key systems by repeating them on additional sections. The keys in one section will not enter the locks in another section because of the difference in the keyway broaching (warding). The GMK or

GGMK will enter all the different keyway sections. It is milled in such a manner so as to bypass the warding in all of the various sections.

Key Set A term used to identify the individual key, such as Key Set AA1. etc,

Hardware Schedule A listing of the Hardware used on a particular job. It includes the type of Hardware, manufacturer, location used, finish, and sizes, etc. It will also include a keying schedule showing just how each locking device that is applied to a door or aperture is to be keyed.

The following are the symbols used on Hardware schedules and their accepted meaning. These are the approved symbols of the American Society of Architectural Hardware Consultants, and they are considered the standard of the industry:

KA (Keyed Alike) When two or more locks are combinated (pinned up) so that they can be operated by the same Change Key.

KD (Keyed Different) Each lock in a group (or a system) is operated by its own Change Key. It may also be operated by a Master Key but never by another Change Key.

SKD (Single Keyed Different) In a Master Key system of any level, this symbol indicates that the lock is to be operated only by its own assigned key. No other key in the system, including master keys, will operate it. Generally used on Food Storage areas, narcotic cabinets and areas where entry is restricted.

X (Cross Keying) means that a lock will be combinated in such a manner that the Change Key that operates another lock will also operate this lock. This is sometimes referred to as **keyed common**. The symbol X is used to denote a lock that is cross keyed. The X will always be used in combination with other letters and/or numbers.

Levels of Master Keying

Master Keying can be very simple or very complex. Practical Master Keying involves five levels of control. These levels are as described and diagrammed and become progressively more complex as they grow.

Level One involves no master keying, and it is most secure of all systems. All locks are operated by their own individual key which is known as a Change Key. The locks are keyed different or alike as required and operated only by the individual key assigned to it. This is the level most commonly used in homes and small stores.

Level Two Each individual lock (or group of keyed alike locks) will have its own Change Key which will operate that lock or group only and, in addition, will have a Master Key which will open all locks in the system or group. This is the simplest form of Master Keying, and it is used for small schools and apartments. Each lock is operated by its own CK and MK. See Figure 1.

LEVEL TWO

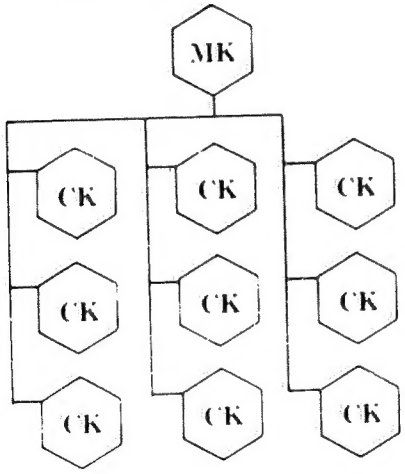


FIGURE 1

Level Three involves the use of a Grand Master Key. A typical system is shown. Under the GMK are two different groups of master keyed locks. Each group will have its own Master Key, and each lock in both groups will have its own individual Change Key. The Grand Master Key will open all locks in both groups while the Master Key will open only the locks directly under its control. Several Master Keyed groups can be under the control of one Grand Master Key. Fairly large master key systems can be established at Level Three. Often used for Hotels, Office buildings, hospitals and a school complex. Each lock is operated by its own CK, the MK assigned to the group and the GMK. See Figure 2.

LEVEL THREE

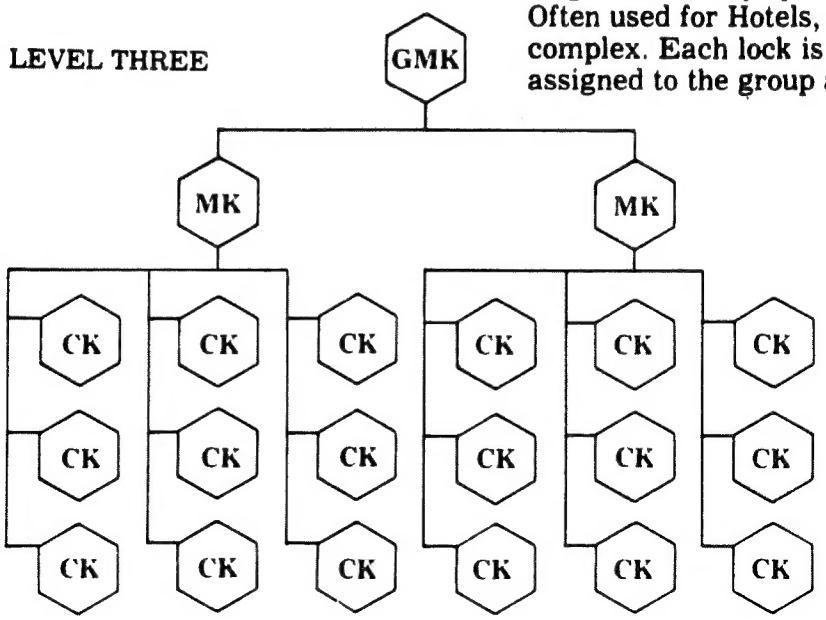


FIGURE 2

Level Four involves the use of a Great Grand Master Key (GGMK) under which two or more GMK systems, described in level three, operate. This level is most often used for large complexes such as universities, industrial complexes, large hotels, and hospitals. All locks are operated by the CK, MK, GMK, and GGMK. See Figure 3.

LEVEL FOUR

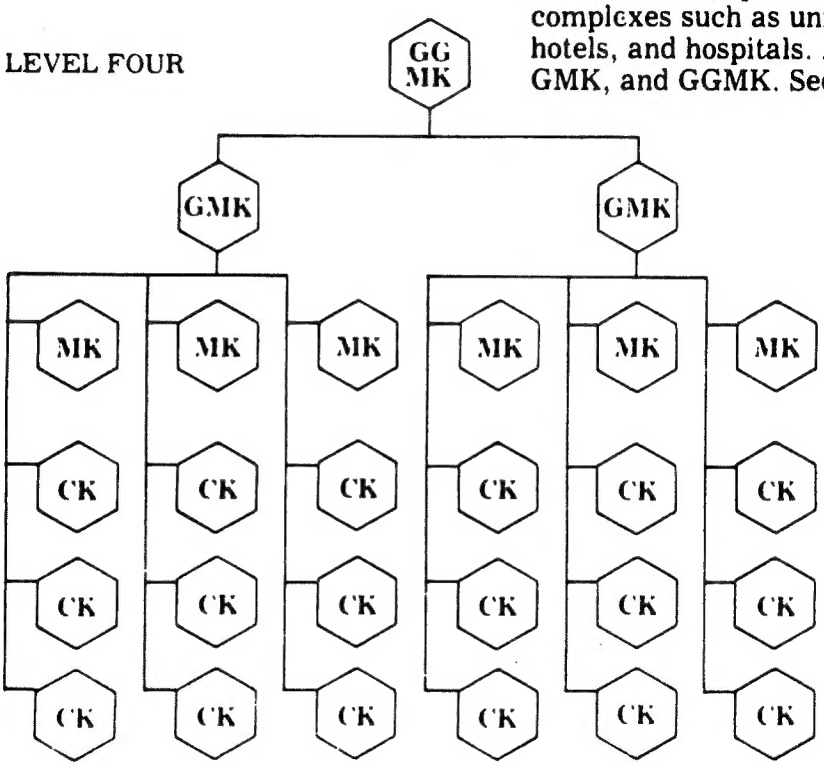


FIGURE 3

Level Five This level should be considered for use only when absolutely necessary. The reasons will be discussed later. Here two or more Great Grand Master Key systems are operated under the control of a key known as the Great Great Grand Master Key. This key will open every lock in all systems under it. Used for large universities and industrial complexes. All locks operated by CK, MK, GMK, GGMK, and GGGMK.

Keying Symbols and Diagrams

After the level of Master Keying required has been determined, what is known as a Hardware Schedule is drawn up. The schedule will show exactly how the building will be keyed up. Based on a layout of the building and the owners or occupants requirements, the schedule shows the relationship of every key and lock in the system. The level of keying and key indentification is done by symbols consisting of letters and numbers. The following charts show the method and symbols employed.

Single Master Keyed Systems — Level Two

When the system consists of only a Master key and a Change Key, the symbol AA will be used to designate the Master Key. All Change Keys in the system will be identified by a number placed **before** the AA (Master Key symbol). The following diagram illustrates this.

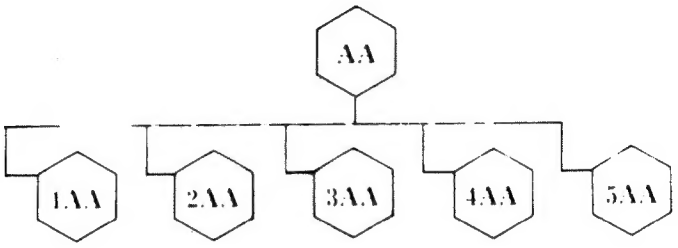


FIGURE 4

Grand Master Key System — Level Three

When a Grand Master Key is used as the top key in the system, the symbol used to identify it will be the capitol letter A. Master Keys under the GMK will be designated as AA, AB, AC, etc. Other symbols are as shown in the following diagram, Figure 5.

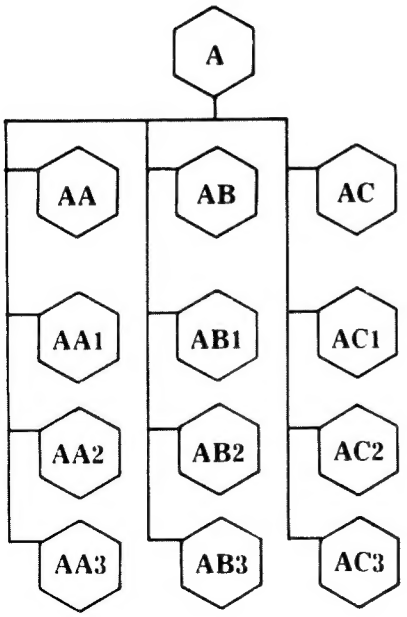


FIGURE 5

In level three, locks AA1 through AA3 will be operated by the GMK, Master Key AA, and the individual Change Key for that lock only. Locks AB1 through AB3 will be operated by the GMK A, the Master Key AB, and the individual Change Key for that lock only. The AA master key will not operate the AB locks and AB master key will not operate the AA locks; however, the GMK A will operate all of the locks in the system. Note that in a Grand Master Key system, the change keys are identified by placing a number **after** the Master Key symbol.

A2A, A2B, A2C etc. When the number of Master Keys exceeds the usable letters of the alphabet, use the letter-number combinations as shown for additional Master Keys.

Great Grand Master Key System — Level Four

In this system the actual initials of the Great Grand Master Key are used to designate the key, GGMK. All other symbols are as shown in the previous diagram. Here again, the change keys are identified by placing a number **after** the master key symbol.

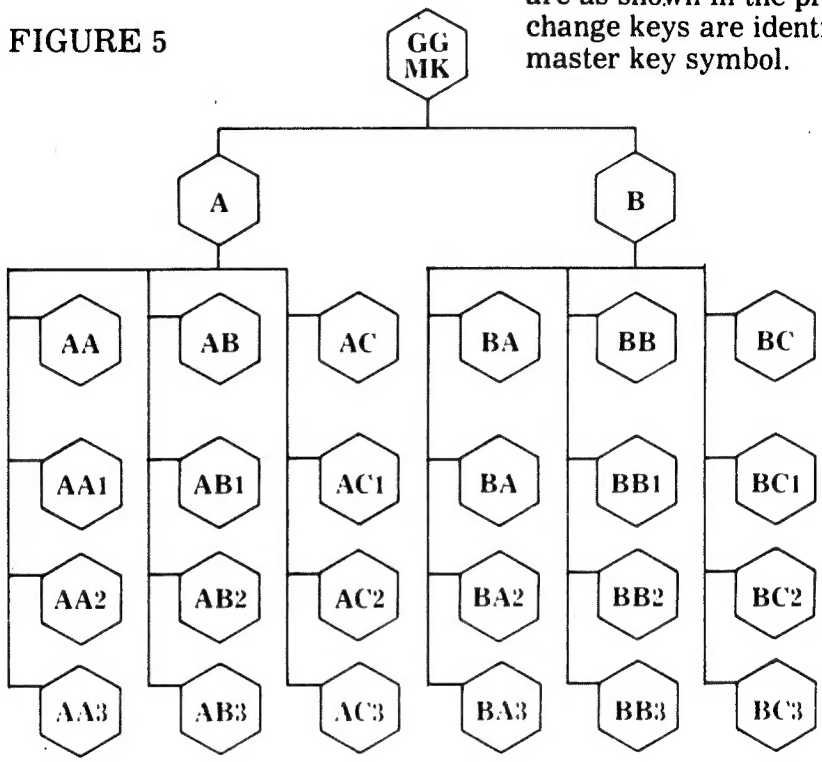


FIGURE 6

Under a GGMK system, if the locks are to be operated by the Change Key Master and GGMK the symbols will be that of the Master Key prefixed by a number such as 1AA, 2AA etc. CARE MUST BE TAKEN TO POSITIVELY IDENTIFY THE SYSTEMS BECAUSE THESE SAME TYPE SYMBOLS ARE USED IN LEVEL TWO MASTER KEYING. THE GMK DOES NOT OPERATE THIS SET-UP.

Great Great Grand Master Key System — Level Five

Again, the top key (GGGMK) is designated by the use of its initials. All other symbols are the same as shown in levels three and four.

Up to this point, we have shown you the major symbols used to identify each key at the various levels. Note that each key symbol indicates the function of the key in the system without requiring any written explanation.

The following are some further uses of the symbols that differ from those shown up to this point:

A When the keyset is shown and identified by the symbol A only, the lock is to be keyed to the Grand Master Key only. The lock will have **NO** change key.

AA When a keyset is shown and identified by the symbol AA only, it means the lock is to be operated by the Master and Grand Master Key only, it will have no change key.

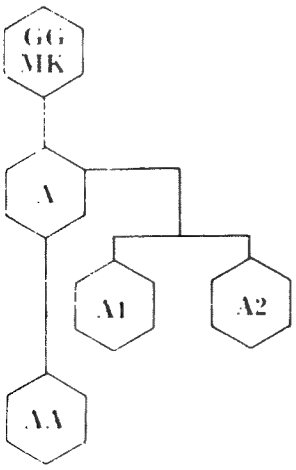


FIGURE 7

A1, A2, etc. These symbols indicate that they are change keys under the Grand Master, A. Each lock has its own change key. Only the GMK and the Change Key operate the lock. See Figure 7.

GGM1, GGM2 etc. These are change keys under the Great Grand Master Key only. The lock is operated by the GGMK and change key GGM1. See Figure 8.

SKD1, SKD2, etc. Single keyed cylinders. These symbols indicate that the lock is to be operated by its own change key only. No other key in the system is to operate the lock.

XAA4, etc. This means the lock is to be cross keyed, that is, keyed so that more than one key in the system will operate it. When this symbol is used, an explanation must follow it.

Example: XAA4 operated by AA2, AA and A.

XIX This means the lock is to be cross keyed as the example above, however, this lock will have no key of its own whereas the above example is identified with the AA master and given a number meaning it will have a key of its own. XIX does not identify the lock with any master.

Example: XIX operated by AA3, AA4, AA and A

The following pages show some examples of Hardware Schedules from which keying charts are made. Notice that all the hardware for a particular job is shown and not just those locks requiring keying. Wherever keying is called for, the key symbol will be found in the column shown as Key Set. The keying schedule is an integral part of a properly prepared Hardware Schedule.

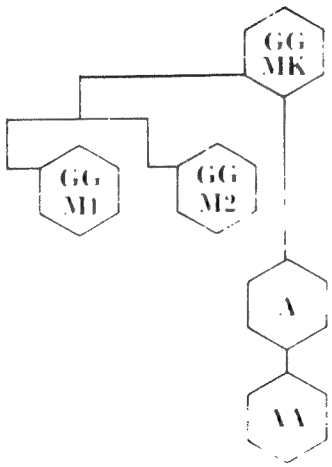


FIGURE 8

CUSTOMER CONSTRUCTION CO.
AVENUE N.W.
WASHINGTON, D.C. 20007

SALESMAN
CONTRACT NO.
DATE REVISED 12/29/78

JOB COMMERCIAL & RESIDENTIAL BUILDING
STREET N.W.
WASHINGTON, D.C.

ARCHITECT

PAGE #1

ITEM	QUANTITY	FINISHING HARDWARE	HAND	KEY SET	MANUFACTURER
		KEYING INSTRUCTIONS:			
		ESTABLISH MASTER "AA" TO OPERATE ALL LOCKS			
		FOR; STREET N.W. - WASHINGTON, D.C.			
	6	MASTER KEYS "AA"			
		ESTABLISH CONSTRUCTION MASTER TO OPERATE ALL			
		LOCKS.			
	6	CONSTRUCTION MASTER KEYS			
		"COMMERCIAL LEVEL"			
		HEADING #1			
		1 EXT DR C2 FROM RENTAL SPACE	LHR	SKD1	
		1 EXT DR C2 FROM RENTAL SPACE	LHR	SKD2	
		ALUM DRS & FRS 1-3/4"			
	2	PAIR CYLINDERS #985 x A.R. CAM CK US10B			FALCON
		BALANCE OF HARDWARE BY DOOR SUPPLIER			
		HEADING #2			
		1 DR C1 SERVICE VESTIBULE FROM RENTAL SPACE	RHR	SKD3	
		1 DR C1 SERVICE VESTIBULE FROM RENTAL SPACE	RHR	SKD4	
		HM DRS & FRS 3-0 x 6-8 x 1-3/4" UL"C"			
	3	PR BUTTS #450 TBB 4½ x 4½ PC			SOSS
	2	LOCK SETS M2510 x 1" DEADBOLT CK US10			FALCON
	2	DOOR CLOSERS #603PA DB			READING
	2	WALL BUMPERS #407½B10			H. B. IVES
	6	SILENCERS G164			GLYNN-JOHNSON

FORM 1

CUSTOMER: DONOHOE CONSTRUCTION CO.

SALESMAN

CONTRACT NO.

DATE REVISED 12/29/78

JOB: COMMERCIAL & RESIDENTIAL BUILDING
3301 "M" STREET N.W.
WASHINGTON, D.C.

ARCHITECT

ITEM	QUANTITY	FINISHING HARDWARE	HAND	KEY SET	MANUFACTURER
		HEADING #3			
		1 DR C3 SERVICE VESTIBULE TO METERS/SPRINKLERS	LH	SKD5	
		1 DR C3 SERVICE VESTIBULE TO ELECTRIC ROOM	LH	SKD6	
		HM DRS & FRS 3-0 x 6-8 x 1-3/4"			
	3	PR BUTTS #450 T 4½ x 4½ PC			SOSS
	2	LOCK SETS S581DL CK RG US10			FALCON
	2	WALL BUMPERS #407½B10			H. B. IVES
	6	SILENCERS GJ64			GLYNN-JOHNSON
	2	ALUM THRESHOLDS #130 - 36"			LINDSTROM
		HEADING #4			
		1 DR C4 RENTAL SPACE TO TOILET	RH		
		1 DR C4 RENTAL SPACE TO TOILET	LH		
		WD DRS & HM FRS 2-6 x 6-8 x 1-3/8"			
	3	PR BUTTS #350 T 3½ x 3½ PC			SOSS
	3	LOCK SETS S3D1 RG US10 x US26			FALCON
	2	WALL BUMPERS #407½S32D			H. B. IVES
	6	SILENCERS GJ64			GLYNN-JOHNSON
		"RESIDENTIAL LEVEL"			
		HEADING #5			
		4 EXT DRS R1 - APARTMENT ENTRANCES	RH	1AA THRU 4AA	
		4 EXT DRS R1 - APARTMENT ENTRANCES	LH	5AA THRU 8AA	
		1 EXT DR R2 - APARTMENT ENTRANCE	RH	9AA	
		1 EXT DR R2 - APARTMENT ENTRANCE	LH	10AA	
		PREHUNG WD DRS & FRS 3-0 x 6-8 x 1-3/4"			
		BUTTS BY DOOR SUPPLIER			

"OVER"

FORM 1

CHAPTER TWO

Master Keying

Master Keying, to state it simply, is to set up a group of locks each of which is operated by its own individual key. This key is called a Change Key (CK) and operates only that one lock. Another key, known as the Master Key (MK), will operate all of the locks in the group.

Someone once said that "Master Keying is the planned destruction of security". Since two or more keys generally operate each lock in a Master Keyed system, security is compromised for convenience and controlled access. The larger a Master Key system becomes the less security it provides.

Because security is truly lacking, the use of Master Key systems should be limited to those applications where it is an absolute necessity; and the end user is made fully aware of the inherent weaknesses in the system provided him. Never sell a Master Key system as a security system.

This section of the MANUAL OF MASTER KEYING will instruct you in the basic methods of setting up Master Key systems. Several methods will be covered as we advance from section to section.

This section assumes that this is your introduction to Master Keying; therefore, it starts with the simplest explanations possible. Even if you have had some experience with Master Keying, don't skip over this section. It will reinforce your present knowledge.

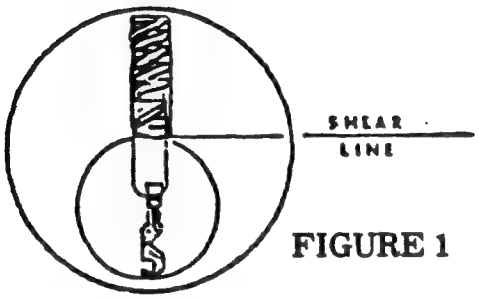


FIGURE 1

We know that a key, which has been cut to the proper depths of cut, will raise the bottom pins to the shear line and operate the cylinder as shown in Figure 1. Master Keying is simply an extension of this principle, and it is accomplished by the addition of a second shear line in the cylinder.

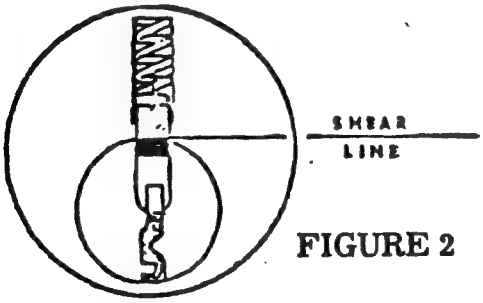


FIGURE 2

Creating a second shear line is accomplished simply by adding a small pin (known as a master pin or master wafer) between the top and bottom pin, as shown in Figure 2. The key that operates the cylinder at this second shear line is known as the Master Key (MK). By putting additional master pins in other pin cells, you can increase the number of keys that will operate the cylinder.

To illustrate the basic principle of Master Keying we use an imaginary cylinder that has only one pin cell. We will show only the plug and key. The shell is not shown. See Figure 3.

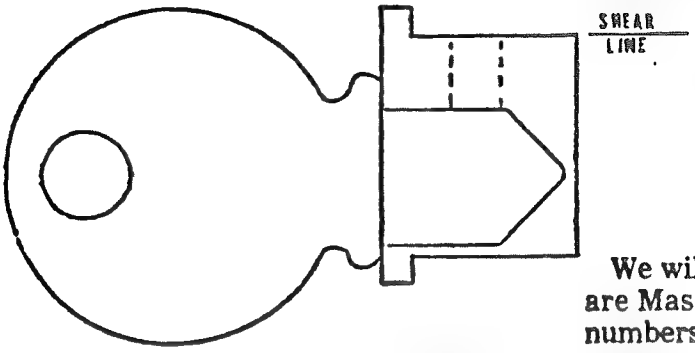


FIGURE 3

We will assume that the manufacturer for the locksets we are Master Keying, used 10 different depths of cuts and numbers them 0 thru 9. Master Keying, however, is done in increments (or steps) of 2, so a difference of 2 or more pin drops always exists between keys in the system See Figure 4. This eliminates having keys one step apart and requiring extremely thin master pins of .015 or .0125 or less. In a new and quality cylinder a pin as thin as .0125 thousandths of an inch might not cause jamming, that is, get caught between the shell and plug; but after a year of wear, tear, weather and abuse, you could possibly have more problems than you could cure. As shown in Figure 4, our steps will be either odd or even. The two are never mixed.

0	1
2	3
4	5
6	7
8	9

FIGURE 4

BITTING	KEY IDENTIFICATION
0	Master Key
2	Change Key #1
4	Change Key #2
6	Change Key #3
8	Change Key #4

FIGURE 5

Using the even bittings, our first step will be to choose one of the five possible bittings for our Master Key.

For simplicity we choose the 0, and the remaining 4 numbers become our Change Keys as shown in Figure 5.

Now let's pin up our cylinder. Because basic Master Keying involves the use of two pins to obtain two different shear lines, we encounter our first rule of Master Keying. It is "THE LOWEST NUMBER IN A COLUMN OF BITTINGS WILL BE THE BOTTOM PIN".

The first cylinder we will MK will be the one operated by Change Key #1 (cut to a #2 depth). The Master Key is cut to a 0 depth. Because 0 is the lowest (shallowest) of the two bittings, we will pin our plug first to the MK as shown in Figure 6. The lowest bitting indicates the shallowest cut on the key and the bottom pin to use with it. As shown, the Master Key with the 0 cut and the 0 bottom pin create a shear line for this cylinder.

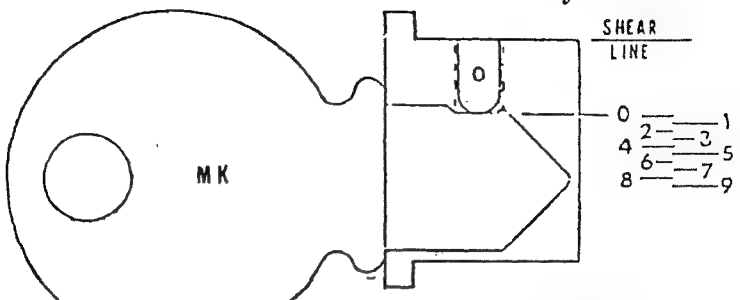


FIGURE 6

Next, we extract the Master Key and insert the Change Key, as shown in Figure 7. The bottom pin, a 0 pin, now drops well below the shear line. This is because the key is cut to a number 2 depth. To create a shear line in this cylinder, we must add another pin - a #2 master pin. The 0 bottom pin and the #2 master pin now create a shear line. The two pins have the same combined length as a number 2 bottom pin. Both the Master Key (with a 0 cut) and the Change Key (with a #2 cut) will now operate this cylinder.

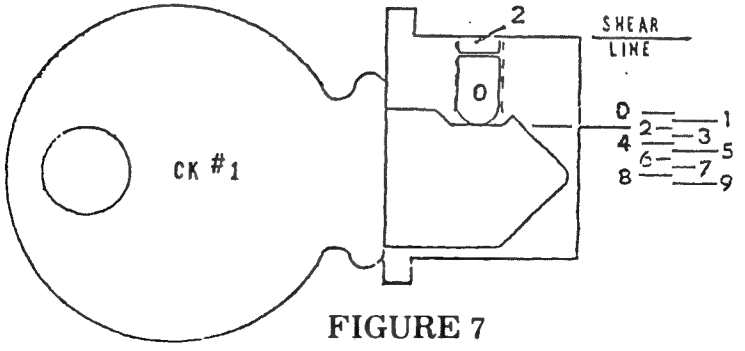


FIGURE 7

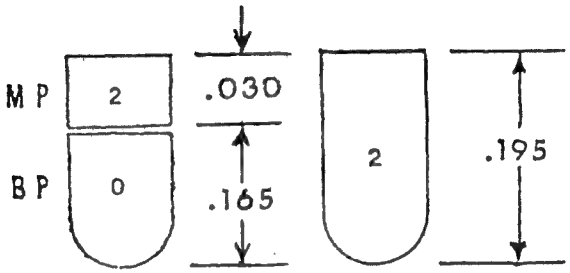


FIGURE 8

In the example just shown, we used a 0 bottom pin and a #2 master pin in our cylinder to create shear lines for MK and CK. The 0 bottom pin created a shear line for the Master Key. It was too short to create a shear line for the Change Key, which was cut to a depth of 2 and required a pin of that length to create a shear line. When we added the #2 master pin, we created an effective length of a #2 bottom pin as shown in Figure 8.

The bottom pin is .165 in length. The master pin is .030 in length. Combined, they have an effective length of .195 which is the same length as a #2 bottom pin, and it will create a shear line for a key cut to a #2 depth. This then is the principle of Master Keying. Creating a second shear line by adding a second pin makes it possible for a second key, known as a Master Key, to operate the cylinder. The cylinder is said to be Master Keyed.

0	1
2	3
4	5
6	7
8	9

FIGURE 9.

In Master Keying it is wise to use an odd number next to an even number. This will eliminate the possibility of having keys of all the same depth which would have to be eliminated from a system, decreasing the number of useable combinations. See Figure 9.

To further illustrate the principles of Basic Master Keying, let us now use a cylinder with two pin cells. Our plug is shown with the Master Key inserted. It is cut to a #4 depth in the first spacing and a #1 depth in the second spacing. See Figure 10.

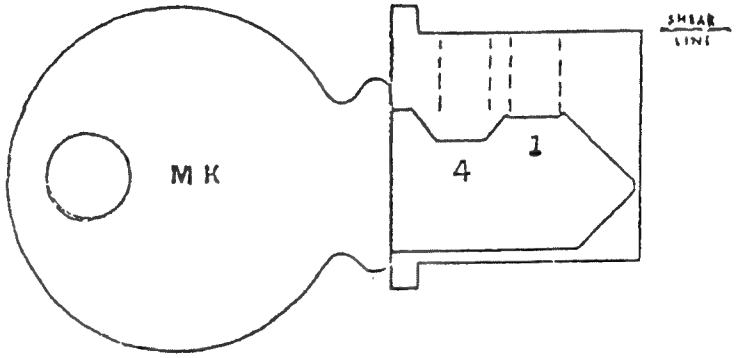


FIGURE 10

CELL #1	CELL #2
4	1
0	3
2	5
6	7
8	9

FIGURE 11

We selected the 4 and 1 from the chart in Figure 9 as the bitting for our MK. This leaves us with 4 bittings in each of the two cells we can use for our Change Keys. Figure 11.

The 4 bittings in cell 1 and cell 2 will give us 16 possible bittings (combinations of numbers) as shown in Figure 12. We obtained the 16 bittings by using the first number in the first column with each number in the second column. As shown in Figure 12, the first four combinations are 0 and 3, 0 and 5, 0 and 7, and 0 and 9.

Now, having used the zero with each of the numbers in the second column, we use the second number in the first column with each of the numbers in the second column. They read 2 and 3, 2 and 5, 2 and 7, and 2 and 9, as shown. We then repeat this procedure with the third and fourth numbers from column one.

MASTER KEY	4	1
	0	3
	2	5
	6	7
	8	9

CHANGE KEY BITTINGS

0 3	2 3	6 3	8 3
0 5	2 5	6 5	8 5
0 7	2 7	6 7	8 7
0 9	2 9	6 9	8 9

FIGURE 12

The Weiser-Falcon Company is currently using increments (steps) of .018 of an inch for their depths of cuts If you were to use the chart to work out a Master Key system for Weiser or Falcon regular cylinders, even more combinations would be unuseable. Cuts of no more than six steps difference can be made adjacent to each other. Therefore, the combinations 0-7 0-9, and 2-9 would have to be eliminated leaving you with thirteen useable combinations.

Shown in Figure 12 are the 16 possible (or theoretical) combinations using just two pin cells in a cylinder Depending on what manufacturer's locks you are using, some of these combinations may not be useable. Cuts on the key, of **no more than 7 steps** difference, can be made next to each other on keys that employ increments (steps) of .015 of an inch or less. The reason is that the cutter, when making a deep cut next to a shallow one, will cut the shallow cut even deeper. The angle of the teeth on the cutter is the cause of this Most of the locksets on the market fall in this category In Figure 12 the 0-9 combination would not be useable. Therefore, you would have 15 useable combinations with which to work.

MASTER KEY	4	1
	0	3
	2	5
	6	7
	8	9

CHANGE KEY BITTINGS

0 3	0 5	0 7	0 9
2 3	2 5	2 7	2 9
6 3	6 5	6 7	6 9
8 3	8 5	8 7	8 9

FIGURE 13

Shown in Figure 13 is another method of progression of the Change Key bittings. In the previous method, we used the first number in the first column with each of the numbers in the second column, and then the second number in the first column with each number in the second column, etc. With this method, we work just the opposite direction, using the first number in the second column with each of the numbers in the first column. Either method is correct. Some teachers of Master Keying prefer one way, some the other. Either way will give you the same identical combinations. Only the sequence will differ.

MK	3	2
	1	0
	5	4
	7	6
	9	8

FIGURE 14

Now, try the exercise shown in Figure 14 to see if you understand the principle of progressing the bitting numbers. The answer is shown at the end of this section. Progress both from right to left, and left to right.

Before pinning any cylinders, or cutting any keys, your complete Master Key system should always be completely worked out on paper including exactly how you intend to place your pins in each cylinder. A simple form, of what is known as a plug Set Up Chart, is shown (Fig. 15) for the first cylinder we will pin up. This is cylinder #6 of the system we worked out in Figure 12. Above the line, the depths of cuts for both the MK and CK is shown for the first and second spacings. Below the line, our chart shows us which bottom pins and which master pins to put in each cell. Remember, we stated the lowest number in a column of bittings was our bottom pin. This principle is clearly shown here.

Master Key Bitting	4	1
Change Key #6 Bitting	2	5
Bottom Pins	2	1
Master Pin	2	4

FIGURE 15

Now, let's pin up our cylinder. Into the plug, we load a number 2 bottom pin in the first cell. This creates a shear line when the Change Key is inserted in the plug. Remember, we said earlier that the lowest number in a list of bittings was our bottom pin. Our MK is cut to a #4 depth in the first position, so we loaded a #2 bottom pin to accommodate the shallower #2 cut of the CK. See Figure 16.

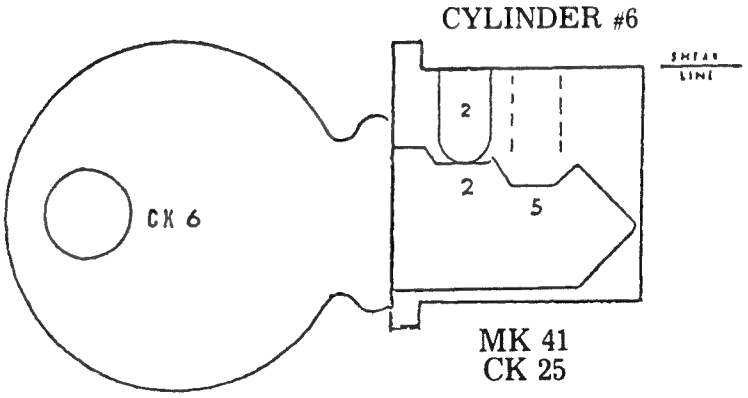


FIGURE 16

Now, let's extract CK#6 and insert the MK. With the MK inserted, the #2 pin in the first cell drops below the shear line, so we insert a #2 master pin to create a second shear line. Both the MK and the CK will now create a shear line in the first position. See Figure 17. With the MK still inserted, we insert a #1 bottom pin in the second cell creating a shear line in this position.

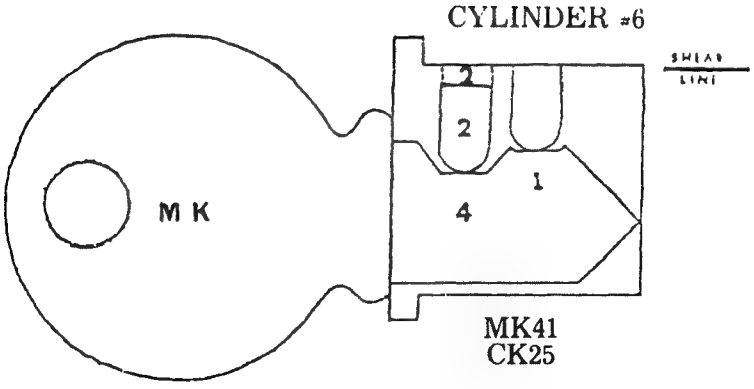


FIGURE 17

We now extract the Master Key and insert CK #6. As we insert the CK, we see that the #2 master pin remains above the shear line and that the #1 pin in the second position drops below the shear line. So, we add a #4 master pin in the second cell to create a shear line for the CK. Both our keys will now operate this cylinder. The position of each of the pins in the cylinder is as shown when the CK is inserted as shown in Figure 18. With the Master Key inserted, the position of the pins in the cylinder is as shown in Figure 19.

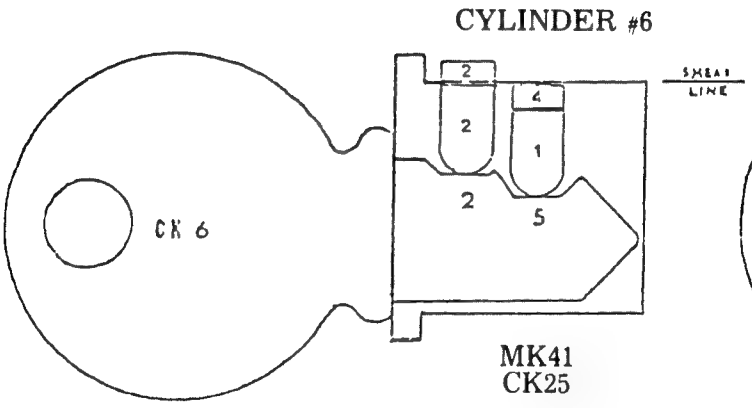


FIGURE 18

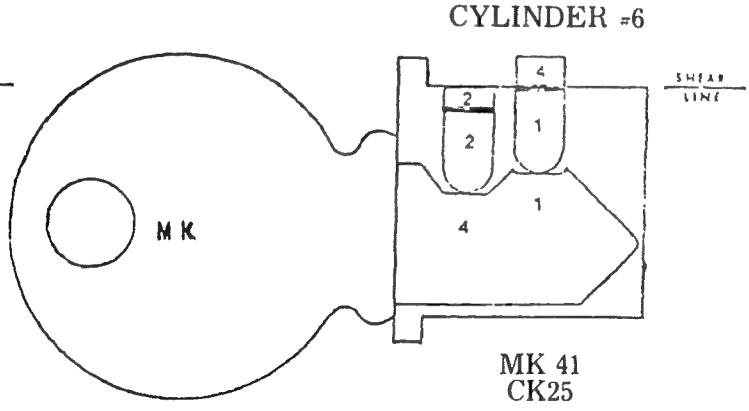


FIGURE 19

Let's pin up one more cylinder from the fifteen bittings we determined useable in Figure 12. We will use bitting number 9. This time we encounter a different situation in that both of the bittings on the Master Key are the lowest numbers. Because these two numbers (the four and one) are both lower than the bittings of the Change Key, our bottom pins will be also a four and a one. These two pins will create a shear line with the Master Key inserted as shown in Figure 20.

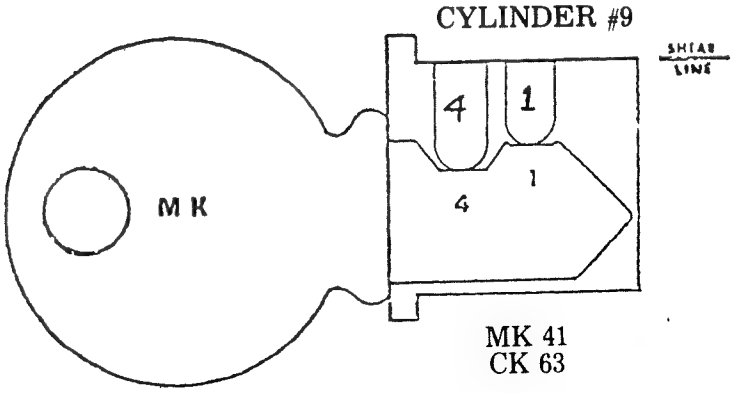


FIGURE 20

When the Master Key is extracted and the Change Key inserted, we see that both the bottom pins now drop well below the shear line. The Change Key is cut to a depth of 6 and 3 in the first and second positions; and will not raise the bottom pins high enough. In the first position the key is cut to a 6 depth, but the pin is only a 4 length so will require the addition of a number two master pin to create a shear line. See Figure 21. In the second position, the Change Key is cut to a depth of 3, but the bottom pin is a one length pin. We must add a number two master pin to create an effective length of a three pin. A shear line is now created in both positions.

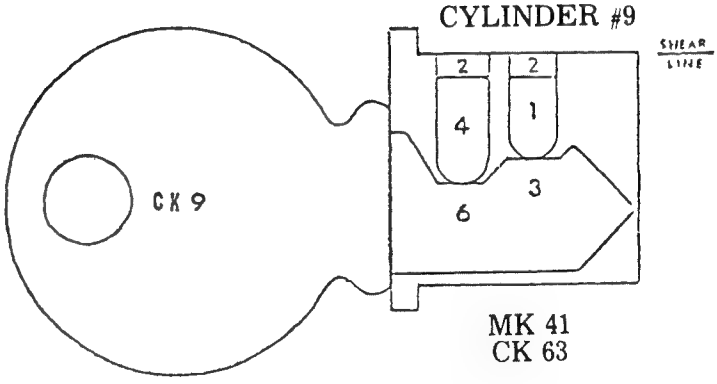


FIGURE 21

Our cylinder is now pinned so that both the Master Key and the Change Key will operate it.

Our Master Key will operate both the cylinders shown in Figures 18 and 21. The Change Keys in our system, however, will operate only the individual cylinders they are assigned to. To illustrate this, see Figure 22. When Change Key 9 is inserted in the cylinder, there is no shear line created so the key will not operate the cylinder. Change Key 9 is cut to a depth of 6 in the first position, but the bottom and master pin only equal a length of 4. Therefore, the driver pin drops down across the shear line preventing the plug from rotating within the shell. The same situation in reverse exists in the second cell. Here the number 4 master pin has been raised and is across the shear line blocking rotation of the plug.

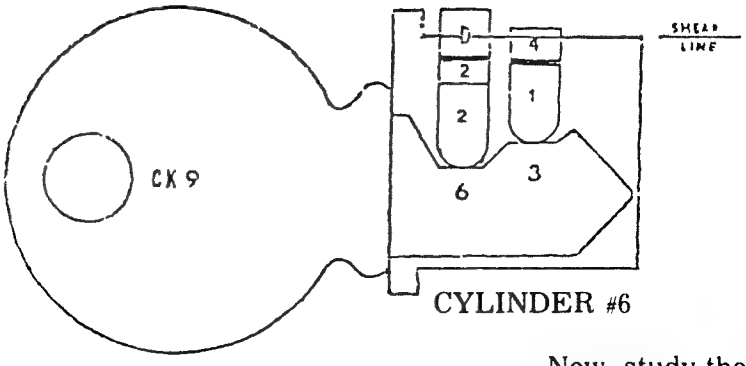


FIGURE 22

Now, study the position of the pins in Figure 23. Here the Change Key for cylinder 6 has been inserted in cylinder number 9. No shear line is created. This will hold true for all of our 15 cylinders if we pin them properly. When we removed the numbers 4 and 1 from the bittings used for Change Keys, we removed all chances of an accidental key interchange in our system. Key interchanges must not be allowed to happen.

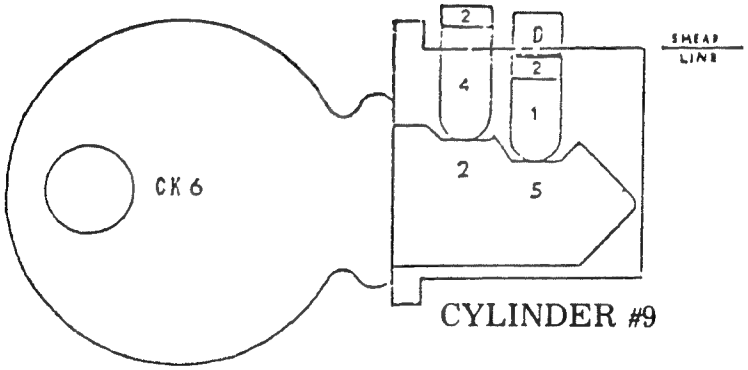


FIGURE 23

In the exercise just completed, we chose the bittings 4 and 1 for our Master Key. The 4 was the length of the bottom pin used in the first cell and the depth of the first cut on the key. This means that the 4 can not be used on any of our Change Keys in the first position in this system. The same holds true for the number 1 in the second position. It can not be used on the Change Key in this position. Imprint this rule on your mind: "**NO BITTING NUMBER CHOSEN FOR A MASTER KEY CAN EVER BE USED ON A CHANGE KEY IN THE SAME POSITION.**" By adhering to this rule, you can eliminate the possibility of a Change Key opening any cylinders other than the one it was designed to open. This rule must be remembered and adhered to.

At this point, stop and read all the material in this section up to this point. Be absolutely certain you understand it before proceeding on. Also, work out a couple more exercises similar to the one in Figure 11. You must understand how to progress bitting numbers before proceeding.

Answer to problem — Figure 14.

MK	3	2
	1	0
	5	4
	7	6
	9	8

Right to Left				Left to Right			
10	50	70	90	10	14	16	18
14	54	74	94	50	54	56	58
16	56	76	96	70	74	76	78
18	58	78	98	90	94	96	98

CHAPTER THREE

PLANNING MASTER KEY SYSTEMS

By this time you should have a good understanding of what the term "Master Keying" means. Now, you will learn how to plan and construct Master Key systems.

In the previous section, you learned that by placing one master pin in a cell hole along with the standard top and bottom pin that we could achieve one Master Key and four Change Keys. By putting a Master pin in two cells (mastering two cells) we could achieve 16 theoretical key changes along with a Master Key.

Now, let's do another exercise utilizing only two pin cells but let's use a standard five pin cylinder.

First, list the five columns (pin cells) as shown in Figure 24, and then under each cell write the possible bittings available in that cell. Here we choose even bittings for the first, third, and fifth columns and odd bittings for the second and fourth columns. Remember these numbers must remain in their individual columns (or pin cells). An odd number cannot be used with an even number nor an even number be used with an odd.

Let's say our system needs eight Change Keys and a Master Key. We need to Master two cell holes to accomplish this. This will give us 16 Change Keys and a Master Key. Always plan to have spare bittings for future expansion and use.

Cell Hole	1	2	3	4	5
	0	1	0	1	0
	2	3	2	3	2
	4	5	4	5	4
	6	7	6	7	6
	8	9	8	9	8

FIGURE 24

From the listing shown in Figure 24, our first step will be to decide which two of the pin cells we are going to "Master". Our choices do not have to be adjacent to each other but for simplicity of teaching we will choose the number four and five cell holes. We could just as well have chosen the first and third or second and fifth or any two we desire. Our next step is to select a bitting for our Master Key. When selecting it, choose it so that at least one cut on it is higher than any cut on a Change Key. The reason for this is to prevent a Change Key from being cut "down" to a Master Key. For our Master Key we choose the bitting 2 5 6 3 0. See Figure 25.

Cell Holes	1	2	3	4	5
	0	1	0	1	0
	2	3	2	3	2
	4	5	4	5	4
	6	7	6	7	6
	8	9	8	9	8
Master Key	2	5	6	3	0

FIGURE 25

Now let's re-write the chart shown in Figure 25 and this time remove the Master Key bittings from the last two columns. Remember we selected columns four and five to progress our Change Key bittings in. We will also omit the bittings from the first three cell holes as well. The bittings of the Master Key 2-5-6 will remain constant in these positions on all 16 our our Change Keys. See Figure 26.

Cell Holes	1	2	3	4	5
Master Key	2	5	6	3	0
				1	2
				5	4
				7	6
				9	8

FIGURE 26

Note one thing about our selection of the bittings for the Master Key; by using the 0 we assure ourselves that no Change Key in our system can ever be altered to a Master Key. All the Change Key bittings in the fifth column are lower than the bitting of the Master Key.

Our next step is to progress our bitting to obtain our 16 Change Keys. Again, we progress them just as we did previously. Progress from left to right or right to left, whichever you desire. See Figure 27.

1. 25612	5. 25614	9. 25616	13. 25618
2. 25652	6. 25654	10. 25656	14. 25658
3. 25672	7. 25674	11. 25676	15. 25678
4. 25692	8. 25694	12. 25696	16. 25698

FIGURE 27

Figure 27 is a listing of the 16 key changes we can derive from the chart shown in Figure 26. Note that the 256 in columns one, two, and three are repeated in all sixteen combinations. The numbers in these three positions are called "Constants" because they remain constant throughout. These constants are the tie between the Master and Change Keys. This will be taken up in detail later. The numbers in columns five and six were the numbers we progressed and are logically called "Progressives".

Depending on the increments (steps) used in the system you are designing, most or all of the 16 combinations are useable.

If our system uses steps of 7 or more, all of the bittings are useable. If our system is a Weiser or Falcon standard using steps of no more than 6 in adjacent cuts, then we must "throw out" combinations number 4 and 13, because both contain steps of 7 in adjacent bittings in the fourth and fifth column.

It is not necessary or even desirable in many cases to use adjacent columns for our progressions. In Figure 28, we have used columns three and four for our progressions.

	1	2	3	4	5
MK	3	8	1	4	2
			3	0	
			5	2	
			7	6	
			9	8	

38302	38322	38362	38382
50	52	56	58
70	72	76	78
90	92	96	98

FIGURE 28

1	4	1	6	3
		3		1
		5		5
		7		7
		9		9

FIGURE 29

To obtain a large number of different keying systems it is only necessary to vary the position of the progressive numbers. In Figure 29 we have used columns three and five.

Note that by placing the progressive numbers between the constant numbers, we have made possible the use of all sixteen combinations. No adjacent steps will exceed either 6 or 7 steps. Careful selection and placement of numbers will allow maximum usage of the combinations in the systems you design. An almost unlimited number of different bitting charts can be created by moving the position of the progression number. Also, note in Figures 28 and 29 - no Change Key can be altered to a Master Key.

If you need more than 16 bittings, you can progress three columns of numbers. Progressing three rows of numbers is no more difficult than two, and gives you 64 combinations. Look closely at the chart, Figure 30, and you will see how it is accomplished. Again, by spacing your progression numbers and choosing the constant numbers wisely, you can get maximum usage of your chart. This time let's use a six pin system. The only difference will be that we add an additional column.

COLUMNS	1	2	3	4	5	6
	x	0	x	8	x	2
		2		0		0
		4		2		4
		6		4		6
		8		6		8

1.	x	2	x	0	x	0	9.	x	2	x	4	x	0
2.		4					10.		4				
3.		6					11.		6				
4.		8					12.		6				
5.	x	2	x	2	x	0	13.	x	2	x	6	x	0
6.		4					14.		4				
7.		6					15.		6				
8.		8					16.		8				

FIGURE 30

Figure 30 shows how we have progressed the first sixteen bittings of the 64 possible. We have done our progression from left to right. In the first four combinations, we have used the 0 in the sixth column with the 0 in the fourth column and with each number in column two. With combinations five through eight, we again use the 0 in column six, but this time we drop down to the 2 in column four and use it with each number in column two. We continue to do this in combinations nine through sixteen, dropping down one number each time in column four. Study Figure 30 and you will see the pattern.

17.	x	2	x	0	x	4	25.	x	2	x	4	x	4
18.		4					26.		4				
19.		6					27.		6				
20.		8					28.		8				
21.	x	2	x	2	x	4	29.	x	2	x	6	x	4
22.		4					30.		4				
23.		6					31.		6				
24.		8					32.		8				

FIGURE 31

Figure 31 shows the next 16 key changes. In Figure 30, we used the 0 in column six with every number in columns 4 and 2. We have exhausted its use. In Figure 31, we start with the second number in column six and progress columns 4 and 2 for sixteen bittings. Actually, this progression is identical to progressing for 16 changes. Continue the same pattern to obtain the next 32 bittings, first using the 6 in column 6 with all numbers in columns 4 and 2, and finally using the 8 with all numbers in columns 4 and 2. Figure 32 shows the progression of the 64 changes.

When progressing three columns of numbers as in Figure 32 (from left to right), the frequency of progression is as follows:

Column two (1st sequence) changes **every** number
Column four (2nd sequence) changes every **fourth** number
Column six (3rd sequence) changes every **sixteenth** number

x	0	x	8	x	2
	2		0		0
	4		2		4
	6		4		6
	8		6		8

1.	x	2	x	o	x	o	17.	x	2	x	o	x	4	33.	x	2	x	o	x	6	40.	x	2	x	o	x	8
2.		4					18.		4					34.		4					50.		4				
3.		6					19.		6					35.		6					51.		6				
4.		8					20.		8					36.		8					52.		8				
5.	x	2	x	2	x	o	21.	x	2	x	2	x	4	37.	x	2	x	2	x	6	53.	x	2	x	2	x	8
6.		4					22.		4					38.		4					54.		4				
7.		6					23.		6					39.		6					55.		6				
8.		8					24.		8					40.		8					56.		8				
9.	x	2	x	4	x	o	25.	x	2	x	4	x	4	41.	x	2	x	4	x	6	57.	x	2	x	4	x	8
10.		4					26.		4					42.		4					58.		4				
11.		6					27.		6					43.		6					59.		6				
12.		8					28.		8					44.		8					60.		8				
13.	x	2	x	6	x	o	29.	x	2	x	6	x	4	45.	x	2	x	6	x	6	61.	x	2	x	6	x	8
14.		4					30.		4					46.		4					62.		4				
15.		6					31.		6					47.		6					63.		6				
16.		8					32.		8					48.		8					64.		8				

FIGURE 32

Try working out the exercise in Figure 33. See if you understand the procedure for progressing three columns. Progress left to right. The answer is shown at the end of this chapter.

x 3	x 7	x 1
1	1	3
5	3	5
7	5	7
9	9	9

FIGURE 33

When there is a need for more than 64 bittings, we progress 4 columns of numbers. This will net us 256 combinations. Progression is done in the same manner as progressing two or three columns. Figure 34 shows an example of progression of four columns. Our order of progression here is column 2, 4, 5, and 6. The sequence of progressions for this chart is:

Column two = Changes every number.
Column four = Changes every fourth number.
Column five = Changes every sixteenth number.
Column six = Changes every sixty-fourth number.

Again, depending on the manufacturer of the locks this system is designed for, some of these bittings may not be useable.

1	2	3	4	5	6
X	1	X	5	0	7
	3		1	2	1
	5		3	4	3
	7		7	6	5
	9		9	8	9

1.	x3x121	33.	x3x161	65.	x3x123	97.	x3x163
2.	5	34.	5	66.	5	98.	5
3.	7	35.	7	67.	7	99.	7
4.	9	36.	9	68.	9	100.	9
5.	x3x321	37.	x3x361	69.	x3x323	101.	x3x363
6.	5	38.	5	70.	5	102.	5
7.	7	39.	7	71.	7	103.	7
8.	9	30.	9	72.	9	104.	9
9.	x3x721	41.	x3x761	73.	x3x723	105.	x3x763
10.	5	42.	5	74.	5	106.	5
11.	7	43.	7	75.	7	107.	7
12.	9	33.	9	76.	9	108.	9
13.	x3x921	45.	x3x961	77.	x3x923	109.	x3x963
14.	5	46.	5	78.	5	110.	5
15.	7	47.	7	79.	7	111.	7
16.	9	48.	9	80.	9	112.	9
17.	x3x141	49.	x3x181	81.	x3x143	113.	x3x183
18.	5	50.	5	82.	5	114.	5
19.	7	51.	7	83.	7	115.	7
20.	9	52.	9	84.	9	116.	9
21.	x3x341	53.	x3x381	85.	x3x343	117.	x3x383
22.	5	54.	5	86.	5	118.	5
23.	7	55.	7	87.	7	119.	7
24.	9	56.	9	88.	9	120.	9
25.	x3x741	57.	x3x781	89.	x3x743	121.	x3x783
26.	5	58.	5	90.	5	122.	5
27.	7	59.	7	91.	7	123.	7
28.	9	60.	9	92.	9	124.	9
29.	x3x941	61.	x3x981	93.	x3x943	125.	x3x983
30.	5	62.	5	94.	5	126.	5
31.	7	63.	7	95.	7	127.	7
32.	9	64.	9	96.	9	128.	9

NOTE: There are 128 more bittings in this sequence for a total of 256. Finish the chart.

FIGURE 34

As we continue to increase the number of columns that we progress, the number of changes available increase. Progressing five columns will give us a Master Key and 1,024 Change Keys. Progression sequences for five columns, one through five will be as follows:

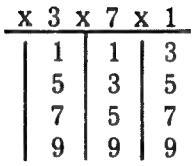
(Left to right progression)

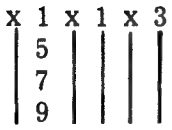
Column one = Changes every number
Column two = Changes every fourth number
Column three = Changes every sixteenth number
Column four = Changes every sixty-fourth number
Column five = Changes every two hundred fifty sixth number

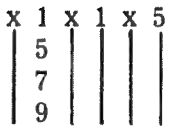
If we progressed all six cells (columns) of a six pin cylinder, we would obtain 4,096 changes with a Master Key.

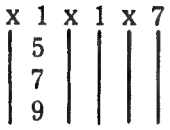
Progressing one column gives us 4 changes
Progressing two columns gives us 16 changes
Progressing three columns gives us 64 changes
Progressing four columns gives us 256 changes
Progressing five columns gives us 1,024 changes
Progressing six columns gives us 4,096 changes

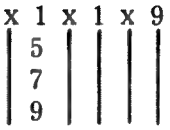
Seldom, however, do we progress all columns (cells) because we generally will need more than one Master Key for our system. Those columns not progressed for Change Keys are used for Master Keys. This will be the next area of instruction we cover.

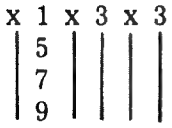


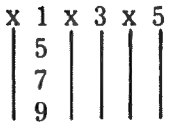


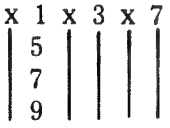


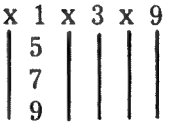


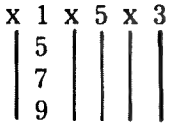


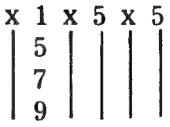


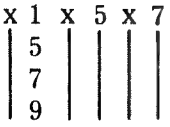


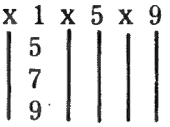


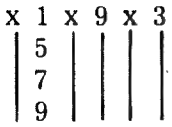


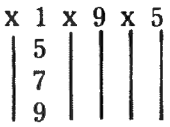


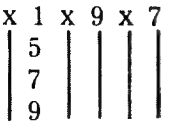


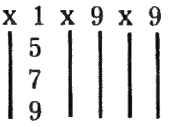












ANSWER TO FIGURE 33

CHAPTER FOUR

PLANNING A GRAND MASTER KEY SYSTEM — LEVEL THREE

Up to this point, we have explained the basic principle of Master Keying and showed you how to select one Master Key and various numbers of Change Keys. Now, let's see how we can go about selecting more than one Master Key. Many times our system will require a Grand Master Key and two or more Master Keys or even a Great Grand Master Key, a couple of Grand Master Keys and one, two, or more Master Keys for each Grand Master Key.

From the exercises we have done up to this point, you already have enough knowledge to select the various Master Keys needed. You need only learn a few rules that apply when choosing them.

Up to now we have arbitrarily selected our Master Key, that is, chose it at random before progressing our Change Keys. Where only one Master Key is needed this is adequate; however, when the number of Master Keys needed exceeds one, then a definite system is needed. The best method of explaining the system is to work from examples.

Let's start with the smallest multiple Master Key system we would probably need; this would be a system with a GMK and two MK's. The GMK will operate all the cylinders in the system and each MK will operate a given number of cylinders.

STEP ONE

First determine the number of keys required for your system (GMK, MK's and CK's). Then, determine the number of pin cells (columns) that will be needed to provide these keys. Remember, never Master any more pin cells than necessary to achieve the required number of keys. To do so is to further destroy what little security exists in Master Key systems. We will discuss this in detail later.

We start our chart by writing the available bittings for each of the cell holes. By now we know that we must work in steps of two, so we will list only our odd and even numbers in separate columns. We have already decided the number of cell holes we need to Master, now we decide which cells (columns) to use. We said we need two Master Keys, so we will use two columns (cells) from which to select our "MK". We could use one cell, but this would only leave us with two spares. We will use two and this will afford us twelve to fourteen spares (depending on how we choose our bittings). We need a minimum of 35 Change Keys under each Master key, so we need to use three columns from which to select our Change Keys. Because the system we are designing is for six pin cylinders, we still have one column left we have not used. We will make this column a Constant number. See Figure 35.

M K	M K	C	C K	C K	C K
0	1	0	1	0	1
2	3	2	3	2	3
4	5	4	5	4	5
6	7	6	7	6	7
8	9	8	9	8	9

FIGURE 35

STEP TWO

Select your Grand Master Key, Figure 36. As always when selecting your top key, try to select bittings in a manner that prevents lesser keys from being altered to it. Select one bitting that will be higher than any bitting in a lesser key in the same position. In our choice of a GMK, we used the "0" bitting in column one. No other key can be cut up to it.

	M K	M K	C	C K	C K	C K
GMK	0	5	6	5	0	3
	2	1		1	2	1
	4	3		3	4	5
	6	7		7	6	7
	8	9		9	8	9

FIGURE 36

STEP THREE

Our next step is to progress columns one and two to obtain our Master Keys. Progress them just as you did the Change Keys. See Figure 37.

0	5
2	1
4	3
6	7
8	9

2 1	2 3	2 7	2 9
4 1	4 3	4 7	4 9
6 1	6 3	6 7	6 9
8 1	8 3	8 7	8 9

FIGURE 37

Figure 38 is a listing of the 16 Master Keys. The Master Keys will always include the remaining numbers of the GMK, in this case the 6503 in columns 3, 4, 5, and 6. The MK will always include all numbers **other than** the numbers under which they are progressed, in this case the 0 and 5. The use of the numbers 6503 on each Master Key ties them to the GMK. They achieve their own individuality from the first two numbers which differ from the GMK.

GMK 0 5 6 5 0 3

1.	216503	5.	236503	9.	276503	13.	296503
2.	416503	6.	436503	10.	476503	14.	496503
3.	616503	7.	636503	11.	676503	15.	696503
4.	816503	8.	836503	12.	876503	16.	896503

FIGURE 38

No number chosen for the GMK bitting can be used on a MK under its control. We are talking now of the progressions columns the Master Keys will be obtained from. Eliminating the two bittings (0 and 5) from the list of bittings we will choose our Master Keys from will assure us this does not happen.

STEP FOUR

Next, we progress the 64 changes. See Figure 39. After we have progressed them, we can use them with the 16 Master Keys we worked out. Notice we have written our progressions horizontally instead of vertically as we did previously.

GMK	0	5	6	5	0	3
				1	2	1
				3	4	5
				7	6	7
				9	8	9

1	2	1	1	4	1	1	6	1	1	8	1
3			3			3			3		
7			7			7			7		
9			9			9			9		
1	2	5	1	4	5	1	6	5	1	8	5
3			3			3			3		
7			7			7			7		
9			9			9			9		
1	2	7	1	4	7	1	6	7	1	8	7
3			3			3			3		
7			7			7			7		
9			9			9			9		
1	2	9	1	4	9	1	6	9	1	8	9
3			3			3			3		
7			7			7			7		
9			9			9			9		

FIGURE 39

C	C	C	P	P	P
0	5	6	5	0	3
			1	2	1
			3	4	5
			7	6	7
			9	8	9

FIGURE 40

This one chart of sixty four key changes can be used with each of the Master Keys. All bittings on a Change Key, other than the bitting the changes were progressed from, are considered constants. See Figure 40.

All of the Change Keys, under a given Master Key, will use the bittings of the Master Key in our system. We originally stated that we needed a GMK and two Master Keys. Figure 41 shows the Master Keys we selected and some of the Change Keys under them.

AA	2	1	6	5	0	3
AA1	2	1	6	1	2	1
AA2	2	1	6	3	2	1
AA3	2	1	6	7	2	1
AA4	2	1	6	1	2	5
AA5	2	1	6	3	2	5

AB	4	1	6	5	0	3
AB1	4	1	6	1	2	1
AB2	4	1	6	3	2	1
AB3	4	1	6	7	2	1
AB4	4	1	6	1	2	5
AB5	4	1	6	3	2	5

FIGURE 41

	C	C	P	P	P
MK	1	6	4	9	6
			0	1	0
			2	3	2
			6	5	4
			8	7	8

FIGURE 42

As you can see from this exercise, Grand Master Keying differs very little from what we had previously learned. It is actually just an extension of the knowledge and rules we earlier learned; therefore, it is very important that you have a thorough knowledge of the art of progressing the changes from two columns to five columns. Note that we have used the appropriate keying symbols here (A, AA, AA1, AA2, etc.) to identify the bittings. Review both of these sections before proceeding on them. Work out the following exercise for practice.

M K	M K	C	P	P	P
0	5	0	3	6	9
2	1		1	0	1
4	3		5	2	3
6	7		7	4	5
8	9		9	8	7

FIGURE 43

Work out the Change Keys for Figure 42, then draw a line through all bittings that could not be used in a Weiser or Falcon Standard system. (Answer at the end of chapter).

Using Figure 43, progress all the Master Keys, list them, then progress all the Change Keys. Next draw a line through all Master and Change Keys that will not be useable in a system where adjacent steps (cuts on the key) were limited to 7. The answer for these exercises will be found at the end of the chapter.

1	6	4	9	6
		0	1	0
		2	3	2
		6	5	4
		8	7	8

	1.	1	6	0	1	0	5.	1	6	0	3	0	9.	1	6	0	5	0	* 13.	1	6	0	7	0
	2.	|	|	2	|	|	6.	|	|	2	|	|	10.	|	|	2	|	|	* 14.	|	|	2	|	|
	3.	|	|	6	|	|	7.	|	|	6	|	|	11.	|	|	6	|	|	* 15.	|	|	6	|	|
*	4.	|	|	8	|	|	8.	|	|	8	|	|	12.	|	|	8	|	|	* 16.	|	|	8	|	|
	17.	1	6	0	1	2	21.	1	6	0	3	2	25.	1	6	0	5	2	* 20.	1	6	0	7	2
	18.	|	|	2	|	|	22.	|	|	2	|	|	26.	|	|	2	|	|	30.	|	|	2	|	|
	19.	|	|	6	|	|	23.	|	|	6	|	|	27.	|	|	6	|	|	31.	|	|	6	|	|
*	20.	|	|	8	|	|	24.	|	|	8	|	|	28.	|	|	8	|	|	32.	|	|	8	|	|
	33.	1	6	0	1	4	37.	1	6	0	3	4	41.	1	6	0	5	4	* 45.	1	6	0	7	4
	34.	|	|	2	|	|	38.	|	|	2	|	|	42.	|	|	2	|	|	46.	|	|	2	|	|
	35.	|	|	6	|	|	39.	|	|	6	|	|	43.	|	|	6	|	|	47.	|	|	6	|	|
*	36.	|	|	8	|	|	40.	|	|	8	|	|	44.	|	|	8	|	|	48.	|	|	8	|	|
*	49.	1	6	0	1	8	53.	1	6	0	3	8	57.	1	6	0	5	8	* 61.	1	6	0	7	8
*	50.	|	|	2	|	|	54.	|	|	2	|	|	58.	|	|	2	|	|	62.	|	|	2	|	|
*	51.	|	|	6	|	|	55.	|	|	6	|	|	59.	|	|	6	|	|	63.	|	|	6	|	|
*	52.	|	|	8	|	|	56.	|	|	8	|	|	60.	|	|	8	|	|	64.	|	|	8	|	|

* INDICATES UNUSABLE BITTINGS IN WEISER-FALCON SYSTEM

ANSWER TO FIGURE 42

M K	M K	C	P	P	P
0	5	0	3	6	9
2	1	|	1	0	1
4	3	|	5	2	3
6	7	|	7	4	5
8	9	|	9	8	7

1. 2 1 0 3 6 9	5. 4 1 0 3 6 8	9. 6 1 0 3 6 9	13. 8 1 0 3 6 9
2. 2 3 0 3 6 9	6. 4 3 0 3 6 9	10. 6 3 0 3 6 9	14. 8 3 0 3 6 9
3. 2 7 0 3 6 9	7. 4 7 0 3 6 9	11. 6 7 0 3 6 9	15. 8 7 0 3 6 9
* 4. 2 9 0 3 6 9	* 8. 4 9 0 3 6 9	* 12. 6 9 0 3 6 9	* 16. 8 9 0 3 6 9

CHANGE KEYS

1. x x x 1 0 1	5. x x x 1 2 1	9. x x x 1 4 1	13. x x x 1 8 1
2. | | | 5 | |	6. | | | 5 | |	10. | | | 5 | |	14. | | | 5 | |
3. | | | 7 | |	7. | | | 7 | |	11. | | | 7 | |	15. | | | 7 | |
* 4. | | | 9 | |	* 8. | | | 9 | |	* 12. | | | 9 | |	* 16. | | | 9 | |
17. x x x 1 0 3	21. x x x 1 2 3	25. x x x 1 4 3	29. x x x 1 8 3
18. | | | 5 | |	22. | | | 5 | |	26. | | | 5 | |	30. | | | 5 | |
19. | | | 7 | |	23. | | | 7 | |	27. | | | 7 | |	31. | | | 7 | |
* 20. | | | 9 | |	* 24. | | | 9 | |	* 28. | | | 9 | |	* 32. | | | 9 | |
33. x x x 1 0 5	37. x x x 1 2 5	41. x x x 1 4 5	45. x x x 1 8 5
34. | | | 5 | |	38. | | | 5 | |	42. | | | 5 | |	46. | | | 5 | |
35. | | | 7 | |	39. | | | 7 | |	43. | | | 7 | |	47. | | | 7 | |
* 36. | | | 9 | |	* 40. | | | 9 | |	* 44. | | | 9 | |	* 48. | | | 9 | |
49. x x x 1 0 7	53. x x x 1 2 7	57. x x x 1 4 7	61. x x x 1 8 7
50. | | | 5 | |	54. | | | 5 | |	58. | | | 5 | |	62. | | | 5 | |
51. | | | 7 | |	55. | | | 7 | |	59. | | | 7 | |	63. | | | 7 | |
* 52. | | | 9 | |	* 56. | | | 9 | |	* 60. | | | 9 | |	* 64. | | | 9 | |

Answer to Figure 43.
* indicates unusable bittings

CHAPTER FIVE

PLANNING GREAT GRAND MASTER KEY SYSTEMS — LEVEL FOUR

We are now ready to move on to Great Grand Master Key systems. Basically, they are accomplished in the same manner as the Grand Master Key system we just finished; however, there are some special considerations. Again, we will do an actual exercise as a means of explaining the system.

We have been asked to design a system requiring two Grand Master Keys under the control of a Great Grand Master Key. Each of the Grand Masters will have two Master keys under their control. See Figure 44.

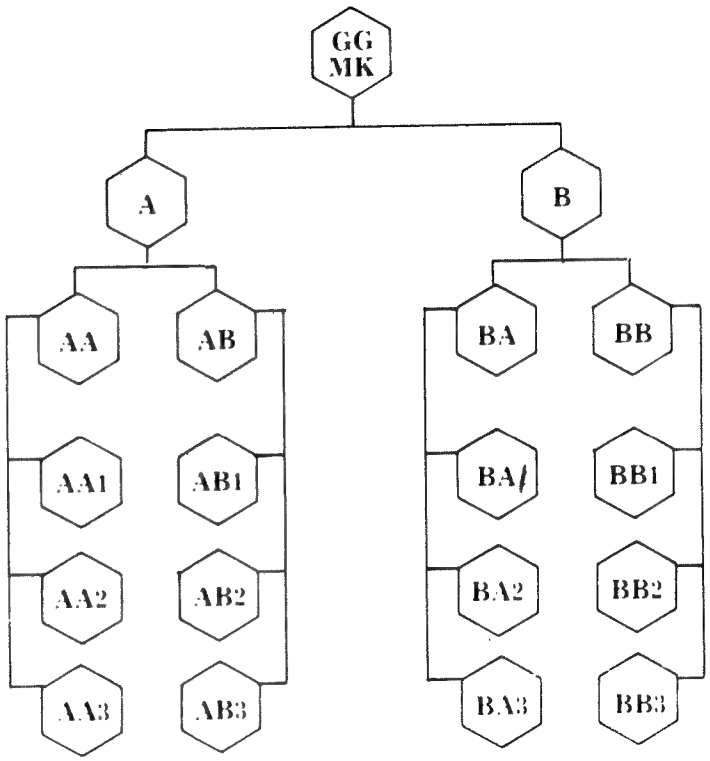


FIGURE 44

COLUMN	1	2	3	4	5	6
GGMK	0	1	0	5	0	5
	2	3	2	1	2	1
	4	5	4	3	4	3
	6	7	6	7	6	7
	8	9	8	9	8	9

GRAND MASTERS

A	2	1	0	5	0	5
B	4	1	0	5	0	5
C	6	1	0	5	0	5
D	8	1	0	5	0	5

FIGURE 45

By now we have gained enough experience so we may skip some of the preliminary steps. Let's start by first choosing our top key, the GGMK. Our choice will be based on the same factors we previously considered when selecting Master Keys. See Figure 45.

The chart shown in Figure 45 will net us 4 GMK's. As shown they are all derived from column one. Note that the GMK's all carry the bitting of the GGMK in the 2, 3, 4, 5 and 6th columns. Also note, we chose the 0 in the first column for the GGMK so none of the GMK's could be altered to it.

If circumstances were such that we required more GMK's we could use columns 1 and 2 for the GMK's giving us 16 GMK's. This will however, reduce the number of master and/or change keys available to us as shown below in Figure 46.

GMK	MK	CK
1	2 3	4 5 6
4	16	64

GMK	MK	CK
1 2	3 4	5 6
16	16	16

GM	MK	CK
12	3	4 5 6
16	4	64

GMK	MK	CK
1 2 3	4	5 6
64	4	16

FIGURE 46

GGMK	0	1	0	5	0	5
	2	3	2			
	4	5	4			
	6	7	6			
	8	9	8			

MASTER KEYS

X	3	2	5	0	5	X	3	4	5	0	5	X	3	6	5	0	5	X	3	8	5	0	5
X	5	2	5	0	5	X	5	4	5	0	5	X	5	6	5	0	5	X	5	8	5	0	5
X	7	2	5	0	5	X	7	4	5	0	5	X	7	6	5	0	5	X	7	8	5	0	5
X	9	2	5	0	5	X	9	4	5	0	5	X	9	6	5	0	5	X	9	8	5	0	5

FIGURE 47

COLUMN	1	2	3	4	5	6
GGMK	0	1	0	5	0	5
	2	3	2	1	2	1
	4	5	4	3	4	3
	6	7	6	7	6	7
	8	9	8	9	8	9

Figure 47 is a listing of the 16 Master keys we obtained by progressing columns two and three. These bittings will use the bitting of the GMK in the first column.

Next, we progress our Change Keys from columns 4, 5, and 6. These Change Keys can then be used with all of the Master Keys.

CHANGE KEYS

1 2 1	1 4 1	1 6 1	1 8 1
3	3	3	3
7	7	7	7
9	9	9	9
1 2 3	1 4 3	1 6 3	1 8 3
3	3	3	3
7	7	7	7
9	9	9	9
1 2 7	1 4 7	1 6 7	1 8 7
3	3	3	3
7	7	7	7
9	9	9	9
1 2 9	1 4 9	1 6 9	1 8 9
3	3	3	3
7	7	7	7
9	9	9	9

FIGURE 48

G G M K		0	1	0	5	0	5
G M K	A	2	1	0	5	0	5
G M K	B	4	1	0	5	0	5
G M K	C	6	1	0	5	0	5
G M K	D	8	1	0	5	0	5

X32505	X34505	X36505	X38505
X52505	X54505	X56505	X58505
X72505	X74505	X76505	X78505
X92505	X94505	X96505	X98505

CHANGE KEYS

121	141	161	181
3	3	3	3
7	7	7	7
9	9	9	9
123	143	163	183
3	3	3	3
7	7	7	7
9	9	9	9
127	147	167	187
3	3	3	3
7	7	7	7
9	9	9	9
129	149	169	189
3	3	3	3
7	7	7	7
9	9	9	9

FIGURE 49

Our completed chart is shown in Figure 49. We are now ready to select our keys for the system we laid out in Figure 44. Figure 50 is a schematic layout of the keys we selected for our system. The system can still be expanded if necessary. There are GMK's C and D plus twelve more Master Keys that can be used with each of the GMK's and up to 64 Change Keys to use with each Master Key depending on what manufacturer's system you are using.

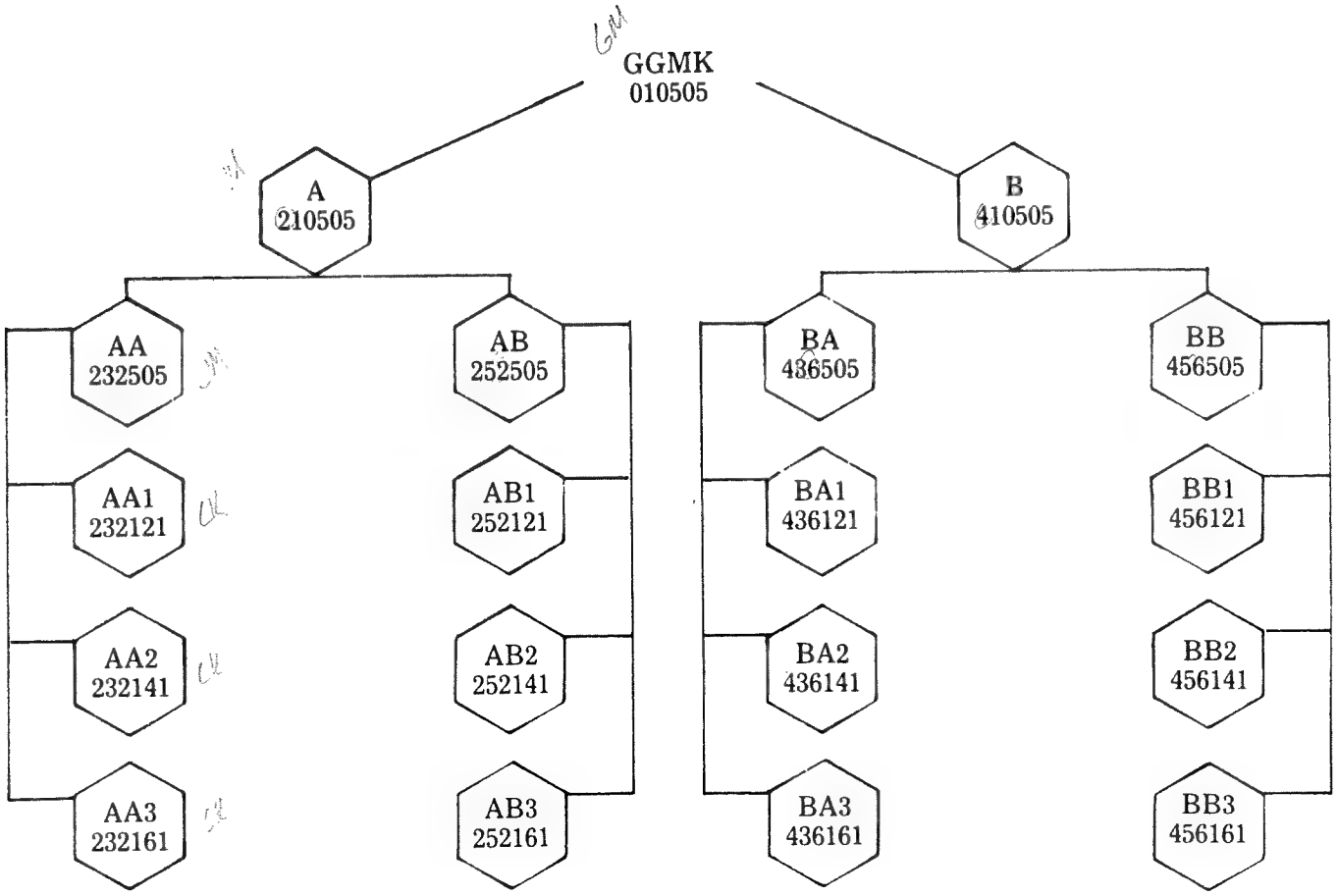

GGMK
010505
A
210505
B
410505
AA
232505
AB
252505
BA
436505
BB
456505
AA1
232121
AB1
252121
BA1
436121
BB1
456121
AA2
232141
AB2
252141
BA2
436141
BB2
456141
AA3
232161
AB3
252161
BA3
436161
BB3
456161

FIGURE 50

CHAPTER SIX

GREAT GREAT GRAND MASTER KEY SYSTEMS — LEVEL FIVE

The usage of GGGMK systems (level five) should be discouraged where only one key section is to be used. Using a GGGMK system on a 6 pin single keyway section will not provide us with enough key changes to do the job generally. See Figure 51.

	G G M K	G M K	MK		CK	
GGGMK	1	0	5	8	5	4
	3	2	1	0	1	0
	5	4	3	2	3	2
	7	6	7	4	7	6
	9	8	9	6	9	8
Number of possible keys.	4	4	16		16	

FIGURE 51

A seven pin cylinder will provide more key changes, but only a limited number of manufacturers provide cylinders of this size.

A GGGMK system is really two GGMK systems operated by a single key as shown in Figure 52.

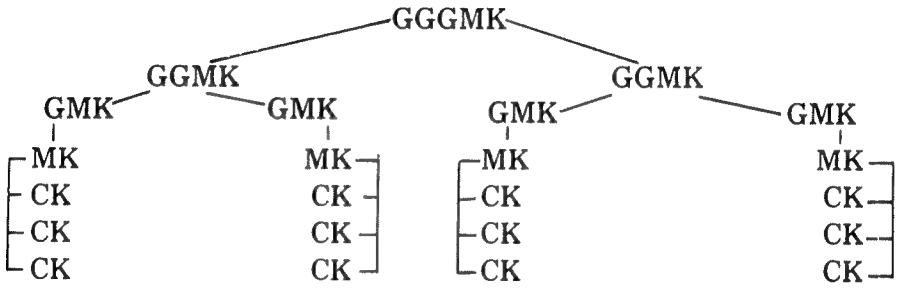


FIGURE 52

If a system is large enough to warrant consideration of a GGGMK, a far more controllable system would be to create separate Great Grand Master Key systems, each independent of the other. This will be a far more controllable set up.

CHAPTER SEVEN

Checking Your Systems

Before physically implementing any Master Key System, that is pinning any cylinders or cutting any keys, the entire system should be laid out on paper. Only by doing this can you be actually certain your system is valid and will do the job it was designed for.

By laying it out on paper I mean to (1) design and draw up your bitting charts, (2) assign the bittings by keyset number to particular openings or locksets and (3) make a plug set up chart for each bitting assigned. I have not included in the above, the drawing up of your hardware schedule (hardware required for the job) or the actual laying out of the system from plans or physical survey. All of these must be completed and approved by all parties before a Master Key system can be designed.

My reasoning for insisting that people who have worked for me do all their Master Keyhing on paper first is based on years of experience of watching employees and Locksmiths go directly from a bitting chart to pinning of cylinders. Almost invarably this leads to unnecessary mistakes which add unnecessary time to the job. Unnecessary time spent on a job because of mistakes, robs you of your rightful profit. If you have obtained the job on a firm bid, then each mistake made in the accomplishment of the job really chews up your profit. Remember - no matter how small or large your operation, TIME is MONEY and mistakes are COSTLY because they consume unnecessary time not to mention what they can do to your reputation.

When designing Master Key systems, a constant check must be kept on your work to prevent interchanges from occurring. The more complicated the system the more checking you should do. Following the rules for good Master Keying will generally keep you out of trouble; however, you can check your work by using the following method. This is particularly good when you have cylinders that must be cross-keyed.

This method of checking involves the use of the plug set up chart we touched on briefly in the basic section. Again, the best method of explaining a system is by using examples. We will use the system we developed in Figure 50. Here we will check to see that the GMK's, MK's and Change Keys open only those cylinders they were intended to.

To start, let us set up a cylinder to the first change under each of the four Master Keys. We will determine the pinning by using the bitting of the GGMK and the Change Key. It is unnecessary to write in the GMK and MK. There, bittings will appear in the cylinder automatically.

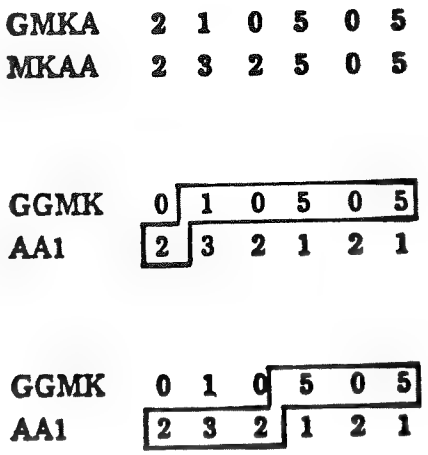


FIGURE 53

Figure 53 shows how the bittings for GMKA and MKAA are included on the plug set up chart thus making it unnecessary to write them in. Now let's check ourselves. First from the bittings of the GGMK and AA1 we select the bottom pins and write them. Remember, the bottom pin is always the smaller of the two numbers, or when referring to key bittings we would say it is always the shallowest bitting. Figure 54 shows how we selected our bottom pins.

GGMK	0	1	0	5	0	5
AA1	2	3	2	1	2	1
Bottom Pins	0	1	0	1	0	1

FIGURE 54

Note that the number of the bottom pin is the same as the smallest number directly above it regardless of whether it is in the Change Key or Master Key. Now, we select our master pins for each cell. The number of the master pin will be the difference between the bottom pin and the largest of the two numbers directly above it. Figure 55 shows this clearly.

GGMK	0	1	0	5	0	5
AA1	2	3	2	1	2	1
Bottom Pins	0	1	0	1	0	1
Master Pins	2	2	2	4	2	4

FIGURE 55

Figure 55 is the completed plug set up chart for cylinder AA1. The six bottom pins and six master pins create 64 different shear lines, or putting it another way, 64 keys can be cut to operate this cylinder. We will go into this in detail later and show you how to use these keys.

Let's see how we use the shear lines to check for interchanges. Let's take the bitting of the GGMK - 010505.

GGMK	0	1	0	5	0	5
AA1	2	3	2	1	2	1
Bottom Pins	0	1	0	1	0	1
Master Pins	2	2	2	4	2	4
GGMK Bitting	0	1	0	5	0	5

FIGURE 56

The combination of pins shown in Figure 56 create a shear line for the GGMK. The bottom pins in the first, second, third and fifth positions create a shear line for our GGMK. In the fourth and sixth columns, it is the combination of the bottom and master pins that create the shear line. Remember, the bottom pins alone can create a shear line, the master pins, however, must be used in conjunction with the bottom pin to create a shear line.

Now, lets check the bitting of the Change Key AA1.

GGMK	0	1	0	5	0	5
AA1	2	3	2	1	2	1
Bottom Pins	0	1	0	1	0	1
Master Pins	2	2	2	4	2	4
AA1 Bitting	2	3	2	1	2	1

FIGURE 57

Now the bitting of the AA Master Key 232505.

GGMK	0	1	0	5	0	5
AA1	2	3	2	1	2	1
Bottom Pins	0	1	0	1	0	1
Master Pins	2	2	2	4	2	4
AABitting	2	3	2	5	0	5

FIGURE 58

Now check the bitting of the GMK A-210505.

GGMK	0	1	0	5	0	5
AA1	2	3	2	1	2	1
Bottom Pins	0	1	0	1	0	1
Master Pins	2	2	2	4	2	4
A Bitting	2	1	0	5	0	5

FIGURE 59

Now, using each of the plug set up charts in Figure 60, let's see if our system is secure from interchanges. It is not necessary to check the GGMK. It was designed to operate all of the cylinders in our system.

GGMK	0 1 0 5 0 5
AA1	2 3 2 1 2 1
Bottom Pins	0 1 0 1 0 1
Master Pins	2 2 2 4 2 4

GGMK	0 1 0 5 0 5
BA1	4 3 6 1 2 1
Bottom Pins	0 1 0 1 0 1
Master Pins	4 2 6 4 2 4

GGMK	0 1 0 5 0 5
AB1	2 5 2 1 2 1
Bottom Pins	0 1 0 1 0 1
Master Pins	2 4 2 4 2 4

GGMK	0 1 0 5 0 5
BB1	4 5 6 1 2 1
Bottom Pins	0 1 0 1 0 1
Master Pins	4 4 6 4 2 4

FIGURE 60

Our first step will be to check the bitting of the A (GMK) key against the plug set up charts of the cylinders under the B (BMK) key. Note that the bitting of the A key 210505 does not exist in either the BA1 or BB1 cylinders. The first column in both cylinders will create a shear line for only a number 0 or 4 cut on a key. Our A key will not open this cylinder.

The same situation exists when you check the B key, 410505, against the shear lines of AA1 and AB1. Only shear lines for the bittings 0 and 2 exist in the first column. The shear line for a number 4 cut on a key does not exist.

Now, check each of the Change Keys against the other cylinders. Read the bitting, then see if the pins or combinations of pins create that shear line. You will find that the system we have created is secure from interchanges.

CHAPTER EIGHT

MOVEABLE CONSTANT PROGRESSION

Moveable Constant Progression, also called Rotating Constant Progression or Hold and Vary patterns, is used where large numbers of change keys are needed with a minimum number of Master Keys. It is best suited to simple Level Two Master Key systems, requiring only a Master Key and numerous Change Keys. A much larger number of Change Keys are available with this system than with standard-progression systems but only at the expense of the majority of Master Key bittings normally available, thus this system is generally used where relatively simple Master Key Systems are required.

Moveable Constant progression is based on the same principals as the type of progression we have used up to this point in the manual. To illustrate the principles of Moveable Constant progression we will start with the simplest system possible, one column progression. Shown in Figure 61 is a chart detailing the steps and sequence used in this type progression for a five pin system.

Columns	1	2	3	4	5	
STEPS 1	X					1 SEQUENCE
2		X				2
3			X			3
4				X		4
5					X	5

ONE COLUMN PROGRESSION
(If X indicates column to be progressed)

FIGURE 61

Step One is to progress column one as shown in Figure 62. Notice that the first column has been progressed. Column 2, 3, 4 and 5 used the bittings of the Master Key.

Columns	1	2	3	4	5
MASTER KEY	1	4	3	6	1
	3	0	1	0	3
	5	2	5	2	5
	7	6	7	4	7
	9	8	9	8	9

FIGURE 62

3 4 3 6 1	1 0 3 6 1	1 4 1 6 1	1 4 3 0 1	1 4 3 6 3
5	2	5	2	5
7	6	7	4	7
9	8	9	8	9

Next, we progress to the second column as shown in Figure 62. Here columns 1, 3, 4 and 5 use the bitting of the master key in each change key. We continue to progress each column until all five have been progressed as in figure 62. There are five columns, each column giving us 4 changes; thus we have a total of 20 changes to our Master Key.

FIGURE 63

Master Key	AA	14361	AA	14361
Change Key	5AA	54361	11AA	14761
Bottom Pins		14361		14361
Master Pins		4-----		---4--

Studying Figure 63 we see that we are using a master wafer in one cell only. Only two keys will operate thse cylinders, the two keys designed for this purpose, the MK and the CK. We also see that there are no "ghost keys" so there are no master keys available other than our designated one.

One advantage of this system of master keying is that it utilizes a minimum number of master pins thus keeping the number of shear lines to a minimum creating a more secure cylinder.

In review, progress one column at a time using only the change key progression. The Master key bitting must never be used in the column being progressed. The columns not being progressed will have the bittings of the Master Key.

Still using a five pin system, let's go one step further and do a 2 column progression. Figure 64 shows the progression chart. Note that we must progress two columns of numbers ten times. Each two columns will give us 16 changes, thus 10 x 16 equals 160 changes and a Master Key available using this chart.

FIGURE 64

	COLUMNS	1	2	3	4	5			
	1	X	X				1	2	
	2	X		X			1	3	S
	3	X			X		1	4	E
S	4	X				X	1	5	Q
T	5		X	X			2	3	U
E	6		X		X		2	4	E
P	7		X			X	2	5	N
S	8			X	X		3	4	C
	9			X		X	3	5	E
	10				X	X	4	5	

TWO COLUMN PROGRESSION

(Progress columns indicated by an X.)

In Figure 65 we have completed the first four steps, columns one and two through columns one and five. These four steps net us 64 changes. Again remember, the master key bitting must never appear in those columns we are progressing. The master key bitting will appear in only those columns not progressed on the change keys.

FIGURE 65

COLUMN	1	2	3	4	5
MASTER KEY	1	4	3	6	1
	3	0	1	0	3
	5	2	5	2	5
	7	6	7	4	7
	9	8	9	8	9

FIGURE 5

xx	x x	x x	x x
30361	34161	34301	34363
2	5	2	5
6	7	4	7
8	9	8	9
50361	54161	54301	54363
2	5	2	5
6	7	4	7
8	9	8	9
70361	74161	74301	74363
2	5	2	5
6	7	4	7
8	9	8	9
90361	94161	94301	94363
2	5	2	5
6	7	4	7
8	9	8	9

(x at the top of the column indicates the columns progressed)

Now lets progress the next three steps, 2 and 3, 2 and 4 and 2 and 5. These three steps will net us 48 more change keys.

FIGURE 66

xx	x x	x x
10161	10301	10363
5	2	5
7	4	7
9	8	9
12161	12301	12363
5	2	5
7	4	7
9	8	9
16161	16301	16363
5	2	5
7	4	7
9	8	9
18161	18301	18363
5	2	5
7	4	7
9	8	9

(x at the top of the column indicates the columns progressed.)

The progressions we have completed up to this point, Figure 65 and 66 have nettted us a total of 112 changes. Let's complete this two column progression.

FIGURE 67

xx	x x	xx
14101	14163	14303
2	5	5
4	7	7
8	9	9
14521	14563	14323
2	5	5
4	7	7
8	9	9
14741	14763	14343
2	5	5
4	7	7
8	9	9
14981	14963	14383
2	5	5
4	7	7
8	9	9

Figure 67 completes progression of the chart in Figure 64, (Two Column progression). We now have a Master Key and theoretically 160 Change Key bittings. Theoretically because some of these bittings will not be usable depending on the system you are using.

In the two column progression exercise we just finished, sub-master keys do exist but in limited numbers. To give an example, let's start with the first 16 changes, that is the top four rows across, all the changes that begin with a number 3. The sub-master that will operate these 16 changes is SMK 34361. Note that the last four bittings of the SMK are Master Key bittings, 4361. All cylinders that are pinned up to the MK 14361 and the Change key bittings beginning with a 3 will contain the shear line that SMK 34361 will establish. See Figure 68.

MK 1 4 3 6 1	MK 1 4 3 6 1	MK 1 4 3 6 1
CK 3 0 3 6 1	CK 3 4 7 6 1	CK 3 4 9 6 1
BP 1 0 3 6 1	BP 1 4 3 6 1	BP 1 4 3 6 1
MP 2 4 - - -	MP 2 - 4 - -	MP 2 - 6 -

FIGURE 68

MK 1 4 3 6 1	MK1 4 3 6 1
CK 5 0 3 6 1	CK 9 4 7 6 1
BP 1 0 3 6 1	BP 1 4 3 6 1
MP 4 4 - - -	MP 8 - 4 - -

Figure 68 shows that the shear line 34361 exists in all cylinders that are pinned to the MK and the changes that begin with a 3. Note the bottom two examples of Figure 68 do not contain a 3 in the first position of the bitting so therefore there is no shear line established for a number 3 depth of cut.

Look at the first example in Figure 68 with CK 30361. Note that there are 4 shear lines established. 10361, 14361, 30361 and 34361. The number two and three shear lines are for our MK and CK respectively. 34361 we used as a SMK for the changes that begin with a 3. The shear line 10361 will appear in all cylinders pinned to a combination that has a 0 in the second position. There are 28 changes that have a 0 in the second position. A key cut to 10361 will open these cylinders. You can find these 28 changes in Figures 65 and 66.

Following this same pattern of thought, look at our second example. Again we have the three shear lines 14361, 34361, the shear line of the Change Key 34761. The fourth shear line is 14761, a shear line that will apear in the 16 changes that have a 7 in the third position of the bitting. A key cut to 14761 will operate as a sub-master for these 16 changes.

The bitting that will operate as a SMK for the second group of 16 changes is 54361. Let's take the bitting 54367 from this group of 16 changes and show the shear lines that are created when a cylinder is pinned to the MK and CK 54367. See Figure 69.

FIGURE 69

Master Key	1	4	3	6	1
Change Key	5	4	3	6	7
Bottom Pins	1	4	3	6	1
Master Pins	4	-	-	-	6

Shear Line	is	
1 4 3 6 1	"	Master Key
1 4 3 6 7	"	SMK for all changes ending in a 7
5 4 3 6 1	"	SMK for all changes beginning with a 5
5 4 3 6 7	"	Change Key

By studying Figures 65, 66, 67, 68 and 69 closely, you will see that pattern of how these SMK's evolve. As always they are just existing shear lines in a cylinder when it is pinned to the Master Key and the Change Key. Also note that the Changes operated by a SMK do not follow an orderly sequence as they do in standard progression. Here they are often scattered throughout the changes. Be careful when using these SMK's. You must be aware of every change they will operate to prevent an unauthorized interchange.

The next logical progression is the 3 column progression. Here we will obtain a MK and 640 changes in a five pin system. Using the existing shear lines from this point on requires considerable care as they are in little or no logical sequence in the manner we are accustomed to. They are usable, however, be sure you are aware of each and every bitting they operate.

The following are the progression charts for 5, 6 and 7 pin systems. Notice the tremendous increase in theoretical changes available as the system gets larger. For example a five pin system using 4 column progression nets us 1,280 changes. A six pin system using 5 column progression nets us 6,144 changes, while a seven pin system using 6 column progression nets us 28,672 changes.

After you have studied this part seriously and understand the charts, work out a few examples for yourself. Save them — you can use them.

FIVE PIN PROGRESSION

X — INDICATES COLUMN TO BE PROGRESSED

STEPS	COLUMNS 1	2	3	4	5	SEQUENCE
1	X					
2		X				
3			X			
4				X		
5					X	

ONE COLUMN PROGRESSION
20 CHANGES

STEPS	COLUMNS 1	2	3	4	5		SEQUENCE
1	X	X				1-2	
2	X		X			1-3	S
3	X			X		1-4	E
4	X				X	1-5	Q
5		X	X			2-3	U
6		X		X		2-4	E
7		X			X	2-5	N
8			X	X		3-4	C
9			X		X	3-5	E
10				X	X	4-5	

TWO COLUMN PROGRESSION
160 CHANGES

STEPS	COLUMNS 1	2	3	4	5		SEQUENCE
1	X	X	X			1-2-3	
2	X	X		X		1-2-4	
3	X	X			X	1-2-5	S
4	X		X	X		1-3-4	E
5	X		X		X	1-3-5	Q
6	X			X	X	1-4-5	U
7		X	X	X		2-3-4	E
8		X	X		X	2-3-5	N
9		X		X	X	2-4-5	C
10			X	X	X	3-4-5	E

THREE COLUMN PROGRESSION
640 CHANGES

STEPS	COLUMNS 1	2	3	4	5		SEQUENCE
1	X	X	X	X		1-2-3-4	
2	X	X	X		X	1-2-3-5	S
3	X	X		X	X	1-2-4-5	E
4	X		X	X	X	1-3-4-5	Q
5		X	X	X	X	2-3-4-5	U
							E
							N
							C
							E

FOUR COLUMN PROGRESSSION
1,280 CHANGES

SIX PIN PROGRESSION

STEPS	COLUMNS 1	2	3	4	5	6	SEQUENCE
1	X						1
2		X					2
3			X				3
4				X			4
5					X		5
6						X	6

ONE COLUMN PROGRESSION
24 CHANGES

STEPS	COLUMNS 1	2	3	4	5	6	SEQUENCE
1	X	X					1-2
2	X		X				1-3
3	X			X			1-4
4	X				X		1-5
5	X					X	1-6
6		X	X				2-3
7		X		X			2-4
8		X			X		2-5
9		X				X	2-6
10			X	X			3-4
11			X		X		3-5
12			X			X	3-6
13				X	X		4-5
14				X		X	4-6
15					X	X	5-6

TWO COLUMN PROGRESSION
240 CHANGES

STEPS	COLUMNS 1	2	3	4	5	6	SEQUENCE
1	X	X	X				1-2-3
2	X	X		X			1-2-4
3	X	X			X		1-2-5
4	X	X				X	1-2-6
5	X		X	X			1-3-4
6	X		X		X		1-3-5
7	X		X			X	1-3-6
8	X			X	X		1-4-5
9	X			X		X	1-4-6
10	X				X	X	1-5-6
11		X	X	X			2-3-4
12		X	X		X		2-3-5
13		X	X			X	2-3-6
14		X		X	X		2-4-5
15		X		X		X	2-4-6
16		X			X	X	2-5-6
17			X	X	X		3-4-5
18			X	X		X	3-4-6
19			X		X	X	3-5-6
20				X	X	X	4-5-6

THREE COLUMN PROGRESSION
1,280 CHANGES

COLUMNS	1	2	3	4	5	6	
1	X	X	X	X			1-2-3-4
2	X	X	X		X		1-2-3-5
3	X	X	X			X	1-2-3-6
4	X	X		X	X		1-2-4-5
5	X	X		X		X	1-2-4-6
6	X	X			X	X	1-2-5-6
7	X		X	X	X		1-3-4-5
8	X		X	X		X	1-3-4-6
9	X		X		X	X	1-3-5-6
10				X	X	X	1-4-5-6
11		X	X	X	X		2-3-4-5
12		X	X	X		X	2-3-4-6
13		X	X		X	X	2-3-5-6
14		X		X	X	X	2-4-5-6
15			X	X	X	X	3-4-5-6

STEPS

SEQUENCE

FOUR COLUMN PROGRESSION
3,840 CHANGES

COLUMNS	1	2	3	4	5	6	
1	X	X	X	X	X		1-2-3-4-5
2	X	X	X	X		X	1-2-3-4-6
3	X	X	X		X	X	1-2-3-5-6
4	X	X		X	X	X	1-2-4-5-6
5	X		X	X	X	X	1-3-4-5-6
6		X	X	X	X	X	2-3-4-5-6

STEPS

SEQUENCE

FIVE COLUMN PROGRESSION
6,144 CHANGES

SEVEN PIN PROGRESSION

COLUMNS	1	2	3	4	5	6	7		
	1	X						1	
STEPS	2		X					2	SEQUENCE
	3			X				3	
	4				X			4	
	5					X		5	
	6						X	6	
	7							7	

ONE COLUMN PROGRESSION
28 CHANGES

	1	2	3	4	5	6	7	
1	X	X						1-2
2	X		X					1-3
3	X			X				1-4
4	X				X			1-5
5	X					X		1-6
6	X						X	1-7
7		X	X					2-3
8		X		X				2-4
9		X			X			2-5
10		X				X		2-6
11		X					X	2-7
12			X	X				3-4
13			X		X			3-5
14			X			X		3-6
15			X				X	3-7
16				X	X			4-5
17				X		X		4-6
18				X			X	4-7
19					X	X		5-6
20					X		X	5-7
21						X	X	6-7

STEPS — SEQUENCE

TWO COLUMN PROGRESSION
336 CHANGES

STEPS	COLUMNS	1	2	3	4	5	6	7	SEQUENCE
	1	X	X	X					1-2-3
	2	X	X		X				1-2-4
	3	X	X			X			1-2-5
	4	X	X				X		1-2-6
	5	X	X					X	1-2-7
	6	X		X	X				1-3-4
	7	X		X		X			1-3-5
	8	X		X			X		1-3-6
	9	X		X				X	1-3-7
	10	X			X	X			1-4-5
	11	X			X		X		1-4-6
	12	X			X			X	1-4-7
	13	X				X	X		1-5-6
	14	X				X		X	1-5-7
	15	X					X	X	1-6-7
	16		X	X	X				2-3-4
	17		X	X		X			2-3-5
	18		X	X			X		2-3-6
	19		X	X				X	2-3-7
	20		X		X	X			2-4-5
	21		X		X		X		2-4-6
	22		X		X			X	2-4-7
	23		X			X	X		2-5-6
	24		X			X		X	2-5-7
	25		X				X	X	2-6-7
	26			X	X	X			3-4-5
	27			X	X		X		3-4-6
	28			X	X			X	3-4-7
	29			X		X	X		3-5-6
	30			X		X		X	3-5-7
	31			X			X	X	3-6-7
	32				X	X	X		4-5-6
	33				X	X		X	4-5-7
	34				X		X	X	4-6-7
	35					X	X	X	5-6-7

THREE COLUMN PROGRESSION
2,240 CHANGES

COLUMNS	1	2	3	4	5	6	7	
1	X	X	X	X				1-2-3-4
2	X	X	X		X			1-2-3-5
3	X	X	X			X		1-2-3-6
4	X	X	X				X	1-2-3-7
5	X	X		X	X			1-2-4-5
6	X	X		X		X		1-2-4-6
7	X	X		X			X	1-2-4-7
8	X	X			X	X		1-2-5-6
9	X	X			X		X	1-2-5-7
10	X	X				X	X	1-2-6-7
11	X		X	X	X			1-3-4-5
12	X		X	X		X		1-3-4-6
13	X		X	X			X	1-3-4-7
14	X		X		X	X		1-3-5-6
15	X		X		X		X	1-3-5-7
16	X		X			X	X	1-3-6-7
17	X			X	X	X		1-4-5-6
18	X			X	X		X	1-4-5-7
19	X			X		X	X	1-4-6-7
20	X				X	X	X	1-5-6-7
21		X	X	X	X			2-3-4-5
22		X	X	X		X		2-3-4-6
23		X	X	X			X	2-3-4-7
24		X	X		X	X		2-3-5-6
25		X	X		X		X	2-3-5-7
26		X	X			X	X	2-3-6-7
27		X		X	X	X		2-4-5-6
28		X		X	X		X	2-4-5-7
29		X		X		X	X	2-4-6-7
30		X			X	X	X	2-5-6-7
31			X	X	X	X		3-4-5-6
32			X	X	X		X	3-4-5-7
33			X	X		X	X	3-4-6-7
34			X		X	X	X	3-5-6-7
35				X	X	X	X	4-5-6-7

STEPS

SEQUENCE

FOUR COLUMN PROGRESSION
8,960 CHANGES

COLUMNS	1	2	3	4	5	6	7	
1	X	X	X	X	X			1-2-3-4-5
2	X	X	X	X		X		1-2-3-4-6
3	X	X	X	X			X	1-2-3-4-7
4	X	X	X		X	X		1-2-3-5-6
5	X	X	X		X		X	1-2-3-5-7
6	X	X	X			X	X	1-2-3-6-7
7	X	X		X	X	X		1-2-4-5-6
8	X	X		X	X		X	1-2-4-5-7
9	X	X		X		X	X	1-2-4-6-7
10	X	X			X	X	X	1-2-5-6-7
11	X		X	X	X	X		1-3-4-5-6
12	X		X	X	X		X	1-3-4-5-7
13	X		X	X		X	X	1-3-4-6-7
14	X		X		X	X	X	1-3-5-6-7
15	X			X	X	X	X	1-4-5-6-7
16		X	X	X	X	X		2-3-4-5-6
17		X	X	X	X		X	2-3-4-5-7
18		X	X	X		X	X	2-3-4-6-7
19		X	X		X	X	X	2-3-5-6-7
20		X		X	X	X	X	2-4-5-6-7
21			X	X	X	X	X	3-4-5-6-7

STEPS — SEQUENCE

FIVE COLUMN PROGRESSION
21,504 CHANGES

COLUMNS	1	2	3	4	5	6	7	
1	X	X	X	X	X	X		1-2-3-4-5-6
2	X	X	X	X	X		X	1-2-3-4-5-7
3	X	X	X	X		X	X	1-2-3-4-6-7
4	X	X	X		X	X	X	1-2-3-5-6-7
5	X	X		X	X	X	X	1-2-4-5-6-7
6	X		X	X	X	X	X	1-3-4-5-6-7
7		X	X	X	X	X	X	2-3-4-5-6-7

STEPS — SEQUENCE

SIX COLUMN PROGRESSION
28,672 CHANGES

CHAPTER NINE
SINGLE INCREMENT PROGRESSION

Keying systems such as KWIKSET that use single increment Master Keying differ very little from the type of Master Keying we have discussed up to this point.

By single increment we mean that all increments (steps) are used in each column that is progressed rather than dividing them into odd and even steps. We can use each increment because it is considerably larger. Kwikset for example uses increments of .023 of an inch as opposed to .015 of an inch. The .023 step is considered sufficient to prevent a key cut only one increment different in the same position from operating it by manipulation.

As always lets work from an example.

MASTER KEY	3 6 1 6 4
	6 1 3 5 1
	7 2 4 7 2
	1 3 5 1 3
	2 4 6 2 5
	4 5 7 3 6
	5 7 2 4 7

Progressing the above bitting layout in the standard manner will give us 7,776 changes under the Master Key. Many of these bittings will be unusable and should be discarded. Bittings that are all the same numbers or only one step apart should be discarded. (*example: 33333 or 23232). Also those bittings having more than two identical numbers next to each other should be discarded. Try to use bittings that have at least one deep cut in the center.

Master Key systems are accomplished in the same manner as with two step systems.

When setting up your numbers under the Master Key, stagger them as we have done so as to provide as much variety as possible in the bittings.

CHAPTER TEN
LONG LIFE MASTER KEY CHARTS — MAKE THEM YOURSELF

The following pages illustrates a simple method of establishing Master Key Charts. You can make up these charts and use all or a portion of them on various jobs. Depending on the size of your jobs, one set of charts are conceivably be used from several months to several years.

This system is based on the use of existing shear lines in a master keyed group of cylinders. Old time Locksmith called these shear lines "Ghost Keys", we now call them INCIDENTAL MASTER KEYS. The system illustrated here is as old as Master Keying itself. It is just a natural outgrowth of the progression of numbers.

When a cylinder is pinned to the top master key and an individual change key from a system, numerous shear lines other than the shear line for Master key and Change key will be formed. These shear lines we will use for sub-master keys rather than the unprofessional method of putting a second or third master wafer in a pin cell to create a sub-master key. Working with the charts illustrated in this chapter you will be master pin to a cell.

What do we mean by existing shear lines and how do we find them?

MASTER KEY 325050

SM No.1	SM No.2	SM No.3	SM No.4	SM No.	
325012	325014	325016	325018		
325212	325214	325216	325218	5	325210
325412	325414	325416	325418	6	325410
325612	325614	325616	325618	7	325610
325812	325814	325816	325818	8	325810

Figure 1

Lets start with column one which consists of change keys 325212, 325412, 325612 and 325812. The sub-master for this group of four bittings is SM No.1 325012 shown at the top of the column. How did we obtain this sub-master? Note that columns one, two, three, five and six all have the same number in each of the bittings. (325__12). Column four however, has a 2, 4, 6 and a 8. The 0 is the bitting we selected in this column for our master key so we will use it in the fourth column of our sub-master, 325012. This 0 is the master bitting for the 2, 4, 6, and 8.

Further investigation will show that this sub-master bitting 325012 is a shear line that exists in all four of the cylinders that would be keyed to the Master Key and the individual change key. This is clearly shown when we make up our Plug Set Up and Key Cutting Charts. Study Figure 2.

MASTER KEY	3 2 5 0 5 0	MASTER KEY	3 2 5 0 5 0
CHANGE KEY	3 2 5 2 1 2	CHANGE KEY	3 2 5 4 1 2
BOTTOM PINS	3 2 5 0 1 0	BOTTOM PINS	3 2 5 0 1 0
MASTER PINS	- - - 2 4 2	MASTER PINS	- - - 4 4 2
MASTER KEY	3 2 5 0 5 0	MASTER KEY	3 2 5 0 5 0
CHANGE KEY	3 2 5 6 1 2	CHANGE KEY	3 2 5 8 1 2
BOTTOM PINS	3 2 5 0 1 0	BOTTOM PINS	3 2 5 0 1 0
MASTER PINS	- - - 6 4 2	MASTER PINS	- - - 8 4 2

Figure 2

Thus we see that by pinning our cylinders to the Master Key and each of the individual change keys the cylinders will each have a common shear line, 325012. If we desire a key to operate only these four cylinders out of the 16 listed, we need only cut the key to the common shear line 325012 and we have ourselves a sub-master key. We did not create this key, therefore we did not have to add additional Master Pins to the cylinder. We merely used what already existed. This simple illustration is the basis for this entire system.

Suppose now that we need a key to operate one cylinder in each of the groups of cylinders listed in Figure 1. Let's take the top row across. The bittings are 325212, 325214, 325216 and 325218. Notice that the bittings in first, second, third, fourth and fifth position of each cylinder is the same, 32521. The bittings in the sixth position are all different and consist of 2, 4, 6 and 8, the bittings we picked for our change keys. Notice that sub-master key No.5 has the same bittings in the first five positions as the change keys but uses the master bitting 0 in the sixth position. The 0 is the master bitting. Again we have not created anything new, this sub-master key (No.5, 325210) is simply a shear line that exists in each of the four listed cylinder combinations. Check the following chart:

MASTER KEY	3 2 5 0 5 0	MASTER KEY	3 2 5 0 5 0
CHANGE KEY	3 2 5 2 1 2	CHANGE KEY	3 2 5 2 1 4
BOTTOM PINS	3 2 5 0 1 0	BOTTOM PINS	3 2 5 0 1 0
MASTER PINS	- - - 2 4 2	MASTER PINS	- - - 2 4 4
MASTER KEY	3 2 5 0 5 0	MASTER KEY	3 2 5 0 5 0
CHANGE KEY	3 2 5 2 1 6	CHANGE KEY	3 2 5 2 1 8
BOTTOM PINS	3 2 5 0 1 0	BOTTOM PINS	3 2 5 0 1 0
MASTER PINS	- - - 2 4 6	MASTER PINS	- - - 2 4 8

Figure 3

Now test yourself by filling in the proper sub-master key bittings in the following example:

MASTER KEY 27296

Sub-Master No.1	Sub-Master No.2	Sub-Master No.3	Sub-Master No.4	Sub-Masters No.5
_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _	
2 7 2 1 0	2 7 2 1 2	2 7 2 1 4	2 7 2 1 8	_ _ _ _ _ No.6
2 7 2 3 0	2 7 2 3 2	2 7 2 3 4	2 7 2 3 8	_ _ _ _ _ No.7
2 7 2 5 0	2 7 2 5 2	2 7 2 5 4	2 7 2 5 8	_ _ _ _ _ No.8
2 7 2 7 0	2 7 2 7 2	2 7 2 7 4	2 7 2 7 8	_ _ _ _ _

Figure 4

By now you understand how we find the sub-masters in a group of related cylinder bittings. There are many of these, let's take a look at where we can expect to find them. Figure 5 illustrates an example of a simple master key system and an explanation of the sub-master keys. Study this until you understand it.

The following chart shows 40 sub-masters for the 64 change keys listed. There are more that are not shown. In the explanation of this chart, we have selected Change Key No.43 and listed the shear lines that would exist in a cylinder combinated to the MK and CK No.43. The explanation shows you which sub-master each particular shear line is. Study this closely.

MASTER KEY FOR THIS PAGE 3 2 9 2 5

C C P P P

1 0 1 0 1
5 4 3 4 3
7 6 5 6 7
9 8 7 8 9

	SM1	SM2	SM3	SM4		
	32921	32923	32927	32929		
SM5	1 32101	2 32103	3 32107	4 32109	32105	SM25
32125	5 32141	6 32143	7 32147	8 32149	32145	SM26
	9 32161	10 32163	11 32167	12 32169	32165	SM27
	13 32181	14 32183	15 32187	16 32189	32185	SM28
	32121	32123	32127	32129		
	SM9	SM10	SM11	SM12		
SM6	17 32301	18 32303	19 32307	20 32309	32305	SM29
32325	21 32341	22 32343	23 32347	24 32349	32345	SM30
	25 32361	26 32363	27 32367	28 32369	32365	SM31
	29 32381	30 32383	31 32387	32 32389	32385	SM32
	32321	32323	32327	32329		
	SM13	SM14	SM15	SM16		
SM7	33 32501	34 32503	35 32507	36 32509	32505	SM33
32525	37 32541	38 32543	39 32547	40 32549	32545	SM34
	41 32561	42 32563	43 32567	44 32569	32565	SM35
	45 32581	46 32583	47 32587	48 32589	32585	SM36
	32521	32523	32527	32529		
	SM17	SM18	SM19	SM20		
SM8	49 32701	50 32703	51 32707	52 32709	32705	SM37
32725	53 32741	54 32743	55 32747	56 32745	32745	SM38
	57 32761	58 32763	59 32767	60 32769	32765	SM39
	61 32781	62 32783	63 32787	64 32789	32785	SM40
	32721	32723	32727	32729		
	SM21	SM22	SM23	SM24		

Figure 5

All bittings enclosed in boxes in Figure 5 are sub-master keys. The four sub-masters across the top of the listing SM1 thru 4, are sub-masters that will operate the 16 change keys directly below them. The four sub-masters on the left side of the page labeled SM5 thru 8 are sub-masters that operate the group of 16 cylinders directly to their right (example: SM6 operates bittings 17 through 32).

The sub-masters on the right of the page SM25 through 40 operate the four cylinders directly to their left. (example: SM35 operates -41 through 44). The sub-masters under each group of four bittings (there are 16 of these) are sub-masters for the four bittings directly above each of the sub-masters.
(example: SM19 is a sub-master for bittings 35, 39, 43 and 47).

The general rule for finding "ghost keys" (sub-masters) is to check a related group of bittings for constant numbers. In those columns that have a bitting that varies throughout the group, use the number from the Master Key for that column in other words, the master bitting for the other four numbers.

The listing shown in Figure 6 shows how Sub-Master Keys can be created from existing shear lines in a cylinder. The sub-master key numbers given refer to those shown on figure 5.

MASTER KEY	3 2 9 2 5
CHANGE KEY No.43	3 2 5 6 7
Bottom Pins	3 2 5 2 5
Master Pins	- - 4 4 2

Existing shear lines for the above cylinder No.43.

3 2 5 2 5	Sub-Master Key No.7
3 2 5 2 7	Sub-Master Key No.19
3 2 5 6.5	Sub-Master Key No.35
3 2 5 6 7	Change Key No.43
3 2 9 2 5	Master Key
3 2 9 2 7	Sub-Master Key No.3
3 2 9 6 5	See note A below.
3 2 9 6 7	See note B below.

Figure 6

Note A: This shear line will exist in all combinations in Fig. 5 that have a 6 in the fourth position. There are 16 of these. A key cut to 32965 will open these 16 cylinders.

Note B: This shear line exists in all combinations in Fig. 5 that have a 6 and 7 in the fourth and fifth positions. There are four of these combinations. A key cut to 32967 will open these four cylinders. It can be used as a Sub-Master Key.

Now let's get into the business of establishing our "Long life bitting charts".

WRITE IN THE PROPER SUB-MASTER KEY BITTINGS IN THE BLANK SPACES.

MASTER KEY 27496

0 1 0
2 3 2
6 5 4
8 7 8

	1. _____	2. _____	3. _____	4. _____	
	1. 27010	5. 27012	9. 27014	13. 27018	_____ 25.
5. _____	2. 27030	6. 27032	10. 27034	14. 27038	_____ 26.
	3. 27050	7. 27052	11. 27054	15. 27058	_____ 27.
	4. 27070	8. 27072	12. 27074	16. 27078	_____ 28.
	9. _____	10. _____	11. _____	12. _____	
	17. 27210	21. 27212	25. 27214	29. 27218	_____ 29.
6. _____	18. 27230	22. 27232	26. 27234	30. 27238	_____ 30.
	19. 27250	23. 27252	27. 27254	31. 27258	_____ 31.
	20. 27270	24. 27272	28. 27274	32. 27278	_____ 32.
	13. _____	14. _____	15. _____	16. _____	
	33. 27610	37. 27612	41. 27614	45.27618	_____ 33.
7. _____	34. 27630	38. 27634	42. 27634	46. 27638	_____ 34.
	35. 27650	39. 27652	43. 27654	47. 27658	_____ 35.
	36. 27670	40. 27672	44. 27674	48. 27678	_____ 36.
	17. _____	18. _____	19. _____	20. _____	
	49. 27810	53. 27812	57. 27814	61. 27818	_____ 37.
8. _____	50. 27830	54. 27832	58. 27834	62. 27838	_____ 38.
	51. 27850	55. 27852	59. 27854	63. 27858	_____ 39.
	52. 27870	56. 27872	60. 27874	64. 27878	_____ 40.
	21. _____	22. _____	23. _____	24. _____	

Figure 7

For each of the 64 Master Keys shown in Figure 9, an individual bitting chart can be drawn up listing the 64 change keys under that Master Key as well as some of the sub-masters that are available for use with them. These 64 pages, one for each master key, along with the Master Key Index comprise a very flexible system. As shown on the index page, these 64 pages of bittings are divided into four sections, pages 1 through 16, pages 17 through 32, 33 through 48 and pages 49 through 64.

To simplify the origination of one of these computer type systems, I have designed two charts. Figure 8, the MASTER KEY INDEX, is the first of these charts (we will see the other later). As well as listing the master keys under the top Master, this chart provides spaces for listing some of the sub-masters that operate the various groups of master keys.

Our first step is to choose our top Master Key and then progress the master key columns to obtain the 64 master keys, listing them in their proper place as shown in Figure 9. Next determine your 16 page sub-masters writing them in their proper columns and finally determine and list the four page masters.

Figure 10 is the chart we will use to list the 64 change key bittings under each of the 64 master keys from the Index page. Naturally there will be 64 of these pages. Figure 11 through 14 shows four of thee pages completed. One page from each of the four sectons.

DATE ORIGINATED

_____

MASTER KEY INDEX PAGES

1	2	3	4	5	6	7

TOP MASTER

_____

CONTROL KEY

_____

ALL BITTINGS THIS PAGE ARE MASTERS

	PAGE		PAGE		PAGE		PAGE		MASTER KEY PAGES	
MASTER KEY PAGE 1 THRU 16	1		2		3		4		1 THRU 4	
	5		6		7		8		5 — 8	
	9		10		11		12		9 — 12	
	13		14		15		16		13 — 16	
PAGE 17 THRU 32	17		18		19		20		17 — 20	
	21		22		23		24		21 — 24	
	25		26		27		28		25 — 28	
	29		30		31		32		29 — 32	
PAGE 33 THRU 48	33		34		35		36		33 — 36	
	37		38		39		40		37 — 40	
	41		42		43		44		41 — 44	
	45		46		47		48		45 — 48	
PAGE 49 THRU 64	49		50		51		52		49 — 52	
	53		54		55		56		53 — 56	
	57		58		59		60		57 — 60	
	61		62		63		64		61 — 64	

NOTE: BITTINGS APPEARING IN BOXES ARE SHEAR LINES THAT EXIST IN A CYLINDER WHEN IT IS PINNED TO THE TOP MASTER ( ) AND THE CHANGE KEY. THESE BITTINGS ARE USED FOR SUB-MASTER KEYS AND WILL OPERATE THE GROUPS OF CYLINDERS INDICATED.

DATE ORIGINATED
4-82

MASTER KEY INDEX 64 PAGES

ALL BITTINGS THIS PAGE ARE MASTERS

1	2	3	4	5	6	7
M	K	S	C	K	S	
1	0	5	4	9	4	
3	2	7	6	1	6	
5	4	9	8	3	8	
7	6	1	0	5	0	
9	8	3	2	7	2	

TOP MASTER
105494

CONTROL KEY

MASTER KEY	PAGE		PAGE		PAGE		PAGE		MASTER KEY PAGES	
	1	321494	2	341494	3	361494	4	381494	1 THRU 4	301494
PAGE 1 THRU 16	5	3	6	3	7	3	8	3	5 – 8	3
	9	7	10	7	11	7	12	7	9 – 12	7
305494	13	4	14	4	15	9	16	4	13 – 16	9
	17	521494	18	541494	19	561494	20	581494	17 – 20	501494
PAGE 17 THRU 32	21	3	22	3	23	3	24	3	21 – 24	3
	25	7	26	7	27	7	28	7	25 – 28	7
505494	29	4	30	4	31	4	32	4	29 – 32	4
	33	721494	34	741494	35	761494	36	781494	33 – 36	701494
PAGE 33 THRU 48	37	3	38	3	39	3	40	3	37 – 40	3
	41	7	42	7	43	7	44	7	41 – 44	7
705494	45	4	46	4	47	4	48	4	45 – 48	4
	49	921494	50	941494	51	961494	52	981494	49 – 52	901494
PAGE 49 THRU 64	53	3	54	3	55	3	56		53 – 56	3
	57	7	58	7	59	7	60		57 – 60	7
905494	61	4	62	4	63	9	64		61 – 64	9

CLF 804

NOTE: BITTINGS APPEARING IN BOXES ARE SHEAR LINES THAT EXIST IN A CYLINDER WHEN IT IS PINNED TO THE TOP MASTER (105494) AND THE CHANGE KEY. THESE BITTINGS ARE USED FOR SUB-MASTER KEYS AND WILL OPERATE THE GROUPS OF CYLINDERS INDICATED.

Figure No. 9 8:10

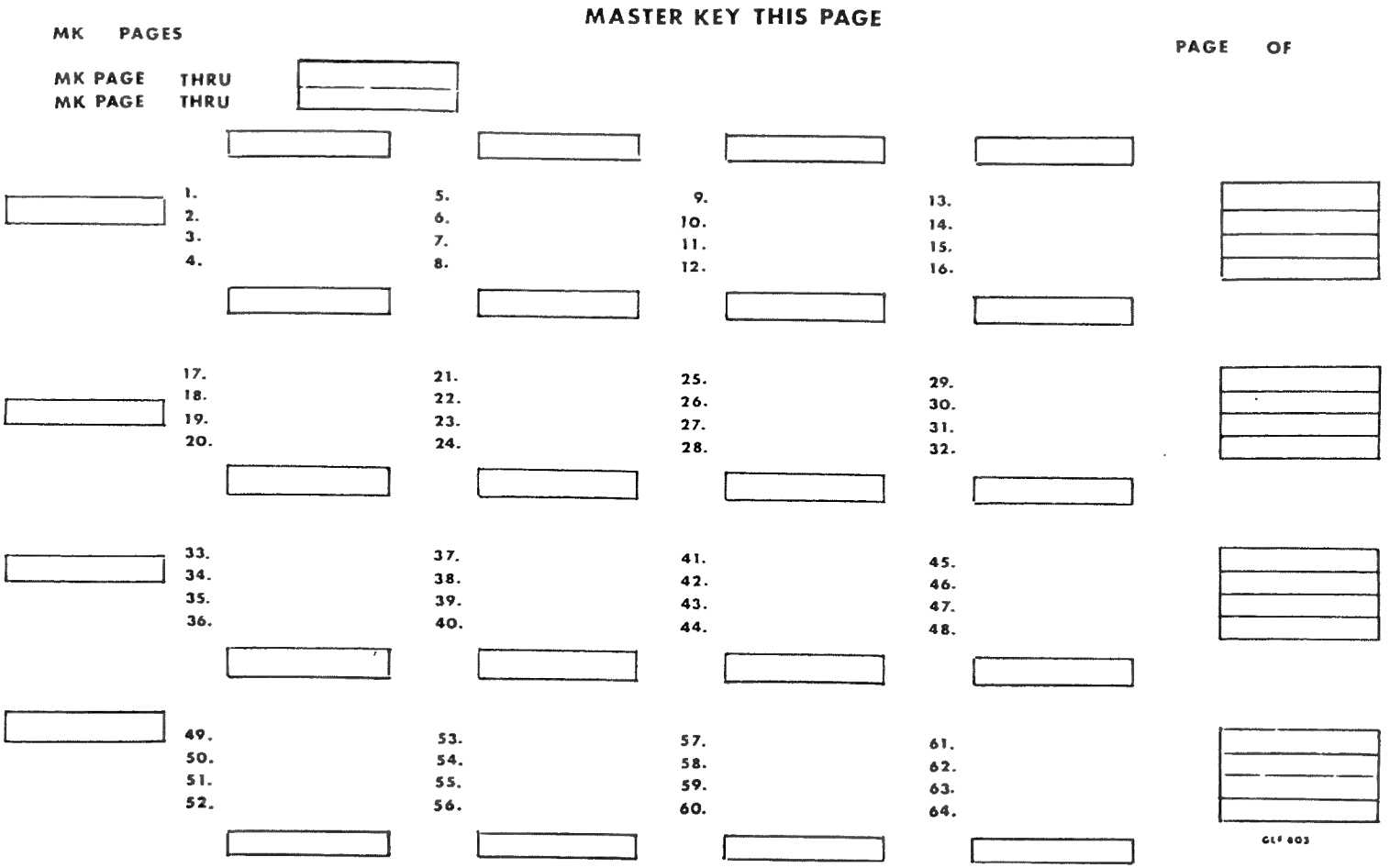


Figure No. 10 9:10

MK 64 PAGES 105494

MK PAGE 1 THRU 16 305494

MK PAGE 1 THRU 4 301494

MASTER KEY THIS PAGE

321494

PAGE 1 OF 64

321414 | 321434 | 321454 | 321474

321490

1. 321010	5. 321030	9. 321050	13. 321070
2. 2	6. 2	10. 2	14. 2
3. 6	7. 6	11. 6	15. 6
4. 8	8. 8	12. 8	16. 8

321410 | 321430 | 321450 | 321470

321090
2
6
8

321492

17. 321012	21. 321032	25. 321052	29. 321072
18. 2	22. 2	26. 2	30. 2
19. 6	23. 6	27. 6	31. 6
20. 8	24. 8	28. 8	32. 8

321412 | 321432 | 321452 | 321472

321092
2
6
8

321496

33. 321016	37. 321036	41. 321056	45. 321076
34. 2	38. 2	42. 2	46. 2
35. 6	39. 6	43. 6	47. 6
36. 8	40. 8	44. 8	48. 8

321416 | 321436 | 321456 | 321476

321096
2
6
8

321498

49. 321018	53. 321038	57. 321058	61. 321078
50. 2	54. 2	58. 2	62. 2
51. 6	55. 6	59. 6	63. 6
52. 8	56. 8	60. 8	64. 8

321418 | 321438 | 321458 | 321478

321098
2
6
8

GLF 803

Figure No. 11 10:10

MK 64 PAGES 105494

MK PAGE 17 THRU 32 505494

MK PAGE 17 THRU 20 501494

MASTER KEY THIS PAGE

521494

		521414			521434			521454			521474	
521490	1.	521010		5.	521030		9.	521050		13.	521070	521090
	2.	2		6.	2		10.	2		14.	2	2
	3.	6		7.	6		11.	6		15.	6	6
	4.	8		8.	8		12.	8		16.	8	8
		521410			521430			521450			521470	
521492	17.	521012		21.	521032		25.	521052		29.	521072	521092
	18.	2		22.	2		26.	2		30.	2	2
	19.	6		23.	6		27.	6		31.	6	6
	20.	8		24.	8		28.	8		32.	8	8
		521412			521432			521452			521472	
521496	33.	521016		37.	521036		41.	521056		45.	521076	521094
	34.	2		38.	2		42.	2		46.	2	2
	35.	6		39.	6		43.	6		47.	6	6
	36.	8		40.	8		44.	8		48.	8	8
		521416			521436			521456			521476	
521498	49.	521018		53.	521038		57.	521058		61.	521078	521098
	50.	2		54.	2		58.	2		62.	2	2
	51.	6		55.	6		59.	6		63.	6	6
	52.	8		56.	8		60.	8		64.	8	8
		521418			521438			521458			521478	

GLF 803

Figure No. 12 11:10

MK 64 PAGES 105494

MK PAGE 33 THRU 48 705491
MK PAGE 45 THRU 48 709494

MASTER KEY THIS PAGE
769494

769414 769434 769454 769474

769490

1. 769010	5. 769030	9. 769050	13. 769070
2. 2	6. 2	10. 2	14. 2
3. 6	7. 6	11. 6	15. 6
4. 8	8. 8	12. 8	16. 8
769410	769430	769450	769470

769090
2
6
4

769492

17. 769012	21. 769032	25. 769052	29. 769072
18. 2	22. 2	26. 2	30. 2
19. 6	23. 6	27. 6	31. 6
20. 8	24. 8	28. 8	32. 8
769412	769432	769452	769472

769092
2
6
8

769496

33. 769016	37. 769036	41. 769056	45. 769076
34. 2	38. 2	42. 2	46. 2
35. 6	39. 6	43. 6	47. 6
36. 8	40. 8	44. 8	48. 8
769416	769436	769456	769476

769096
2
6
8

769498

49. 769018	53. 769038	57. 769058	61. 769078
50. 2	54. 2	58. 2	62. 2
51. 6	55. 6	59. 6	63. 6
52. 8	56. 8	60. 8	64. 8
769418	769438	769458	769478

769098
2
6
8

GLY 803

Figure No. 13 12:10

MK 64 PAGES 105494

MK PAGE 99 THRU 64 905494
MK PAGE 57 THRU 60 907494

MASTER KEY THIS PAGE
987494

PAGE 60 OF 64

		987414		987434		987454		987474	
957490	1.	987010	5.	987030	9.	987050	13.	987070	987090
	2.	2	6.	2	10.	2	14.	2	2
	3.	6	7.	6	11.	6	15.	6	6
	4.	8	8.	8	12.	8	16.	8	8
		987410		987430		987450		987470	
987492	17.	987012	21.	987032	25.	987052	29.	987072	987092
	18.	2	22.	2	26.	2	30.	2	2
	19.	6	23.	6	27.	6	31.	6	6
	20.	8	24.	8	28.	8	32.	8	8
		987412		987432		987452		987472	
987496	33.	987016	37.	987036	41.	987056	45.	987076	987096
	34.	2	38.	2	42.	2	46.	2	2
	35.	6	39.	6	43.	6	47.	6	6
	36.	8	40.	8	44.	8	48.	8	8
		987416		987436		987456		987476	
987498	49.	987018	53.	987038	57.	987058	61.	987078	987098
	50.	2	54.	2	58.	2	62.	2	2
	51.	6	55.	6	59.	6	63.	6	6
	52.	8	56.	8	60.	8	64.	8	8
		987418		987438		987458		987478	

CLP 603

Figure No. 14 13:10

Making up 64 of these bitting charts seems like a lot of work and it can be, if not done properly. There are several short cuts you can take to minimize the effort required to complete them. Let's go through making up a set of these charts step by step. We will assume you have already done the Index Page.

First Step: Write in only those bittings shown in Figure 16. These numbers are primarly the Change Key bittings and other numbers that are common to all keys.

Second Step: Make four copies of the chart you just completed. Use one for each of the four sections. Write in the number of the sixteen page master as shown in Figures 17 thru 20. Using our example we have written the 2 on the first copy, the 4 on the second copy, the 6 on the third copy and finally the 8 on the fourth copy. Now because there are sixteen pages to each section make 16 copies of each of these four pages.

Third Step: The remaining portion of your job consist of inserting just two numbers in each of the vacant spaces of the 64 pages, not to big a job compared to doing one complete page at a time. Figure 21 shows the completed chart for the first Master Key, 210503

DATE ORIGINATED
5-80

MASTER KEY INDEX 64 PAGES

ALL BITTINGS THIS PAGE ARE MASTERS

1	2	3	4	5	6	7
M	K	's	C	K	's	
0	5	8	5	0	3	
2	1	0	1	2	1	
4	3	2	3	4	5	
6	7	4	7	6	7	
8	9	6	9	8	9	

TOP MASTER
058503

CONTROL KEY
—

MASTER KEY	PAGE		PAGE		PAGE		PAGE		MASTER KEY PAGES	
PAGE 1 THRU 16	1	210503	2	230503	3	270503	4	290503	1 THRU 4	250503
	5	2	6	2	7	2	8	2	5 – 8	2
	9	4	10	4	11	4	12	4	9 – 12	4
258503	13	6	14	6	15	6	16	6	13 – 16	6
PAGE 17 THRU 32	17	410503	18	430503	19	470503	20	490503	17 – 20	450503
	21	2	22	2	23	2	24	2	21 – 24	2
	25	4	26	4	27	4	28	4	25 – 28	4
458503	29	6	30	6	31	6	32	6	29 – 32	6
PAGE 33 THRU 48	33	610503	34	630503	35	670503	36	690503	33 – 36	650503
	37	2	38	2	39	2	40	2	37 – 40	2
	41	4	42	4	43	4	44	4	41 – 44	4
658503	45	6	46	6	47	6	48	6	45 – 48	6
PAGE 49 THRU 64	49	810503	50	830503	51	870503	52	890503	49 – 52	850503
	53	2	54	2	55	2	56	2	53 – 56	2
	57	4	58	4	59	4	60	4	57 – 60	4
858503	61	6	62	6	63	6	64	6	61 – 64	6

GLF 804

NOTE: BITTINGS APPEARING IN BOXES ARE SHEAR LINES THAT EXIST IN A CYLINDER WHEN IT IS PINNED TO THE TOP MASTER (058503) AND THE CHANGE KEY. THESE BITTINGS ARE USED FOR SUB-MASTER KEYS AND WILL OPERATE THE GROUPS OF CYLINDERS INDICATED.

MK 64 PAGES 058503

MASTER KEY THIS PAGE
503

PAGE OF 64

MK PAGE THRU 5 503
MK PAGE THRU 8503

		523		543		563		583				
501	1.	121	5.	141	9.	161	13.	181		101		
	2.	3	6.	3	10.	3	14.	3		3		
	3.	7	7.	7	11.	7	15.	7		7		
	4.	9	8.	9	12.	9	16.	9		9		
		521		541		561		581				
505	17.	125	21.	145	25.	165	29.	185		105		
	18.	3	22.	3	26.	3	30.	3		3		
	19.	7	23.	7	27.	7	31.	7		7		
	20.	9	24.	9	28.	9	32.	9		9		
		525		545		565		585				
507	33.	127	37.	147	41.	167	45.	187		107		
	34.	3	38.	3	42.	3	46.	3		3		
	35.	7	39.	7	43.	7	47.	7		7		
	36.	9	40.	9	44.	9	48.	9		9		
		527		547		567		587				
509	49.	129	53.	149	57.	169	61.	189		109		
	50.	3	54.	3	58.	3	62.	3		3		
	51.	7	55.	7	59.	7	63.	7		7		
	52.	9	56.	9	60.	9	64.	9		9		
		529		549		569		589				

GLF 803

Figure No. 16 16:10

MK 64 PAGES 058503

MK PAGE THRU 25 503

MK PAGE / THRU 16 258503

MASTER KEY THIS PAGE

2 503

	2 523	2 543	2 563	2 583	
2 501	1. 2 121 2. 3 3. 7 4. 9	5. 2 141 6. 3 7. 7 8. 9	9. 2 161 10. 3 11. 7 12. 9	13. 2 181 14. 3 15. 7 16. 9	2 101 3 7 9
	2 521	2 541	2 561	2 581	
2 505	17. 2 125 18. 3 19. 7 20. 9	21. 2 145 22. 3 23. 7 24. 9	25. 2 165 26. 3 27. 7 28. 9	29. 2 185 30. 3 31. 7 32. 9	2 105 3 7 9
	2 525	2 545	2 565	2 585	
2 507	33. 2 127 34. 3 35. 7 36. 9	37. 2 147 38. 3 39. 7 40. 9	41. 2 167 42. 3 43. 7 44. 9	45. 2 187 46. 3 47. 7 48. 9	2 107 3 7 9
	2 527	2 547	2 567	2 587	
2 509	49. 2 129 50. 3 51. 7 52. 9	53. 2 149 54. 3 55. 7 56. 9	57. 2 169 58. 3 59. 7 60. 9	61. 2 189 62. 3 63. 7 64. 9	2 109 3 7 9
	2 529	2 549	2 569	2 589	

GLF 803

Figure No. 17 17:10

MK 64 PAGES 058503

MASTER KEY THIS PAGE

4 503

PAGE OF 64

MK PAGE THRU 45 503

MK PAGE/7 THRU 32 458503

		4 523			4 543			4 563			4 583				
4 501	1.	4	121	5.	4	141	9.	4	161	13.	4	181		4 101	
	2.		3	6.		3	10.		3	14.		3		3	
	3.		7	7.		7	11.		7	15.		7		7	
	4.		9	8.		9	12.		9	16.		9		9	
		4 521			4 541			4 561			4 581				
4 505	17.	4	125	21.	4	145	25.	4	165	29.	4	185		4 105	
	18.		3	22.		3	26.		3	30.		3		3	
	19.		7	23.		7	27.		7	31.		7		7	
	20.		9	24.		9	28.		9	32.		9		9	
		4 525			4 545			4 565			4 585				
4 507	33.	4	127	37.	4	147	41.	4	167	45.	4	187		4 107	
	34.		3	38.		3	42.		3	46.		3		3	
	35.		7	39.		7	43.		7	47.		7		7	
	36.		9	40.		9	44.		9	48.		9		9	
		4 527			4 147			4 567			4 587				
4 509	49.	4	129	53.	4	49	57.	4	169	61.	4	189		4 109	
	50.		3	54.		3	58.		3	62.		3		3	
	51.		7	55.		7	59.		7	63.		7		7	
	52.		9	56.		9	60.		9	64.		9		9	
		4 529			4 549			4 569			4 589				

GLF 803

Figure No. 18 18:10

MK 64 PAGES 058503

MASTER KEY THIS PAGE
6 503

PAGE OF 64

MK PAGE THRU 65 503
MK PAGE 33 THRU 48 658503

		6 523			6 543			6 563			6 583	
6 501	1.	6 121		5.	6 141		9.	6 161		13.	6 181	6 101
	2.	3		6.	3		10.	3		14.	3	3
	3.	7		7.	7		11.	7		15.	7	7
	4.	9		8.	9		12.	9		16.	9	9
		6 521			6 541			6 561			6 581	
6 505	17.	6 125		21.	6 145		25.	6 165		29.	6 185	6 105
	18.	3		22.	3		26.	3		30.	3	3
	19.	7		23.	7		27.	7		31.	7	7
	20.	9		24.	9		28.	9		32.	9	9
		6 525			6 545			6 565			6 585	
6 507	33.	6 127		37.	6 147		41.	6 167		45.	6 187	6 107
	34.	3		38.	3		42.	3		46.	3	3
	35.	7		39.	7		43.	7		47.	7	7
	36.	9		40.	9		44.	9		48.	9	9
		6 527			6 547			6 567			6 587	
6 509	49.	6 129		53.	6 149		57.	6 169		61.	6 189	6 109
	50.	3		54.	3		58.	3		62.	3	3
	51.	7		55.	7		59.	7		63.	7	7
	52.	9		56.	9		60.	9		64.	9	9
		6 529			6 549			6 569			6 589	

GLF 803

Figure No. 19 19:10

MK 64 PAGES 058503

MASTER KEY THIS PAGE
8 503

PAGE OF 64

MK PAGE THRU 85 503
MK PAGE 49 THRU 64 858503

8 523 | 8 543 | 8 563 | 8 583

8 501

1. 8 121	5. 8 141	9. 8 161	13. 8 181
2. 3	6. 3	10. 3	14. 3
3. 7	7. 7	11. 7	15. 7
4. 9	8. 9	12. 9	16. 9
8 521	8 541	8 561	8 581

8 101
3
7
9

8 505

17. 8 125	21. 8 145	25. 8 165	29. 8 185
18. 3	22. 3	26. 3	30. 3
19. 7	23. 7	27. 7	31. 7
20. 9	24. 9	28. 9	32. 9
8 525	8 545	8 565	8 585

8 105
3
7
9

8 507

33. 8 127	37. 8 147	41. 8 167	45. 8 187
34. 3	38. 3	42. 3	46. 3
35. 7	39. 7	43. 7	47. 7
36. 9	40. 9	44. 9	48. 9
8 527	8 547	8 567	8 587

8 107
3
7
9

8 509

49. 8 129	53. 8 149	57. 8 169	61. 8 189
50. 3	54. 3	58. 3	62. 3
51. 7	55. 7	59. 7	63. 7
52. 9	56. 9	60. 9	64. 9
8 529	549	8 569	8 589

8 109
3
7
9

CLF 803

Figure No. 20 20:10

MK 64 PAGES 058503

MK PAGE / THRU 4 250503

MK PAGE / THRU 16 258503

MASTER KEY THIS PAGE

210503

	210523	210543	210563	210583	
210501	1. 210121 2. 3 3. 7 4. 9	5. 210141 6. 3 7. 7 8. 9	9. 210161 10. 3 11. 7 12. 9	13. 210181 14. 3 15. 7 16. 9	210101 3 7 9
	210521	210541	210561	210581	
210505	17. 210125 18. 3 19. 7 20. 9	21. 210145 22. 3 23. 7 24. 9	25. 210165 26. 3 27. 7 28. 9	29. 210185 30. 3 31. 7 32. 9	210105 3 7 9
	210525	210545	210565	210585	
210507	33. 210127 34. 3 35. 7 36. 9	37. 210147 38. 3 39. 7 40. 9	41. 210167 42. 3 43. 7 44. 9	45. 210187 46. 3 47. 7 48. 9	210107 3 7 9
	210527	210547	210567	210587	
210509	49. 2 129 50. 3 51. 7 52. 9	53. 2 149 54. 3 55. 7 56. 9	57. 2 169 58. 3 59. 7 60. 9	61. 210189 62. 3 63. 7 64. 9	210109 3 7 9
	210529	210549	210569	210589	

GLF 603

Figure No. 21 21:10

There are several ways to use one of these extended Master Key systems. Depending on the size and complexity of the system required, you can use all or a portion of the system. Let's use a small 16 page system to show the various uses of this system. (This is not a part of a 64 page MK system but a complete system of its own). All explanations refer to the charts on Figures 22.

Used exactly as shown on the Index Page (Fig.22), it is a Level 4 Great Grand Master Key system. The various keys in the system are:

GGMK	105494	
GMK A	305494	Sub-Master Pgs. 1 thru 4
GMK B	505494	Sub-Master Pgs. 5 thru 8
GMK C	705494	Sub-Master Pgs. 9 thru 12
GMK D	905494	Sub-Master Pgs. 13 thru 16

MK AA	325494 Pg.1	MK CA	725494 Pg.9
MK AB	345494 Pg.2	MK CB	745494 Pg.10
MK AC	365494 Pg.3	MK CC	765494 Pg.11
MK AD	385494 Pg.4	MK CD	785494 Pg.12
MK BA	525494 Pg.5	MK DA	925494 Pg.13
MK BB	545494 Pg.6	MK DB	945494 Pg.14
MK BC	565494 Pg.7	MK DC	965494 Pg.15
MK BD	585494 Pg.8	MK DD	985494 Pg.16

There are 64 change keys under each of the 16 Master keys listed above. Pin all cylinders to the GGMK and the individual change key.

There are several other ways to use this system also. A Level Three system (GMK) can be created in the following manner:

GMK A 105494

MK AA page 1	MK AE page 5	MK AJ page 9	MK AN page 13
MK AB page 2	MK AF page 6	MK AK page 10	MK AP page 14
MK AC page 3	MK AG page 7	MK AL page 11	MK AQ page 15
MK AD page 4	MK AH page 8	MK AM page 12	MK AR page 16

Again there are 64 changes under each Master. Pin all cylinders to the GMK and the individual change key.

A large Level Two Master Key system can be created by using the Top Master Key, 105494 and every change key bitting on all 16 pages. This will net you a MK and 1,024 change keys. Pin all your cylinders to the top master key and the individual change key bitting.

A simple Level Two master key system can be devised by using any one page of the 16. Use the page master key and the 64 change keys under it. Pin your cylinders to the page master and the individual change key. If you believe that you may need more change keys at a later date, pin your cylinders to the top master key and the individual change keys then you can add any one or more of the pages at a later date.

A small Level Three Grand Master Key system can be devised by using any one page. For example using page one our keying would be as follows:

GMK A (Top key Page One)

MK AA	325094	Change keys 1 thru 16
MK AB	325294	Change keys 17 thru 32
MK AC	325694	Change keys 33 thru 48
MK AD	325894	Change keys 49 thru 64

Each master key will have 16 change keys under it. Pin all cylinders to page MK 325494 and the individual change key.

There are other ways to use the system but they are just variations on those listed. You can use your 64 page systems in the same manner as we have the 16 page system. Sub-master keys will run throughout the system.

DATE ORIGINATED
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MASTER KEY INDEX 16 PAGES

ALL BITTINGS THIS PAGE ARE MASTERS

1	2	3	4	5	6	7
MK	MK	C	CK	CK	CK	
1	0	5	4	9	4	
3	2		6	1	6	
5	4		8	3	8	
7	6		0	5	C	
9	8		2	7	2	

TOP MASTER
105494
CONTROL KEY

MASTER KEY	PAGE		PAGE		PAGE		PAGE		MASTER KEY PAGES	
PAGE 1 THRU 16	1	325494	2	345494	3	365494	4	385494	1 THRU 4	305494
	5	5	6	5	7	5	8	5	5 – 8	5
105494	9	7	10	7	11	7	12	7	9 – 12	7
	13	9	14	9	15	9	16	9	13 – 16	9
PAGE 17 THRU 32	17		18		19		20		17 – 20	
	21		22		23		24		21 – 24	
	25		26		27		28		25 – 28	
	29		30		31		32		29 – 32	
PAGE 33 THRU 48	33		34		35		36		33 – 36	
	37		38		39		40		37 – 40	
	41		42		43		44		41 – 44	
	45		46		47		48		45 – 48	
PAGE 49 THRU 64	49		50		51		52		49 – 52	
	53		54		55		56		53 – 56	
	57		58		59		60		57 – 60	
	61		62		63		64		61 – 64	

GLF 804

NOTE: BITTINGS APPEARING IN BOXES ARE SHEAR LINES THAT EXIST IN A CYLINDER WHEN IT IS PINNED TO THE TOP MASTER (105494) AND THE CHANGE KEY. THESE BITTINGS ARE USED FOR SUB-MASTER KEYS AND WILL OPERATE THE GROUPS OF CYLINDERS INDICATED.

Figure No. 22 24:10

MK 16 PAGES 105494

MK PAGE 1 THRU 4 305494

MK PAGE THRU

MASTER KEY THIS PAGE

325494

		325490		325492		325496		325498
325094	1.	325010	5.	325012	9.	325016	13.	325018
	2.	3	6.	3	10.	3	14.	3
	3.	5	7.	5	11.	5	15.	5
	4.	7	8.	7	12.	7	16.	7
		325090		325092		325096		325098
325294	17.	325210	21.	325212	25.	325216	29.	325218
	18.	3	22.	3	26.	3	30.	3
	19.	5	23.	5	27.	5	31.	5
	20.	7	24.	7	28.	7	32.	7
		325290		325292		325296		325218
325694	33.	325610	37.	325612	41.	325616	45.	325618
	34.	3	38.	3	42.	3	46.	3
	35.	5	39.	5	43.	5	47.	5
	36.	7	40.	7	44.	7	48.	7
		325690		325692		325696		325698
325894	49.	325810	53.	325812	57.	325816	61.	325818
	50.	3	54.	3	58.	3	62.	3
	51.	5	55.	5	59.	5	63.	5
	52.	7	56.	7	60.	7	64.	7
		325890		325892		325896		325898

325014	
3	
5	
7	
325214	
3	
5	
7	
325614	
3	
5	
7	
325814	
3	
5	
7	

GLF 803

Figure No. 23 25:10

MK 16 PAGES 105494

MASTER KEY THIS PAGE
345494

MK PAGE / THRU 4 305494
MK PAGE THRU

345490 345492 345496 345498

345094
1. 345010 5. 345012 9. 345016 13. 345018
2. 3 6. 3 10. 3 14. 3
3. 5 7. 5 11. 5 15. 5
4. 7 8. 7 12. 7 16. 7

345014
3
5
7

345090 345092 345096 345098

345294
17. 345210 21. 345212 25. 345216 29. 345218
18. 3 22. 3 26. 3 30. 3
19. 5 23. 5 27. 5 31. 5
20. 7 24. 7 28. 7 32. 7

345214
3
5
7

345290 345292 345296 345298

345694
33. 345610 37. 345612 41. 345616 45. 345618
34. 3 38. 3 42. 3 46. 3
35. 5 39. 5 43. 5 47. 5
36. 7 40. 7 44. 7 48. 7

345614
3
5
7

345690 345692 345696 345698

345894
49. 345810 53. 345812 57. 345816 61. 345818
50. 3 54. 3 58. 3 62. 3
51. 5 55. 5 59. 5 63. 5
52. 7 56. 7 60. 7 64. 7

345814
3
5
7

GLF 803

345890 345892 345896 345898

Figure No. 24 26:10

MK 16 PAGES 105494

MK PAGE 5 THRU 8 505494

MK PAGE THRU

MASTER KEY THIS PAGE

525494

		525490		525492		525496		525498	
525094	1.	525010	5.	525012	9.	525016	13.	525018	525014
	2.	3	6.	3	10.	3	14.	3	3
	3.	5	7.	5	11.	5	15.	5	5
	4.	7	8.	7	12.	7	16.	7	7
		525090		525092		525096		525098	
525294	17.	525210	21.	525212	25.	525216	29.	525218	525214
	18.	3	22.	3	26.	3	30.	3	3
	19.	5	23.	5	27.	5	31.	5	5
	20.	7	24.	7	28.	7	32.	7	7
		525290		525292		525296		525298	
525694	33.	525610	37.	525612	41.	525616	45.	525618	525614
	34.	3	38.	3	42.	3	46.	3	3
	35.	5	39.	5	43.	5	47.	5	5
	36.	7	40.	7	44.	7	48.	7	7
		525690		525692		525696		525698	
525894	49.	525810	53.	525812	57.	525816	61.	525818	525814
	50.	3	54.	3	58.	3	62.	3	3
	51.	5	55.	5	59.	5	63.	5	5
	52.	7	56.	7	60.	7	64.	7	7
		525890		525892		525896		525898	

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Figure No. 25 27:10

MK 16 PAGES 105494

MASTER KEY THIS PAGE
725494

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MK PAGE 9 THRU 12 705494
MK PAGE THRU

	725490		725492		725496		725498	
725094	1. 7250[illegible]		5. 725012		9. 725016		13. 725018	725014
	2. 3		6. 3		10. 3		14. 3	3
	3. 5		7. 5		11. 5		15. 5	5
	4. 7		8. 7		12. 7		16. 7	7
	725090		725092		725096		725098	
725294	17. 725210		21. 725212		25. 725216		29. 725218	725214
	18. 3		22. 3		26. 3		30. 3	3
	19. 5		23. 5		27. 5		31. 5	5
	20. 7		24. 7		28. 7		32. 7	7
	725290		725292		725296		725298	
725694	33. 725610		37. 725612		41. 725616		45. 725618	725614
	34. 3		38. 3		42. 3		46. 3	3
	35. 5		39. 5		43. 5		47. 5	5
	36. 7		40. 7		44. 7		48. 7	7
	725690		725692		725696		725698	
725894	49. 725810		53. 725812		57. 725816		61. 725818	725814
	50. 3		54. 3		58. 3		62. 3	3
	51. 5		55. 5		59. 5		63. 5	5
	52. 7		56. 7		60. 7		64. 7	7
	725890		725892		725896		725898	

GLF 803

Figure No. 26 28:10

WRITE IN THE PROPER SUB-MASTER KEY BITTINGS IN THE BLANK SPACES.

MASTER KEY 2 7 4 9 6

0 1 0
2 3 2
6 5 4
8 7 8

	1. 27490	2. 27492	3. 27494	4. 27498	
	1. 27010	5. 27012	9. 27014	13. 27018	27016 25.
5. 27096	2. 27030	6. 27032	10. 27034	14. 27038	27036 26.
	3. 27050	7. 27052	11. 27054	15. 27058	27056 27.
	4. 27070	8. 27072	12. 27074	16. 27078	27076 28.
	9. 27090	10. 27092	11. 27094	12. 27098	
	17. 27210	21. 27212	25. 27214	29. 27218	27216 29.
6. 27296	18. 27230	22. 27232	26. 27234	30. 27238	27236 30.
	19. 27250	23. 27252	27. 27254	31. 27258	27256 31.
	20. 27270	24. 27272	28. 27274	32. 27278	27278 32.
	13. 27290	14. 27292	15. 27294	16. 27298	
	33. 27610	37. 27612	41. 27614	45.27618	27616 33.
7. 27696	34. 27630	38. 27634	42. 27634	46. 27638	27636 34.
	35. 27650	39. 27652	43. 27654	47. 27658	27656 35.
	36. 27670	40. 27672	44. 27674	48. 27678	27676 36.
	17. 27690	18. 27692	19. 27694	20. 27698	
	49. 27810	53. 27812	57. 27814	61. 27818	27816 37.
8. 27896	50. 27830	54. 27832	58. 27834	62. 27838	27836 38.
	51. 27850	55. 27852	59. 27854	63. 27858	27856 39.
	52. 27870	56. 27872	60. 27874	64. 27878	27876 40.
	21. 27690	22. 27892	23. 27894	24. 27898	

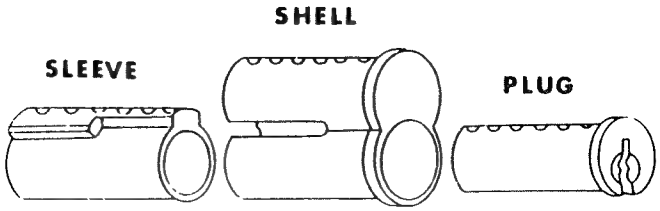
Figure 27

CHAPTER ELEVEN

Master Keying Interchangeable Core Cylinders BEST AND FALCON TYPES

Master Keying of FALCON and BEST type Interchangeable Core cylinders is done in the exact same manner as Master Keying standard pin tumbler cylinders with the exception of choosing a CONTROL KEY. Of course I am referring to the "paperwork" master keying and not the actual hands on pinning which is considerably different.

Because information on the Interchangeable core cylinders has been limited in the past let's review their construction and operation before continuing on because it has a definite effect on Master Keying the core.



INTERCHANGEABLE CORE ASSEMBLY

FIGURE 1

As shown in Figure 1 the I.C. cylinder is comprised of three major parts, the shell, sleeve and plug. The sleeve goes into the shell and the plug into the sleeve. Into this assembly goes the necessary pins and springs to operate the various keys in the system.

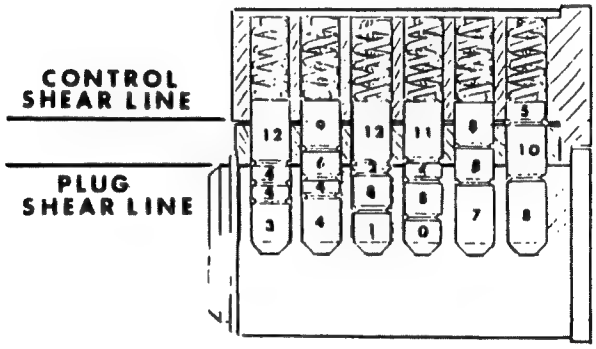


FIGURE 2

As can be seen in Figure 2 there are considerably more pins used in an I.C. than in a standard cylinder. Because of this Master Keying must be done in the manner we have described throughout (especially Chapter Ten). The practice of using additional pins in a cell to create sub-master keys can not be tolerated here. The lengths of a stack of pins is limited,

therefore the addition of more pins means that each of the pins in the core will of necessity be reduced in size. The more the number of small pins there are in a cell hole the greater the potential there is for problems.

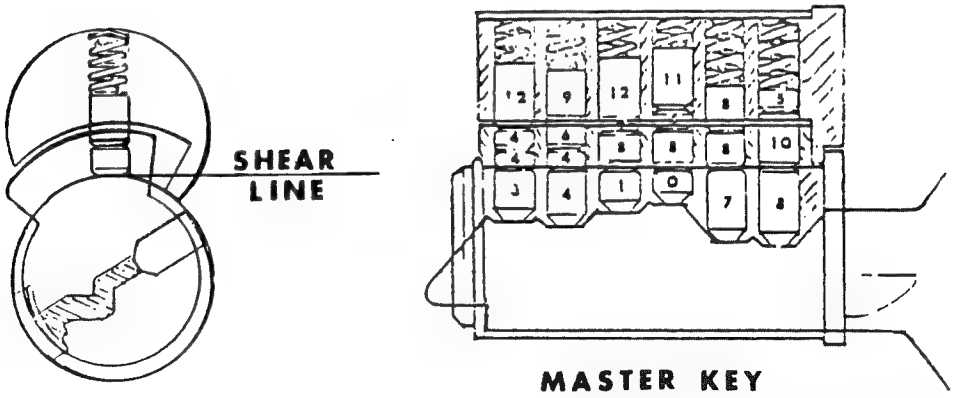


FIGURE 3

There are two distinct shear lines in an Interchangeable core. Figure 3 shows the first of these, the operating or plug shear line. All Master Keys and Change Keys operate at and create this shear line. This shear line is located between the plug and the sleeve.

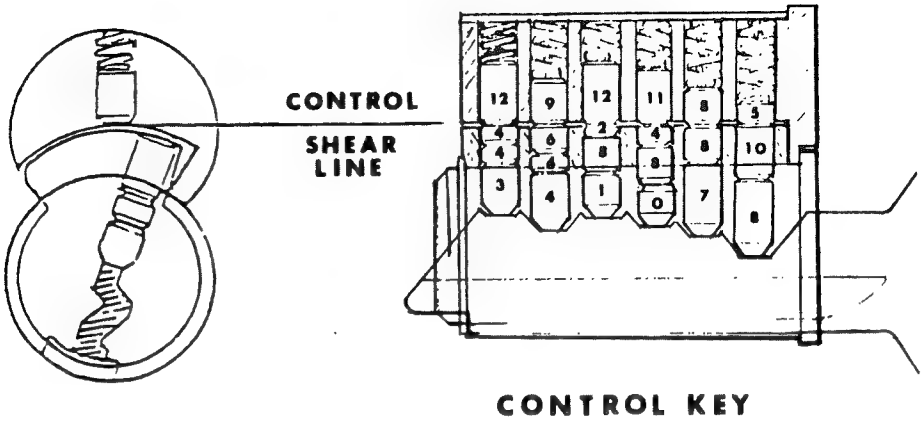


FIGURE 4

The second shear line is located between the sleeve and the shell and is shown in Figure 4. **Only** the CONTROL key operates and creates this shear line.

Two points to remember are, there will always be a minimum of three pins in each cell hole-bottom, control and top pin. You should never use more than four pins to a cell hole if at all possible. (Bottom, master, control and top pin).

Interchangeable cores can be Master Keyed to the same extent as standard cylinders with one exception. Cross Keying should never be done with I.C. cylinders. Maison master keying will guarantee cylinder operating problems.

Omitting all the pins from all but one or two cells, also to achieve Cross Keying, is definitely out. This will guarantee that the core can be removed as easy as it can be neutralized by anything you can get into the keyway. One sure way of loosing an account is to set his system up in a manner that causes him to lose cores as fast as he installs them.

Like a standard pin tumbler cylinder, the I.C. can be keyed different (KD) Just set up your system to the Change and Control keys. This will give you exactly three pins in each cell. There is a good degree of security in doing this as only one shear line exists at the plug or operating level Only the change key will operate the core. No master key is used This is a good procedure to use on perimeter areas.

The two shear lines, operating and control can not be mixed and any attempt to pick the core using standard picking procedures and tools will generally fail.

As we stated at the beginning of this chapter, Master Keying Interchangeable cores is done exactly the same as standard pin tumbler cylinders. Everything you have learned this far in previous chapters applies here as well. The ten increment system, which Falcon uses, (BEST A-2 system) employs increments of 0 to 9 and two step progression The BEST A3 and A4 system uses single progressions.

To master key the I.C. cylinder the only thing you need learn is how to select your Control Key. There are three ways The first method is to select one of your Change Key bittings. Select one that is under a Master Key that isn't used extensively in your system or better still a Master Key that you will not use in the system.

In a system such as shown in Figure 5 the Master Keys 010741, 210741 and 410741 can all be altered to the top Master Key so we will use these only when absolutely necessary. A change key selected from one of these would be a good choice.

	MK	MK	MK	CK	CK	CK
MASTER KEY	6	3	2	7	4	1
	8	5	4	9	6	3
	0	7	6	1	8	5
	2	9	8	3	0	7
	4	1	0	5	2	9
CONTROL KEY	4	1	0	5	6	3

FIGURE 5

From the matrix shown in Figure 5 we have selected the bitting 410563 to use as our Control Key. Because the increments or drops in the ten increment (A-2) system is only .0125 thousandths of an inch, keys with bittings adjacent to our Control Key can be both purposely and accidently manipulated to act as Control Keys. To avoid this happening, the keys with the bittings shown in Figure 6 should never be used in our system.

410363	410565
410365	410583
410383	410585
410385	

FIGURE 6

Another method of selecting a Control Key is based on use of bittings that are in both Top Master Key and the Change Keys. There are two facts you should know about the operating mechanics of the core when using this system.

1. When the Control Key and a Master or Change Key are cut to the same bitting in a space - both keys will create a shear line at both the control and operating (plug) shear line.

2. It is the Control pin that causes the plug and sleeve to rotate 15° clockwise together. As shown in Figure 4, the Control Pin is across the shear line causing the two parts to move as one. Note that the Control shear line is between the Top pin and Control pin.

	MK	MK	MK	CK	CK	CK
CONTROL KEY	1	4	7	2	5	4
MASTER KEY	1	4	7	4	9	2
	3	6	9	6	1	4
	5	8	1	8	3	6
	7	0	3	0	5	8
	9	2	5	2	7	0

FIGURE 7

In Figure 7 we have chosen a Control Key that has both bittings from the Top Master Key and Change Keys. Remember we stated previously that when the Control Key has the same cut as either the MK or a CK a shear line will be created at both levels in that position. This means there will be no pin across the shear line between the plug and sleeve in this position. With the Control Key we have selected, the maximum number of pins (control) that will be across the shear line at anytime, activating the sleeve will be six when change keys are used.

Because we have chosen numbers that can appear in the Change Keys in columns 4, 5 and 6, the minimum number of pins that will be blocking the sleeve from rotating would be three. This situation could occur if we ever cut and used any of the change keys that end in the bittings 2, 5 and 4. Three pins blocking the sleeve is sufficient however there is another problem. Because the Control Key and Top Master have the same bittings in the first three positions and the bitting 254 is pinned in every cylinder to accommodate the Control Key, the shear line 147254 (Control Key) will actually exist at both the Control and operating level when a core is pinned up to accommodate any of the change keys ending in 254. Our Control Key can create both shear lines. This can prove troublesome when attempting to use the Control Key to remove the core.
SOLUTION: Don't cut any of the change keys ending in 254.

A third way of obtaining a Control Key is to use numbers opposite those in the Master and Change keys. If the Master and change bittings are even numbers, use an odd number for your Control Key. See Figure 8.

CONTROL KEY	6	3	4	7	6	3
MASTER KEY	1	4	7	4	9	2
	3	6	9	6	1	4
	5	8	1	8	3	6
	7	0	3	0	5	8
	9	2	5	2	7	0

FIGURE 8

When using this method remember **do not** use a zero (0) in the Control key with a 9 in either the Master Key or Change Key. To do so would require the use of an number one wafer for a control pin. This pin doesn't exist (See Fig. 9).

CONTROL KEY	0	0	
MASTER KEY	1	3	
CHANGE KEY	9	9	
Bottom Pins	1	3	*The number 1
Master Pins	8	6	wafer does not
Control Pins	*1	1*	exist.
Top Pins	13	13	

FIGURE 9

If at all possible the use of the number two wafer as a control pin must be eliminated. This can be done very simply by never using a 0 or a 1 bitting in the control key.

As shown in Figure 10 the use of numbers 0 and 1 when used in the previous two forms of selecting a Control Key can cause the same problem-use of numbers 2 wafers as Control Pins, something that should be avoided at all cost. Never use a 0 or a 1 for your bitting in the Control key.

CONTROL KEY	0	1	0
MASTER KEY	4	9	8
CHANGE KEY	8	7	6
Bottom Pins	4	7	6
Master Pins	4	2	2
Control Pins	2	2	2
Top Pins	13	12	13

FIGURE 10

Another problem exists at the other end of the scale. Because of the unique construction of the Interchangeable Core with two separate shear lines, certain build ups of pins in a stack will create a near shear line at the control level when there is no key in the core. This can be avoided by not using two numbers deeper than a seven (7) in the Control Key. See Figure 11.

CONTROL BITTING	
a. 3 8 5 6 7 4	Acceptable
b. 4 9 6 3 8 5	Acceptable
c. 5 8 9 6 9 6	Unacceptable

FIGURE 11

To put it another way, a stack of pins consisting of the Bottom, master, control and top pins that total 17, 18 or 19 are to close to the Control shear line to be acceptable.

IN SUMMARY DO NOT USE THE NUMBERS 0 OR A 1 IN YOUR CONTROL KEY BITTING. ALSO, NEVER USE MORE THAN TWO NUMBERS DEEPER THAN A 6 IN YOUR CONTROL KEY BITTING, AND SEPARATE THE NUMBERS AS SHOWN IN FIGURE 11 a & b.

CHAPTER TWELVE

HOW TO OBTAIN ADDITIONAL BITTINGS FROM AN EXHAUSTED BITTING LIST

Although it is not a good practice, there is a method of obtaining a limited number of additional bittings in a Master Key system when all of the bittings have been used. This applies only to two step progression and not to single step progression. There are some inherent weaknesses in it but with caution they can be avoided. We will discuss these precautions later.

Using the simplest system possible let's see how we can obtain additional bittings from an exhausted system. As always let's work from an example.

Our system is a simple level two, five pin set up. From it we have obtained one Master Key and 1,024 changes. These were obtained by progressing all 5 columns of numbers, which was detailed in earlier chapters. Since each bitting has been used to its maximum extent we cannot use them again but must find them elsewhere.

Columns	1	2	3	4	5
Master Key	1	6	3	8	5
	3	8	5	0	7
	5	0	7	2	9
	7	2	9	4	1
	9	4	1	6	3

FIGURE 1

Our method involves using certain numbers which would normally be forbidden. Let's use column five of Figure 1 to demonstrate.

We cannot use the 7, 9, 1 or 3 again but we can use certain of their opposites (even numbers) if we stay at least 2 steps from the Master Key. By using the 0, 2 and 8 we have three additional bittings we can use for column. Notice we do not use the 4 or 6 because they are only one step away from our Master Key and proper master keying dictates that we do not use a number one master pin in two step progression.

We can pick up three bittings in each of the five columns. For example in column 4, we can use the 1, 3 and 5 as additional bitting numbers.

Figure 2 shows the additional 15 numbers we can use to obtain bittings from, for the Master Key system shown in Figure 1.

Column	1	2	3	4	5
Master Key	1	6	3	8	5
	4	9	6	1	8
	6	1	8	3	0
	8	3	0	5	2

FIGURE 2

From the additional 15 bitting numbers shown in Figure 2 we can obtain two-hundred and forty three (243) additional key changes. Most of these new changes will be just one step away from our original changes we obtained from the matrix in Figure 1.

Figure 3 is a partial listing (81) of the 243 changes we can obtain by using numbers opposite of the originals and two steps from the Master Key.

4 9 6 1 8	4 1 6 1 8	4 3 6 1 8
0	0	0
2	2	2
3 8	3 8	3 8
0	0	0
2	2	2
5 8	5 8	5 8
0	0	0
0	2	2
4 9 8 1 8	4 1 8 1 8	4 3 8 1 8
0	0	0
2	2	2
3 8	3 8	3 8
0	0	0
2	2	2
5 8	5 8	5 8
0	0	0
2	2	2
4 9 0 1 8	4 1 0 1 8	4 3 0 1 8
0	0	0
2	2	2
3 8	3 8	3 8
0	0	0
2	2	2
5 8	5 8	5 8
0	0	0
2	2	2

FIGURE 3

The danger of using bittings this close is pretty obvious. If you are ever required to use a system such as this - always try to use these new bittings physically in an area as far separated from the originals as possible to discourage and eliminate the possibility of one key being used in a cylinder with a bitting just one step off. With very little manipulation these keys can often open another cylinder in the system.

THINK TWICE BEFORE USING THIS SYSTEM

CHAPTER THIRTEEN

Modifying A Standard Progression To Obtain Additional Bittings

There are times when setting up a Master Key system that you will require more change keys under certain Master Keys than your system normally can provide. For instance, you are working with a six pin system and you require 36 Master Keys. All of the Master Keys with the exception of two require forty or less changes, these two require 80 changes each plus spares. (Always plan for possible future expansion).

The above requirements outwardly appear impossible to satisfy for the following reasons. We have learned with standard two step progression that progressing three columns of numbers will net us 64 master keys or change keys. Check the KEY BITTING ARRAY in Figure 1.

MK's			CK's		
1	0	7	2	5	4
3	2	9	4	7	6
5	4	1	6	9	8
7	6	3	8	1	0
9	8	5	0	3	2
nets			nets		
64			64		

Figure 1

As shown in Figure 1 we can obtain the 36 MK's we require and have up to 28 spares depending on our MACD (Maximum Adjacent Cut Difference). We cannot however satisfy the requirement of 80 plus changes for two of our 36 Master Keys. Eighty plus changes require we progres four columns.

There are three ways to fullfill this requirement. The first is to put your system on more than one keyway, use sectional keyways, in this manner we can progress four columns under the two Master Keys that require 80 plus changes. Our GMK can still be the same.

The second method and the one I most strongly advise using if possible is to sell your customer on using a seven pin system if it is available or change to a lockset where it is available. This same situation can occur in five pin systems and here you should definately sell a six pin system. Five pin cylinders never should be used for anything other than private residences.

The third method is one very similar to the first method I mentioned except it is accomplished on the same key section. This method will net us 48 Master Keys with sixty-four changes under each Master Key and four master keys with 256 changes.

To obtain the number of Master Keys and change Keys needed we will progress the Master Key columns in the following Manner:

GMK	MK			CK		
1	0	7	2	5	4
3	2	9	4	7	6
5	4	1	6	9	8
7	6	3	8	1	0
—	8	5	0	3	2

Figure

Figure 2 is the Key Bitting Array we will use to obtain our 48 Master Keys. Note we have removed the number 9 from the first column, we could have removed any one of the four numbers, your choice is arbitrary. Progressing columns one two and three nets us the following 48 Master Keys.

3 2 9 2 5 4	5 2 9 2 5 4	7 2 9 2 5 4
1	1	1
3	3	3
5	5	5
3 4 9 2 5 4	5 4 9 2 5 4	7 4 9 2 5 4
1	1	1
3	3	3
5	5	5
3 6 9 2 5 4	5 6 9 2 5 4	7 6 9 2 5 4
1	1	1
3	3	3
5	5	5
3 8 9 2 5 4	5 8 9 2 5 4	7 8 9 2 5 4
1	1	1
3	3	3
5	5	5

Figure 3

Our next step is to obtain the Master Keys that will net us 80 or more changes. To do this we progress columns one and two only for a total of 4 Master Keys. In column we use only the number nine as shown in Figure 5.

GMK 1 0 7 2 5 4

9 2
4
6
8

9 2 7 2 5 4 9 4 7 2 5 4 9 6 7 2 5 4 9 8 7 2 5 4

Figure 4

Our last step is to progress columns 3, 4, 5 and 6 for a total of 256 change keys. Each of the 4 Masters shown in Figure 4 will have 256 changes. These four columns are progressed in a normal manner.

There are many times when Master Key systems require this type of keying. I prefer this method when possible over using two or more keyways because invariably control of the key sections, especially the Master section is soon lost or non-existent.

CHAPTER FOURTEEN

CROSS KEYING OR — "HOW TO RAPE A MASTER KEY SYSTEM"

Cross Keying or as it is sometimes called Keyed Common, is an out and out rape of whatever security, control or integrity a Master Key system may have.

Too many AHC's, Locksmiths and others that plan Master Key systems have little or no understanding of how lock cylinders must be prepared to accomplish Cross Keying, nor do they understand the damage Cross Keying does to a Master Key system.

Cross Keying means to pin a lock cylinder in such a manner that more than one key in the system will operate it. There are two types of Cross Keying, Controlled and Uncontrolled.

Controlled Cross Keying is where two or more change keys under the same Master Key as the lock cylinder intentionally operate the cylinder. Uncontrolled Cross Keying is where two or more change keys under different Master Keys intentionally operate a lock cylinder.

The imagined necessity for Cross Keying is created by peoples reluctance to carry two keys if they can avoid it. Also responsible, are the people who create Security systems and Master Key systems because they fail to adequately inform their clients of the resultant loss of both CONTROL and SECURITY that Cross Keying effects upon their system.

Over the years, 75% of the time I have been able to discourage a client from using Cross Keyed locks in his system simply by explaning how each lock cylinder must be pinned and then demonstrating the inherent weaknesses of Cross Keying.

What must be done to Cross Key a lock cylinder?

Let's explain by example and let's use a large apartment or condominium complex. The exact same factors and results will also apply to industrial, institutional, commercial and military installations but the apartment-condominium use of Cross Keying illustrates the fallicy of using Cross Keying because of its possible effect on the lives and property of people who are forced to chose to employ it. I say forced to use it because if you are living in a so-called Security Apartment or condominium and your main entrance locks are of the mechanical type chances are your locks will be keyed in one of two ways.

Say we are requested to supply a Master Key system for a 75 unit apartment complex (not large by todays standards). They require the individual apartment Entrance Key to also operate the Main Complex entrance door as well as the doors to the garage area and the exterior gates to the garage. This is a very common request. The lock cylinders for the main entrance, garage entrance and exterior garage gates must all be keyed alike in a manner that will allow each of the 75 different apartment keys plus Master Key(s) to operate them. Each of the 75 apartment keys and Master Key(s) have different bittings (cuts) so they will operate only their intended locks and not a neighbors.

Cross Keying a cylinder can be done in one of two ways only. First it can be loaded with Master pins, two or more in each cell hole to accommodate all the keys that must operate it. This is called Maison Master Keying. This will generally result in a minimum of three or four hundred shear lines in the lock cylinder. Each of these different shear lines accommodates a different key that will operate the lock. That is, three or four hundred keys will now operate this lock and there is nothing we can do about it. If you doubt this statement, remember that a five pin cylinder pinned with a bottom pin, two master pins and a top pin in each of the five pin cells can be operated by 243 different keys, that is 243 different shear lines exist in the cylinder. A six pin cylinder such as used in industrial, institutional or commercial applications, pinned in the same manner, has 729 different shear lines. Seven Hundred and twenty-nine keys will operate the cylinder. Any key that will enter the keyway of one of these cylinders has an excellent chance of being used to neutralize it particularly if the key is "jiggled" a bit. Moving the key in and out while rocking it helps to create an even greater number of shear lines.

Seldom however do Maison Master Keyed cylinders contain as few pins as we stated above. In most instances there will be three to four master pins in each cell along with the bottom pins creating well over a thousand keys that will operate the cylinder. This situation comes about when we are required to Cross Key a cylinder under two different Master Keys, (Uncontrolled Cross Keying). Practically every bitting used in the system must be embodied in the Cross Keyed cylinder. Not only can any key that will enter the keyway be manipulated to neutralize it but anything you can get into the keyway to "agitate" the pins while applying torque can also be used. I know of cases of burglary where I am certain unauthorized entry was gained by this method. I honestly believe that if some apartment dwellers knew exactly how much security they were provided on their main entrance doors, they would sue their landlords and I can't say I'd blame them.

The second and more criminal method of Cross Keying is to completely leave out most of the pins in a lock cylinder. It is not unusual to find lockcylinders in large commercial and industrial buildings as well as on entrances to apartment complexes that have only a bottom pin, three or four master pins and a top pin in one pin cell only. The remaining cells will be empty. This allows all the keys in the system to operate the cylinder. Enough master pins are loaded along with the bottom and top pin in one cell only to accommodate the first or last cut of each of the keys in the system. Practically anything that will enter the keyway, (nail file, etc.) can be used to neutralize the lock. It takes absolutely no skill or technique to accomplish unauthorized entry.

When a client requests Cross Keyed locksets explain the manner in which they will be keyed and the resulting loss of security. Have two cylinders pinned up in this manner and demonstrate. This should help to convince him that carrying two keys instead of one is not that great a burden on his ego.

Good security dictates that the perimeter of an installation not be on the same Master Key system as the enterior and this applys to apartments and condominiums as well. Loss of a key that operates a perimeter opening as well as an enterior system compromises the entire system. All perimeter locks should be keyed alike (if at all possible) so that no master pins are used in the cylinders. Also use a security type of cylinder and locking mechanism on the exterior openings.

In lieu of cross keying, carrying two keys (more if necessary) is the only way you can maintain any control or security with your Master Key systems. It is standard practice in the automotive industry to key their auto's to two keys. The buyer has no choice and for once this is good. Hopefully lock manufacturers, A.H.C.'s and Locksmiths will soon refuse to supply Cross Keyed systems.

CHAPTER FIFTEEN

Master Keying — "The Planned Destruction of Security"

G.L. Finch

Master Keying provides controlled access and convenience of operation. When planning or selling a Master Key system, the user should be made to understand that Master Keying reduces the security of a lock. The degree in reduction of security is in direct proportion to the complexity of the system. Stated simply, the more complicated the required system, the less security it provides.

There is no argument with the necessity for Master Keying. Therefore, we should understand the inherent weaknesses and limitations of it. This article, and future ones, will discuss what Master keying can and can not do and how it effects security.

When we hear the term "Master Keying" we immediately think, "That's a system where two or more keys operate the lock". To say "That is an understatement", is putting it mildly. The part of the statement "or more keys" is the subject of this article.

One of the first rules of good Master Keying is to never use any more master pins in a cylinder than necessary to achieve the number of keys needed. In the language of the Keying Engineer or Locksmith who is constructing the system, this translates to "Never use any more pin cell (chambers) than needed to obtain the desired amount of keys and leave room for future expansion." This article will show what happens in a cylinder when master pins are added and the effect upon security they have.

A standard six pin cylinder with bottom and top pins can only be operated by one key. This is considered a level one type keying system and is the most secure. In a Master Key system this type of cylinder is called a SKD (Single Keyed Different) cylinder. Large or sensitive Mastered Keyed installations should consider the use of this type keying on all perimeter gates and entrances. Should a key or padlock become lost or stolen, the entire master key system will not be compromised; however, even more important is the fact that only one key operates the cylinder and the importance of this will become more apparent as we continue. Figure 1 shows the top and bottom pins in a SKD cylinder. Only one shear line exists in this cylinder. By shear line we mean, the top of the plug, where the top and bottom pins split when a proper cut key is inserted allowing the key to turn. Throughout this article we will call these shear lines "key combinations".

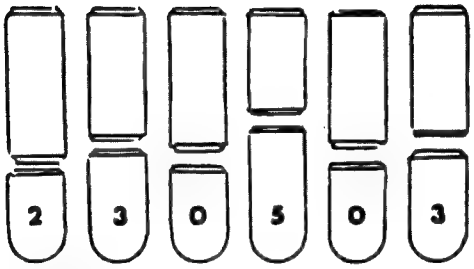


FIGURE 1

The simplest Master Keyed cylinder would be one operated by two keys only. This would require the addition of one master pin to the set up shown in Figure 1. The pin could be added to any one of the pin cells; however, we will use the first cell for purposes of illustrations. This additional pin now creates a second combination, and a key can be cut to operate the cylinder. Figure 2 shows this cylinder pinning set up.

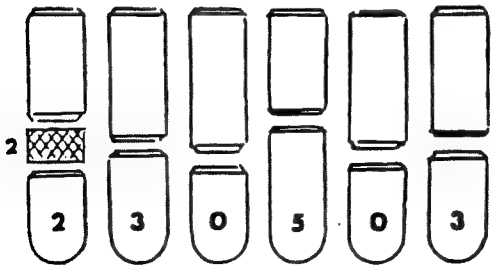


FIGURE 2

The key that operates the original SKD cylinder was cut 230503. In figure 2 we have added a number 2 master pin. As shown, a second key cut to 430503 will now operate this cylinder.

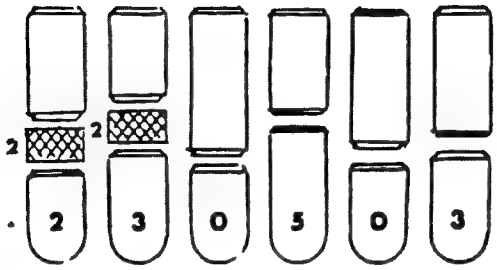


FIGURE 3

Good master keying decrees that no more than one master pin per cell is used, so in Figure 3, we have added a second master pin in the second cell. The addition of the second master pin now creates four key combinations. We can now cut four keys that will operate this cylinder. The master pin we added was a number 2. The key combinations that will operate this cylinder are 230503, 250503, 430503 and 450503. Now we add another master pin, a number 4, in the third cell.

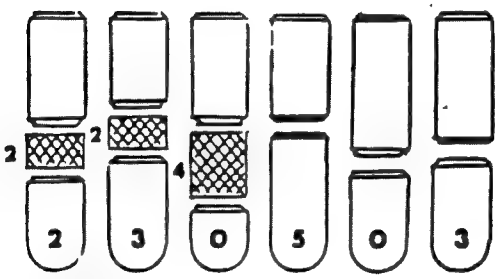


FIGURE 4

The addition of the third master pin doubles the number of combinations we had previously. Whether or not you want them, you now have created eight combinations by the addition of the master pins as shown in Figure 4. These combinations are:

1.	230503	5.	430503
2.	234503	6.	434503
3.	250503	7.	450503
4.	254503	8.	454503

FIGURE 5

The number one combination, 230503, in Figure 5, is the combination created by the bottom pins. The next seven combinations are shear lines created by combining the bottom and master pins. A key cut to any one of these combinations will operate this cylinder. Now we add still another master pin.

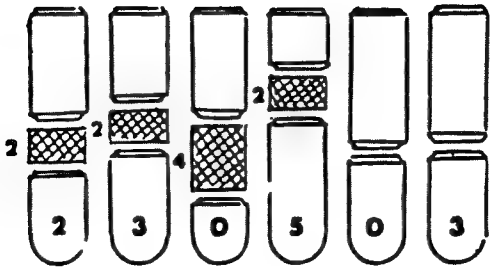


FIGURE 6

Sixteen combinations are created by the addition of a master pin in the fourth cell. Notice that each time we add a master pin in another cell the number of shear lines (key combinations) doubles. The sixteen keys that will operate a cylinder set up as shown in Figure 5 are shown in Figure 7.

1.	230503	6.	250503	9.	430503	13.	450503
2.	230703	6.	250703	10.	430703	14.	450703
3.	234503	7.	254503	11.	434503	15.	454503
4.	234703	8.	254703	12.	434703	16.	454703

FIGURE 7

At this point, we should mention that these additional key combinations, which we are creating by the addition of more master pins, is unavoidable if we are to obtain the number of change keys and master keys we require in a system. A cylinder pinned as shown in Figure 6 is just one of the possible two hundred fifty-six that can be obtained by using four pin cells in a cylinder for master keying. How these 256 combinations are obtained is not the subject of this article, that is taught in Basic Master Keying. As we stated, using four pin cells will net us one master key and two hundred fifty-six change keys. Should we require additional master keys, we would be required to use the fifth pin cell.

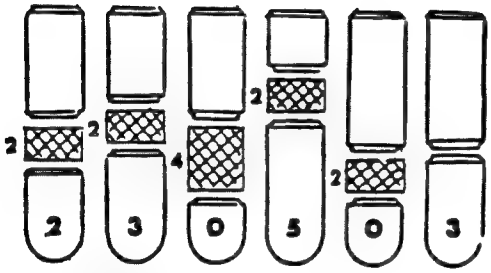


FIGURE 8

Figure 8 shows that we have added a number 2 master pin in the fifth pin cell. The addition of this pin doubles the number of combinations we had previously to thirty two. Thirty-two keys can be cut that will operate this cylinder. We won't list the thirty-two combinations, we will let you work them out for yourself.

Least we confuse you, understand that individual cylinders pinned in five pin cells as shown in Figure 8 can be operated by just thirty-two keys; however, a Keying Engineer or Locksmith when designing a Master Key system can utilize these five cells to obtain a tremendous number of key changes.

A cylinder combinated as shown in Figure 8, depending on the number of master keys needed, can be one of as many as 1024 different cylinders. If we had 1024 changes, we could theoretically have 1 Grand Master Key, Four Master Keys, and 1,024 change keys, or 1 Great Grand Master Key, 4 Grand Master Keys, 64 Master Keys and 16 Change keys. These are but two of the ways this particular set up could be utilized.

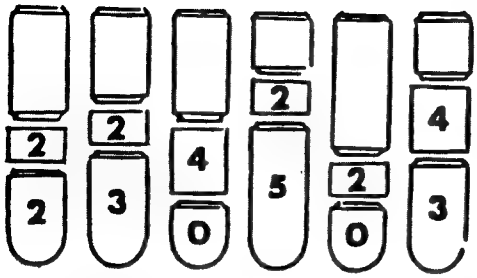


FIGURE 9

BP 230503
MP 224224

Figure 9 shows a pinning set up for a six pin cylinder with a master pin in each hole and the resulting sixty-four key combinations that are created. Sixty-four keys can be cut that will operate this cylinder.

230503	250503	430503	450503
507	507	507	507
523	523	523	523
527	527	527	527
703	703	703	703
707	707	707	707
723	723	723	723
230727	250727	430727	450727
234503	254503	434503	454503
507	507	507	507
523	523	523	523
527	527	527	527
703	703	703	703
707	707	707	707
723	723	723	723
234727	254727	434727	454727

In a simple Grand Master Key system, the average individual cylinder will be generally operated by the GMK, MK, and the individual Change Key. That is only three keys, but in a cylinder set up as the one in Figure 9, 64 keys operate it, 61 more than needed. These 61 keys are called GHOST KEYS. This is a very appropriate name for them, because unless we understand them and how to use them, they will come back to haunt our system. Utilized properly, however, they can be used by us to greatly extend our systems. Friendly Ghosts one might say.

As we stated at the start, Master Keying a cylinder reduces the amount of security it provides. By now it should be apparent that when so many different operating combinations exist in a cylinder, any key that will enter the cylinder can be manipulated, (used as a lock pick) in an attempt to neutralize the cylinder, and the chances of success will be good. As a youngster my people would not let me have picks, but it didn't take me long to learn that if I obtained a dozen or so keys, each cut differently and would enter the keyway, I had about as much chance to neutralize the cylinder as they did. I am sure that I am not the only person who ever discovered this, and most of them were not locksmiths.

When the system is one that uses a keyway that is common and very easy to have keys duplicated at local hardware and department store key cutters, the situation just described is compounded. Commercial and Industrial master key systems should never be on less than six pin cylinders and never on common residential type keyways. Industrial systems should use or consider 6 pin restricted or controlled keyways.

As stated earlier, the additional key combinations that are created by the addition of master pins in a cylinder is unavoidable up to a point if we are to achieve the necessary number of keys to operate our system. We also stated earlier that good master keying practices do not use more than one master pin a cell hole. What happens when we do?

Using the same six pin cylinder, with a master pin in each of the six cells, lets us now add another master pin in the first cell. That gives us two master pins in this cell along with one master pin in each of the other five cells.

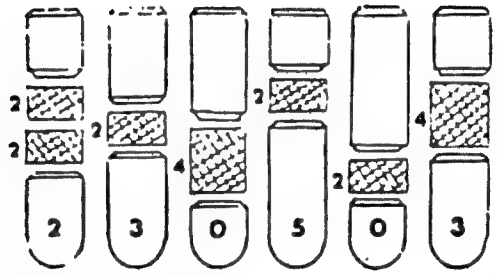


FIGURE 10

By the addition of this seventh master pin, we have now created a total of ninety-six different key combinations that will open this cylinder. The addition of one more master pin in the second cell would create 144 different combinations that would operate this cylinder.

By now, I hope I have made my point — Master Keying reduces the security of a lock or cylinder. The degree of reduction of security is in direct proportion to the complexity of the system desired.

When selling or installing a Master Key system, the buyer or user should be told exactly what he is getting in the way of security. Do not represent Master Key systems as security systems when used with standard pin tumbler type cylinders.

CHAPTER SIXTEEN

OBTAINING CHANGES UNDER THE GRAND MASTER KEY

Often a Master Key system will require Change Keys that operate under the GMK only. A typical example would be the office of the President of a firm where his Secretary shares his outer office. He naturally wants no one to have access to his office except the secretary and himself. He wants access to his entire organization so he requires the Top Key in the system. He does not want the Secretary to have access to anything other than the office suite they share. To accomplish this, the architect and the keying schedule designers will call for a change key under the GMK known as GM 1. What they are saying is that only the GMK and the Change Key will operate this door when the cylinder is properly pinned. No other Masters in the system operate the cylinder.

How do we obtain these changes? It's very simple, in the same manner we obtain the two Masters with 80 each changes in chapter THIRTEEN. We must dedicate at least one number from the MK progression columns to the GMK changes. The procedure is identical to the obtaining additional bittings under specified Master Keys.

Page 3:13 Figure 4 is to be used as an example here for obtaining changes under the GMK. The only difference is that from the four Master Keys shown only the changes are used from the particular Masters chosen. The Master Key is never cut nor issued; it can never be used in the system. An example of how the GM 1 cylinder would be pinned is shown in Figure 1. Note we have used a change key bitting from under the Master 967254.

GMK	107254
GM 1	969476
Bottom Pins	107254
Master Pins	862222

Figure 1

As shown in figure 1 above, none of the Master Keys or ChangeKeys in this system will operate this cylinder, nor will the GM 1 Key operate any other cylinder in th system.

To my surprise I have found that very few understand the proper manner of selecting changes under the GMK. They do what appears as the proper extention of the knowledge of Master Keying they possess and for once this is wrong.

I have seen countless systems where the GM 1 operated as a submaster key. The natural inclination is to select the numbers from the change key columns of the KEY BITTING ARRAY. This is what happens when this method is used.

GMK	107254
GM 1	107698
Bottom Pins	107254
Master Pins	---444

Figure 2

Though the cylinder GM 1 is secure and can be operated only by the two keys shown, the GM 1 key will operate all cylinders in the system that are pinned to the GMK and have a key cut to 698 in the last three positions. Every Master Key in the system all 64 or 48 as the case may be will have a change key cut to 698 in the last three positions.

CHAPTER SEVENTEEN

ANALIZING EXISTING SYSTEMS FOR POSSIBLE EXPANSION

Often a customer will ask you to add to an existing Master Key system where no keying records exist. Never commit yourself to accepting the job until you have as much info as possible and analize it. Lets work from examples.

The customer can furnish only the following keys. No keying records exist. He is certain that these are the only Master Keys used. (Figure 1)

GMK	A	032745
MK	AA	258745
MK	AB	274745
MK	AC	450745

Figure 1

Using the GMK as our foundation, we construct a key bitting array (KBA) from only the numbers known to us as GMK and the three Master Keys. (Fig. 2)

GMK	A	032745
		254
		478
		0

Figure 2

MK	AA	258745
MK	AB	274745
MK	AC	450745

After studying figure two we can make the following valid assumptions.

a. The Master Keys are progressed from columns one, two and three. We know this because none of the numbers of the GMK in the first three columns have been used in the Masters in the same positions. This system will give us 64 theoretical Master Keys.

b. All changes were obtained from columns four, five amd six. Sixty four theoretical changes are available. The Master Keys bear the GMK constants in these positions indicating these are the Change Key progression columns on the Masters.

We now construct a complete Key Bitting array (KBA) from which we can make further assumptions and decisions. (Figure 3).

GMK	A	032745
		254967
		476189
		698301
		810523

Figure 3.

MK	AA	258745
MK	AB	274745
MK	AC	450745

Further study of the Key Bitting Array indicates that the person who designed the system knew proper master keying procedures making our job easier. Though only three of the sixty four possible Master Keys have been used they have been choosen very carefully. Note that none of the Master Keys can be altered to the GMK. Also note that no one of the Masters can be altered to any of the other two. Each of the Master Keys differs from the others by a minimum of four increments in at least one position on each key making it difficult to manipulate a Master Key in another system.

Because of the care shown in the selection of the Master Keys we must assume that the same care was taken in the selection of our Change Keys, used under each Master Key. If this is a valid assumption, there is no way of determining which one of the sixty four change keys were used.

Using this example let's look at some possibe customer requests and our reaction to them

CUSTOMER REQUESTS: Our customer is adding a new addition to his business. He wants his addition to be under Master Key AA and needs fifteen more Change Keys.

OUR RESPONSE: As we have pointed out there is absolutely no way of knowing what Change Keys have already been used therefore any of the fifteen additional changes we would select would be duplicates of the ones already on the job. If there is time and the customer is willing to pay for it each of these fifteen keys could be tried in each and every lock on the job to be certain that they do not duplicate keys already in the system. Remember this is additional work and you must get paid for it. If they are not willing to pay the additional cost our recomendation is to put this addition under a new Master Key. there are up to sixty one available depending on the Maximum Adjacent Cut Specification (M.A.C.S.). By doing this we can guarantee the integrity of his system. If it is vital that this addition be on Master Key AA we would then advise that the entire current system under the AA Master he rekeyed along with the new addition to a new Master Key. This would be the most costly of the three methods we have suggested but by far the most controlable and secure.

CUSTOMER REQUEST: Our customer requests two new Master Keys be established under the Grand Master Key and that five locks of a new addition be under the Grand Master Key only. OUR RESPONSE: No problem. We select two of the remaining sixty one Master Key bittings for the two new Masters. The changes are selected in the standard manner from the last three columns. As for the Five locks under the GMK only, from the KEY BITTING ARRAY (KBA) in figure 3 we select the bitting 8 54 from the sixty four Master Keys in columns one, two and three. We will use these numbers (8 54) as our constants on the change under the GMK. Our changes will be taken from columns four, five and six just as we would any change keys. The five changes under the GMK should be:

GM1	854967
GM2	854167
GM3	854367
GM4	854567
GM5	854987

Figure 4

By using the number eight for the first number in the changes under the GMK, we now have reduced the number of Master Keys available as shown on our Key Bitting Array (KBA).

GMK A	032745
	254967
	476189
	698301
	-10523

Figure 5

The KBA in Figure 5 will produce fourty eight Master Key bittings. The sixteen Masters that could be progressed under the missing number 8 can now be used for special purposes. For instance if you need keyed different cylinders not under the GMK or any Master Key you can use the Change Key bittings from any of the Masters begining with an eight (8) except for the Masters begining with 854 which we used in figure 4. Four bittings could be:

850167
850169
850161
850163

Figure 6

Should you need a Master Key with the changes that will not be under the GMK you can select another one of the Masters from those beginning with an 8, say 859745. The changes will be mastered to the Master Key only, the GMK will not operate this set up.

CHAPTER EIGHTEEN

CHAIN KEYING

In the many years I have been creating and servicing Master Key systems I don't believe I have ever seen anything written concerning this form of Master Keying and perhaps for good reason. It is very limited in its scope and opportunity for usage. Only three times in the last twenty five years have I been called upon to create one of these type systems and each time it was for a state agency. It is simplicity itself yet confusing to anyone not possessing a solid background in Master Keying. To demonstrate let's work from an example.

A customer places the following requirement with us. He needs seven locksets keyed in the following manner:

LOCK # 1 operated by key #1 - Key 1 operates all cylinders.

LOCK # 2 operated by key #1 and 2 - Key 2 operates all cylinders below it.

LOCK # 3 operated by key #1,2 and 3 - Key 3 operates all cylinders below it.

LOCK # 4 operated by key #1,2,3 and 4 - Key 4 operates all cylinders below it.

Lock # 5 operated by key #1,2,3,4 and 5 - Key 5 operates all cylinders below it.

Lock # 6 operated by key #1,2,3,4,5 and 6 - Key 6 operates cylinders 6 and 7 only.

LOCK # 7 operated by key #'s 1 thru 7 - Key 7 operates cylinder 7 only.

Our first step will be to select our top key, which is the #1 key and really our Top Master Key. Next construct the KEY BITTING ARRAY based on our choice of a Top Master Key.

```
3 6 1 4 1 0
-----------
5 8 3 6 3 2 *a
7 0 5 8 5 4 *b
9 2 7 0 7 6
1 4 9 2 9 8
```

Figure 1

As the number one lock will be operated by its own key only we will pin that cylinder to the number one key, the Top Master Key 361410. There will be no master pins in this cylinder.

The principle of Chain Keying is to add one master pin to each additional cylinder added to the system. Our system will be constructed based on row *a shown in Figure 1. Below are the keys we will use in our system.

```
#1 361410 (TMK)
#2 381410
#3 383410
#4 383610
#5 383630
#6 383632
#7 583632
```

Figure 2

Look closely and you will see that what we have done is to add one number from the KBA (row *a) to Key #2 in the second position. In Key #3 we added an additional number from the KBA (row *a) and continued to do so for each of the remaining keys until we had used each of the numbers in row *a. To obtain the seventh key we dropped down to the 7 in the first column, second row of our KBA. This is as far as we can go, to add any more numbers from the second row will create interchanges, existing keys will open cylinders they are not intended to.

Now if we make up our Plug Set Up Charts for each of the 6 cylinders under the TMK and check our shear lines we see that each key operates only its intended cylinder or cylinders. Take each key bitting and check it against the shear lines available in each

cylinder to prove the system is valid.

Cylinder #2	Cylinder #3	Cylinder #4
BP 361410	BP 361410	BP 361410
MP -2----	MP -22---	MP -222--
Cylinder #5	**Cylinder #6**	**Cylinder #7**
BP 361410	BP 361410	BP 361410
MP -2222-	BP -22222	BP 222222

Figure 3

Though we cannot add any more cylinders to this chain we can construct three more chains from our KBA. The top key in each of these chains will be the same Top Master Key, 361410. The individual keys will work only within their own chain. If constructed and pinned properly their will be no interchanges between chains. The following chain is constructed on row *b of our KBA.

1.	361410	#2 BP 301410	#3 BP 301410
2.	301410	MP -6----	MP -64---
3.	305410		
4.	305813	#4 BP 301410	#5 BP 301410
5.	305850	MP -644--	MP -6444-
6.	305854		
7.	705854	#6 BP 301410	#7 BP 301410
		MP -64444	MP 464444

Figure 4

Now check the bittings and Plug Set Up charts in Figures 2 and 3 against those in Figure 4 and you will see their is no interchanges nor will there be in the two remaining chains that can be constructed from the KBA.