

West had said something not too complimentary with regard to the tone of society in the colonies. He (Sir Edward Braddon) had been all his life mixed up with military men; he had lived practically a military life for years and years in cantonments, living and sharing a soldier's life, and, in fact, being practically a soldier, except having to get up early in the morning and go on parade. He had fought side by side with British soldiers, and lived with them; but going straight from India to Tasmania, he found nothing whatever in the society he there mixed with that grated upon his military instincts in the slightest degree. He believed he had been fair and only fair to the colonies. His advice to Anglo Indians was purely disinterested, because he regretted to see many of them here wasting forces which might be of infinite service to the colonies, and who, as Mr. Perceval said most distinctly, would be gladly welcomed and appreciated there.

SIXTEENTH ORDINARY MEETING.

Wednesday, April 12, 1893; FRANCIS COBB, Treasurer of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

- Barker, Frederic William, 7, Ferndale-road, Sefton-park, Liverpool.
 Batten, George Henry Maxwell, 3, Ralston-street, Tedworth-square, S.W.
 Martin, Major Gerald Ward, H.M. Assay-office, Mint, Bombay.
 Rozario, Louis Charles do, Hongkong.

The following candidates were balloted for and duly elected members of the Society:—

- Chatterton, Alfred, College of Engineering, Madras.
 Knight, Edgar William, Junior Athenæum Club, W.
 Schiller, Frederick William, 205, Brixton-road, S.W.
 Simmonds, T. C., Burton-road, Derby.

The paper read was—

THE CONSTRUCTION OF LOCKS AND SAFES.

BY HARRY W. CHUBB, A.M.Inst.C.E.

The subject of old locks and their keys is one which has received a considerable degree of attention, and those which are noticeable chiefly for the beauty of their artistic forms, have taken precedence, being treated popularly from time to time in illustrated periodicals.

Modern inventions have also created interest, but interest of a different kind, more utilitarian—in fact, scientific. It need not, however, be taken for granted that the two views are incompatible; or, in other words, that a sharp line must be drawn, say, at the end of the 17th century, to divide the artistic from the mechanical. As a matter of fact, the gradual growth or evolution of the locks in common use to-day can be traced, with but few missing links, from the earliest forms. Overlaying, and sometimes almost obscuring, the mechanical intention, is the work of the artist, this being invariably characteristic of the period when the artist-worker lived. This is true no less of Roman times than when French and German smiths of the middle ages encrusted their lock-plates with Gothic mouldings and carved their delicately-shaped key-bows. As the styles of architecture and its kindred arts succeeded one another, age after age, the decoration and treatment of locks and their keys were affected by the same changes; mechanically, they altered also, not, however, always for the best, when looked at from the modern point of view. One cannot, therefore, say that their advancement in the two respects has been together, but the connection between the two is at all times interesting and often instructive. Mechanical invention, pure and simple, is just as much subject to the general laws of progress as everything else. So also is the work of the designer—mechanician and designer being equally inventors in the true sense of the word. When you have the two qualities combined in one man, as they were frequently in the Middle Ages, you get a result that is self-evident; and although it cannot be said that the progress then in craft equalled the progress in art, there is yet a greater harmony between the two than when they are separated, or in any other way specialised. Whilst the inventive faculty has had, and still has, so much to do with the locksmith's craft, this is hardly the opportunity to analyse it; but I think the axiom will be readily granted that, viewed broadly, it is not purely a matter of spontaneous genius or mere mental accident, but is, as I have suggested, a faculty admitting and responding to cultivation.

Before entering upon the subject proper of this paper, there is one minor branch that may be mentioned. I refer to the use of seals. The effect of the seal is an ethical one—as long as the moral tone of the community is good. The Egyptian store-house keeper sealed up his

large earthenware corn jars, using clay as the material to take the imprint of his matrix. One notable Biblical instance occurs when Darius and his lords sealed the door of Daniel's den. No lock was needed where the king's device had been impressed, and the king alone could undo his own work. The survival of sealing to the present day, for securing our Post-office despatches and Customs vaults, shows that where there is an obvious intention on the part of authority that certain things shall be left alone, that wish is respected. The use of a personal or corporate device, first and still employed as a means of identification and of legal power, readily lends itself to this purpose.

Amongst early fastenings, those intricately made by knotted thongs or ropes should not be omitted, for with these nomad pastoralists tied up their tents. The Gordian knot will, of course, occur to everyone in this connection.

No one has more clearly traced the early growth and sequence of lock mechanism from the primeval door bar than Lieut.-General Pitt-Rivers. Doing for locks what he has done for weapons, for certain conventional designs, &c., his contribution to their history is of great value. Besides tracing their development, he has followed the various types along the known lines of early trade, showing how they became distributed.

The present wooden lock of Egypt—the Dub'beh—supposed on fair grounds to be the same as that used 4,000 years ago, has been illustrated and described so often that it is almost needless to do so again. That the two locks are identical is highly probable: the water-raising "shadoof" has remained through this long period, and there are other evidences of similar mechanical crystallisations in the East. Indeed, a recent description of a wall painting in the temple at Abydos, given by the late Miss Edwards, almost proves the point. She writes of "Rameses II. . . . in the act of opening the door of a shrine by means of a golden key formed like a human hand and arm." This closely agrees with the oft-quoted account—now 100 years old—given by M. Denon, of a painting in the great temple at Karnak, and both descriptions are true of the present day lock and key.

It is quite reasonable to suppose that the first barring of a door was done by means of a cross beam, either dropped into sockets or sliding in staples fixed on the door; and it is equally reasonable to suppose that if it slid, a vertical pin dropping into a hole through the

staple and beam together, kept the beam in place.

If the beam was *inside* the door, and had to be released in order to slide it back, then one kind of key was necessary to take out the pin; of this I shall speak presently. But if the beam was on the *outside*, then the locking pin must be hidden, and can only be reached either through a hole in the beam, or else through a hole in the staple. The Egyptians adopted the former method; other primitive peoples adopted the latter. They—the Egyptians—shortened the beam into a long bolt, and made it hollow for part of its length, so as to reach the pin, hidden in beam and staple through the beam itself. The key, which was pushed up the hollow, had pegs on it to match the pins which held the bolt—for the one pin was now multiplied. When the key was well "home," it was raised, and so its pegs lifted up the pins out of the way, leaving the bolt free. Then the bolt was drawn back by the key, the pegs of the latter filling up and engaging with the holes till then filled by the pins. You notice the shank of the key is the arm, the pegs are the fingers of the hand. We shall see how this principle of dropping pins—true tumblers—was adopted with variations by the Romans.

Now, as to another class of primitive locks, those in which the pins were reached through a hole in the staple and not through the bolt. There is good reason to believe they were once remarkably widespread, though now chiefly found on the fringes of culture. You see them at the present day in some parts of Scandinavia, in the Hebrides and Faroe Islands, and the peasant of Normandy still makes them for his gates and barns. They have also been observed upon the West Coast of Africa; and Herr Andreas Dillinger, of Vienna, whose name is known in Germany in connection with the historical study of locks, states they are in use in the less frequented parts of Galicia, Roumania, and Servia. The hole in the staple by which to get at the pins is a horizontal one above the bolt. The pins are square in section, and are notched on their sides for the key to pass, and get into position before being lifted. The key is usually flattish, with little side projections which engage the pins. After they are lifted, it is necessary to pull back the bolt by hand, thus making a marked and essential difference between this lock and that of Egypt, in which the bolt is withdrawn by the key itself. They vary in detail, some having

two sets of pins, the key passing between the sets; in others the pins have holes right through them for the key, not merely side notches.

The next two classes of primitive locks are those in which the beam or bolt was mounted on the inside surface of the door. In this case, if fastened by the tumbler pin, it would not be so necessary to conceal it as when both were outside the door. There are some curious sickle-shaped pieces of iron found now and again, which look as if they were made for the purpose of putting through a hole in the door, and pulling up or pushing up the pin. Perhaps they simply engaged the bolt in a direct fashion, and, being turned from the outside, moved it to and fro. But they vary in their outlines too much for this supposition to be probable, some being full sickle-shape, and others only slightly cranked or bent, and in some well-preserved specimens their ends have been carefully shaped, as if to fit a hole exactly. They have been found at many places in France and Germany. General Pitt-Rivers well authenticates some he himself found near Lewes, to the late Celtic period. In connection with these he also discovered some coins cast in tin, of debased Greek design, and points out how this shape of key agrees precisely with a description given by the Greek writer, Eustathius, in the 12th century, who states that this kind, although still in use, were considered antique. This coincidence is extremely curious and interesting, and makes one wonder if the Phœnicians had been the agents of its distribution.

At last we come to the fourth primitive type of lock, the bolt or beam being still inside the door. In this type the bolt was kept out by the projection of a spring or springs, which spread out against the side of the staple in the same way that an unwilling boy spreads out his arms and legs against the jambs of a doorway through which his schoolfellows try to push him. The first function of the key is to compress the springs. It is a flattish one, with return prongs or hooks on its end. It is first passed through a horizontal slit in door and bolt; then turned a quarter-circle, and pulled. The pull brings the prongs to bear upon the springs of the bolt, making them lie flat, and so clear of the fixed obstructions at their ends. The bolt is then free to slide back, and this is effected by simply sliding back the key, for its prongs are now embedded in the bolt. The keys of these locks are numerous found among Roman remains, and locks of this

kind are stated to be in use still in Norway.

Having thus very briefly stated what is known of the primitive kinds of locks, let me take the last type, and show how closely allied its mechanism is to that of the Roman padlock. Looking at the diagram, you will see the lock consisted of two parts—a body, and what, for want of a more accurate term, may be called a hasp, or bolt. The hasp carries on its lower side a pair of spreading springs, and these enter a hole in the end of the body when the two pieces are being put together. When the hasp is pressed right "home," the springs, which, during the operation have been gradually closed up, now fly out inside the body, and so hold the two parts together. To take them apart the springs must be compressed, and this is done by the key, which is pushed through a hole in the body against their sides near the point, and slides along them. The springs are simply flexible barbs.

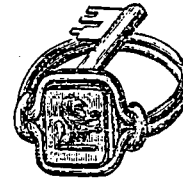
It is no wonder that loose, portable locks, like those used to secure baggage of all kinds in transit, should become well known and distributed, especially along the ancient lines of trade. But as this style of padlock is found to be the almost universal one now in China, one is tempted to ask who was the first and true inventor, Roman or Celestial? They are seen, too, all over the East, being shaped and decorated in ways peculiar to their own countries. Here I have a modern Japanese of dragon-shape, two others with hidden key-holes, and a fourth—Chinese—in form of a conventionalised dog. His tail turns up right over his body, and goes through the back of his head, its end forming the tongue; this is the hasp. To release it, the key enters a hole in his chest, and you push the tail right out. There are some bodies of Roman ones in the British Museum like this Chinese curiosity, but looking more like horses than dogs. All these have the diverging springs. There is one in the Indian Museum in which, to close up the springs, the key is turned as in an ordinary padlock of the present day, not simply pushed in, and a large class of mediæval padlocks—French ones more especially—are made like this. The Romans had other kinds of padlocks as well, the security parts of which were made like those of their fixed locks. Here is a copy of one made from an original at Pompeii.

Now as to the Roman fixed locks. Many archæological "finds" indicate what these

were, but none so clearly as those unearthed at Pompeii. I will show you on the screen some specimens photographed by a friend for me in the Naples Museum, and you will see from these, as well as from the wall diagram, how closely these locks are akin to the Egyptian. The bolt is now much shortened, and is concealed behind a front plate; it is still held, when locked out, by vertical pins falling down into it. The parts are now mostly, if not all, of metal, sometimes in a wooden casing or block. The pins vary in sectional shapes, being oblong, square, and triangular, as well as round, and are pressed down by a flat spring. The key has projections or teeth formed on it, corresponding to the pins, and reaches the bolt through a hole in the front plate. The pins being pressed up by the key projections, the bolt is free, and can slide to and fro, precisely as in the Egyptian lock. Roman keys are found much more commonly than their locks, and some are of such shapes that it is not always easy to say what their locks were like. There is a key with its "bit" angle shaped; one angle is cut to operate bolt pins in the way just now described, the other is pierced with holes, as if to pass fixed obstructions or wards. Many of the keys were undoubtedly turning ones, having solid stems called "pins," or else made with hollow stems called "pipes." The pipes were sometimes drilled right up, so that any dirt or other obstruction could be pushed through. I believe this simple device appears in three separate English patents, and not a year passes without some enthusiastic inventor re-discovering it, and offering to part with his idea for a consideration. Here are two old bronze keys of this kind, dug up in London. On the wall is a picture of one taken from Molina's "De clavibus veterum." This picture brings us to a class of Roman keys that is quite unique, and which, although well suited to present wants, is, strange to say, not in demand. These are the keys attached to finger rings. Whilst not found as numerous as those of other types, you cannot visit an antiquarian museum without seeing specimens of them. Their bits are as diverse as those of the larger keys. Here are five specimens on one of the show boards. These are replicas cleverly made after originals at Naples. A few only are found combining signets with keys on one and the same ring. It was the Roman wife to whom, as a bride, when crossing the threshold of her new home, the house

keys were given. They were all hers, with one exception. That exception was the key that kept the wine. This her husband held. The hoops of the ring keys are all large, being of a size suitable for a masculine finger, and it is likely that they may have been specially for the locks that secured the wine amphoræ. Just now I suggested that it was a pity this combination of ring and key is seldom met with in general use. Many years' personal experience has shown me that it is an extremely convenient combination. The key folding behind the signet of this ring opens

FIG. 1.



KEY, FOLDING BEHIND SIGNET (Modern).

several locks *en suite*; there is less chance of losing it than if on a chain, and its effect upon Customs officers—even on a New York examiner—when produced to open trunks and bags, is marvellous.

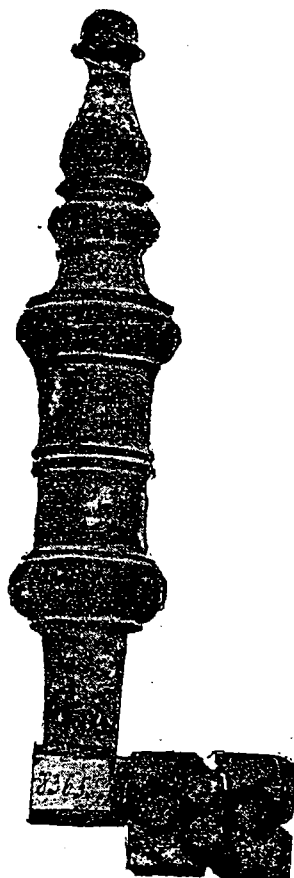
Here let me mention what there is bearing upon our subject among the objects recently found at Silchester, Hants. There are quite a number of iron hook keys of various sizes, with their prongs arranged in different ways; there is the iron hasp with barbed springs of a padlock, a bolt in bronze for a fixed lock, with perforations for triangular pins (this in very good preservation), and there are two of the neat little finger ring keys.

Coming down to the Byzantine period, one has to regret the absence of information about locks and keys. One need not wonder at this. "The empire preserved much, but did not add to the treasures of civilisation" (Garnett). In gold and silver work the Greeks still excelled, and the golden lions by the side of the throne of Alexius Comnenus, that sprang up and growled, no less than the mimic forest with automatic birds behind the throne, attest their mechanical skill. In all probability the existing forms of locks and keys, as regards mechanism, at any rate, were adhered to.

I will now show you a few transparencies on the screen prepared from photographs of objects in the museum in Naples, very kindly taken for me by a friend. These will exhibit the characteristics of the Pompeian work.

About the shapes and ornamentation of the key shafts there is no light Greek touch, such as you find breathing through the higher forms

FIG. 52



POMPEIAN KEY (Naples Museum).

of Roman art; still they have an interest of their own, and have not been previously illustrated.

At last, in the 7th century, and in the now more settled West, a metal-working personality appears, St. Eloy. He was probably the first to found what would now be called a "laboratory of art metal;" and this was in connection with his abbey. Three centuries later comes St. Dunstan, in early life working at the forge himself, and even later, when burdened with the heaviest cares of the State, still, at his leisure, fostering the growth of art in metal. Other great men, long since those times, have found relaxation in the blacksmith's art. I recently came across an old jingle, in which of Louis XIII. it is said—

" Sometimes into his forge he goes,
And there he puffs and there he blows,
And makes both locks and keys."

This is said of him when he was young. Charles I. indulged his caprices in the same direction, and, later yet, Louis XVI.

With the commencement of the Mediæval period, we get to shapes of keys more like our own, and working more like them than the preceding types. The sliding and pushing have given place entirely to turning movements, the keys being either made pipe-fashion, to slide on to a fixed pin in the lock, or else made solid, and terminating in the projecting pin, which fitted a socket or hole cut in the back plate of the lock. Later on, the section of the pipe was not always circular, sometimes it was triangular, and the pin on which it was pushed was shaped to fit it. Of course, provision was then made for the pin itself to turn with the key. The outside of the key, too, was fluted, and the lock pin then became a barrel as well, revolving in bearings at both ends. But this is anticipating, for these varieties do not appear until Renaissance times.

One feels greatly tempted at this point to make an excursion into the wider field of metal-work in general, for it was then that the smiths' art began to take shape and prominence. Our study is but a small branch of the art not being specialised till modern times, and it is somewhat of a barbarism to strip off a lockplate from, say, a cathedral door, and show it alone. Unaccompanied by the graceful curves of the hinge straps that flow across the door to it, a good deal of charm is lost. With the introduction of the pointed style in the 12th century, the culture of iron-work, no less than of the other metals, begins to move side by side with architecture. The Church, becoming richer from her share in the world's increasing wealth, secures not only the services of the best laymen, but increases—especially in France—the number of her monastery schools in which the arts were variously taught. From these emerged many a masterpiece in iron, silver, and gold, fashioned by hands that were guided not more by art feeling than by a love for the sacred edifice the work was to adorn. Besides, there was plenty of time to do what had to be done—lives of hurry were unknown. Even in those days the results were not taken as matters of course. They excited admiration and wonder. Witness for instance the compliment paid to Biscornette, a layman, the maker of the hinge work for the doors of Notre Dame, Paris. They said he could never have produced anything so beautiful without the devil's help.

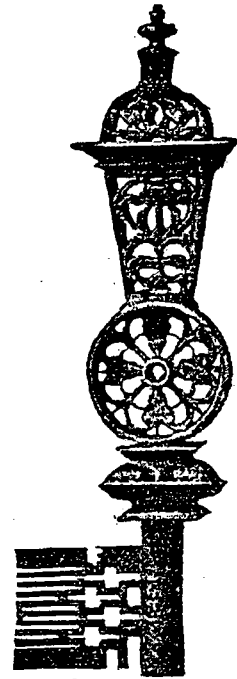
Perhaps professional jealousy started this rumour, if so, it was all the more a compliment. At any rate he disappeared suddenly one day, and the secret methods he had discovered died with him (Burty).

These very early keys have their humble bows in symbolical, or, speaking generally, in ecclesiastical shapes—trefoils, quartrefoils, and the like. Most remaining to us are of bronze, and, like many of the finely wrought-iron specimens of later date, have thus escaped the melting pot that, from time to time, as coffers got empty, engulfed art work made in the more precious metals. Here is one with an almost spherical bow, pierced. This early lock is the ancestor, in direct and unbroken line, of the ordinary tumbler lock of to-day. It had a bolt prepared by a notch for the key to actuate—locksmiths call this notch a "talon"—and it was held in place by a tumbler. The tumbler, instead of moving vertically, was hinged. The word "catch" describes it better than tumbler. A part of it came down over the bolt to reach the key, and the first thing the key did, as you turned it, was to lift up the catch; then, as you went on turning, the key caught the bolt in its notch and moved it. The wall picture, with the sliding door bolt, is one of these. You will notice the bolt has a hasp or tongue coming off at right angles to it, and this enters the lock, and is there secured by the internal bolt. Liger, I think it is, ascribes these locking bolts to the 13th century. You can see them on the cathedral doors of Chartres, Rouen, and in some of our own cathedrals, and I once met one in a very unexpected place. This was on the door of the inner temple building at Kandy, where the piece of ivory called Buddha's tooth is kept. Presently I will show you a photo of it. The surface decoration of the lock has nothing Gothic in it, and it did not look imported, but no one knew its age. Within the same building was another surprise, the iron grille surrounding the tooth itself being fastened with two Chubb's padlocks!

Besides these 13th century locks with the single tumbler, those with fixed wards were in use, their keys showing numerous and intricate slits and perforations to pass over and around them. Warded locks appear to have been the chief kind used for many centuries. Amongst the primitive we found four types: at this stage we have but two—the letter padlock does not come until the commencement of the 17th century.

Certainly the most beautiful specimens of keys are those we now meet with belonging to the 15th and early 16th centuries. A good specimen authenticated to 1530-1570, and now at Frankfort, is shown in diagram. Others in

FIG. 3.



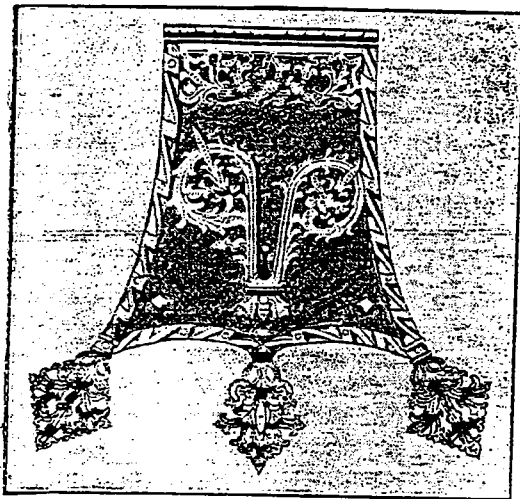
(Florence Museum.)

the Florence Museum I will show on the screen. There are a few at South Kensington, and some in the Musée Cluny. For perfect proportion in all their details and minute workmanship, they have never been excelled, even by the later Renaissance keys. Their four-sidedness and breadth gives them a strong sturdy look, but this is lightened by the gracefulness of their pierced tops and sides, allowing the same play of light and shadow that you get through the tracery of a Gothic window. Hence flat pictures alone do not show their beauty; you must see them in order to be able to appreciate them. Of course, they are awkward to hold, and you could pick their locks, but such criticisms are the property only of the 19th century—the century which commenced by making roses, flowers, and branches in cast-iron for suburban villa gates, and has not quite got out of the habit yet. Now, also, we get the highly-ornamental lock plates of French and Flemish make, the Italians devoting themselves chiefly to the adornment of sword-hilts and other articles. The French locks, and even escutcheons, showed considerable skill in adorn-

ment. The mouldings of the traceries upon them are made of layer upon layer of saw-pierced plates, one plate on top of another, their edges forming the members of the miniature mouldings. Where there are no figures or other devices, to which the traceries are only secondary, there is sometimes a background of brass. This gives a contrast in colour, and adds effect, for traceries are primarily intended to be seen by transmitted, and not by reflected light. If by reflected light, then the mouldings must be deep, so as to give rich shadow.

The German work of this period excelled more, from the artistic point of view, in the decoration of their lock plates than in fine keys. To begin with, the outlines of the plates

FIG. 4.



LOCK-PLATE (Augsburg).

are more fanciful. The surface decoration of the plates consists of a single thickness of metal, cut out and embossed, to represent conventional flowers and fruit growing on stems that branch out gracefully from below the keyhole. The converging branches thus form guides by which to find the keyhole on a dark night, or when, from other causes, it was difficult to hit upon it (Wyatt). Recently, this idea of external projecting guides to a keyhole was patented in England. There is an interesting thing about these German lock-plates that partly accounts for their shape. Their bolts were generally spring ones, and, to get long—though not always easy-acting—springs to act upon them, the end of the plate was made much wider, in order to hold and cover them. Hence, you see, there is a direct

result of form springing from utility. You can see it in these old German locks I have here, obtained in Nuremberg. On another board is a copy of a Japanese lock-plate of similar shape, but this shape, though common to many Japanese locks, is not, I think, owing to the same cause. One can tell to what extent the Germans prized their pretty plates, when it is known that their owners carried them from place to place to place when changing residence (Labarte).

FIG. 5.



DESIGN BY JOUSSE, 1627.

Renaissance work pure and simple now claims our attention, and we are able to point to some very pronounced specimens, as regards keys especially. A *serrurier*, named Mathurin Jousse, published a book on his trade at Paris in 1627. He discourses on the behaviour of apprentices to their masters, and of their treatment by their masters; tells how he prepares his metal, and how he shapes his

tools; descants on the shapes of padlocks; gives names to multitudinous key-wardings; describes a file-cutting machine, and finishes up with an invalid's wheeling chair, and artificial arms and legs made in sheet iron. The book is fully illustrated, and one of his four keys is reproduced in diagram. Another of his keys is almost exactly like the celebrated Strozzi key from Florence, now in the possession of Baron Adolphe Rothschild, and said to have been made by Benvenuto Cellini; but M. Piot, a French writer of authority, doubts this. Jousse incidentally says that, ordinary padlocks, with spherical bodies (here is one) were easy to make, but, when they had two hasps, and a key going in each side to secure each hasp, they were difficult. Here is an exact copy of one of these, the original being in possession of a friend in Germany. Jousse also says that a lot of time was unnecessarily wasted, through apprentices having to spend so much over their guild work required for initiation. Would that there were some such high standard to be passed now! In Germany, apprentices formally smoked themselves into their guild, using pipes in shape of keys. Jousse's escutcheon plates, whilst, no doubt, true to his times, show classical grotesques painfully conceived, but even they are not as repellent as some of the later German ones. These latter have been illustrated in a series of process photos, lately published at Munich. In these, mere surface scratches do duty for bold incision, and hardly any *repoussé* is used to give force to designs that need it.

In viewing these two periods, the Française and Renaissance, we almost lose sight of the mechanism in the art. With the exception of the French letter padlock (about 1615) security seems to have been sought in elaborate arrangements of internal guards or "wards." These previously mentioned were projecting pieces of metal, plates and curved pins, that swept round from the bolt to one side of the keyhole, and were fastened generally in a separate casing or box, hence called "box of wards." The key was shaped to clear them, and so get at the bolt. The bolts being usually "spring," it was not necessary that the key should turn right round, so a good many wards were used that would not have been possible otherwise. Here is one set of wards illustrated in a book published 1767 by Hamel du Monceau. Had the key made a complete, instead of only a partial revolution, it would, of course, cut these wards right off.

The puzzle padlock, as is well known, was improved by a French mechanic, Regnier, at the end of the last century, but this was only one of the many things he did in combination locks. Anyone interested in the details of these will do well to study Bottermann's folio 1781, and may then be surprised to see how little there is new under the sun. When keys were made of irregular shapes in cross-section and passed into their locks through keyholes cut to fit them—that is externally as distinct from being internally warded—there is considerable variety. The most curious one I have met with is illustrated in diagram, and was made for presentation to Napoleon I.

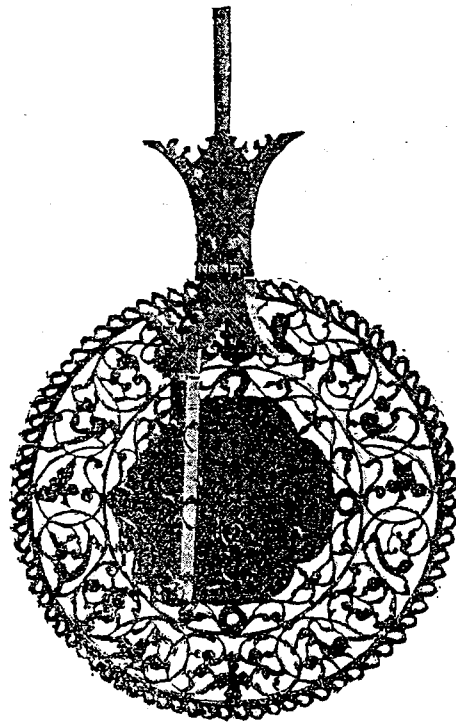
The work done by the English during the Mediæval and Renaissance periods is not as noticeable as that produced on the Continent. South Kensington has one show-case of English locks, and several of French and German. Even the well-known lock-plate on St. George's Chapel, Windsor, is ascribed to Quintin Matsys (Wyatt), and we know that although, at an early date, the grilles around the tombs of Henry III., and of Eleanor, Edward I.'s queen, were done by Englishmen, foreign workers were being constantly invited over, even down to the end of the 17th century, when Tijou designed the gates for Hampton Court Palace. Tijou, by the way, illustrates four perfectly charming key bows. They are delightfully delicate and free in design. But I think to England is due the credit of decorating the stock lock, and certainly the combination of pierced bright or black iron over the strongly marked grain of oak is effective.

To get a good idea of the keys of the last century, one cannot do better than visit the collection of Chamberlain's keys, bequeathed by Mr. Octavius Morgan to the British Museum in 1888. They come from Spain, Portugal, various German States, and Denmark. The times and courts of our own King Georges are well represented amongst these eighty odd specimens. Two unnamed ones are double-ended pipe keys, drilled right through from end to end, and have circular-sliding bows that can be pushed up over either bit to make a handle for the other; they are nearly all gilt, and their bits are in many cases beautifully warded; as for the art of their bows, with the exception of some of the earlier ones, they are decidedly heavy. In at least one of them the emblematic and official idea is so paramount that the key-bit has disappeared altogether, leaving only the bow and

stem; this is but natural, for often disused limbs lose their functions, and in a few generations vanish.

These emblems of office suggest to us the symbolical ideas that have, as it were, hung about keys in all ages, prominent among them being that attaching to the presentation of a key to the Jewish Rabbi on his institution, representing that in future the duty is his of unlocking and exhibiting sacred truths to the people. To those doctors of the law who did not do their duty came the condemnation:—"Woe unto you, lawyers! for ye took away

FIG. 6.



(Birmingham Museum.)

the key of knowledge. . . ." There are many other Scriptural references to the symbolical use of the key as an emblem of power and authority that will at once occur to us. These ideas, too, survive in folk lore and superstitions, keys being used as talismans to prevent the entry of witches into houses, or held by gipsy women when prophesying or fortune telling (Dillinger).

The spirit of applied science that sprang up 100 years ago did not leave locks untouched. First came Barron, so altering and duplicating the old pivoted tumbler, or catch, that it or they had to be lifted to an exact height to free

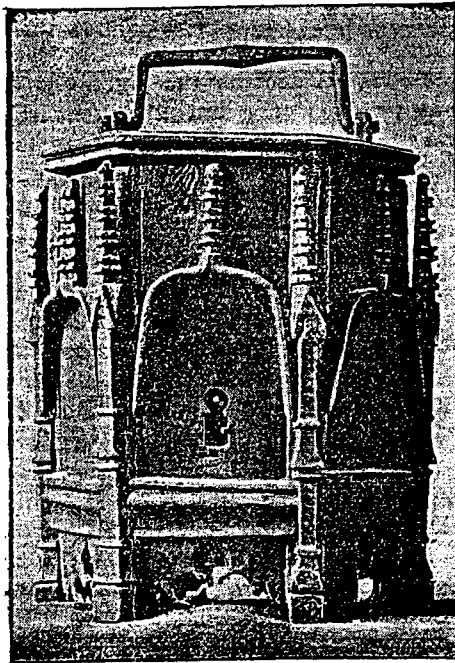
the bolt; and then Bramah, whose ingenuity was as much, or more, displayed in the machines he made to construct his locks as in the locks themselves. Many other names there are of subsequent inventors, all duly chronicled, with their mechanical ideas, in the Patent-office, and more often known to us by this means than by the extent to which their locks have survived. Many inventions have lived for a time, but the Chubb lock, originally patented in 1818, has met with popular and continued appreciation, and now has a stronger vitality than ever. There is always a section in every community that demands things of the highest grade, and to this section the Chubb lock has always appealed. May I here be permitted to state, simply as a matter of fact and without egotism, a curious matter bearing on this point of quality: it has a philological aspect too. In the Straits Settlements the Chinese dealers have introduced a new adjective into their pigeon English; they speak of a "Chubby pair of trousers," or "a Chubby pot of jam," meaning that it is the best of its kind. The Chubb-lock first achieved its notoriety chiefly from the fact of its containing a mechanism called the detector, by which the owner could tell if anyone had been lifting up its tumblers too much. This it still has in a slightly different form. Its tumblers vary in number, from six up to ten, according to the size and nature of the lock (a few small sizes have less than six). Contrary to the popular idea that the kinds of Chubb lock are comparatively few in number, the variety is so great that it takes a long experience to master their details.

I will now turn back to the early strong box, for its development into the safe and steel room is so closely connected with locks that the two may, in their modern aspect, be treated together. Dr. Schliemann, in "Troy and its Remains," tells us he thinks he found remnants of King Priam's treasure box, and gives an illustration of its probable key. In the Middle Ages cellars and vaults for storing valuables were protected by wooden doors sheathed with iron plates. Chests were made of oak or other hard wood, often strongly bound with iron bands, and sometimes, as in a beautiful specimen preserved at Knowlhouse, Sevenoaks, covered with leather. The German, or so-called Dutch, chests one meets with, made of little iron plates, riveted together under bands, owe their peculiar construction to the fact that large sheets of iron were not produced. The rolling mill was

unknown, and plates and strips had to be simply hammered out. Mounted on the inside of their lids were numerous spring bolts, all worked from one warded central key. Padlocks, too, were often used to secure them. In chests of this kind the goldsmiths of Lombard-street kept their bullion when in the reign of Charles II. London merchants first adopted the banking system. The foundation of the Bank of England, in 1694, marks the commencement of a distinct epoch in the idea of credit that prevailed in England. This idea, permeating every branch of society, has developed with the country's increasing wealth, and is indicated by the present numerous joint-stock and

our advanced civilisation, and the fact of lessening crime, the ingenuity of safe-makers has to be constantly at work to baffle the army of skilful scamps called burglars. Commencing with the productions of American makers, it is necessary to note that they draw a very sharp distinction between safes intended to withstand fire and those to resist burglars. Where a safe is wanted for both risks, a small burglar safe is usually fixed inside one of the other kinds. Anyone, with but little trouble, can force open an American fire safe, and the purchaser is perfectly aware of this. Whilst the outside is made of rolled iron or steel, the inner portion of the door, containing the lock and bolt work, as well as the rebating into which its numerous

FIG. 7.

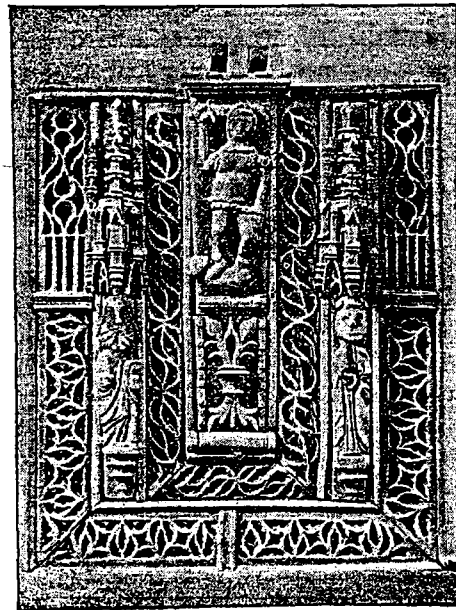


CASKET (Florence Museum).

private banks. Cast-iron safes and doors, easily fractured by concussion, were in vogue well into this century, but gave place to those made of rolled iron. This is now in its turn being displaced, the recent strides in the manufacture of that purer form of iron, called steel, having made it possible to substitute this more efficient and reliable material.

It is not my intention to describe in detail the requirements of a good safe, nor to weary you with the difference in quality of the various English makers. My purpose is rather to place before you some particulars of the latest developments here and in America. Despite

FIG. 8.



CASKET (Florence Museum).

rebated edge shuts, is generally made of cast iron. These castings are fairly tough, and are not brought through to the outside. The thickness between the inner and outer skins is filled up with materials, selected for their non-conducting qualities. These are probably more various than those used for the same purpose in England, and include hard-setting cement concrete, which gives a certain amount of additional strength to the safe, compositions in a constant state of moisture, mixtures of dry plaster, asbestos, and other finely divided materials. Some commercial salts are often added to the dry mixtures for

the sake of the water of crystallisation which they contain, and which they give off in the form of aqueous vapour when heated in a fire. The Americans, as a rule, make their safes with a greater thickness of fire-proofing than is done here, in order, I presume, to cope with increased risk. Added to this, they often introduce internal sheet-iron doors behind the main doors, entirely covering up the fittings of the safe, or else a layer of sheet-iron, or prepared wood, is fastened to the inside of the main door a little apart from it. Keyless combination locks are used in place of key locks to fasten the main bolts. These, having only one spindle, are operated by a revolving dial on the outer face of the door, the edge of the dial being generally marked off into a hundred divisions. To open the lock, the dial is revolved until the predetermined numbers to which the internal discs of the locks have been set are successively brought to a fixed mark. These discs or wheels, three or four of which are in each lock, are called tumblers—some-what erroneously in my opinion, for we have already seen what tumblers, whether falling pins or pivoted levers, really are. There is one variety of American combination lock that is a very interesting mechanical study, for its inventor has cut himself adrift completely from the past in designing it. As however it would take too long to describe it, I will simply refer you to the wall diagram, and to a sample of it on the table.

In American safes intended to resist burglars several thicknesses of steel of different degrees of hardness are employed, and all joints between the plates are carefully made, and closed or covered with forged bands. To give extreme hardness, so as to resist drilling, cast metal similar to speigeleisen, and, therefore, capable of being chilled, is in some cases run in between the outer and inner plates of the safe. The strength of some of the United States Safe Deposit Vaults is very great, resulting partly from the emulation of different owners as much as from necessity. One system recently introduced proposes to use solid blocks of chilled iron, grooved, keyed or bolted together, not less than 12 inches thick. Upon the doors of other vaults a good deal of ingenuity is concentrated. One I recently saw in the country of big things is 8 inches thick. This was made not of cast steel or iron, but of rolled plates of varying degrees of hardness, riveted or bolted together. It measured about $7\frac{1}{2}$ feet \times 4 feet, and was hung upon crane hinges, shutting into its seating in the

front of the vault with numerous rebates and three double grooves and tongues. The fit was so accurate that you could almost cut a sheet of paper between the meeting edges of the door and its surrounding frame. American practice adheres almost universally to the round bolt, made so as to revolve freely, with the idea of thereby frustrating any attempt to saw it through. The bolts are secured by two or more keyless combination locks, and by a chronometer lock, commonly called a "timer," which controls the bolts independently of the others. No doors of safe deposits, bank vaults, or safes of importance, are without "timers," and it is computed that there are not less than from fourteen to fifteen thousand in use. If a burglar, either by force or fraud, obtains the secret of the numbers of the combination locks, he cannot open the safe, provided the "timer" be on guard. The owner, when closing his door for the night, sets his time-lock to run off guard at any hour he selects the following morning, say at nine o'clock, and at that time or after, he can open the door. Timers are all capable of being set to run 72 hours, so as to go over Sundays, or, if necessary, from Saturday to Tuesday. To prevent the possibility of a lock-out, through the failure of springs or other accidents, modern timers have three distinct movements in them, any one of which is strong enough to run the lock off guard should the other two fail. One gentleman, Mr. Holmes, has contrived an ingenious electrical attachment to counteract the effects of a lock-out; another, Mr. Dalton, makes his timer work in conjunction with an auxiliary combination lock, which can only be brought into action when the timer stops. Here is a timer with three movements, which I hope presently to show you at work on the screen by powerful reflection. The existence of the timer, together with the popular reliance placed on it, has enabled the American manufacturers to meet a new method of attack. Discarding drills, blowpipes, gunpowder, and other antique aids to their profession, burglars have, within the last few years, been studying the advantages of nitroglycerine. To introduce it through the door they have pressed or wedged in the spindles, either of the locks or the bolt handles (English makers generally taper these the opposite way, viz., outwards). Though it is not possible to drive the spindle right in, enough space is obtained to inject the yellow fluid. Then, piling books and office furniture in front of the door, they await the blow-up. Of course, this

method, involving as it does some noise, is not well adapted for city operations. What I am saying is not romance. It has been attempted, sometimes successfully, at least twenty-five times. I should be very sorry to think that, by learning such facts as these, any English burglar might be induced to risk his life as well as his liberty, for it is not the duty of any safe maker, with a well-ordered mind, to instruct thieves how to do their work. All I want to do is to show you how this has led up to a new application of the timer. You will see from this method of burglary it became desirable to do away with all spindle holes through the door, and the problem was, then, how to work the main bolts. This has been solved by the use of powerful spiral springs, enclosed in a box mounted inside the door. One set of springs is for throwing the bolts, and there is another for retracting them. When the door is open the springs are wound up, or rather compressed, ready for action. From the nature of the mechanism it is impossible simply to wind up one set without the other. On closing the door, the first set throw out the bolts, either immediately by means of a contact trigger mechanism, or else by a small auxiliary time movement, and the door is locked for the night. The triple timer controls the second set of springs by means of catches, and at the appointed hour next morning releases these, and the main bolts automatically fly back. Thus ordinary locks are quite dispensed with, and reliance is wholly placed in the stored power of the springs, governed by the timer. This arrangement is sometimes applied in duplicate. It might be thought that the catches, being somewhat delicate, could be disarranged by external explosion, but this has been proved to the contrary by experiment. I have heard the objection raised that under this system the bolts, not being always held out by a rigid mechanism, may under certain circumstances be worked or pushed back; but in all work with any pretensions to good quality, it is just as difficult to get at the bolt heads as it is to get through any other part of the safe, or its door. The fact that there are not less than two thousand of these automatic arrangements in use at the present day in the United States shows that they are entirely practical.

In England there is a large variety in the nature of the materials employed for the better class of safe-work. The object, as everyone knows, is to use a material which shall be sufficiently hard to resist drilling or other

cutting instrument, and yet at the same time sufficiently tough, so as not to become fractured under percussion or pressure. To the system of running hard metal in between softer plates, may be added that of case hardening, that is, converting into steel the outer surfaces of iron plates of good quality, so largely done now with the working parts of machinery. Plates, or slabs, are also made up upon the model of war ships' armour, *i.e.*, with layers of high carbon steel welded and rolled in between layers of iron or mild steel. The high carbon steel gives the resistance necessary to keep out cutting instruments, the softer material contributing the toughness. Usually and preferably these layers are continuous, so that no part of the structure is unprotected; they are generally five in number, being either three of hard or two of soft, or *vice versa*. If made with two of hard and three of soft, the outer layer of hard steel is covered by one of the soft, but this does not interfere in the least degree with the efficiency of the hard steel, or modify the molecular change that takes place

FIG. 9.



CHUBB'S ARMOUR-PLATE.

in it during the final chilling process. If, however, a hard steel face is desired, it is just as readily made as the other. It is the presence of carbon in steel which makes it hard, and steel with .6 per cent. of carbon in it is, therefore, more difficult to work than that with the usual per-centage of .17 to .18. I mention this degree of carbon—.6 per cent.—because it is a kind of dividing line between steel that is easily worked and that which gives some difficulty—although not by any means insuperable—to hand tools. Safe-makers look with considerable interest upon the experiments of metallurgical experts in the production of steel alloys, so as to obtain a perfectly homogeneous plate, having the two properties of hardness and toughness sufficiently developed for their purposes.

In treating these armour plates in the workshop, I have applied special emery wheel machinery, so as to produce exactly the sizes required after hardening, and thereby obviate the errors of fitting that are unavoidable if the plates be first planed in the ordinary way, and

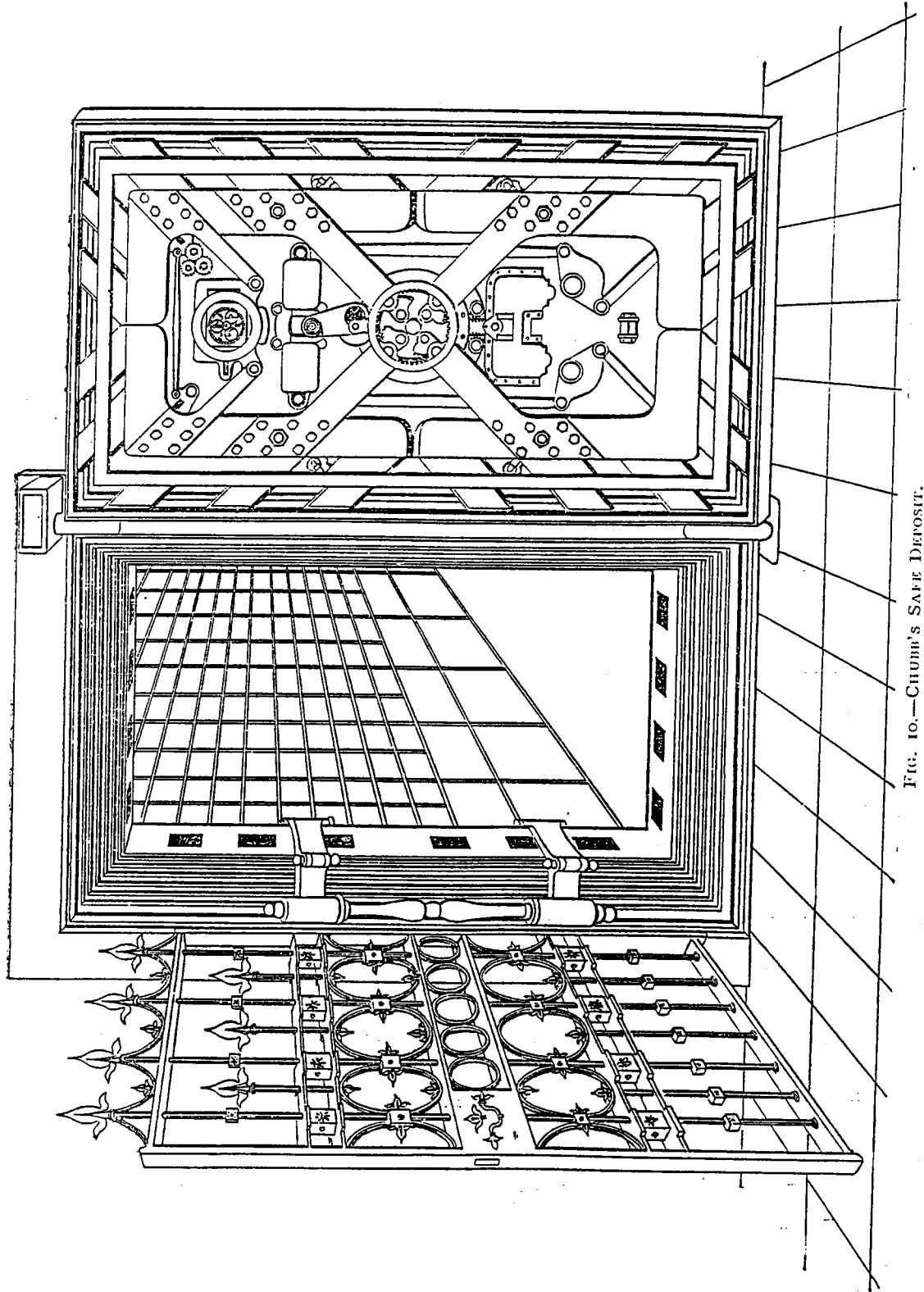
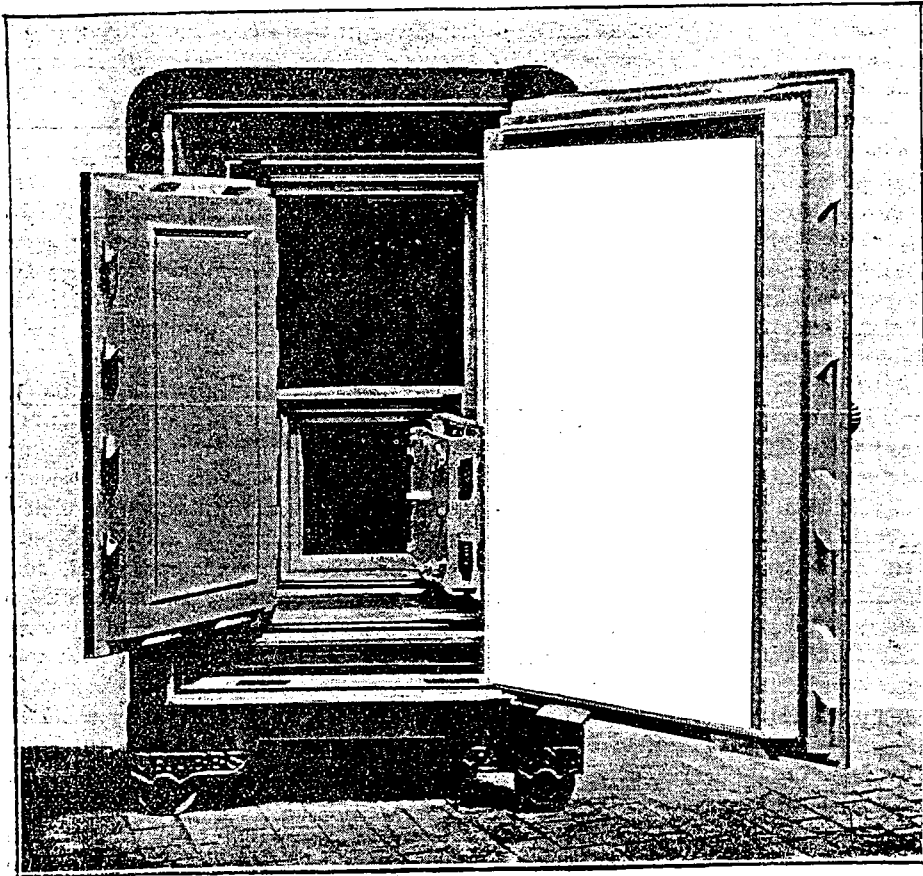


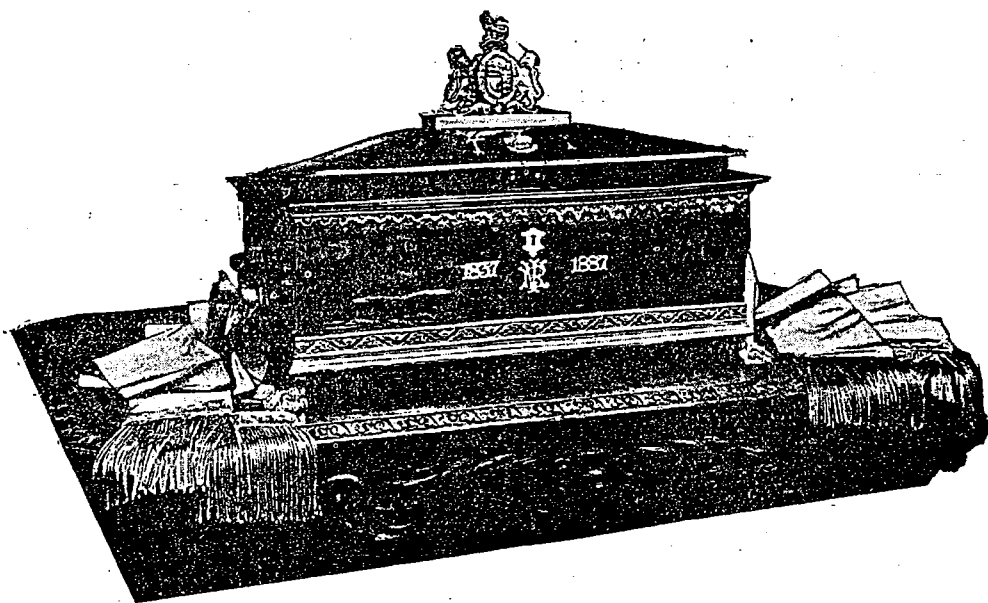
FIG. 10.—CHUBB'S SAFE DEPOSIT.

FIG. 11.



A TRIPLE SAFE.

FIG. 12.



CASKET IN FOUNDATION-STONE, IMPERIAL INSTITUTE.

subsequently hardened. I always dispense with jointing wherever it is possible to bend, or in any other way turn a corner; and these armour plates are as readily and as satisfactorily bent under the round-edge system of safe-making as if they were simply mild steel plates. Movable emery wheels are also applied to cleaning off the heads of composite rivets, and generally producing smooth and level surfaces where necessary.

Fastening the door into its frame has received considerable attention from all English safe-makers, resulting in bolts that claw, clutch, hook, screw, expand, or interlace. Those shown on the diagram of the Chubb door do not shoot forward at right angles to the four sides, but move out at angles of 45 degrees; on each edge some go one way and some the other, thus pointing in opposite directions. By this method they form compound dovetails between the door and its frame, holding the two firmly together in case of attempted wedging. The diagram shows a door of somewhat unusual strength, the bolts being secured, not only by double acting key locks, but also by keyless locks and a "timer."

It is often possible, in the lighter and weaker kinds of safes—safes, I mean, that can be opened with either a pickaxe or a sardine tin opener—to so "make them up" that they may deceive any but experts. This is done by giving the safe an appearance of constructional solidity it does not possess, by showing a thick front all round the door, the door itself seeming to be a plate of solid metal. In reality the appearance is produced by small packing bars, to which, on each side, are fastened sheets of iron no thicker than two folds of brown paper. The joints are filled, or covered with "stopping," and careful painting—sometimes slightly scratched in order to produce an attractive idea of second-handness in the minds of unwary customers—completes the semblance of a safe. It is easy enough to make these as heavy as the real things, by using some weighty material for the fire-resisting (?) filling. What reliance can be placed upon them has been proved in many a fire, for amongst the *débris* of ruined walls one sees them lying about literally in pieces—their contents nowhere.

The safeguard against all this is, of course, to deal only with makers of standing and repute, who will say exactly how the safes of their various qualities are made, the thickness, and material of the plates, &c. Even then it is not an easy task to make a selection, and

the puzzled purchaser sometimes seeks professional and independent advice to decide between the rival claimants for his custom. Safe makers are constantly being asked how long their safes will stand a fire, and how long they will resist burglars? To these queries it is almost impossible to give decided and definite answers. The more ready a maker is to give a guarantee that his safe is absolutely fire and thief-proof, the more cautious should a customer be in accepting the statement. Nothing is perfectly proof against fire and thieves, and the degree of protection obtained largely depends upon the sum of money expended.

Electric burglar-alarms are often used as adjuncts for security in many banks, the system employed being that in which a constant current is maintained, as distinct from the ordinary dwelling-house alarm, where the bell is only rung if the circuit be completed instead of being broken. But it is not sufficient to insure the bell ringing simply if the wires be cut, for burglars with any knowledge of their business will join the wires outside the object protected, so as to leave the electrical circuit still complete. Hence a reliable system should give the alarm even if the wires be joined, as well as cut. The little model I have here, of a strong-room door fitted up with such an alarm, illustrates this. By turning either of the keys, or by breaking either of the wires, or by even joining the wires, the bell at a distance is rung. There is, therefore, a positive advantage in leaving the wires exposed, so as to invite tampering with them. Electricity may also be applied to other objects in connection with strong-room or safe-work, such as locking up-gates at a distance, but it must always be borne in mind that wherever a constant current is used the batteries require periodical attention.

Before closing, I should like to refer to the diagrams of some ornamental Chubb master-keys of recent Exhibitions. These are heraldic in character, the proper colours being rendered by translucent or opaque enamels.

On the screen I will presently show a photograph of another piece of modern art-work, viz., the casket now embedded in the foundation-stone of the Imperial Institute, shortly to be opened by her Majesty the Queen.

The many branches of the subject I have brought before you are so voluminous that it has been impossible, in the time at my disposal, to enter fully and perfectly into any one of them. I have simply endeavoured to indicate

the principal steps in their history and development.

How great is the literature of the subject will be seen in the list of books attached, which will I hope serve as a reference to some extent for those who are sufficiently interested to go more thoroughly into it. In compiling this list of books I am largely indebted to the assistance of the Keeper of the Printed Books in the British Museum, Dr. Leitschuh, of Bamberg, and other gentlemen.

APPENDIX.

LIST OF WORKS AND ARTICLES, RELATING PARTLY OR WHOLLY TO LOCKS, KEYS, OR SAFES.

- Aitken, W., "Locks," in Beavan's "British Manufacturing Industries." London, 1876, 16mo.; 1877, 8vo.
- Androuet du Cerceau. Twenty plates. Paris., fol.
- Baudrimont, "Dictionnaire de l'Industrie." Tome x. Paris, 1841, 8vo.
- Berthaux, L., "Le Parfait Serrurier." Two parts. Dijon, 1851, 8vo.
- Bordeaux, J. H. Raymond, "Serrurerie du Moyen Age." 1858, 4to.
- Bötterman, J de, "Supplément à l'Art du Serrurier." Paris, 1781, fol.
- Briez, "Notice sur la Serrurerie de Picardie." Abbeville, 1857.
- Burty, P., "Chefs d'Oeuvre of the Industrial Arts." London, 1869.
- Burty and Thiollet, "Modèles de Serrurerie." Paris, 1826.
- Butes, J., "Logistica." Lyons, 1559, 8vo.
- Cardeno, G., "De Subtilitate." Nuremberg, 1550, fol.
- Carlsruhe Exhibition. "Deutsche Kunst-schmiede und Schlosserarbeiten." Carlsruhe, 1887.
- Chubb, G. H., "Protection from Fire and Thieves." London, 1875, 8vo.
- Clarkson, D. A., "Ancient Iron Work." London, 1860, fol.
- Daly, César, "Motifs divers de Serrurerie." 2 vols., 1881-82, fol.
- Deufer, J. et E. Muller, "Album de Serrurerie." Paris, 1872, 4to.
- Demont, "Nouveau Traité de Serrurerie." Paris, 1851, 4to.
- Denison, E. B. (Lord Grimthorpe), "Clocks and Locks." Edinburgh, 1857, 8vo.
- Dictionaries and Encyclopædias:—"Encyclopædia Britannica" (9th Edition); London. "Rees's Cyclopædia;" 1819, London. "Knight's Mechanic Dictionary;" 1878, New York. "Ure's Dictionary of the Arts;" 1875, London. "Zell's Popular Encyclopædia;" 1871, Philadelphia.
- Ferrand, J., "Le Charpentier-Serrurier." Paris, 1881, 4to.
- Ferdrin, L., "Nouveau Livre de Serrurerie." Paris, 1723, fol.
- Fosbroke, "Encyclopædia of Antiquities." London, 1840, 8vo.
- Grivaud de la Vinceille, C. M., "Arts et Metiers des Anciens." Paris, 1819, fol.
- Hamel du Monceau, "Description des Arts et Metiers. Art du Serrurier." Paris, 1767, fol.
- Hefner-Alteneck, "Serrurerie du Moyen Age;" Paris, 1869, 4to. "Eisenwerke;" Frankfurt-on-Main, 1886, 4to.
- Hobbs, A. C., "Locks and Safes." London, 1868, 12mo.
- Husson, F., "Dictionnaire Pratique du Serrurier." Paris, 1872, 8vo.
- , "La Serrurerie et ses objets d'art . . . Rappports sur l'Exposition Universelle de 1878." 1879, 8vo.
- Jousse, M., "La Fidele Ouverture de l'Art du Serrurier." Paris, 1627, fol.
- Kabdebo, Stg. v., "Wiener Schmiede (und Schlosser) Werke." Dresden.
- Kellen, D van der, "Le Moyen Age." Amsterdam, 1864, 4to.
- Kunst-Schmiede-Eisen-Sammlung. Munich, 1881.
- Labarte, "Les Arts Industriels du Moyen Age" (vol. ii.). Paris, 1866, 4to.
- Lacroix, P. and F. Seré, "Le Moyen Age" (vol. iv.). Paris, 1848-51, 4to.
- Lane, "Modern Egyptians," 1849.
- Lane-Fox (see Pitt-Rivers).
- Lavedom, B., "Guide Pratique de Serrurerie Usuelle." Paris, 1867, 4to.
- Liger, F., "La Ferronnerie Ancienne et Moderne." Paris, 1873-75, 8vo.
- Mallet and Fairlie, "Safe Challenge Contest." London, 1868, 8vo.
- Montfaucon, "L'Antiquité Expliquée" (tome iii.).
- Notling, E., "Studie über Altroemische Thür und Kasten-Schlössen." Mannheim, 1870, 8vo.
- Paulin-Desormeaux, "Nouveau Manuel du Serrurier." Paris, 1866, 8vo.
- Persin, H. de, "Serie de prix pour le reglement normal des travaux de serrurerie et charpentes metalliques, paratonnerres." 1882, 8vo.
- Pignorius, L., "De Servis." Patavii, 1694, 4to.
- Piot, E., "La Sculpture à l'Exposition" (2nd series, vol. xviii.; "Strozzi," key, p. 825.
- Pitt-Rivers, Lieut.-Gen., "On the Development and Distribution of Primitive Locks and Keys." London, 1883, 4to.
- Plon, E., "Benvenuto Cellini" (pp. 365-7). Paris, 1883, 4to.
- Piice, G., "Fire and Thief-proof Depositories." London, 1856, 8vo.
- Pugin, "Designs for Iron and Brass-work." London, 1836, 4to.
- Ruschdorf, "Abbildungen Deutscher Schmiede (und Schlosser) Arbeiten." Berlin.

- Robinson, J. C., "Treasury of Ornamental Art" (plate 70). London, 1857, imp. 8vo. "Catalogue of Soulages Collection." London, 1856, 8vo.
- Roussel, P. W., "Histoire et Description du Chateau d'Anet." Paris, 1875, fol.
- Sala, G. A., "The Battle of the Safes." London, 1868, 8vo.
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- Sanguinetti, A., "La Serrurerie . . . au XIX. Siècle." Paris, 1875, 8vo.
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- Silvain, H., "Carnet du Serrurerie-constructeur." 1879, 12mo.
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- Tomlinson and Mallet, "Locks and Safes." London, 1868, 12mo.
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- Wasmuth, "Die Schmiedekunst." Berlin.
- Weise, "Dresdener alto Schmiedenwerke." Dresden.
- Wilkinson, "Manners and Customs of the Ancient Egyptians." London, 1878.
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- Chatwood, S., "Locks and Safes." *Journal of the Society of Arts*, 1888.
- Chubb, J., "On the Construction of Locks and Keys." Institute of Civil Engineers, 1850.
- Chubb, J., "On the History and Construction of Latches and Locks." Society of Arts, 1851.
- Cumming, H. Syer, "History of Keys." Archaeological Association, 1856.
- Higgin, "A Sketch of the History of Ancient Door Fastenings." Lancashire and Cheshire Historical Society, 1850.
- Tonks, "Gold and Silver Keys." Birmingham Architectural Association, 1888.

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- "American Historical Record," vol. ii., p. 122.
- "Art Journal," vol. ix., p. 85; also vols. for 1852, pp. 218, 250, 305.
- "Bankers' Magazine," vol. ii., pp. 572, 632.
- "Cassell's Magazine of Art," vol. ii., p. 75; and vol. iii., pp. 16, 174.
- "Chambers's Journal," vol. xviii., p. 405; vol. xlviii., p. 107; vol. liii., p. 648.
- "Cornhill Magazine," vol. xii., p. 623.
- "Cosmopolitan," October, 1891.
- "Good Words," vol. xx., p. 85.

- "Journal of Franklin Institute," Philadelphia, vol. lxxviii., p. 66; and vol. lxxv., p. 202.
- "Saturday Magazine," April, 1839.
- "Journals" of the Archæological Institute and Association.

DISCUSSION.

Mr. S. S. BROMHEAD asked whether Mr. Chubb had considered the question of utilising aluminium in the manufacture of keys, as, when people had a number of keys to carry, the question of weight was of considerable importance. Any metal which would not oxidise must, to a great extent, preserve a lock from becoming hard in its movements. Personally, he felt very much obliged to Mr. Chubb for his admirable paper, and the many beautiful illustrations which adorned the walls of the room. If possible, he hoped that something approaching the American key of the Yale latch could be introduced into this country, as one of their great advantages was the small space they occupied in the pocket. He should be glad to know whether there was any practical objection to adopting a flat key, because, if not, and it could be made of aluminium, it would be very light.

Mr. R. L. COLE said that, as an architect, he was very much interested in the construction of strong-rooms, and regretted that no details had been given with regard to the construction of floors and ceilings. Everyone knew that strong rooms were subject to attack by burrowing; many successful attempts had been carried out in this manner and, therefore, he should like to know what was the most generally adopted system in America for floors and ceilings. He noticed in one of the illustrations thrown on the screen that the joints appeared to be riveted on the outside, but in his opinion the best plan was to make the joints so that they were not externally visible. Of course, the circumstances under which the safe had to be fixed had in all cases to be considered. With regard to time locks, he rather gathered from the remarks of Mr. Chubb that his opinion was that these were really the locks of the day.

Mr. H. B. WHEATLEY said one point which must have struck every one was the artistic beauty of the old keys shown by Mr. Chubb, thus illustrating what we know from other sources, that locksmiths in olden times were artificers who were held in the highest esteem. There was one safe of great interest which had not been referred to, viz., the chest which held the Domesday Book in the Record-office. This chest had three locks, which were broken open in the time of Edward I., when the treasury at Westminster was robbed. Another matter with regard to the robbery from safes worth noting was the robbery of the king's treasure in the reign of Edward the Confessor. In Mr. Hubert Hall's interesting book on the "Antiquities of the Exchequer," there was an account

of the robbery of the chest which stood in the bedroom of the king. In early times the treasury of the king was usually kept in his bed-chamber, and on one occasion the Chamberlain had left the door of the chest open while he went to pay some of the servitors of the Palace. In his absence the kitchen scullion came in, and thinking the king was asleep, took out some of the money. The king happened to be awake, and he, thinking the Chamberlain would soon be back, called out to the man to fly quickly in case the Chamberlain should return, in which case he would not leave him a halfpenny to take away. This showed a sense of humour in Edward the Confessor, which reminded him of the well-known story of Charles II. and the pickpocket.

Mr. CHUBB said that he had made keys of aluminium, but found they had no wearing property. If the noses of the steps of the key were not very hard they would not wear for any considerable time. With regard to the desirability of a flat key, he might say they could be made for the ordinary Chubb lock. People had the impression that flat keys were more readily copied, and, to a certain extent, this might be true. The degree of accuracy required in a good lever lock was of a very fine degree. It would be more easy to copy a flat key than one with a pin or pipe to it. He tested the degree of accuracy some time ago, and found that in a little three-inch lock the difference of 1-200th part of an inch in the length of one of the steps of the key was just sufficient to prevent a wrong key from acting. This test was made by means of a micrometer, which gauged to the 1-10000th of an inch. With regard to the details of floors and ceilings of strong-rooms, he had not endeavoured to touch on architectural features, but he considered the best thing was to have no floor at all; in other words, to have a cellar under the strong-room which could be occasionally inspected. If there was a cellar, the burglar would have first to burrow into this before getting to the strong-room. With regard to the ceiling, he preferred to have it arched, as in the event of a fire (which was the chief thing to be considered), any beam or joist, or large piece of metal-work, which became detached and tumbled down, would have its fall considerably broken. No doubt in the illustrations thrown on the screen the joints in the plates of the strong-rooms had external sitch bars, but it was just as easy to make them internally, and this was often so done. A perfectly smooth and flush surface presented more difficulties to the burglar than anything which had projections on it. With regard to time-locks, he had endeavoured as far as possible not to express any opinion, but merely to state facts. There was no doubt they were being used more and more, and it was simply a question of time as to how soon they would become general in this country:

The CHAIRMAN said he was sure everyone would appreciate the labour which Mr. Chubb had been

good enough to undertake in the preparation of so interesting a paper. He had commenced with the Egyptians, gone on to Chinese and Japanese, and eventually brought them down to the most modern and scientific time-locks, and under these circumstances he had much pleasure in asking the meeting to record a cordial vote of thanks to Mr. Chubb.

The vote having been unanimously passed, the meeting adjourned.

Mr. SAMUEL CHATWOOD writes:—The shortness of the time available after the reading of Mr. Harry Chubb's interesting paper on ancient locks precluded the possibility of discussion of practical matters in connection with the safe and lock controversy. I was personally disappointed that Mr. Harry Chubb only devoted a very few minutes to modern locks, and hardly touched English security arrangements at all, but rather magnified American practice, particularly in the matter of safe deposit work and time-locks. Of course, in one paper it would be impossible to cover the ground, and Mr. Harry Chubb selected ancient locks as the base of his very interesting paper. I was surprised to hear him, at the close of the discussion, ascribe the time-lock to the Americans, as it is distinctly an English invention, the patent for which was offered to me at my Manchester office some 35 years ago. I believe the inventor was a Salford man. I declined to purchase it, as I found the attempt to raise the standard sufficiently great in those days without attempting the introduction of the time-lock. The time-lock was no good on safes which the burglar could force, and before the Cornhill burglary our bankers even would not pay for good safes, and when, in 1865, I wrote a letter to the *Times*, that a really burglar-proof safe must be made of intersected steel two inches thick, a quality which our bankers and jewel merchants were not willing to pay for, the late Mr. Milner retired to his room and wept, asserting that my impossible standard would ruin the trade; but now that this standard has been accepted, the time-lock is of value for the protection of the holders of the keys, as these can only be used after the time for which the time-lock has been set before the locking up of the safe or strong-room. The time-lock found its place in America, where the keys or the lock combination could only be held by a bank officer at the risk of his life, until they were made of no avail except in business houses, and the instrument has been developed and perfected to a high degree; but the invention was submitted to me in practicable form by the patentee, as I state, about thirty-five years ago. Touching the American safe deposit work, it should be stated that the proprietors of these safe deposits in America are wealthy corporations, who do not hesitate to expend upon them some £50,000; whereas, in England, it is usual to form a small limited liability company, with just enough capital to pay for the safes and strong-rooms, often in hired buildings, but with no capital

to fall back upon in the event of accident or of the fraud of their servants. The renter in these safe deposits is at the mercy of the officers of these small safe deposit companies, as the compartment, of which he holds one key, is in no sense a safe, but only a lock-up of a flimsy description, apart from the strong-room, the keys of which are controlled by the servants of the safe deposit companies; whereas, the renter should be able to feel that the key in his own possession should secure him absolutely against the possibility of his safe being broken open, apart from the strong-room in which it is placed. Touching the question of the metal poured between plates, I remark that it does not owe its hardness to chilling action at all, as before we can pour it between the two steel bodies of our intersected steel safes, we are obliged to expand them by heat, otherwise the unequal contraction would so distort and twist them as to render the system impracticable. The excessive carbon renders the speigel forming the intersecting cones and intermediate plate so hard, that it will cut glass like a diamond, without any chilling action, which it will be seen is impossible of application in this system of manufacture. As to fire-proofing in America, I was amused to watch the filling of the safes, and observed that the inner and outer shells were stayed and propped, whilst the cement was poured in and set, and satisfied myself that it was really the stone wall thus formed which constituted the strength of the ordinary American safe. On the question of suitable steel for defeating the burglar's drill, of course it will be evident that steel with .6 carbon will not offer much resistance to the burglar's drill, though it will increase somewhat the cost of workshop manipulation. The true principle for defeating the burglar's drill is, after all, a combination of hard and soft metals; the soft to protect the hard from fracture by concussion, and the hard to protect the soft from being cut away; and to this particular branch of the subject I have devoted much attention for the past 33 years, my first patent having been taken out in 1860. I followed this up by introducing solid plates of steel, with high carbon centres and soft exteriors; and, in 1885, I invented, as a cheap substitute for our patent hard centre compound steel, the system of hard-strand steel, *i.e.*, plates of soft steel, with strands of high-carbon steel formed by placing high-carbon steel bars in the ingot moulds, heating them *in situ*, then filling up with ingot iron or low-carbon steel. I communicated this invention to the New British Iron Company, at their Corngreave Works, Birmingham, in 1885, but I have not found the plates made under this latter plan drill-proof, but good against the cutting of large holes in the doors of safes or sides of strong-rooms, which was, indeed, the object I had in view in making the invention. I have been led to make this note somewhat longer than I should have made my remarks, had time permitted in the discussion, but I trust you will be able to find room for them.