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The Armor Business in the Middle Ages

The establishment of the Conservatoire des Arts et Métiers in Paris in 1799, following a conception for a museum of science and industry outlined by Descartes a century and a half earlier, was the beginning of a type of institution which has great significance to business history. Many industrial museums have since been established. Some have grown to vast exhibitions of industrial machines and processes, such as the Science Museum in London, the Deutsches Museum in Munich, the Technical Museum in Vienna, and the Museum of Science and Industry in Chicago. In America and in Europe many smaller museums have also been established to illustrate some particular aspects of industrial development. Among the outstanding ones in America are the Edison Museum, established by Henry Ford in Dearborn, Michigan, the Industrial Museum of the American Steel and Wire Co. at Worcester, Massachusetts, and the John Woodman Higgins Armory, of the Worcester Pressed Steel Co.

These museums are educational in purpose. They aim to display machines, processes, and products, in order to bring about a better understanding of industrial production as a factor in our civilization and to foster a deeper appreciation of invention, engineering, design, and craftsmanship in industrial production.

John W. Higgins, president of the Worcester Pressed Steel Co., has been a leader in emphasizing the educational objective of the industrial museum as an adjunct to every manufactory.[1] He has urged its value both to the industrial worker and to the

[1]Mr. Higgins, who has a close familiarity with the history of the steel industry and particularly with armor, has generously given invaluable help in the writing of this article and has contributed the illustrations.

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public in general. His museum, which is one of the outstanding manufacturers' museums in the United States, is a striking expression of his conception of such an institution as an instrument of education. His specialty is sheet steel. The "ancient wing," comprising a collection of steel armor, arms, implements, and tools, chiefly from the mediaeval period, illustrates impressively its founder's conviction that art and craftsmanship can be joined in industrial production and that we can profit from a better appreciation of the artisanship of the past.

To the business historian, industrial museums are invaluable records of industrial activity through all the stages of business development. Mr. Higgins' collection is in itself a history of the steel industry, particularly that part of it which utilizes sheet steel. It exhibits and extols modern steel products but devotes equal space and most of its library to that industrial epoch which preceded our own great modern development in steel when artistry and hand craftsmanship produced masterpieces. The "modern wing" offers precision, efficiency, strength, and quality in mass production, but the mediaeval wing expresses dexterity, functional adaptation, and sincerity of purpose with charm of design and patina—qualities sought for our products of the future.

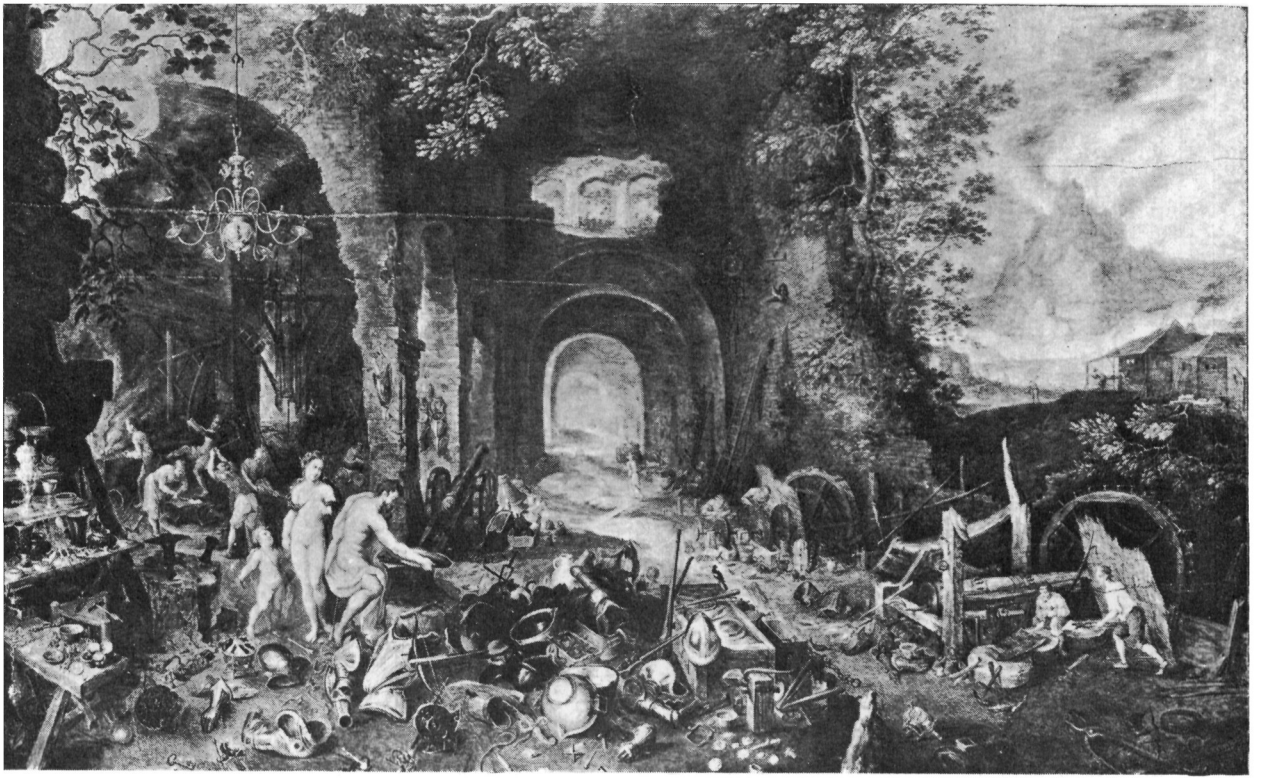
In the Higgins Armory are steel arms, armor, and utensils from many countries and from different periods of time. There are swords and scimiters, misericordes and maces, axes, halberds, lances, and shooting weapons of many kinds. But most important is the armor—the defense armor of the mediaeval knight with his horse and of the foot soldier and the ceremonial armor of knight, emperor, and the young prince. The collection contains the work of such master-craftsmen as a Negroli, a Missaglia, a Colman, Piccinino, and Peffenhauser. It contains artifacts from prehistoric times to that period which ended in the decadence of the armorer's art and craft.

Even a short visit to the Higgins Armory leaves a deep impression of beauty of material, of design, and of workmanship and a sense of the long ancestry of our modern steel industry and of the cultural background out of which it has developed. One authority says that "it is, to a large extent, to the excellence of defensive armour and weapons that we owe much of the development of art and craftsmanship all over Europe."[1]

This collection illustrates the development of iron as a material

[1]Charles Ffoulkes, *The Armourer and His Craft* (London, 1912), p. 1.

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"THE FORGE OF VULCAN," by Jan Brueghel, 1600

In the Collection of the Higgins Museum
Worcester, Massachusetts

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factor in our civilization. Steel is in reality old—iron ore was smelted before 2000 B. C. and steel was produced before 1000 B. C. Aristotle in 350 B. C. described a method of making steel that was thereafter followed in essentials for over a thousand years. The Wootz steel of India and the steel of Damascus were renowned in ancient Asia. The latter was advertised in Europe by the crusades, and the Toledo steel blades of the Middle Ages were made by essentially the same processes. The discovery of means of producing a higher furnace temperature for the refining of the metal made possible improvement in the quality of steel. Mediaeval armor shows clearly that improvement.

Agricola explains in his famous book on metals how iron and steel were made in the late Middle Ages.[1] For smelting the ore a hearth was used with a crucible almost one foot deep and one and one-half feet wide. In the crucible were placed charcoal, lime, and the ferrous ore. The burning charcoal, stimulated by air blasts from bellows run by water power, melted the iron in eight to twelve hours. When the melting was finished, the mixture was run out to cool, was beaten with wooden mallets to chip off the slag, and was then hammered on an anvil with a trip hammer raised by water power. It was reheated in the smith's forge and shaped into bars on his anvil.

"By skill with fire and fluxes is made that kind of iron from which steel is made," says Agricola. The iron bars were broken up into small pieces and mixed with crushed stone. A crucible was filled with charcoal, and, when the charcoal was glowing, the master blew in blasts of air and poured onto the charcoal the mixture of iron and flux. Into the middle of the melted iron he then put four iron masses, each weighing thirty pounds, and heated them fiercely for five or six hours, frequently stirring with a bar. The resultant masses were then lifted onto an anvil, were beaten with a hammer raised by a water wheel, while still warm were plunged into water, and were again hammered. To make still purer steel, the resulting mixture of iron and steel was again passed through the same process. Thus, says Agricola, the iron was "changed into pure steel, which is much harder and whiter than iron."

The quality of mediaeval steels varied. Many legends grew up

[1]Georg Agricola, *De Res Metallica* (translated by Herbert C. Hoover and Lou Henry Hoover, London, 1912), pp. 423-425. Practically the whole book, according to the Hoovers, was written from observation; it was published in 1555.

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about secret processes of craftsmen, spring waters with miraculous power of tempering, and other mysterious methods for producing superior steel. As a matter of fact, the real secret of the great variation in quality, aside from that caused by heating and hammering, lay in the ore itself. The excellence of the steel in the swords made at Toledo was attributed to the water and the sand of the Tagus River, while actually the ore used contained natural refining alloys, such as tungsten, nickel, and manganese. Similarly the steel made at Innsbruck, which was vastly superior to Italian steel, was made from ore containing manganese.

After the steel had been made, refined, and forged, the next step in the work of the armorer was designing the armor to fit his patron. A visit to a collection of armor is an impressive lesson in design. Indeed, the Higgins collection epitomizes the problem of invention and design as a constant challenge in the making of all things. The best Gothic armor is the finest example we have of shaping and adapting intractible metals to serve their purpose, following well-tried methods, to protect and defend man and horse against the thrusting, cutting, or crushing weapons of the day and still not impede their action in offense and escape. That is functionalism at its best. The later armor of the Renaissance shows the subservience of defense to style in costume and decoration, which eventually weakened the suit for combat. It is significant that, as the armorers gave more and more attention to decoration, they lost the art as well as the constructional skill of their fathers.

In construction the early armorer was a master. Chain mail armor, which was used exclusively by the early crusaders, was made of rings of hand-hammered wire, which antedated the invention of wire-drawing and required patience and high skill in forging and riveting the joints. How much of such mail was used may be judged from the fact that in one thirteenth-century battle six thousand horses were blanketed with chain mail. But the coat of mail gave protection from cutting only, and not from thrusting and crushing. At the most vulnerable places, therefore, steel plates were gradually added to the mail. Plate contributed two valuable qualities: it distributed the effect of crushing blows and glanced off the cutting and thrusting weapons. As weapons increased in destructiveness and as the foot soldier became more and more effective, in the thirteenth and fourteenth centuries, armor had to be strengthened. Hence more and more plate came to be used until, about 1400, the whole body was covered, though foot soldiers

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wore chain mail underneath their plate armor as late as the seventeenth century.

The armorer learned by long experimentation to make effective plate armor. He had to forge plates of many shapes and thicknesses and to fasten them together into an articulated suit. His ingenuity in cutting, fitting, and joining the pieces from hard steel, in such a way as to give considerable freedom of movement, excites our admiration. At first the different pieces were joined with leather thongs or straps, but later the sliding rivet was utilized. By the late fourteenth century the separate plates and lames—one suit contained 235 pieces—were so well formed and so skillfully joined with sliding rivets that a *cap-a-pie* suit of armor allowed its wearer a remarkable freedom of movement.

The height of craftsmanship in armor-making came about 1540. By then, it is said, the only discomfort to the wearer of the best armor was that of the weight. The weight was reduced by utilizing fluted plates, the glancing property and strength of which were increased by an ingenious corrugating of the sheet metal. This was the invention of Konrad Seusenhofer, who worked under Emperor Maximilian's personal supervision, and that type of armor is known today as "Maximilian."

In the second half of the sixteenth century began a period of decadence. Though not so effective, the armor of that period is admired for the ingenuity of forging skill and the variety of design and decoration which it represents. Its distinguishing feature is subservience of design to the style of the pageant costume of the time. Some parade suits of armor were made with the puffed and slashed sleeves of the Renaissance court costume; they were decorated with perforations, engravings, and embossings (gilded, silvered, or oxidized), and they were even inlaid with gold and set with jewels.

At this stage, artists for designing decoration, goldsmiths, and jewelers were brought into the workshops. This had a decadent influence on battle and tilting armor. Decoration destroyed the glancing surface and also interfered with the play of articulated plates. Even the great Italian and German masters, such as Piccinino and Peffenhauser, violated efficient armor craftsmanship to demonstrate their manual dexterity and skill in steel.

From the middle of the sixteenth century was felt still another influence, the improvement in firearms. The weight of the armor

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had to be increased to make the armor bullet-proof, and in time it became too heavy to be endured by man or horse. After 1600 three-quarters or half suits were worn, and by 1700 little armor was used, except for jousting. The contest between the musket and arquebus on the one hand and the armor on the other finally ended in the complete disuse of battle armor until the production of modern alloy projectile-proof armor plate.[1]

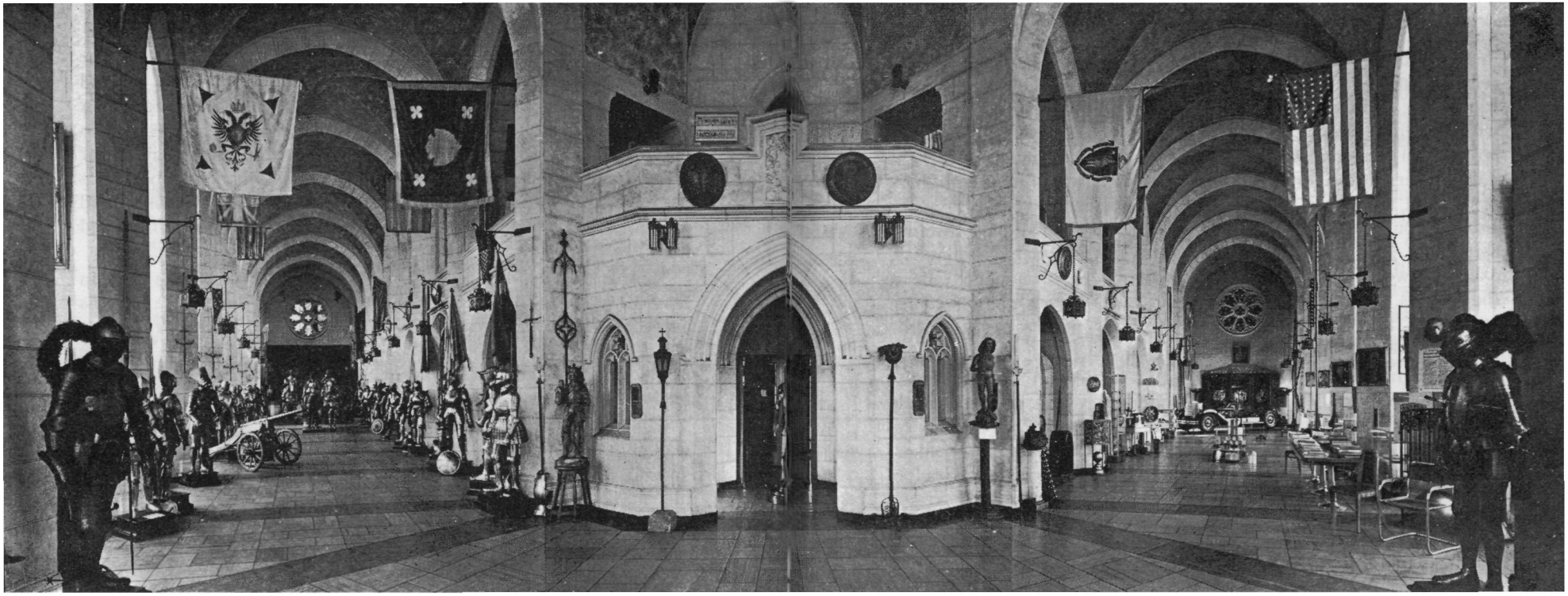
To the business historian a large collection of arms and armor suggests many questions. Impressed with the remarkable art and craftsmanship expressed in metal, he sees it all as the output of a dynamic civilization that was driving forward in business as in other ways. He is interested in knowing how the business in armor was organized, how it was conducted, and by whom its operations were guided. Who were the entrepreneurs in the industry, and what did they and their generation gain from their investment and their effort?

Unfortunately, the business of the armorer is known only in fragments. Very little historical research has been done on this aspect of the history of arms and armor. Still, adding fragments which we do know about the business to the knowledge we have of the craft, we get something of a picture of this very important mediaeval industry.

The drive behind the industry was the almost constant state of war or need of defense. In feudal Europe defense was organized around the individual lord and continued down to the knight and his man, and as national states were formed national armies of mercenary soldiers appeared (about 1328-1350). Until the coming into effective use of firearms in the eighteenth century, fighting was largely hand to hand, and the better-armed and -armored fighter had the greater chance of survival and victory. Morale was of tremendous importance, and nothing so disorganized morale as the fall of the leader. Since the fate of an army might depend on how well-equipped was its leader, it was essential that the leader have the best arms and armor possible. On the men of the ranks even inferior armor undoubtedly had a psychological effect that in itself was of considerable importance.

[1]This armor, except for infantry helmets and trench breastplates, is mounted on gun carriages and on battleships—a battleship is a suit of armor for 1,400 men.

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THE JOHN WOODMAN HIGGINS ARMORY

Worcester, Massachusetts

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Thus, two things were needed: the expeditious arming and armoring of many men and the equipping of the leaders for the greatest effectiveness regardless of cost. Both of these commanded high design and craftsmanship, while one necessitated a large manufacturing industry.

There is in historical studies a curious dearth of references to trade in arms and armor. Apparently there are two reasons for this: the business in war equipment, like other business, has received relatively little attention from historians; and trade in such equipment, especially in armor, was sporadic and small compared with peacetime trade as a whole. This is not to say that there was no trade in arms and armor. We know that the English Merchant Adventurers in the seventeenth century imported Nuremberg "harness," and that there was obviously a considerable trade in arms. But the bulkiness of plate armor worked against long-distance shipping. And, because it did not pass state borders in quantity, except as worn by soldiers, armor did not get a prominent place in the records. Moreover, the cheaper and poorer armor has not been preserved, and that which remains bears witness only to the industry that produced the finest armor.

The armor industry was generally carried on in small units near the demand. The cheaper equipment was apparently made close to the buyer; the knight's armor was generally made by the local armor-smith, as was surely that of the ordinary foot soldier. It was different with the members of the upper hierarchy of leadership; they engaged famous armor-makers to make their armor during times of peace, regardless of distance or expense. Even the leaders, however, developed and patronized with pride their home armories. Kings and emperors hired famous armorers to come to their courts in order to take orders for armor and even to execute special orders and to teach their apprentices; and frequently—presumably after mercenary armies came to be used—rulers maintained their own permanent staff of arms- and armor-makers. The Republic of Venice had a large public armory; so did the Court of Mantua; France developed works at St. Etienne; and Henry VIII established his famous armory in Greenwich, where he employed Augsburg and Milanese craftsmen and the "Almain" armorers from Brussels.

Circumstances often tended, however, to overcome the local nature of the industry. Germany and Italy had the double advantage

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of an early start and a concentrated demand. Long experience, great demand, and competition gave them a large number of highly skilled craftsmen. Both had local iron supplies; southern Germany had the best ore available for the making of highest-quality iron and steel, although the purest iron ore was mined in Sweden and in Spain. It was this combination of circumstances which made Milan and Brescia in Italy and Innsbruck, Augsburg, and Nuremberg in Germany the greatest centers of the industry, while Spain became famous for its Toledo blades, immortalized by the poets of chivalry. The extent of the industry may be suggested by the fact that the armorers of Milan in 1427 in a few days made armor to outfit 4,000 cavalry and 2,000 infantry.

The head, heart, and hand of the industry were the master-armorer and his forge. He might work for another or attach himself to a court, or he might have his own forge and carry on his own business as a petty capitalist. If he conducted his own shop, he hired journeymen and had apprentices and even followers comprising a school. Important masters had their own trade marks, or *poinçons,* which were stamped on their products. The craftsmen were members of armorers' gilds which also had their own gild marks.

Usually the maker of war equipment specialized functionally to a considerable degree. Antonio Missaglia, the famous Italian armorer, in 1492 leased his own iron mine. But most armorers probably bought their iron in billets from distant smelterers and refiners or from iron merchants; they also reworked and altered old armor and were at times supplied with metal by their order customers. Most famous armorers seem to have made their own plate steel from ore which they imported from specified mines, the iron of which they had tested previously and found "bullet proof." Much of the work was done on order, to individual measurements and designs. The armorers received many commissions through the sedentary merchants. These merchants apparently often served as distributors of the product.

There were varying degrees of specialization in the product. The arms industry displayed a high degree of specialization even as to location, a fact which shows that there must have been a considerable trade and competition in weapons. Toledo, Toulouse, and Bordeaux made swords; Cologne made halberds; Versey, misericordes; and Barcelona, bucklers. The armor-maker might

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make a whole suit or only a part, and some armor shops specialized in the making of single parts. As early as 1347 London, where armor-making developed later than on the Continent, had a gild of helmet-makers.[1] Specialization seems, however, to have lessened as the practice of fitting plates into a whole well-articulated and riveted suit replaced the use of sections of plate for only the more exposed parts of the body.

The individual armor establishments varied greatly in their organization of the work, from the small establishment of master and apprentice or helper to the large factory with some repetitive specialization, from which much work was let out to home craftsmen whose women and children all worked. The hammering of the plate was often specialized, and some plate hammer-mills were run by water wheels, where millmen, hammer-men, and platers worked at their separate trades. Designing might be the work of a special artist; perhaps the most famous of designers was Albrecht Dürer. The decorating of the armor was another process, while ornamenting and embellishing it in the period of decadence became in reality a jeweler's job.

Armorers' tools, descriptions of tools and processes, and even pictures of armor shops or factories give a wealth of information about this business. In the Higgins Armory is a small armorer's shop with forge, anvils, hammers, swages, tongs, and an uncompleted helmet from early modern times. A contemporary etching gives a picture of the shop of Konrad Seusenhofer, the great armorer of Maximilian I, containing the usual forge, anvil, and tools.[2] The most interesting picture in the Higgins museum is "Venus at the Forge of Vulcan," the original sixteenth century painting on oak panel by Jan Brueghel, the elder, called the "Velvet Brueghel." This picture, reproduced on page 51, records the entire armor industry by bringing together more processes than were usually, if ever, under one management.

The scene of the workshop pictured by Brueghel is laid in a large castle, with an erupting volcano—symbolizing the smelting of iron—viewed through an opening in the distance. Outside also are little huts with windlasses where the ore is being mined. In a far

[1]Later incorporated with the armorers' gild, which still exists under a charter granted in 1708 to the Company of Armourers and Brasiers in the City of London.

[2]Ffoulkes, *op. cit.*, p. 24.

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corner of the castle hall are smelting furnaces and a casting hearth; and nearer the foreground of the picture is a forge for fire gilding. To the right are water wheels and trip hammers, and in the foreground Vulcan works at his anvil surrounded by a wide range of tools and products. There are the large shear, a long-handled swage for stamping grooves and edgings on metal plates, and a burring device for turning the edge of the metal; tongs, pincers, hammers, dies for stamping, bench vise, hand vise, repoussé hammer on a three-legged stool—these are but some of the tools lying around.

The heads of the larger workshops were master-craftsmen who had in reality become industrial entrepreneurs. As providers of capital, employers of labor, and managers of the production and the sale of armor they were business men as well as craftsmen. About such master-craftsman entrepreneurs we have a great deal of fragmentary information.

One collection of short biographical sketches[1] deals with about a hundred of the most famous Continental arms- and armor-makers. These masters were all known internationally for their skill, and their services were widely sought. Let us look at three family groups for what they show of the business of armor-making. Since these, of course, represent the *de luxe* business in armor, they are not representative of the whole industry.

One of the first to acquire wide fame was the Missaglia-Negroli family of Milan. In the middle of the fourteenth century a Negroli of Missaglia in Italy went to Milan as an arms-maker. His son, Tomaso, became an armorer and worked with the father; he brought undying fame to Milanese "harness" and raised their school to a position of leadership in the industry. In 1430 was born Antonio, the son of Tomaso. Like his father he became Milan's most famous armorer of his generation, and he continued to hold their Milanese workshop in first place. Sources tell of his activities from 1450. He made a great deal of armor for crusaders as well as for the nobility of Europe. Beginning in 1466 he received 20,000 *lire* for 100 suits of armor for the soldiers of a duke. One record says that the armor in process in his workshop was at one time worth many thousands of *ducats*.[2]

[1] Wendelin Boheim, *Meister der Waffenschmiedekunst vom XIV. bis ins XVIII. Jahrhundert* (Berlin, 1897).

[2] If this was the Venetian *ducat*, it was worth slightly less than the $2.50 gold piece of the United States.

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Of the same family, in the sixteenth century, were Filippo and Giacomo, who were known by the original family name of Negroli. They were brothers and partners. Filippo became the more famous of the two, acquiring great wealth and a title. He executed orders for the greatest rulers and the nobility of several European states. In sixteen years of work on orders from French royalty and nobility he is said to have earned 50,000 *thalers*.[1]

Another famous group was comprised of three generations of the Colmans of Augsburg: Lorenz, Koloman, and Desiderius. Their ancestor had in 1377 come to Augsburg from Basel, and the father of Lorenz was an armor-maker who owned his own shop. Lorenz worked with him, gaining the attention of the court of Maximilian, the Holy Roman Emperor. After making armor for several persons of high rank, he was named court armorer. By 1500 he was both famous and well-to-do; indeed, he was in a position to help the emperor himself with loans. In 1506 he received for a suit of armor 4,000 *florins*,[2] paid through the great merchant Fugger.

Lorenz's son Koloman is known to have worked for the Mantuan court in 1507. In 1512 he began work for the Spanish court; and in 1516 Emperor Maximilian I ordered of him, through Conrad Peutinger of Augsburg, a suit of silver armor. In 1524 Charles V asked him to come to Spain, but Koloman excused himself by saying that he had a wife and children and enough work ordered by princes and nobles to take him two years to execute.

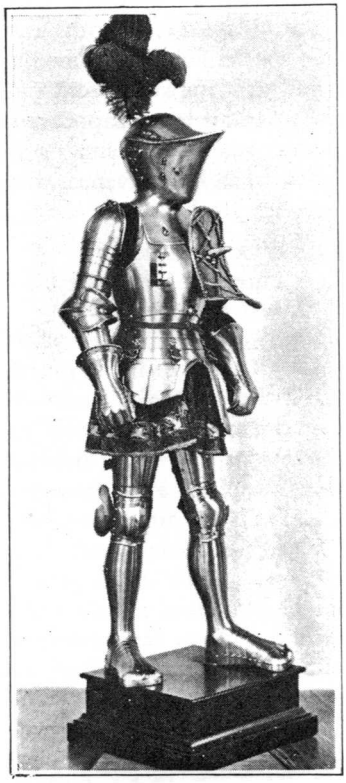
Koloman's son Desiderius was a brilliant and famous armor-maker. It is said that in 1543 he made a suit of armor for Charles V in three weeks. In 1549, according to records, he was paid 765 *scudos*[3] by Philip II of Spain for ten helmets, and in 1550 he was given 3,000 *scudos* for one suit of armor.

The Seusenhofers of Innsbruck were of an Augsburg family of armorers. Hans Seusenhofer, 1470-1550, was born in Augsburg and worked under a well-known armorer. In 1516 he became armorer to Maximilian I, and he also worked for many foreign rulers and nobles. Hans' brother Konrad was also court armorer to Maximilian I, and as such he was chiefly responsible for develop-

[1]If this was the German silver *thaler*, it was the equivalent of about 71 cents in American money.
[2]Probably the Florentine equivalent of the *ducat* of Venice.
[3]A *scudo* was a little less than an American dollar.

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ing the famous fluted armor which, because of its excellent glancing quality, gave a high degree of protection for its weight. His greatest difficulty as a business man seems to have been in making collections—he had a lifelong struggle with Maximilian to get payment for his work. Jörgen, the son of Hans, likewise received orders from foreign royalty and nobility, notably at Prague and in France. He seems to have executed his orders chiefly at Innsbruck.



A Suit of Spanish Armor, 1520
At the Higgins Museum

These armorers represented the élite of the industry and perhaps the highest development of the armor business of the time. Besides them there were countless local smiths who never acquired fame and the many itinerant journeymen whose capital was their skill and their chest of tools. And there were also the merchants. We know that they dealt in arms and "harness," transmitted orders for custom work, and made payments. They may also have financed production and even managed it to some extent.

However, it is the master-armorers, the general managers of the industry, who are of special interest in the history of this business in steel. They were, as was noted above, the organizers, the risk-takers, and the profit-makers as well as the trained craftsmen and engineers. We are interested in what they contributed to the industry in their own time, but we are also interested in what they passed on to the industry of our time.

Their business experience and their knowledge of metals, as well as their capital—all handed down from father to son and from master to apprentice—no doubt contributed in some measure to the modern steel industry. Probably only to a small extent did their

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skill as designers and craftsmen go into the making of the industry which succeeded them. That industry became a mass-production industry; and today our furnaces and mills produce in mass—from the same ore mines—plowshares, rails and locomotives, structural shafts, automobiles, engines, watches, hair springs, and jewelry, utilizing the hundred different controlled alloys for special purposes. Handicraftsmanship in the iron industry was, on the other hand, the inheritance of the village blacksmith, and horseshoeing and art ironwork became his special fields. In time the demand for horseshoeing disappeared and art ironwork went out of style. Then the skill of the iron craftsman all but disappeared. But the armor which the mediaeval armorer made still remains as an inspiration for today, as an example of what inventiveness and skilled craftsmanship can do in working with steel.

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