Ottavio Vittori - Anna Mestitz

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Translated and edited by James A. Gray

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PREFACE

Although the tremendous task of rescuing Venice consists mainly of painstaking restoration of paintings, structural repair of aging palazzi, and chemical treatment of statuary, there occasionally emerges a discovery of exciting interest to those concerned with the authenticity of works of art.

During the course of the extensive program of Venice Committee of the International Fund For Monuments, we have come across a number of "finds", most notably during the restoration of the famous cycle of Tintoretto's in the Scuola di San Rocco where our restorers discovered 18th Century additions and alterations which are now removed so that the paintings can be viewed as originally conceived by Tintoretto.

Equally exciting are the discoveries revealed in this book by Ottavio Vittori detailing his research into the "bronze cancer" reportedly afflicting the four golden horses which were already old when placed upon the Loggia of San Marco about 1204 A.D.

Early in his research Dr. Vittori enlisted the aid of a collaborator whom he calls Demetria, in real life his co-author Anna Mestitz, an attractive young technician in his research laboratory in Bologna. She supplies the needed element; the design sense to complement (and reassure) the scientific finds.

Dr. Vittori projects his personality as Everyman, playing down his very impressive qualifications as a physicist. He is interested in the total problem of the horses — not just the condition of their surface at this moment in time. But in investigating this very surface he uncovers a wealth of historical and artistic information.

Dr. Vittori is himself a warm and personable individual exuding a bemused charm. As I got to know him I discovered that beneath his easy social manner was the tenacity which spurred his inquisitive mind to run down even the slimmest clue in the investigation of the horses — a tenacity which he displayed during our "negotiations" over the editing of my translation of this book.

Dr. Vittori, who now directs the CNR (National Research Council) Laboratory in Venice, smilingly observes "When I did the research on the horses, I was in Bologna and had nothing to do with the 'physical' problems of Venice. Today, because of developments which had nothing to do with the horses, I find myself heading the laboratory which has everything to do with the problems of Venice".

James A. Gray
Executive Director
International Fund
For Monuments

Venice
October 1976

Nous ne cherchons jamais les choses, mais la recerche de choses

(PASCAL, "Pensées", 135)

Few scientists interpret the physics of the world which surrounds us using an artistic vision of the harmony of Nature. To the best of them, to my friend and colleague Frank H. Ludlam, this book is dedicated.

CHAPTER ONE

Parking one's car in Piazzale Roma has become a major undertaking.

I remember that the last time I drove to Venice — something like two or three years ago — I had to wait in line only at the cashier's window while checking out. But today when I arrive I find myself caught up in a long line. The fertile mind of the local bureaucracy has created a new hurdle: registration upon arrival. The line moves slowly like that of the money order window in a postoffice. And when my turn finally arrives, I find that registration consists merely of receiving a little yellow ticket in exchange for the red ticket given me by the parking attendant.

Most tourists accept this unforeseen waste of time with calm resignation. But the American in front of me examines his yellow ticket attentively and then glances at me, his eyes friendly but quizzical. I understand perfectly. Since his arrival in Italy harassment such as this has frequently been his lot. He can no longer marvel at anything. I am unable to return his smile.

I realize that I have lost a great deal of time and, as is unfortunately a habit with me, am very late.

I hurry across the square and with rare luck, take the correct vaporetto, the "Diretto" for San Marco. Once before I managed to take the slower "Accelerato". I was late then, too.

The PROFESSOR WHO KNOWS ALL ABOUT THE HORSES (hereinafter PROFESSOR W) is waiting for me in Florian's. Until last night I knew nothing about this venerable old establishment. As a matter of fact I heard the name for the first time from this same PROFESSOR W over the phone when he said that we should meet at Florian's. Just Florian's — nothing else.

Before setting out I asked my friend, THE GREAT ART CRITIC, with whom I share a house (actually the house is his but I share it along with his cigarettes and his television set — fringe benefits which are not considered in the rent for my apartment). He agrees that it is inconceivable that an adult Italian not know about Florian's. He explains, somewhat sarcastically, "Florian's is in Venice — in a charming little square called San Marco". He obligingly sketches me a map. "Now, pay attention. Here on this side of the square there is a little church — and if you have a moment, do have a look because it is not bad; and under the arches, more or less about here, is the place you are looking for".

I have no difficulty locating it; small rectangular marble-topped tables, pictures on the red velvet walls. To have to enter such a place is usually embarrassing for me. But this time the warmth of the boiserie and the old world charm have their effect. The impeccable waiters receive me with that special smile reserved for patrons and I feel immediately at home.

PROFESSOR W greets me most cordially, ignoring my conspicuous tardiness — perhaps he, too, has been lulled by the timeless quality of this little world — and, seated before a fragrant breakfast, we begin our conversation. I come straight to the point

and explain the nature of my visit:

The BIG BOSS in Bologna summoned me to inform me that I have been nominated to take part in a commission of scientists convened to study the causes of the deterioration of the four golden horses on the Basilica, and to formulate proposals for their restoration. The initiative was that of the Procurator of the Basilica of San Marco. I do not tell PROFESSOR W that the BIG BOSS, noting my hesitation, had rapidly concluded our conversation by pointing out that the problem involves important scientific aspects which only a highly enlightened physicist could tackle, declaring, "Who else but you, dear friend?".

The trouble with the BIG BOSS is that he always gets his way. I tried to express some reservations about my usefulness in the task that he asked me to take on and hinted at other important responsibilities which required my full participation; all to no avail. As on other occasions, I emerged from his office not only convinced of my singular genius and competence for solving the problem of the horses, but imbued with the determination of James Bond setting off on one of his most perilous missions.

I do explain to PROFESSOR W that my usual field of work is of quite another nature. I am an experimental physicist studying the physiochemical processes which occur in the atmosphere, mechanisms of gases and particles in fluids ranging in scale from the microscopic to the planetary. But it is also true that I know something about chemical reactions between atmospheric gases and particles and surfaces exposed to the air. I hint that the task entrusted to me does not greatly inspire me, but that an invitation issued by the BIG BOSS is unfortunately more than an invitation. Particularly because the BIG BOSS is above all else, a Venetian. I assure PROFESSOR W that I will do my best with the problem concerning the horses.

He tells me that one of the horses, that in the worst condition, has been removed from the Loggia and set up in an air-conditioned room; this "laboratory" horse will be available for examination by those doing the research for the Commission.

I am reluctant to tell PROFESSOR W how little I know about the golden horses. I ask him a few questions of a general nature trying to be as vague as possible. But I must have made some inept blunder because I see from his expression that he is wise to me — for I know less about the horses than a tourist to Venice clutching his "Venice in One Day" guide-booklet.

So much the better, because PROFESSOR W takes advantage of the time remaining before the meeting to give their history:

The story takes us back to the Middle Ages, to the early years of the Thirteenth Century. The Roman Empire in the West has been defunct for several centuries, but the Eastern Empire is flourishing and powerful. Europe, divided into many states, is united by the Crusades. The common effort to repossess the Holy Sepulcher serves to partially smooth over the various disputes among member states of Christendom. The Pope is the real master of the Western World.

The Third Crusade, that of Richard the

Lion-Hearted, is terminated and with notoriously little success. The capital of the Kingdom of the Franks has moved to Acre, while Jerusalem and the entire coast south of Jaffa remain securely in Saracen hands.

The beginning of the 13th century is the ideal moment to announce a new Crusade. On the Papal throne sits Innocent III, a Pope of great authority with all the cards in his favor for ordering a new Christian effort against the Saracens. But unfortunately for the papacy, enthusiasm for the Crusades is not so fervent as in previous years. It isn't easy to find a fearless, honest, brave and loyal knight willing to fight solely for the Cross.

The IV Crusade, that of Innocent III, reveals how much Western Christendom has changed.

The leaders of the participating armies turn to the Venetian Republic for the transport of men, arms and provisions. The Venetians state their conditions and, after lengthy negotiations, a price is set for the use of Venetian ships and sailors. Venice is not asked to participate directly in the Crusade, but a series of circumstances makes her an active participant. For one thing, Venice is the only state which has had frequent commercial contacts with the East, in particular with the Greco-Byzantine Empire.

These relations have been by no means always cordial. If the Byzantine Emperor were liberal and disposed to foreign collaboration, all went well with Venetian commerce. All this changed when a new Emperor came to power and adopted an autocratic policy. Then the Byzantines administered their own commerce and tolerated no foreign interference. Should such interference be discovered, the powerful Empire dealt with it severely. In Constantinople during these periods, campaigns of reprisal and provocation were set in motion, particularly against Venice. It was during one of these campaigns that the Byzantines attempted to burn the Venetian fleet.

About the time that the Fourth Crusade is called, a palace revolt deposes the Emperor with whom Venice had enjoyed good relations. The usurper revitalizes the xenophobic program and commerce with Venice is again endangered.

At that moment Venice has a great and powerful Doge, Enrico Dandolo, a man of remarkable military and political accomplishments who has, at the age of 85, experienced about everything including an extraordinary torture at the order of a Byzantine Emperor.He came out of that ordeal much the worse for wear — the flashing blade having reduced him to almost total blindness. For one such as he, accustomed to commanding a great fleet driven by the wind and guided by the stars, the handicap must have been sorely felt. But he betrays little sign of old age or infirmity; his mind is clear, his character strong, and he knows how to make bold decisions in the name of Venice.

About this time the deposed emperor (the one favorable to Venice) lets it be known that, once restored to the throne, he would be prepared to pay the costs of transporting the crusading armies, but to Constantinople rather than to the Palestinian coast. In addition to this financial consideration he

would also make valuable trade concessions to Venice.

Doge Dandolo is unquestionably pleased with this proposal and realizes how it might help resolve another thorny problem: along the Dalmatian coast several nominally Venetian cities have rebelled and are unmoved by the blandishments of emissaries of the Venetian Republic.

Enrico Dandolo decides, as it were, to kill two birds with one stone. To the leaders of the Crusade he suggests that Venice could be very lenient about the terms of payment if the armed crusaders were to lend a hand in bringing the troublesome Dalmatians into line. The Crusade leaders agree and this particular phase is carried out without difficulty.

Meanwhile in Rome, Pope Innocent III becomes concerned at the delay, and at the intrigues which have diverted the Crusaders to objectives other than the recovery of the Holy Sepulcher. He dispatches a series of strong messages to the heads of the armies urging that they launch their crusade without further delay. Dandolo ignores the Pope and pursues his own course. He wants the other bird!

The Venetian fleet lifts anchor and, with a large part of the crusading army aboard, sails not towards the Holy Land as ordered by the Pope, but towards Constantinople, as ordered by Dandolo.

Constantinople falls against the combined onslaught of the Crusaders and Venetians. The deposed Emperor regains his throne and almost immediately dies. Greek insurgents slay his son, proclaim a new Emperor and drive the Crusaders back onto the Venetian ships. Doge Dandolo stubbornly refuses to abandon the campaign and, after months of seige, the walls are scaled and all opposition collapses.*

Constantinople is the richest and most beautiful city in the world — the depository of works of art borne of the genius of Greece and Rome. The evolution of culture, which in Europe has been stalled for centuries, has flourished steadily in the East where the achievements of the human spirit have reached unimagined heights. Unfortunately, the victors do not limit themselves to slaughter and plunder, but destroy a great wealth of documents attesting to the achievements of Byzantine civilization. Manuscripts and paintings are destroyed and prized bronzes melted down for use as war material.

Enrico Dandolo knows what he wants. He is the perfect example of a ruthless servant of his country. To ensure a lasting prosperity and commercial security for Venice, he makes a bold decision. He will rebuild the Roman Empire!

"Cose dell'altro mondo!" — a Neapolitan expression which translates roughly to "Out of this world" or "Incredible!"

Here we have a man of eighty-five, whom modern social organizers would have spending his twilight years feeding the pigeons in Piazza San Marco. Instead he commands a great fleet carrying a crusading army to the East and, with a strategy worthy of Julius Caesar, he conquers the capital of the most powerful empire on earth, supervises its destruction and now plans the rebuilding of the Latin Empire!

* Editor's note: April 1204.

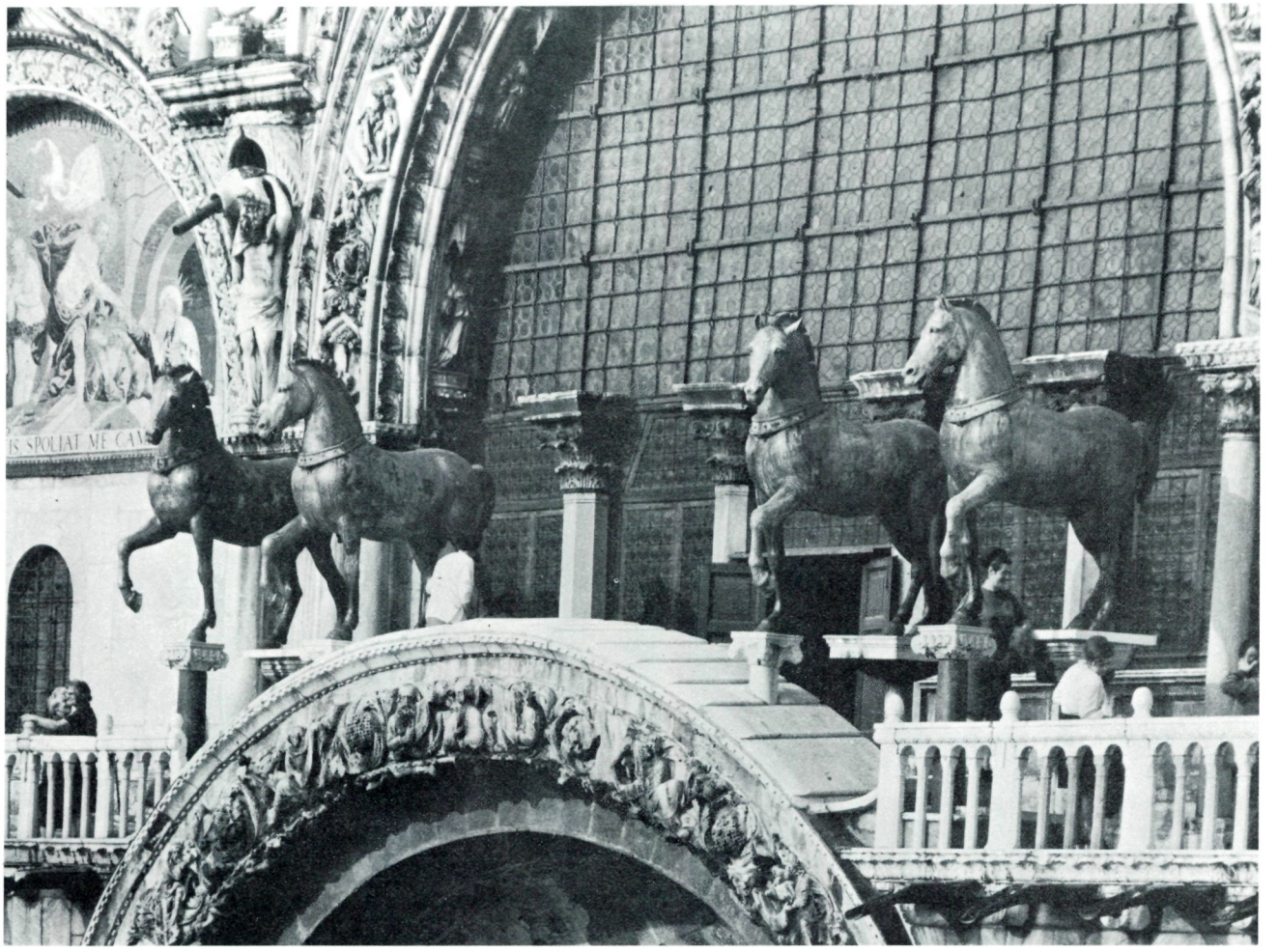


Figure 1. *The four horses of San Marco.*

Dandolo declines the nomination as Emperor of Constantinople, taking instead for himself and future Doges of Venice the title "Lord of one quarter part and a half of the Roman Empire".

It is difficult to believe that a man of his stature could have personally participated in the carnage. We can imagine him standing immobile in some great square of Constantinople, gazing in admiration with his poor old eyes at the top of a tall edifice where stand four glorious golden horses. Perhaps the harmonious beauty of the gilded bronzes brings home to him the full import of his achievement — or rather, for one of his nature, Venice's achievement. He decides that for the future, the golden beasts will symbolize the struggles of the Venetians for commerce with the East and the independent spirit of their Republic. He decrees that the four golden horses be taken not as individual booty, but for the people of Venice.

Dandolo had no way of foreseeing the far-reaching consequences his deeds were to have on the future of his city. The Byzantine Empire which has been dealt such a crushing blow had until then been the sole bulwark against Turkish expansion. History cannot be written with "ifs" but it is perhaps possible that the decline of the Byzantine Empire was indirectly responsible for the adversities suffered by Venice in subsequent centuries — the bloody struggles with the Ottoman Empire — victory sometimes on one side, sometimes on the other — until the famous battle of Lepanto when the fate of Venice and all Christendom was decided, thanks to another doughty Venetian of the same mold as Enrico Dandolo.*

The four horses are carried off to Venice where they are received in triumphant ceremony. It is decided by popular decree that they be mounted on the Loggia of the Basilica of San Marco to reign over the fortunes of Venice for centuries to come. These fortunes have varied considerably but the horses are still up there and Venice is still above water.

The horses remained on the Loggia for almost six centuries regally watching over the fortunes of Venice. During this period only a few scholars sought to learn anything about them and no one thought to inquire about their origin. There they stood and were accepted by all as something fixed and immutable. Nor were they much mentioned by the celebrated writers of the past. Petrarch was the first to write that he had seen them in Venice.

At the beginning of the last century the four horses began to move; first, by order of Napoleon after his conquest of Venice. The story is well known. Reaching an agreement with Austria, Napoleon attacked the city and, after a long and weakening seige, it capitulated. The victorious French behaved very much as had the Crusaders six centuries earlier in Constantinople.

Among the spoils of war demanded by Napoleon were important works of art. Paris was to become the Art Capital of Europe! Venice shared with other conquered cities the burden of offering up a rich collection of paintings. At some point in the operation, the French decided that the four golden horses might provide the most fit-

* Editor's note: 75-year old Sebastiano Venier.

Figure 2. *Napoleon's soldiers removing the four horses for transportation to Paris.*

ting monument to the conquests of Napoleon. They were taken down from the Loggia and transported to Paris where they were shunted from one pedestal to another until 1807 when they were harnessed to a triumphal chariot atop the Arc du Carrousel. An ambitious servant of the Emperor conceived the idea of placing a statue of Napoleon in the chariot, but the Emperor quickly squelched the plan, saying "I am not one for whom statues should be made. Let the Victory Chariot remain, but empty". One wonders whether the declaration was prompted by unusual modesty or an excess of megalomania.

There they remained for seven years until, with the fall of Napoleon after the "One Hundred Days", the Emperor of Austria ordered the four horses returned to Venice. And, as a fitting bit of sentiment, it was decided that, since a Dandolo had brought them first to Venice, another Dandolo should bring them back. Anyone with the slightest knowledge of Venetian history knows that a Dandolo is always to be found, and found he was, to escort the horses back to Venice and their Loggia of San Marco.

During World War II they were taken down and moved to a safe place to protect them from enemy . . . and friendly troops. In 1945 they were placed again on the Loggia.

Only in recent years, actually since the war, have the horses been the object of technological and archaeological study. Today many scholars are pondering the origins of the horses — not their relatively recent acquisition by Enrico Dandolo, but, in archaeological terms when, how, why, and by whom they were cast.

Theories on the subject are many and conflicting. There is the basic question as to whether they are of Greek or Roman origin — and in terms of time alone this could vary their age by about five centuries. If they are Greek, they could date from the fifth or fourth centuries B.C. If they are Roman, they might belong to a much later period — possibly that of Nero.

Research may be based on the most varied elements: the morphological characteristics of the horses (race, species, quality, and so on), the symbol that they may have represented in the past, the composition of the alloy of the casting, etc. Some researchers devote attention to historical documents, or to other archaeological discoveries linked with their history.

PROFESSOR W tells me that during the meeting later this morning, I will be given the technical data relative to the metal alloy of the horses. It appears that the alloy used is far from being the most suitable for casting.

Some historians claim that the Romans of Nero's time were perfectly capable of producing a good bronze alloy, while the Greeks of the period of Lysippus probably knew very little about it. Others suggest that although at one time the Romans were masters of the techniques of casting bronze, they probably lost this knowledge over the centuries. Still others argue that the Greeks did not normally gild their bronzes, but this hypothesis can be disputed by other data.

The morphological aspect of the horses'

structure must also be considered: they are seemingly not of that trim, fleet horse which for some is the Greek ideal of equine beauty. This opinion is questionable if one examines finds whose origins are indisputably Greek.

One alert writer pointed out that while close up the horses may appear thickset and ponderous, from the distance they give the impression of being slender and agile. Another important and frequently discussed aspect is the presence of trappings. There is clear evidence of harness having been present. The Greeks rarely burdened their sculptured horses so, while the Romans would have made four horses together only as a quadriga. It is suggested that Nero himself was represented as the driver of the chariot drawn by our four horses.

Historical documents throw little light on the subject. Several writers of the past speak of four golden horses, in different places and at different periods in history: once in Delphi, once at Chios, and another time in Rome. Some scholars believe that different sets of horses may have been involved, while others hold that the same four horses were moved about over the centuries.

PROFESSOR W detects that I am hooked, and that my curiosity has been sufficiently aroused. But it is not, as he probably imagines, that my professional interest as a physicist has been stirred, but rather because of a longtime pseudo-archaeological fantasy. As a boy, I explored the catacombs of St. Agnese looking for the subterranean passage which in Roman times connected the catacombs with the banks of the river Aniene. A schoolfriend and I devoted two summers to the research. More recently, I worked out a system using highly sensitive instruments for measuring magnetic fields in the hope of locating Alaric's burial place in the bed of the Basento River, a dream that I have not abandoned.

I think back over what PROFESSOR W has told me and I try to imagine what these four golden horses could actually mean for Venice today. Certainly, they are no longer closely associated with the conquest of Constantinople. They are no longer spoils of war. For centuries they have symbolized Venice's struggles to defend Christianity, and in turn Western culture. Standing up there on the Loggia, they tell us why Europe is as it is today. They speak, unfortunately, only to us Westerners because the inhabitants of Constantinople, or today's Istanbul, may think differently about the turn of events.

It is time to go to the Palazzo of the Procuratoria to join the meeting and I note with satisfaction that PROFESSOR W picks up the check.

CHAPTER TWO

I am presented to the other members of the Commission who do not seem particularly impressed with my references. The meeting is yet to be officially opened and they stand around in small groups discussing the horses. It is immediately evident that they have already known each other for some time. I understand very little of their conversation of which I hear occasional fragments; gold coins incised with horses, blisters in castings, tassels, and archaeological explorations in Turkey. I get the impression from the language they are using, and their references to their work, that each knows his business. (I refer to both technicians and archaeologists).

The meeting opens officially with an address by the Procurator of San Marco who explains that the Procuratoria is an organ of the Church and that it is responsible for the Basilica and all the art that it contains. The interest of the Procuratoria in the art for which it is responsible is more like that of a proprietor than that of a custodian.

The words of the Procurator are very clear. The problem which confronts the Commission is the condition of the horses, the members present are those entrusted with the task, and the amount of money budgeted for the project is so much, etc. He asks the illustrious scientists not to be sidetracked from their mission which is to determine why the horses are in such condition and then to study the procedure for restoring and preserving them. He concludes by saying that the funds for this research come from an appeal by the Turin newspaper La Stampa to its readers, clearly indicating the widespread interest in the rescue of the horses. Members are asked to keep faith with these anonymous contributors and not needlessly spend these funds. He then asks that the members seated around the table immediately formulate a program that is detailed, clear, realistic and above all, has a scheduled completion within a reasonable time.

I am very much inpressed with the clearly expressed intent of the Procurator and I am fully in favor of the control which he places on the expenses of the research. I am aware, however, that once again I am undertaking a project solely for glory (if there is any) and, when the research is completed, no one will ask me to present a bill. But at least I am not being taken in, for I am already accustomed to this arrangement. As a matter of fact, I would feel embarrassed were I forced, as are doctors and attorneys, to establish a price for my services.

Reviewing step by step the speech of the Procurator, I find myself comparing it with other presentations of work programs, on other occasions, seated with other experts, around other tables. I conclude that these priests know how to operate. From something which the Procurator said, it is perfectly clear that the functionaries of the Procuratoria will carry out to the letter the mandate entrusted to them. But in addition they profoundly love the works of art in their custody. They suffer and worry about the deterioration of the bronzes and marble and are eager to participate actively in the battle

against the general deterioration which has been afflicting Venice. And then I remember that during his introductory remarks, the Procurator said nothing about the efforts of the Italian Government on behalf of Venice. He never mentioned either the national or regional governments. It would seem as though he were back in the time of the Venetian Republic when Venice stood alone.

After a series of lengthy answers to questions posed by the members, we begin to examine individual points of view. All members had diligently prepared written proposals and these are read aloud and discussed. The brief bit which I submit is obviously improvised here and there. Unfortunately, most of the proposals enter directly into the immediate problem without adequate background information and I therefore cannot understand the nature of the corrosion which we must remedy.

I follow very closely the presentation of a PROFESSOR OF METALLURGY FROM NOVARA (hereinafter PROFESSOR M) who has studied in detail the structure of the bronze of the horses, the composition of the alloy, the condition of the coating of gold, and the surface of the metal under this coating. His experience is not limited to the four horses for he has already examined other antique cast objects. He tells of his recent examinations, not mentioning the general condition of the horses, since such information is presumed to be known by those present. He attacks the problem of examining the alloy, citing the difficulty that he encountered in trying to obtain a sample for analysis. He explains in detail how he constructed an apparatus with which he was able to remove a sample. I understand immediately the difficulty that such an operation entailed. To carve out a tiny core of about 1 mm in diameter, separate it from the body and then remove it — all with the same instrument — must be a very difficult task. I try to imagine how much time and patience went into the preparation of a tool of that precision.

He goes on to describe the results of the spectrographic examination of the samples thus obtained: the alloy used for casting the horses is a bronze composed of copper, lead and tin, with impurities of iron and traces of other elements, including mercury. The percentages of tin and lead are very small — exceptionally small for bronze — thus accounting for the poor results of the castings as is evident by the presence of many plugs and craters on the surfaces of the horses. The presence of mercury is interesting. It might help establish a date in the technology of the gilding and this would be very useful for those trying to date the horses.

I learned only a few years ago that there are two methods for gold plating a bronze, both known from ancient times. The first employs an amalgam of gold and mercury. Such an amalgam can be achieved either by mixing gold directly with mercury, or by immersing the gold in a mercury compound. Depending upon the proportion of the mercury, the amalgam may be either liquid or solid. An amalgam of gold and mercury — let us assume that it is in liquid form — is spread over the surface of the

bronze which is then heated. The mercury evaporates and the gold is deposited shining and beautiful on the surface of the bronze.

The other method is the use of gold leaf — extremely thin sheets — which is applied under pressure to the surface to be gilded.

PROFESSOR M reveals that the creator of the four bronze horses used both methods. First, he used the amalgam and subsequently applied the gold leaf. He goes on to recount the results of the micrometallographic examination from which he had obtained important information about the characteristics of the alloy. From the crystalline structure in the alloy, he is able to establish that the bronze of the horses had been cooled and then reheated. He maintains that the formation of the observed alloy structure can be characteristic of the amalgam process. He adds that it is probable that a charcoal fire was used to reheat the castings. He describes the nature of the corrosive action currently taking place on the horses. He terms it "not serious" and pauses at this point to illustrate the results of a similar analysis which he has done on other monuments of bronze. He has determined that on some alloys there develops a type of corrosion which attacks directly the microscopic structure of the metal. In such cases the corrosion invades intimately the entire bronze and causes a process of deterioration which is irreversible.

The numerical values which he provides reveal that the bronze which was used to cast the four horses contains about 98% copper, a concentration about equal to that of commercial copper sold today.

At this point I begin to put together ideas. I recollect all that I had heard at Florian's about the origin of the horses. I match that against the results of the analysis reported by PROFESSOR M and I realize how important the information about the alloy could be for the archaeological investigation of the horses.

One fact appears certain: the unknown artist confronted the casting of this very difficult work without even the most rudimentary technical notion about the composition of a good alloy. To cast a bronze with such a high percentage of copper (and at this point I would say that it should no longer be referred to as bronze) must have been a titanic undertaking. The addition of tin and lead in proper proportions not only lowers the melting point of the alloy which becomes liquid at a much lower temperature, but improves the flow of the molten metal. An alloy of copper, tin and lead in the correct proportions runs freely in the mold. Pure copper, or a bronze poor in tin and lead like that used for the horses presents a sluggish liquid which solidifies too easily in the narrow parts of the mold. The results of a casting with such an alloy must be disastrous. Only an expert foundryman might appreciate the dismay which our great artist must have felt at the completion of the casting. Once removed from the mold, the horses exhibited surfaces of shiny copper marred by countless holes and craters like an enormous Swiss cheese. Undoubtedly the artist had already seen other castings with the same appearance and he

did not lose heart. He carefully trimmed away the ragged borders of the craters and, with infinite patience and exceptional skill, plugged the hundreds of holes with a series of accurately fitted intarsia to render the entire surface smooth and homogeneous.

The problems which he must have confronted to maintain that alloy in a molten state during the casting exceed my imagination. That which Cellini* recounts of the dramatic night of the casting of the Perseus gives one a rough idea. Even though he was very ill with fever (happily cured by an enormous plate of salad), Cellini ran around the house gathering up plates and flatware to add to the molten bronze, and chopping up tables and chairs to throw into the fire to maintain the temperature. Cellini, also, used an alloy poor in tin. But the circumstances were different because Cellini knew perfectly well the exact proportions of copper, tin and lead for a good alloy. But he had no choice. He had already spent the money which the committee had advanced for the purchase of the tin. Knowing Cellini as we do, we can easily surmise how he spent the money. He was confident, however, that once the Perseus was cast, there would be no way of knowing that he had misappropriated the Committee's money. But master caster though he was, Cellini could never have anticipated the difficulties which he was to encounter trying to pour into the mold an alloy so low in tin.

Let us compare the dimensions of the Perseus and the experience of the foundrymen of Cellini's day to the poor technical knowledge possessed by the ancient artist when he cast the tremendously greater mass of the four horses. This should give us some idea of the strength of character possessed by that unknown sculptor.

I have some doubts about the purpose of the duplicate gilding purportedly carried out by the artist. I cannot believe that he merely wished to use a surer method, and I suspect that the gold deposit from the amalgam was so thin that it didn't completely conceal the outlines of the metal inlays. I begin to think that nothing went well for our artist.

The meeting is recessed until afternoon when the Commission will visit the horses, or more precisely, the horse which has been removed fom the Loggia.

We go, finally, to lunch in a well-known restaurant. By chance, I manage to sit near the CHIEF ENGINEER OF THE BASILICA who is in charge of the horses. From him, I learn other things. He tells me about the most important happenings with the horses, some of which he has personally experienced. He talks of the golden bronzes as if they are his creatures.

With elegant but direct allusions, he admits some reservations about the interest which we scientists might have in his horses. He doesn't question our professional qualifications but makes it very clear that he hopes that the damage which we must necessarily inflict on the "laboratory" horse during our research will be at least less than that suffered during its first 20 to 25 centuries. He talks to me at great length about previous misguided attempts at research. I like his gentlemanly manner and the sincerity with

* 1500-1571

which he expresses his reservations. I feel a little guilty but do not understand why. During the conversation, I take advantage of the occasion to reveal my ignorance on the subject. He appears to appreciate my frankness and I get the impression that I have made a friend.

The magnificent lunch is over and I have the vague impression that the bill must have been substantial.

We enter the Basilica and, by means of a tightly curved stairway, reach the horses. It is my first time up on the Loggia. Crowded together as we are with colorful groups of tourists, the custodian carefully singles us out and permits us to pass without paying. We enter the air conditioned room where, mounted on a wooden platform, stands one of the four giant patients.

I know nothing about breeds of horses but have the impression that this is not a steed about which a horse fancier could speculate as to pedigree. To me it resembles a 2nd class riding horse more than a prancing steed yoked to a racing chariot.

The consultation is brief. While the others discuss intarsias, craters and "bronze cancer", I discover (for the others it is apparently well known) that the entire surface of the horse is covered with cuts and scratches, some of which are green while others, particularly the horizontal ones, are black. Clearly visible are the edges of the gold leaf that outline the black scratches.

I ask for an explanation but get very little — that some say that it is evidence of a corrosion not well identified; others that the scratches are acts of vandalism by soldiers of the English detachment which guarded the horses in Paris after the defeat of Napoleon; and another widespread opinion is that it is evidence of the feverish efforts of thieves to remove the gold.

The visit draws to an end and we make final arrangements for the next meeting. It is decided that each member take away a sample of the greenish substance which, as its color would indicate, probably contains a high percentage of copper. We are to make whatever analysis we feel appropriate. The other members of the Commission decide that to better examine the horse, it be opened by removing the head from the body. I am told that writers of the past all held that each horse was put together like a chocolate Easter egg; that the artist had cast separately the two practically symmetrical sides of each horse and then attached them together. That the two parts are instead the head and the body was discovered by accident when a horse fell during one of the moves.

The collar which each horse wears conceals perfectly the joint of the head and the body. I ask myself whether the collar was intended to be a decorative element or was conceived only to hide the joint of head and body.

We conclude our visit with the horse and we part with best wishes for successful research. When I step outside the Procuratia, I find that it is pouring and the Piazza is like an enormous swimming pool with the water already ankle deep. I am forced to run and naturally I do not have an umbrella. I have never possessed one. Again

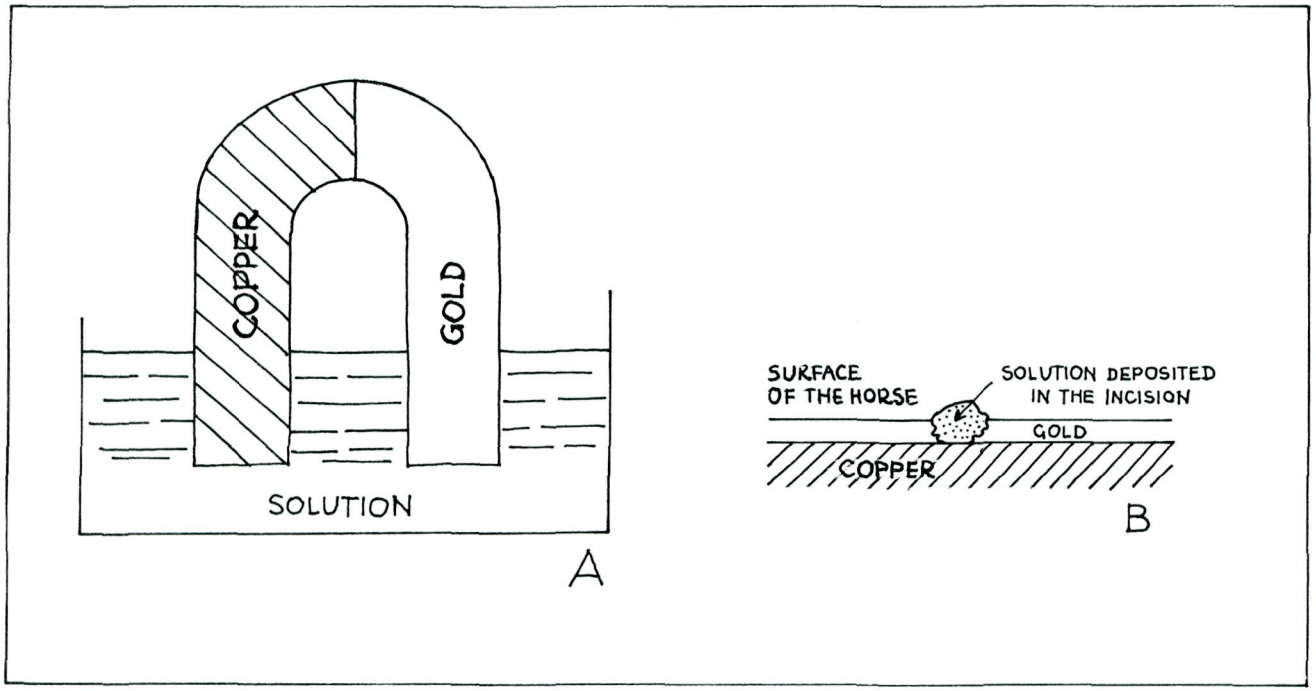


Figure 3 a & b. *Schematic drawing of a galvanic pile. Two metals joined at one extremity and immersed in a salt solution. The different electrical potentials of the two metals cause the passage of an electric current between them. The copper emits positive charges (actually copper atoms) into the solution towards the gold. In the process the surface of the copper becomes pitted or corroded. The copper particles entering the solution form copper compounds. On the surface of the horses the process is as depicted in Figure 3b. Contact between the metals is direct except in the incisions which are filled with the solution formed by the condensation of atmospheric moisture which also contains its share of pollutants. The galvanic chain is the same in both instances despite the differing geometry.*

We must remember that the processes of corrosion can be made more complicated by a wide range of mechanisms.

The galvanic pile (or chain) is so called because of the famous experiment of Galvani in which the leg of a frog jerked each time the frog lying on a copper surface was touched by an iron pin and a copper pin. In that experiment the elements of the chain were: copper — liquid in the nerves of the frog—iron.

I take the correct vaporetto and I feel like a seasoned Venetian capable of distinguishing the Diretto from the slower Accelerato.

Wet from head to foot, I join a long line to pay the parking charge, retrieve my car, and drive towards the Autostrada and Bologna. In a futile effort to dry myself, I turn up the heater to the maximum. I try to sum up the events of the day and form a preliminary evaluation of what I have seen and heard. I have difficulty concentrating because my feet are wet and cold. The car heater works well but the condition of the feet doesn't change. I begin to understand what my wife had in mind when she repeatedly urged me to buy a decent pair of shoes. As the car passes Rovigo, I am practically dry and my thoughts return to the horses. I have the feeling that in the general scheme of things which I have formulated, even though only approximate, something very important is missing.

I am stimulated by the enormous network of scratches on the surface of the "laboratory" horse and I cannot rid myself of the impression that the various explanations as to their origin are based on speculation. I promise myself that I will consult everything that has been written on the subject. Meanwhile, I begin to examine one by one the causes that were reported to me.

I am ready to exclude the idea that they are caused by corrosion of a chemical or electrochemical nature. I know of no realistic mechanism which could corrode the gold exposed to the atmosphere. I am aware that the air of Venice is reputed to be bad, but it is inconceivable that it contains a mixture of nitric acid and hydrochloric acid — the famous acqua regia — in concentrations high enough to attack the gold. I therefore rule out a chemical attack and I turn my attention to the process of electrochemical erosion. This occurs when two or more metals connected to each other are immersed in, or are present with, a solution containing dissolved salts. Two pieces of different metals joined at one end while the other extremities are immersed in a salt solution (Figure 3) constitute what is called a galvanic chain. Because of their atomic structure, the two metals possess an electric potential different from one another causing the passage of an electric current from one metal to the other. In the process one of the metals is consumed and its surface, initially smooth, takes on a spongy appearance. One might say that the metal has corroded. The solution can become colored by forming salts of the metal that it has consumed.

I try to apply this mechanism to the case of the four horses. When the gilded bronze surface is dampened by atmospheric moisture (which always contains substances in solution) there is set up a reaction between the gold and the copper. In this reaction the metal which corrodes is the copper, while the gold remains intact. An atom of gold will not dissolve during this electrochemical process regardless of the composition of the solution. The gold is spared from the corrosion at the expense of the "weaker" metal. In the case of the horses, the electrochemical process would have to consume more than 1600 pounds of copper — the entire horse — before we could talk of cor-

rosion of the gold surface.

The green color which one observes on the surface is that of the copper salts which were formed during the electrochemical process that has been going on until now. But we must rule out the electrochemical process as a cause of the scratches because as we have seen it does not account for the strips of gold which have disappeared.

During the meeting in the Procuratoria, I was shown an article published in an international magazine which reported the results of an analysis of the corrosion on the surface of another gold-plated bronze of Venice. Amongst the chemical substances found, all containing copper, there was an organic salt of this metal — copper oxalate. The conclusions reported in the article are vague. The author suggests that the process which produced the copper oxalate had possibly been brought about by the activity of certain bacteria, not specifically identified. I have heard of bacteria which metabolize metals but I am completely uninformed on the subject. I promise myself to ask a university colleague who knows all about bacteria. I would say that it is difficult to carry on a conversation with him on any subject, even the composition of the new government, without having it turn to bacteria.

I start to examine the other theories which were advanced. Again I promise myself to read everything available on the subject, but at the moment, I can only express doubt about the possibility that the scratches are the result of vandalism. The principal characteristic of a disfiguring scratch is that it is usually in the form of a Z — the Sign of Zorro. The disfigurement on posters of political parties during pre-election periods, or on those advertizing coming movie attractions, all have a common form — the Sign of Zorro. I plan to carefully examine the scratches on the horses.

I pass to the theory about thieves, a theory advanced by many authors including some relatively recent ones. Frankly, I find it difficult to accept. I remember the very narrow width of the scratches and I cannot believe that a thief worth his salt would operate in such an inefficient manner. If he wished to remove the gold from the surface, he would use a pallet or large scraper — most certainly not the needle-pointed tool that made these scratches. I make a calculation of how much gold the "needle thief" could remove with one of his scratches and conclude that the quantity would be so small that trying to remove it from the point of the tool would in itself be a problem.

I have completely confusing ideas but I am firmly convinced that I must devote most of my investigation to the problem of the scratches.

I arrive in Bologna with an empty tank and completely exhausted. Unfortunately, my day is not yet over because I must participate in a bridge tournament. To allay my partner's anxious concern, I assure him as I sit down at the table, that I am in brilliant form.

I have no comment about the outcome of the tournament and I prefer to forget my partner's remarks about my brilliant form.

CHAPTER THREE

The next morning as I enter the laboratory in Bologna, I have the uncomfortable feeling that I am not up to confronting the awaiting problems and giving them the attention they require and deserve. I can't get my mind off the four horses.

I don't know how to explain to my colleagues that I am to dedicate a portion of my time to this unusual work. In an effort to quickly interest them in the problem, I give a brief run-down on the events of the day in Venice. But the more I talk, the more concerned their expressions become.

I know exactly what is in their minds — that "here we go again! This one has taken on another crusade and will give his all to those four horses about which we don't care a damn, putting off until God knows when the completion of our important research — our real work!".

I hint at the romantic aspect of the history of the four golden horses but my words fall upon a sea of indifference. I change my approach, saying that I am duty bound to carry out the task which I have accepted. But they know me too well to be moved by such declarations of integrity. The discussion gets heated and each one takes the opportunity to tell me in no uncertain terms just what he thinks. "When have I ever respected a pledge to do something if the subject didn't interest me?" They cite, one after the other, my notoriously unfulfilled pledges of the past. "And what do horses have to do with physics? Or better yet, what does physics have to do with horses?".

They remind me of other discussions that we have had during past more friendly conversations and my Quixotic defense of our mandate as scientific researchers — that, and they quote me, "we must not get involved in problems outside the field of our competence". They rehash the paradoxes which from time to time have involved me and in which I have expressed opinions about the limitations of physics when crudely applied to certain problems — for example, the control of automobile traffic in Bologna. I remember the incident: the sadism of the Assessor for Traffic who each day invented something to help win his battle against owners of private cars. It got to the point where we were discussing the possibility of using a physico-mathematical model for solving the problem. I had said that it had in physical terms, one and only one solution: if the flow of traffic is to remain constant at every point in the network of streets, as is true with the flow of liquids in pipes, the width of the street multiplied by the velocity of the automobile must always give us the same figure. A rapid calculation showed that in the older center of the city where the streets are quite narrow, the automobiles would have to travel at about 200 miles an hour.

Other paradoxes are brought up and then they renew their heavy attack on the four horses. I try to bend with the character of the conversation. I admit that I am prepared neither in the history of art nor in the matter of traffic control, but I am qualified to tackle certain portions of the prob-

lem confronting the horses. "I will confine my interest to those aspects which I feel to be within my competence". They do not believe that I will limit my interest to such a marginal aspect of the research.

From the waggish, witty tone, the conversation passes to the serious, and they insist that work in the laboratory must continue and that, whether I want to or not, I must actively participate in the research in progress. I advance a conciliatory proposal — that I will work on the horses only during my free time. A humorous, futile attempt since they all know that I have no free time. Finally, realizing that I am determined and that further efforts to dissuade me are a waste of time, they pretend that they believe my promises and we part good friends.

I hear no comment when, a half hour later, I endeavor to enlist help in preparing to go and collect samples of the substance of corrosion deposited on the horses. I am able to persuade the BEARDED ONE to lend a hand. He knows everything about chemical and mechanical techniques. In record time, he prepares everything necessary. He describes in detail exactly what we must do and he gives me a practical demonstration. Knowing well from past performance my poor manual dexterity, he shows me how I must place the samples within the small containers. I declare that I understand and that I will do my best not to mix the samples and containers. He gives me a red pencil with which I am to write on the containers the necessary data so as to identify the exact spot from which the sample is taken.

Immediately I organize another trip to Venice. My explanation is that I must collect samples for an additional analysis. I know perfectly well that the PHYSIOCHEMIST OF PADUA is capable of doing this much better than I and with much less trouble since Padua is so close to Venice. In reality, I want to return to Venice to examine without distraction the scatches on the horses. I decide to go the next morning.

During breakfast I hear on the radio that it is raining heavily all over Italy and I realize that it would be foolhardy to brave the slippery roads in my old car. I leave Bologna driving a smashing new sports model rented from Hertz.

I arrive in Venice and encounter the usual long lines at Piazzale Roma. Wet to the skin, despite a new raincoat, I find myself again in the room with the ailing horse. I collect the samples in accordance with the instructions of the BEARDED ONE. I am pleased because, after two or three faulty attempts, I succeed and place the samples in the containers, seal everything as instructed, and then devote myself to a careful examination of the scratches.

My first exploration is reassuring. I do not find the famous sign of Zorro. I concentrate on examining the chest of the horse where the scratches are for the most part black, meaning that the corrosion process is less active. The black is the color of the layer of oxide which covers the bronze alloy. It is not truly a process of corrosion. Copper, exposed to the air, becomes black. I also carefully examine the green scratches. The green is the color of the products of

Figure 4. *Detail of a portion of the network of black and green lines, the latter appearing white on the photo and more ragged than the black lines.*

the corrosion of copper. I note that while the greater part of the black scratches are horizontal, the green ones are nearly all vertical. The complex of scratches thus resembles a network of black and green lines.

The black lines are cleanly cut scratches with perfectly defined edges and regular paths. In comparison, the green lines have irregular edges with the color running unevenly. Where the accumulations of the green substance have filled the cracks entirely, the green spreads to an area wider than the scratch.

The watery solution which has corroded the copper, either by chemical or electrochemical attack, must have flowed from the top towards the bottom. The flow was channelled in the green scratches which prior to their corrosion must have had the same characteristics as the black ones. This makes me realize, before anything else, that the water which caused the corrosion is not rain water, but water from the condensation on the surface of the horses.

The corrosion process must be as follows: the horses are in open air, in an elevated position and well exposed to the sky. During the night the metal is cooled as its heat is radiated towards space.

The radiative cooling of bodies is a phenomenon which we observe frequently. When we open a refrigerator, the sensation of cold comes not from being engulfed in cold air but because our body loses heat through radiation towards the interior of the refrigerator and we feel this loss of heat. The heat lost by radiation from the body is absorbed by the cold interior walls of the refrigerator.

The same thing occurs when bodies are exposed to the sky. The heat radiated by one body towards another cooler body passes through space as does light. The sky is much colder than a refrigerator. When we leave our car parked in the open on a clear evening, we come back to find the top covered with tiny droplets of moisture. The top of the car is cooled by loss of heat through radiation towards the sky, i.e., towards space. The loss of heat causes a lowering of the temperature of the top of the car, and the moisture which we observe is the atmosphere's vapor which has condensed on the cool surface.

Similarly with the bronze horses, their backs are cooled by radiation towards the cold sky. The air's moisture condenses and is deposited on the upper parts of the horses. In Venice with water just a few feet away, the process is frequent and substantial.

The moisture which condenses contains in solution the corrosive substances prevalent in the air of Venice, particularly sulphur dioxide. The condensed moisture is therefore a weak solution of sulphuric acid which attacks the copper either chemically or (because of the presence of gold) electrochemically. The copper dissolves in the solution to form copper sulphate and other compounds, giving us the green color.

From the backs of the horses, the acid solution runs down the sides, channelled in the scratches which hold it by surface tension. The corrosive processes work on the copper and when the water evaporates during the day, the greater part of the green substance accumulates in the scratches.

Figure 5. *Detail showing the rivulet form of the green lines (white in the photo) which are nearly all vertical.*

Night after night, day after day, the condensation-evaporation cycle is repeated and the deposits of the substance continue to build up in the scratches. It is evident that the water runs more easily in the vertical scratches than in those horizontal. When the deposits fill the scratch to the brim, the solution runs out of the scratch and causes the vertical line to look like a thin rivulet.

Once understanding with good probability the mechanism of the corrosion, I examine the parts of the horses where the black lines are abundant. Temporarily putting aside the annoying interference of the green lines, I attempt to attach some significance to what I see.

All at once the network of signs is transformed and appears to me a harmonious composition. For an instant I have the impression that I understand everything but I do not allow myself to be carried away by enthusiasm because I realize that what I perceive is the result of a subjective observation — that it is even probable that I already had this idea in mind before arriving at my observation.

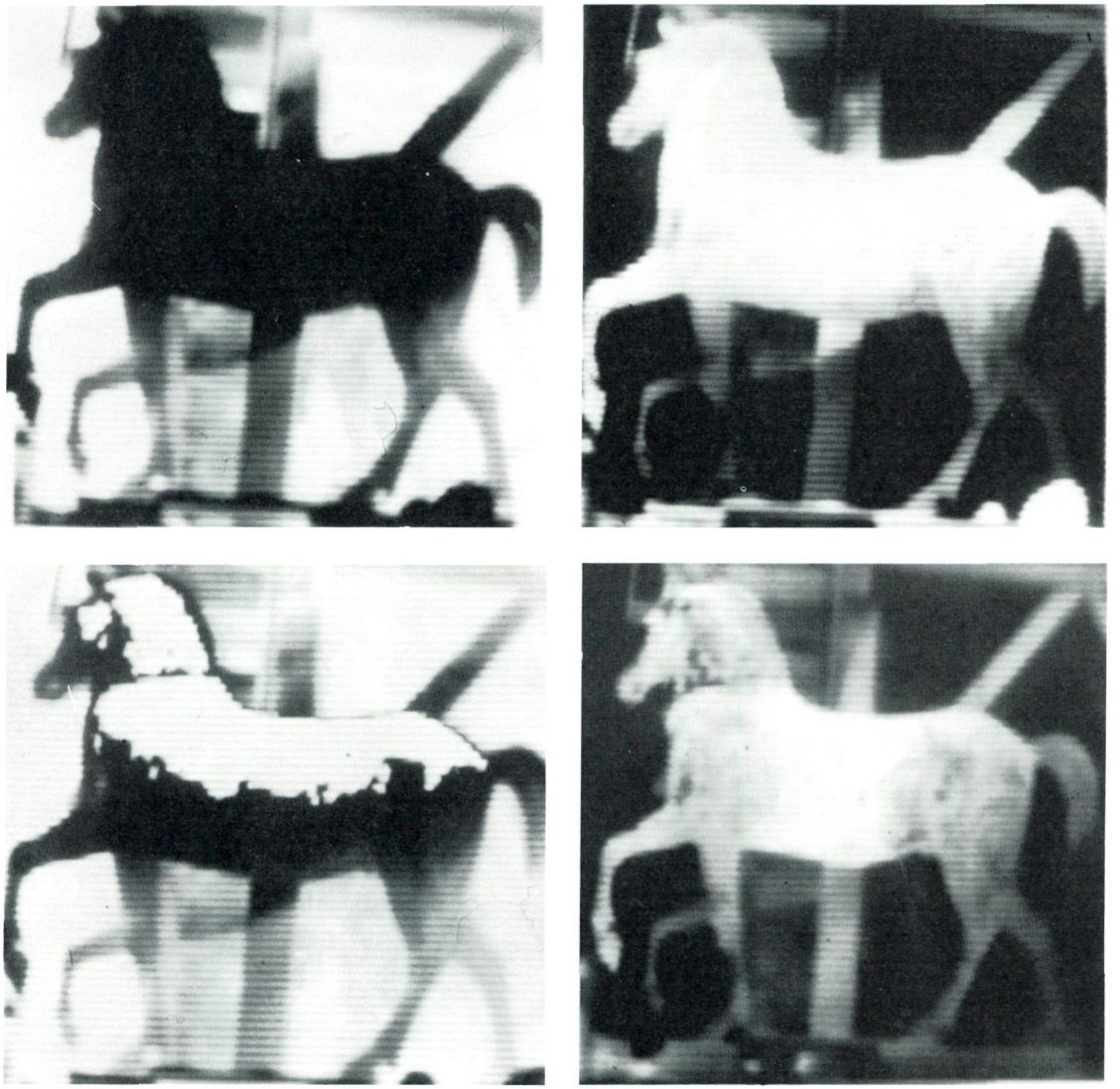
I must go somewhere and think calmly. I say a hurried goodbye to everyone, thank the functionary of the Procuratoria for his courteous help, collect the containers holding the samples and that evening I am again in Bologna.

The next morning I enter the Lab with a certain self-assurance. The idea of which I have caught a glimpse has grown stronger. I have the feeling that I am about to put my hand on the most important element of the entire investigation about the horses.

A quick check on the status of the normal activities of the Lab shows that most of my colleagues are very busy and will therefore not be able to assist in attacking the horse problem in depth. I want very badly to discuss with them the hypotheses which I have formed on this last visit to Venice. I also feel the need to consult with someone who has a mental approach different from mine. I decide to talk with Demetria, a colleague with a particularly artistic sense, and outstandingly good taste in color, composition and design.

In this new field of research I move with a certain insecurity and a discussion with Demetria, who knows little or nothing of physics, will surely be precious because she doesn't allow herself to be influenced easily by the opinions of others, including mine. She is a person who thinks with her own head and is equipped with a pronounced critical spirit which often brings her into heated discussions. If she doesn't share a spoken opinion, she might possibly remain silent, but in all likelihood she will in some manner let the speaker know how she feels. To give an idea of her independent spirit it is sufficient to recount her behavior during a visit of an illustrious American scientist whose friendship I value highly.

He is the happy, kind and unassuming type whom in Italy we would call a "bonaccione" (good guy). His sense of humor, I must frankly admit, often leaves me perplexed. His jokes, which he tells as humorous, are acceptable only because he explains them at the end with a sonorous and contagious laugh.



Figures 6. *Four photographs to illustrate the cooling-heating cycle of the horse. Photographs were taken with a special infrared device which is sensitive to the differences in temperature which show up as differing intensities in the photographic print.*

Demetria speaks excellent English and was present on this occasion because she was to translate a manuscript. I do not remember at which point my American friend revealed that there had recently been published a widely read book on physics of the atmosphere in which I had been cited twice. To illustrate to Demetria the creative level which I am capable of attaining, he recounts the episode for which I am most famous in American scientific circles — the time I invented the fork and spoon!

It was in Tokyo during a small congress of scientists. One evening my colleagues and I decided to try a restaurant in a remote part of the city, a place where only Japanese is spoken. During the meal we found ourselves in great difficulty with the chop sticks. Because of an erroneous interpretation of my gestures, I was served an enormous piece of fish with the consistency of uncooked cod. After several futile attempts to attack the fish, efforts which evoked hysteria in everyone present (occidental colleagues as well as Japanese patrons at other tables), I set aside those inefficient pieces of wood, folded my arms and stared at the fish. I ventured some comment about the wooden implements and then, goaded by my companions, I began to conceive an instrument to handle such food. Basing my remarks upon the concepts of physics, I succeeded slowly in successive steps, overcoming notable obstacles on a theoretical level to invent a species of fork. It wasn't as perfect as those of today (comments my friend), but it was a good prototype. He then went on to recount my analogous effort to invent a prototype of the spoon, and he concluded his narration laughing heartily and slapping his knee.

I had followed the story attentively and probably assumed an air of pleased participation. My friend turned his smiling face towards Demetria. His candid expression could have softened the heart of a traffic cop. But for my American friend, and in part also for me, Demetria's reaction was a dash of ice water. She arose without a word, gathered up the scattered papers, threw us a look of infinite pity, and strode out of the room.

My friend's smile froze on his lips and, in a very concerned tone, he asked if he had said something which could be offensive to a lady. I remember answering so as not to hurt his feelings that probably he had talked too rapidly for Demetria to catch the more humorous details of the story.

In spite of this part of her character, she is the only one in the Lab available at this time to help me in this new and unusual research.

I give her the details of my visits to Venice and I illustrate the ideas which came to my mind after examining the scratches, adding the elements which I believe support such ideas. I note from her reaction that she is interested in verifying my hypotheses. Before she can change her mind, I telephone to the FACTOTUM of the Procuratoria of San Marco, an alert young man full of initiative. I ask him to escort Demetria on her visit to the horses.

She leaves by car the following morning for Venice and I anxiously await her return

that evening. I had hoped that she would telephone to give me her reaction but she doesn't.

The next morning in the Lab, knowing her spirit of contradiction, I am prepared to argue in support of my convictions. Happily this isn't necessary. She reports that her impressions about the configuration of the scratches coincide perfectly with mine.

We decide to confront the task of verifying our theory and we map out a general program of research, dividing the tasks between us.

She reports observations which she has made about the structure of the scratches — observations which can easily be documented and may be very useful. These new elements definitely rule out the hypotheses of acts of vandalism or thievery. She reports that on the horse's mane, where the surface is particularly rippled, thus appearing a crowded succession of ridges and cavities, there is not one scratch. She adds that the eyes of the horses are intact — they have no scratches. This circumstance means nothing to the hypothesis about thievery since the eyes were not gold plated. But it must certainly be considered alongside the possibility of vandalism. The eye is a fundamental element of expression, whether it be that of an animal or a man in works of art. It is one of the prime targets in the disfigurement of paintings and statues. I recall the disfigured busts in the Pincio, in Rome, and I must agree with Demetria's declaration. She also reports that the teeth of the horses are in perfect condition.

Demetria reports another interesting observation — the depth of the scratches. She notes that the incision made to remove the gold left no discernible mark on the underlying metal surface, clearly demonstrating that whoever made the incisions did so with delicate precision. This makes it even more inconceivable that the scratches are the result of a stab of a bayonet, knife or chisel wielded by a vandal.

But Demetria's acute observations do not end there. She adds that in some areas the points where the scratches begin are on an almost straight (if imaginary) line.

Our initial program will be to read whatever we can find on the subject and compile an exhaustive photographic documentation on the scratches.

The hypothesis which we propose to verify is that they are the result of a delicate work by an expert engraver. And I have begun to believe that this expert engraver is, in fact, the unknown author of these masterpieces.

Demetria observes that the entire network of incisions must have taken a great deal of time and infinite patience and she wonders why the sculptor went to all this trouble.

I reveal to Demetria other elements of the picture which is forming in my mind — elements which support all that we have hypothesized. These are elements in a field about which I know something: the physics of the eye and vision.

The human eye is stimulated by the light emitted from objects which enter its field of vision. The eye stimulus does not depend on the intensity of the light emitted

by the entire object but on the intensity of that emitted by its unit of surface — we call it brilliance. Stated succinctly, the stimulus to the eye is the same if from a part of the object as if from the entire object. There can be many examples to demonstrate this, one being the case of an observer looking at night from the street to a window pane which is uniformly lighted from within. His eye receives a certain light stimulus. If the window shade is lowered partially, leaving illuminated only a portion of the window, the stimulus that the eye of the observer receives is the same.

An object illuminated by the sun and reflecting all of this light (a surface capable of reflecting all light does not exist), would induce in the eye of the observer the same stimulus as would the sun, regardless of the apparent dimensions of the object.

A gold object illuminated by the sun dazzles the eye of the observer exactly as does the sun, regardless of the size of the object. The eye cannot determine whether the object is round, square, smooth or wavy. An eye looking at completely gilded bronzes illuminated by the sun can barely distinguish their outline and certainly could not appreciate the modelling and complexities of their surfaces.

Leonardo said: "NOTHING CAN BE DISTINGUISHED WITHOUT LIGHT AND SHADOW. LIGHT AND SHADOW ARE GIVEN BY LIGHT".

We have said above without explanation that the stimulus induced in the eye by a luminous object is not proportional to the quantity of light which the object emits in the direction of the eye, but simply that emitted from a portion of its surface which, for practical computations we can assume to be one square centimeter, one square foot, etc.

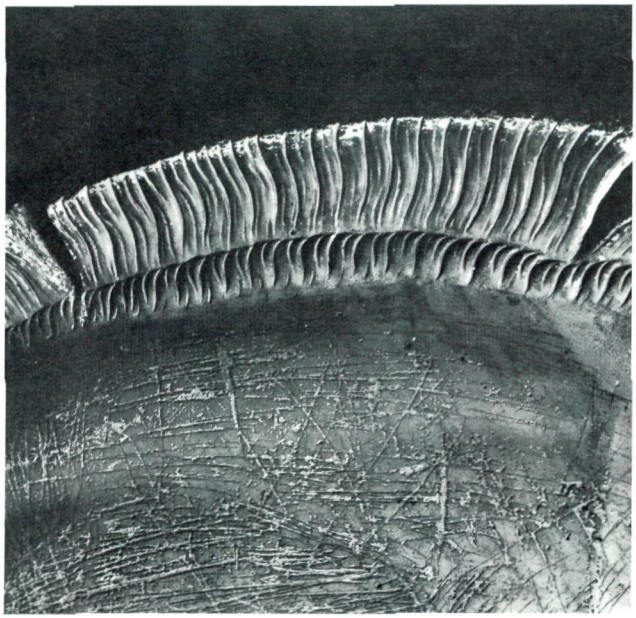
In short, the stimulus is the same if the eye looks at a small portion of the surface, or at all of it. Therefore, it would appear unnecessary to add anything further about the gilding of the four horses.

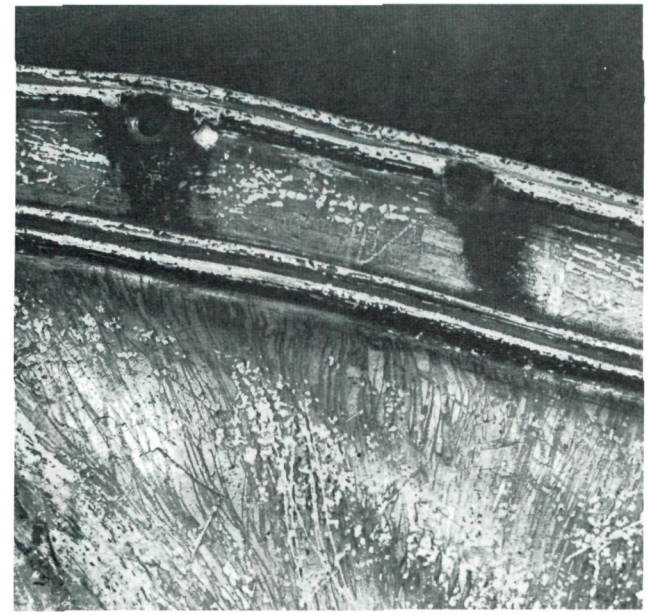
I believe (Demetria is less convinced) that some readers may desire a further explanation of the phenomena of light stimulus.

Let us try to construct a model to illustrate the mechanism of vision: it involves the object — eye — observer.

The eye is an optical instrument containing elements sensitive to light. When it receives a stimulus from the light of an object, it transmits a signal to the brain of the observer who has what is commonly called "light sensation" of the object.

The structure of the eye is the key to understanding the type of reaction which the light provokes in the observer. Some of us remember the toy cameras which were once given to children. These were working cameras even though they permitted no adjustment for focus or time of exposure. The eye behaves more or less like one of these toy cameras except that, in the place of the film, there is the retina composed of many tiny rectangles (the light sensitive elements), one adjacent to the other and each acting or reacting independently. Each sensitive rectangle receives a stimulus from a part of the lighted object and transmits its separate signal to the brain which puts it all together in a mosaic reproduction of the





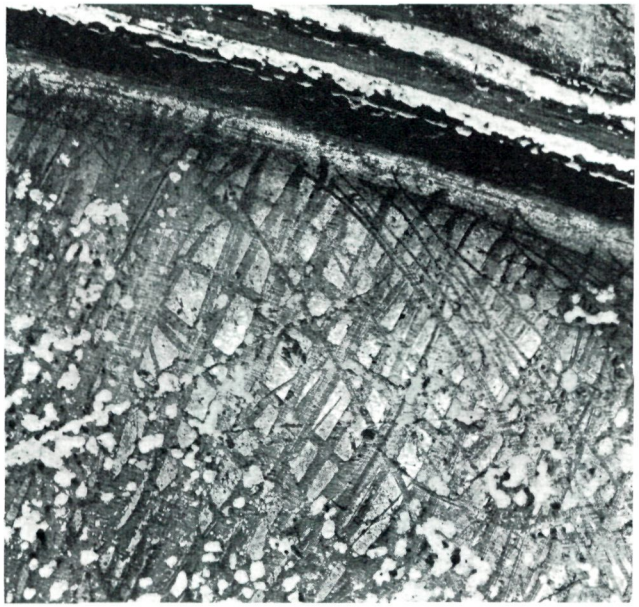
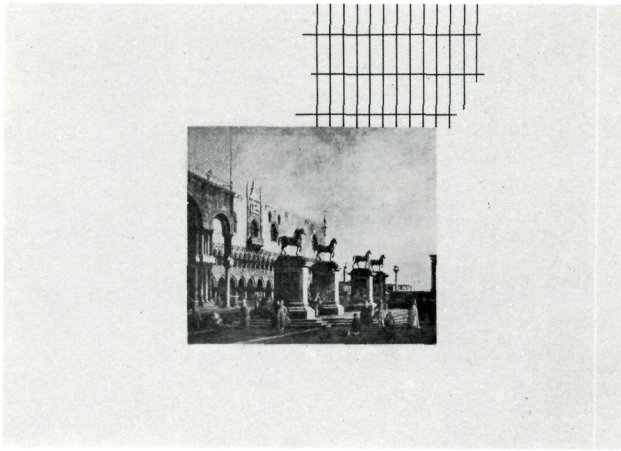
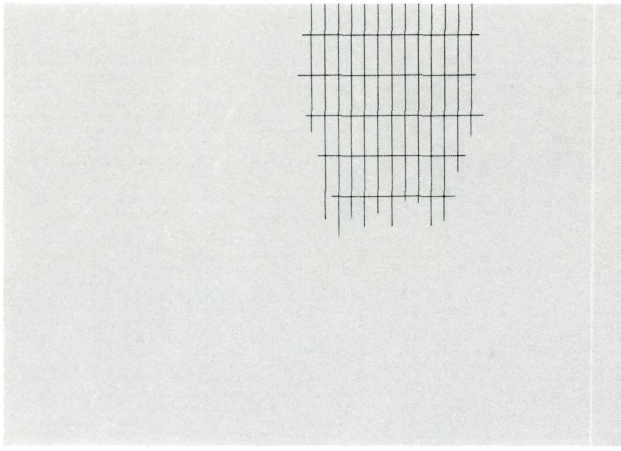


Figure 7. *Detail of the mane which has no scratches.*
Figures 8 & 9. *Two photos of the area below the collar. Figure* 8 *clearly shows that the incisions begin at an equal distance from the collar. The enlargement in Figure* 9 *corroborates this observation.*

Figures 10 to 13. *Details of the head (on this page) and the chest and rump (on the page opposite). The network of green and black scratches presents a pattern which is difficult to reconcile with the hypothesis of chance.*





Figures 14 & 15. *Two photographs of a hypothetical wall taken under identical conditions of light by a normal camera "adapted" to work as a toy camera. On each photo we have drawn an arbitrary network of small rectangles. In one photo (Figure 14), the diminishing of the wall surface is obtained by hanging a picture on the wall: it is a little-known painting — Canaletto's "Capriccio Veneziano" in which the four horses are pictured in the middle of the Piazzetta with Palazzo Ducale in the background. The painting hangs in Windsor Castle — a fact which should not surprise Canaletto experts who know that Windsor Castle is also called the "alpha and omega of Canaletto".*

object being observed.

Let us take two photographs produced by the toy camera and cut them up into tiny rectangles to simulate the light sensitive rectangles of the eye.

The photographs used happen to be two similar views of a wall.

In photograph number one the wall is smaller than it is in photograph number two. Nevertheless the "white" in any of the rectangles of photograph number one is as "white" as its mate in photograph number 2, i.e., the quantity of light that falls on the rectangle is the same in both cases.

In our model, the rectangle in the photo stimulates the light sensitive element in the retina. It follows, then, that the quantity of light which arrives to the light sensitive element of the retina is also the same. The signal which the tiny rectangle in the retina sends to the brain is therefore the same in both cases. That is, the light sensation which the wall provokes in the eye of the observer is also the same.

In short, "the stimulus that generates the light sensation is not the sum of the stimuli. Each stimulus is independent of the others".

Suppose, for the sake of an absurd example, the stimuli are added together. Large objects would then appear brighter than small objects. A laundered sheet would appear whiter than a laundered pillowslip. One can imagine the havoc that this would play with television commercials for detergents!

It must have been planned that the four golden horses were to be displayed outdoors

after casting. Once the artist had installed them on their pedestal, he must have realized to his dismay how much the sun impoverished his work. The robust pectoral bulges were no longer visible nor was the play of the muscles in the legs; the harmony of the features of the head was completely destroyed: patches of light without shade. He must have understood that the only means available for him to restore to his sculpture the wealth of details he had created with such skill was to redesign it, to remodel it in some fashion so as to achieve the play of light and shadow which the sun was destroying.

The black copper oxide beneath the gold was the medium which he would use to achieve his plan to reduce the reflectivity of the gold surface sufficiently so that the stimulus induced in the eye of the observer would be less than dazzling.

We have already seen evidence of the strength of character and determination of our unknown genius and we cannot be surprised that he would arm himself with a burin to painstakingly remove narrow strips of gold, line by line, incision by incision so as to make an orderly network of lines of the black of the copper underneath. He made a thick network in the concave parts, and a loose one where the reflection was less critical. I add that he probably varied the thickness of his incisions because he was aware of the resolving ability of the human eye. That is, that at the distance which the horses would be from the observer, the eye could not distinguish the lines individually, but would appreciate the total effect. We should be able, on the basis of the average width of the lines, to calculate the ideal distance that the horses should be from the observer.

We convince ourselves that the events couldn't have gone differently. They fall in line perfectly with the splendid figure of the artist which we are piecing together. We are further stimulated in our research which is becoming ever more fascinating. We decide to begin immediately on the project of photographic recomposition proposed by Demetria.

First of all, we must verify that the scratches are not the haphazard work of some vandal, but follow a definite pattern. Then we must verify the hypothesis that the network of scratches was incised to remodel the surface of the horses to achieve the effect of light and shadow.

A new expedition to Venice is planned and coordinated with the young FACTOTUM who is to have available a good photographer — an expert in art documentation.

The BEARDED ONE prepares for me a device for taking fresh samples which I believe are necessary because the analysis of the earlier samples revealed the famous copper oxalate discussed in the article shown me in Venice. This development disturbs me because I have no desire to get involved in bacteria.

From what I understand, the bacterial corrosion process is anything but clear and I would like to ensure against the possibility that everything that we cannot explain in the field of corrosion ends up under this label.

The presence of oxalate in the samples which I took is not, however, 100% certain. They were analyzed with an X-ray diffraction instrument which can determine the crystalline structure of materials, even in tiny quantities. The analysis is read off the meter in the form of a graph with a series of peaks. With the aid of an already prepared table, it is possible to associate the structure of one peak, or a group of peaks, with a given chemical substance. When the quantities of material to be analyzed falls below a certain level, some of the peaks may be difficult to interpret.

In the case of the samples which I collected, the analysis made by a dear colleague GEOLOGIST indicates that in a certain area the peaks may, with a good approximation, correspond to the presence of copper oxalate. To be certain, however, it would be necessary to make additional analyses with larger quantities of the material.

For those interested in knowing more about the analytical process with X-rays, we open here a brief parenthesis.

This type of analysis is possible because light can be diverted in a certain way (diffraction) when it encounters an object of dimensions about equal to the wave length of the light. This phenomenon occurs also when light encounters a void of these dimensions. In short, diffraction can occur when light encounters a mass or a void. The sole condition is that the dimensions of the mass (object or body) or void nearly equal the wave length of the light. The head of a pin, the eye of a needle, a hair, the weave of a fabric, etc., have dimensions (of masses and voids) that cause the diffraction of normal light waves. X-rays are "light" of such short wave length that objects in every day use do not cause their diffraction. Voids of dimensions close to the length of X-rays are the spaces between the atoms of a crystal. A crystal is composed of certain atoms packed together in an orderly way at equal distances. Atomic distances vary from one crystalline compound to another. A crystal bombarded with X-rays will divert some of them through diffraction. The angle of the deviation is proportionate to the distance which separates the atoms. The greater the distance between atoms, the less is the angle of deviation of the X-rays. From this it can be seen that an apparatus which can measure the deviation of the X-rays can give us solid information about the crystalline structure and in turn, the composition of the substance being bombarded with X-rays.

For an example, let's take a small quantity of quartz powder and place it under an X-ray bombardment. Figure 16 is a schematic diagram of the operation. The diffracted rays are distributed in all directions. If we place a photographic plate perpendicular to the line B-B of Figure 16, we will record the diffracted rays. Figure 17 is such a record with the white dots representing the diffracted X-rays.

It is relatively simple to understand a system capable of revealing the X-rays in their various directions and to diagram their relative light signals. In the place of the photographic plate with its luminous spots, we would have a graph as in Figure 18

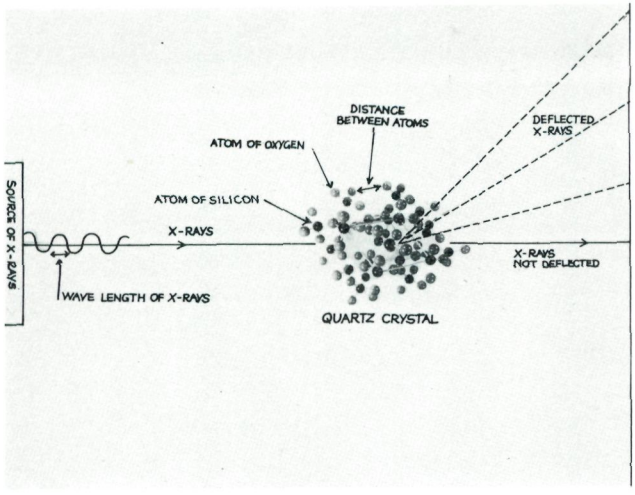


Figure 16.

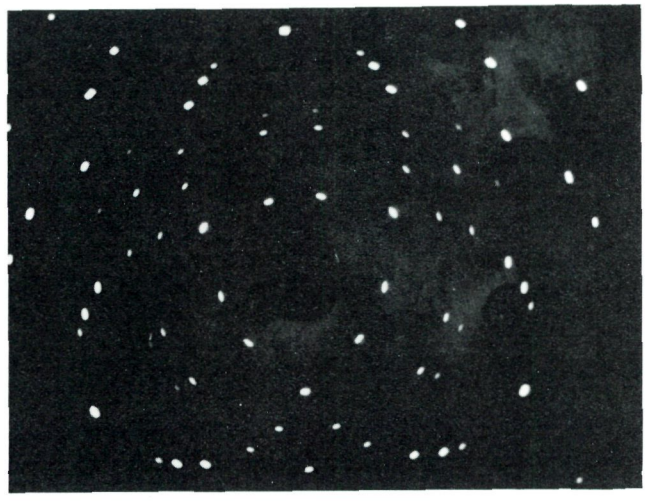


Figure 17. *Photographic record of X-ray bombardment.*

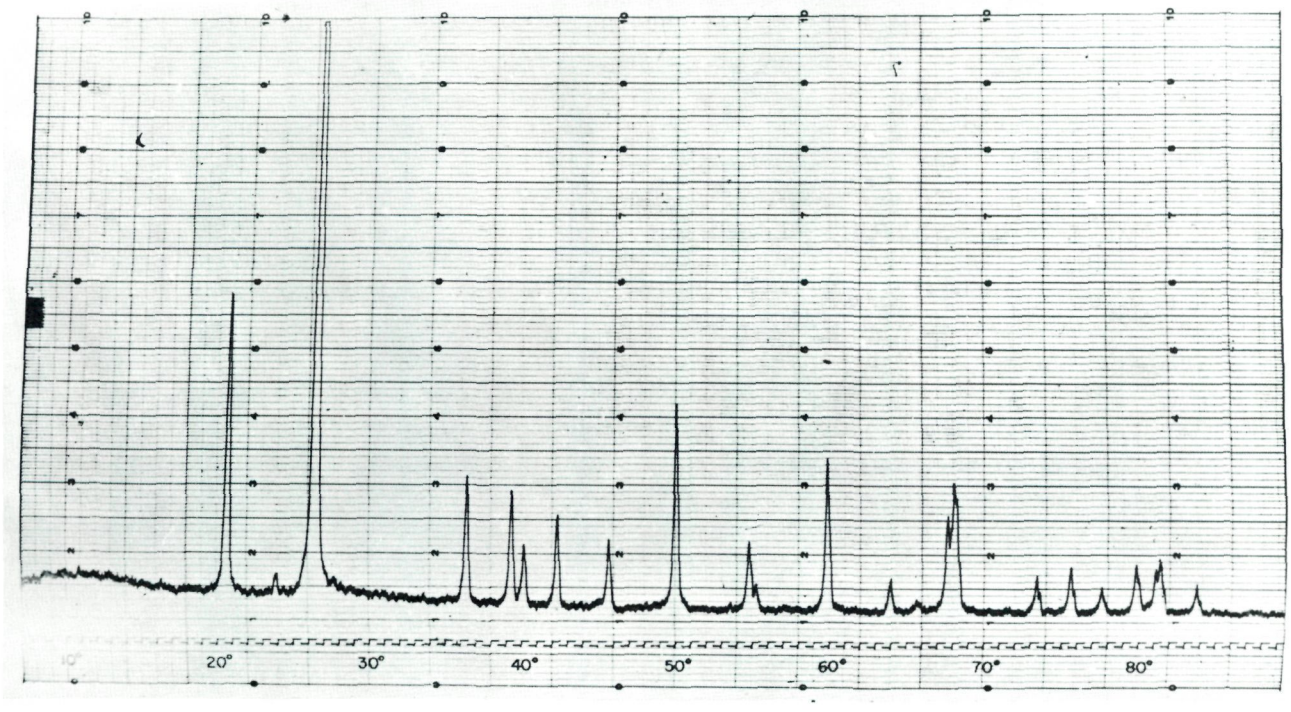


Figure 18. *Diffractogram of X-ray bombardment.*

wherein the luminous spots (of the photograph) become peaks and the dark areas are zero.

For our projected visit to Venice we plan a busy program. Demetria and I leave together by train and three hours later are in the Basilica where the two photographers are waiting. We detail for them the features which we wish documented. While we are choosing the portions of the horses' surfaces, we notice a few things that neither Demetria nor I had observed previously — things that further support the validity of our hypotheses.

While examining with a magnifying glass the areas holding the most scratches, I discover some very fine lines which are close together and perfectly parallel to each other. I also note that the start of each incision is cleanly and sharply cut as if by a sure hand. In some places these fine incisions trace a straight line while in others they are curved. We decide to include these areas among those to be photographed. But to obtain a good documentation of anything so fine, the photograph will have to be taken through a microscope.

Demetria and the photographers agree on the series of enlargements to be made. For example, the chest of the horse will be photographed in its entirety and then certain sections for detail enlargements. We already have a general idea about how the documentation will be assembled. All photographs will be taken in color and then in black and white.

We decide to enrich the number of photographs so that the documentation of the chest of the "laboratory" horse can be compared with an analagous one on another horse. (The horses are not all identical but form two pairs, of which each horse has raised a different front foot.)

I want very badly to examine the chests of the other horses but these, unfortunately, extend far out over the railing of the Loggia. I climb out on the legs of one but can make only a cursory examination from this precarious perch. I am able to determine, however, that the chests of the other horses have similar networks of scratches.

The photographers balk at my suggestion that they attempt to photograph the chests while leaning out over the railing. The able young FACTOTUM comes to my aid saying that the Procuratia owns a movable scaffolding sufficiently high to take a man up to the level of the horses. He agrees to have it moved into position for the photographers.

The University of Padua is a stone's throw from Venice, and its collection of documents and reference material, particularly about Venice, is possibly the richest held by any Italian university. I make a quick trip there hoping to gather a little more bibliographical material on the four horses. (I have already checked out the Marciana Library in Venice.) I realize that whatever is available in Padua will take a good deal of time to find. Fortunately, a good friend, an excellent mathematician and physicist, to say nothing of his skill as a pianist, lives in Padua. Although I know full well that it is an imposition, I ask his help in gathering the material. As it turns out, it is easier than

I had anticipated. His wife knows a young lady who works in the institute where part of the information I seek is to be found. Assured that the task is in good hands, I return to Venice to busy myself with the collection of corrosion samples.

As I said earlier, the green substance is deposited principally in the vertical scratches. It is a tedious, time consuming effort but, with the patience of Job, chip by chip, I succeed in collecting more than I had previously. As I search for a better source of the substance I make an exploratory probe into the ear of the horse. To my pleasant surprise, I find a large chunk of green material — thousands of times more than I was able to scrape up from the surfaces of the horses.

I deduce that since the interior of the ear is not gold plated, the substance was formed by a chemical, rather than an electrochemical process (because the latter requires the presence of another metal).

Demetria and I gather up our precious cargo and return to Bologna very pleased that everything, for a change, has gone so smoothly. We carry back a great deal of information and grandiose ideas.

A few days later the photographs arrive. They are magnificent, the work of true professionals. We notice immediately that the disconcerting effect of the green lines is much more pronounced in the photographs than to the naked eye. Demetria and I discuss this at length and we agree that the best way to demonstrate our viewpoint is to make a graphic reconstruction of representative portions of the network of scratches. Demetria is quite capable of pursuing this phase of the program without help (or interference) from me. I pursue the matter of the large deposit from the ear of the horse.

Our friend the GEOLOGIST is pleased with the quantity of material which I bring back. His analysis by X-ray diffractogram reveals extremely detailed information. There are present all the typical substances from the chemical and electrochemical corrosion of copper when immersed in, or exposed to, a solution containing pollutants normally found in the atmosphere. But the large chunk contains not even a trace of copper oxalate! This about rules out the theory of bacterial corrosion and, needless to say, I feel greatly relieved.

But I wonder why it is that copper oxalate is found on the surface of the horse and not in the ear. Remembering that the ear from which I retrieved the chunk curves downward and thus shields the interior from above, I deduce that the substance which forms the oxalate must be deposited from above. And since it is an organic material it must come from living organisms. It doesn't take much intelligence to narrow it down to the pigeons!

This starts me on a feverish search for information about pigeon droppings, and more particularly, whether or not they contain oxalic acid.

A dozen telephone calls to public health agencies, the university, etc., produce no one who has any idea about the chemical composition of pigeon excrement. One professor says that it must surely contain uric acid, but he is not sure about the presence of

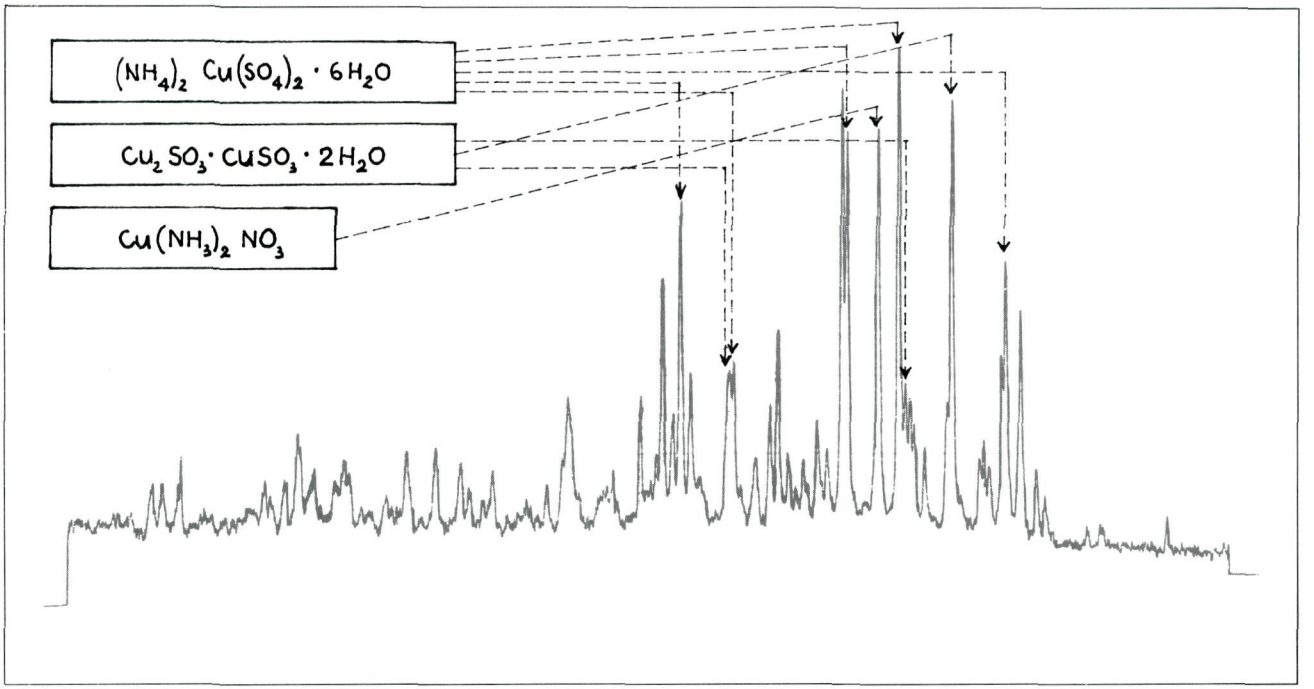


Figure 19. *Diffractogram of the large chunk of green substance found in the ear of the horse. While there are numerous peaks indicating the presence of complicated compositions of copper, copper oxalate is not among them. This illustration and that of figure* 21 *are shown merely to give the reader an idea of the complexity of the chemical interpretation of the analysis.*

oxalic acid. This paucity of information is appalling. For years I have been reading in the newspapers that the pigeons must be exterminated, sterilized, or eliminated somehow because they cause so much damage. I had always thought that the damage was produced by their excrement. I am sure that someone, in some part of Italy or the world, has done an analysis of pigeon droppings but I have no idea how to reach that person.

I despair of finding this information neatly printed and readily available, so I decide to obtain a sample for an analysis. I don't want a complete analysis but a simple one to determine whether or not oxalic acid is present.

I contact a friend who works in the University and knows all about bees. She does research on the language of these highly organized little insects. She is a woman of exquisite kindness and she readily agrees to help. She puts me in contact with another lady who promises to have delivered to me a suitable quantity of pigeon droppings. During our telephone conversation I learn that the technical name for the droppings is "colombina" — from the Italian word for pigeon — "colombo", and also means dove, or little pigeon.

Two days later I receive two packages — a big one and a small one, both carefully wrapped. I try in vain to interest someone in our laboratory to help me get an analysis of the excrement. Demetria even refuses to telephone to the Commodities Institute which employs high level analytical chemists. She says that the "colombina" is not a commodity and she doesn't wish to be made a fool of. I am temporarily stumped because I cannot find ready assistance among my friends at the university. Then I remember that a few years ago I had an allergy which was never identified but which required that I take a useless series of blood tests. I remember that the chemist who did the analysis for me was a friendly person. I telephone to him and he remembers me. After I explain the problem, he says that he would be happy to help but unfortunately his laboratory does not do oxalic acid determinations. He could, of course, detail the method of doing the analysis but at this moment he is too busy. But to help me, he is prepared to attempt a rapid analysis with an oxalic acid precipitation method followed by a microscopic analysis.

I send him the large package. A little while later he calls to say that the package did not contain pigeon droppings but little jars of perfumed honey. Realizing that the kind friend who studies bees had taken the occasion to send me a gift of honey, I explain to the chemist and send him the other package.

He sends this back a few days later with a note saying that he was able to devote very little time to the analysis but that there were revealed traces of oxalic acid. He adds that it would be inadvisable to rely completely upon the examination and I again feel blocked in my research. I decide against further telephone calls since I realize that what interests me is not the presence of oxalic acid, but whether the reaction of "colombina" with copper salts produces a

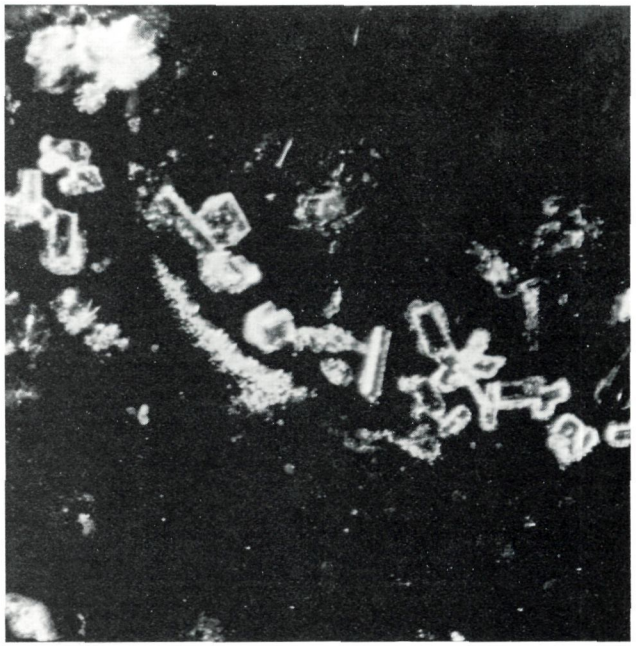


Figure 20. *Microphoto of a specimen of a solution of Colombina and calcium salts, being examined to determine the presence of oxalic acid. In the photo the neat crystals of calcium oxalate are clearly visible.*

substance which, examined by the X-ray diffractometer, shows the same distribution of peaks as did the corrosion substance on the horses.

Stated in these terms, the problem becomes much more simplified. One has merely to prepare a solution of copper salts and add to it a filtrate of "colombina", dehydrate the mixture and examine the residue "copper columbinate" under the X-ray diffractometer. I perform the chemical steps of this operation and send the material to my friend the GEOLOGIST. A short time later he reports that I have hit pay dirt: the X-ray diffractogram prepared from the residue shows the same distribution of peaks as did the substance found on the horses. Copper oxalate is definitely present.

This annoying aspect of our study is thus resolved and, to my great satisfaction, the theory about bacteriological corrosion is eliminated.

It is clear that among the polluting substances present with the moisture condensed on the surface of the horses there is also the "colombina" which is dropped by the pigeons roosting on the backs or dive bombing from above.

Meanwhile Demetria has prepared the apparatus (a type of VIEWGRAPH) to project the photographs onto a 4 foot by 4 foot translucent glass. We determined that this size enlargement will best illustrate our theory about the network of scratches, Figure 22 shows a rough approximation of the apparatus.

Details of the photograph appear sharply on the translucent glass. Her task is to

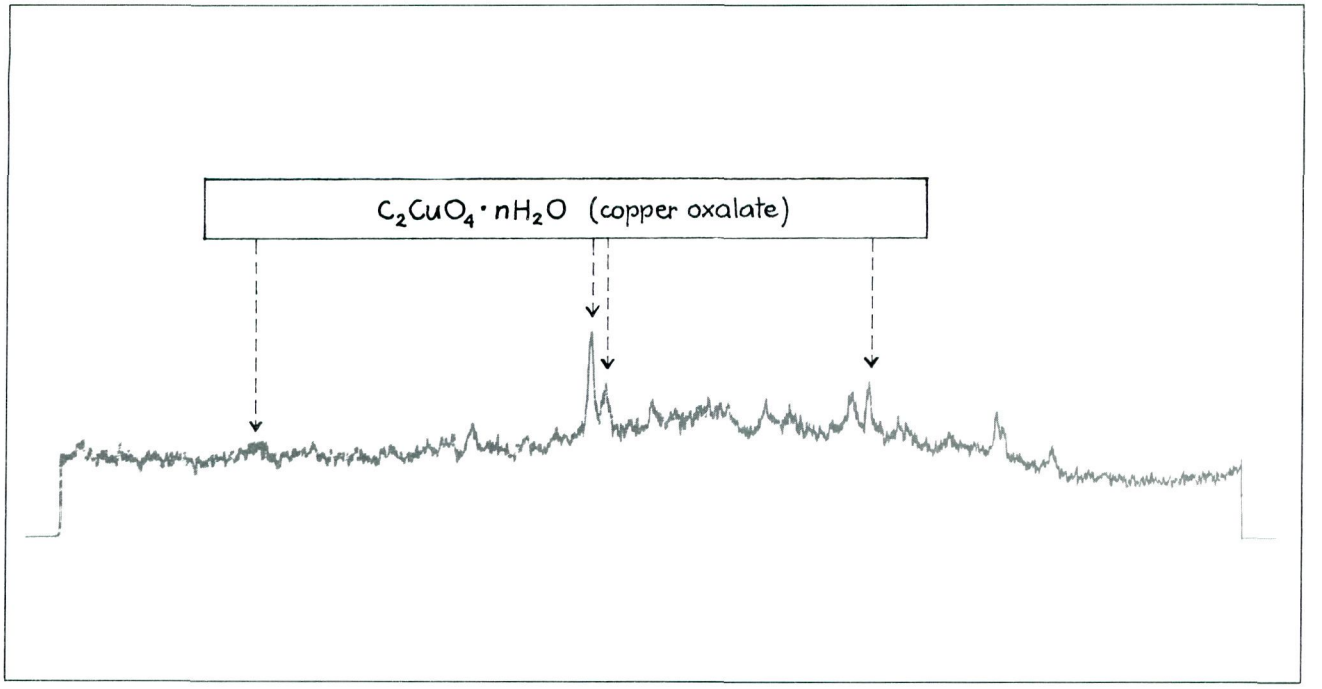


Figure 21. *Diffractogram of copper "colombinate" showing the definitive presence of copper oxalate. To identify the other peaks would take a lifetime and by someone who knows more about it than we.*

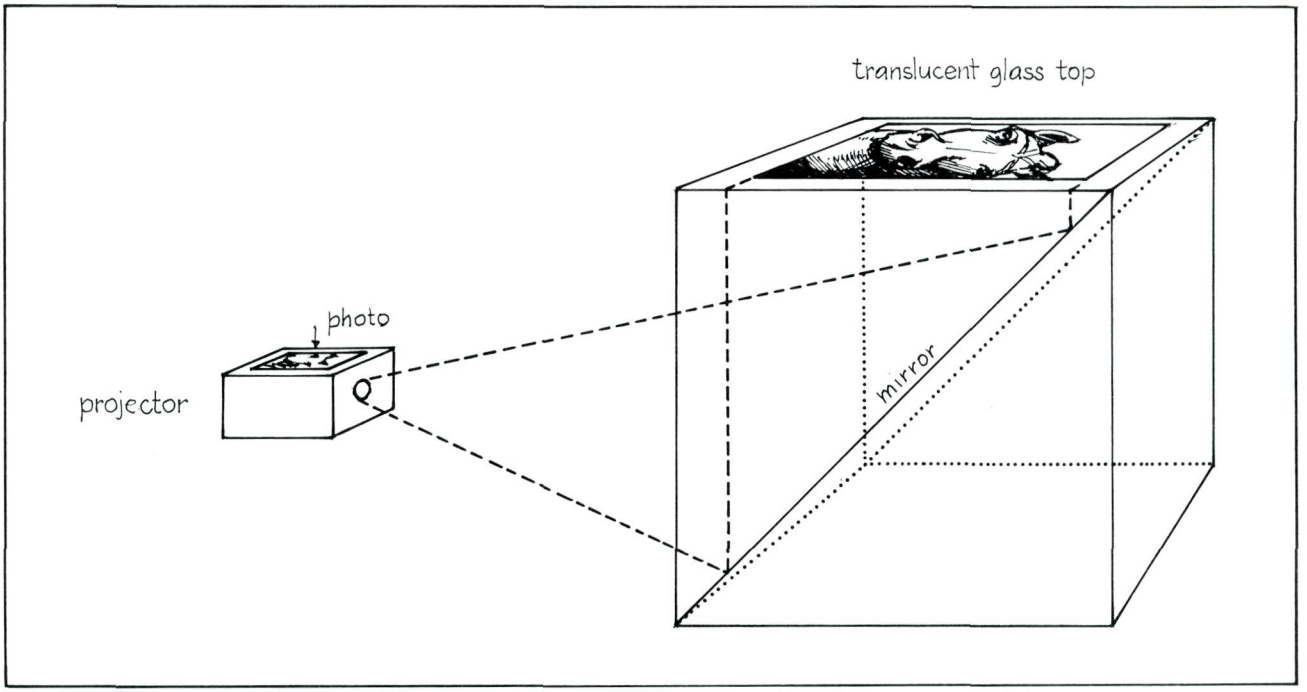


Figure 22. *Schematic diagram of the system used to reproduce the network of scratches on the surface of the horses.*

copy onto tracing paper (placed on top of the glass) all of the lines visible in the photograph. The black lines are easy to follow but the green lines often require a complex interpretation. They are generally irregular because of the build-up of the corrosion substance which spreads unevenly onto the adjacent surface of the horse.

Demetria has studied the photographs very carefully. She points out that some of the green lines have portions where the black is still visible. She feels confident that with patience and perseverance she can reproduce the trace of the original lines even where the corrosion conceals them.

There are a great number of drawings to be done. The chest, for example, will require six to eight. Her first drawing covers the entire horse and she is tracing the most significant lines which will serve as reference points to assemble the mosaic of other drawings. The enlarged sections will also be projected on the screen and she will copy onto her drawing all details of the lines. The final operation will be to place together the detail drawings utilizing the reference points on the complete drawing.

She tells me that according to her calculations, it will take her longer to trace the complex of lines than it took the sculptor to engrave them. I don't see how I can help her. She suggests, wisely, that I give a little more attention to the laboratory which I have been neglecting badly.

With her usual efficiency, Demetria quickly finds an assistant — a dear friend who is an art history teacher and possesses a sure hand. We explain to her what we are trying to demonstrate and she joins us enthusiastically. Demetria thinks that we need also an expert draftsman and so I enlist the aid of a collaborator who works at the Mt. Cimone Observatory. The three of them then attack the inhuman task with enthusiasm and determination. Within a few days they have completed several drawings.

As they get into the enlargements, Demetria mentions again the difficulty of tracing the green lines where the corrosion has obscured them. Examination of even the more enlarged details does not help appreciably. We decide to reconstruct only those portions that can be accurately interpreted even if some of the details of the network of incisions are omitted.

Suddenly, as we begin to copy the scratches on the head, there emerges a detail which casts some doubt on our entire hypothesis. Demetria doesn't seem to share my concern about the new revelation, declaring that the first drawings indicate that we are on the right track.

The disturbing evidence is that the scratches are present where they shouldn't be and that is in the traces of the trappings which the horses once possessed. These traces are quite evident and the gold along their paths has been removed (see Figure 23). Easily distinguishable are the cleanly cut edges of the gold leaf which was removed and is now replaced by thin traces of corrosion. The scratches which we believe to have been made by the unknown artist continue inside the trace of the trappings. They go from one side to the other as though the trappings hadn't been there when the incisions

Figure 23. *Detail of the head of one of the four horses. Easily visible is the strip where the trappings were removed. The hole in the forehead served to hold the trappings in place.*

Note that the network of scratches includes also the area of the trappings as if they never existed.

were made.

We don't relish the complication which this discovery brings to our research. Rereading the sparse documentation on the trappings, I conclude that although they must have been added to the horses in ancient times, no one seems to have bothered to learn when and where they were applied or removed.

The current thinking appears to be that when the artist completed the castings, he applied the harness mechanically — that is, just as he would on a living horse. He then covered everything with gold leaf and that later the gold that covered the trappings was cut along their edges as they were removed, presumably before the horses were taken away from Constantinople. But after discussing this theory, Demetria and I agree that it doesn't hold up.

We can think of no valid reason why the artist, who was doubtless a first class sculptor capable of modeling even the smallest details of the horses' tendons, muscles, etc., would not want to cast the trappings along with the rest of the horse. Once the head was covered with gold leaf, no difference could have been noted between a direct casting and a subsequent mechanical application. It would have been much easier for him to cast the harness already on the horses than to apply it afterwards. An expert foundryman tells me that a sculptor tends to include in the casting as many details as possible.

Another trip to Venice is indicated. I plan to examine the traces of the missing trappings and to photograph those scratches that we earlier decided to examine in detail.

CHAPTER FOUR

The microscope which I take with me is not a normal "table model" but one having a head with fixed lens, mounted on a strong metal structure that allows images to be examined in any direction. The entire apparatus consists of tripod, tubes, joints and rods packed together. I load into my car a large box weighing in excess of 60 pounds.

When I arrive in Venice the day is extremely hot and humid and it is only with difficulty that I manage to get the big box to the wharf. I am not up to carrying this load on a vaporetto and so I take a motor launch. Unloading at Piazza San Marco I manage, after a long tiring search, to find a porter. I tell him exactly where I want the box taken — up to the level of the horses on the Loggia of the Basilica. He doesn't bat an eye. He lifts the box onto his cart (I note that it is designed to easily negotiate the gentle steps of the bridges of Venice). We enter the Basilica and reach the foot of the steep stairs that lead to the Loggia. He drags the box onto the floor and folds his arms. When I say that he is to carry the box up to the Loggia, he whines in pronounced Venetian dialect "mi son vecio, sior" (I am old, Sir). We have a long discussion — the talk being mine — his participation being shrugs and "mi son vecio, sior". I remind him of our agreement and that the most important part is that the box be carried, no matter how, to the top of the stairs. I ask him to get a younger colleague to help. He assures me with affirmative gestures that he will do this. I pay him and he leaves. Neither he nor his promised helper return.

After a fruitless tour of the Piazza looking for this bandit or another porter, I realize that I will have to carry the box myself. I lived for many years in the mountains and I often carried my children on my back, even two at a time, on long hikes. I console myself with the thought that the box is more or less the same weight, and I start up the stairs.

I arrive at the top with my clothes soaked and my legs trembling. I then realize that years have passed since I climbed the mountains with those sweet little burdens and that the stairs are different from a mountainside. But the real difference is the size and shape of the box, whose corners are far sharper than the bottoms of small children.

Entering the air-conditioned room, I manage with some difficulty to assemble the microscope. After a few trials I discover that despite its range of movement, I have difficulty in focusing it on the tiny areas which I wish to examine. After a tiring series of attempts, I manage to achieve a fairly good focus and take some pictures. I have serious doubts about how they will turn out.

While I am mulling over what else I must do, Demetria telephones to remind me to arrange with the photographer for pictures of other details, particularly of the metal inlays. She is referring to something she has observed in the Lab: one of the photographs clearly shows traces of an intarsia so accurately inlaid that it is difficult to distinguish from the surrounding metal.

Earlier in this book, you may remember, I reported that the horses' surfaces are marred by numerous inlays. Some of these are done so accurately that they are hard to locate. Others, which obviously were done much later, are the work of clumsy craftsmen.

The distribution of the green rivulets and black lines both on and adjacent to the original, neatly done inlays, confirms my theory about the effect of the condensed water on the corrosion of the horses' surface. (See explanation in caption under Figure 24.)

These thoughts aside, I sum up the immediate tasks confronting me: arrange for photographs of the inlays, explore with the microscope the tracings of the harness, and take more samples of the corrosion substance.

Once again, the BEARDED ONE has supplied the ideal equipment for my task. This time it's even more efficient. With one of the special devices I begin to collect corrosion substance from the trace of the harness. I place these samples in a series of numbered small containers, and then enter on a piece of paper the characteristics and sources of the samples. I note an expression of restrained disapproval on the face of the FACTOTUM. I cannot determine whether this is because he fears that my clumsiness may cause unnecessary damage, or because he simply disapproves the idea of anyone tampering with his dear horse.

In an effort to reassure him, I explain the reason for what I am doing: we believe, I tell him, that during the removal of the strip of gold as they were about to add the trappings, a little of the precious metal may remain. If we can find even a speck of it on the surface where the harness was placed, it would be a piece of information vital to our research.

I then go to other parts of the horse for additional samples. After further efforts, I realize that I still need more for an effective analysis. I have already collected practically all of the corrosion substance from the trace of the trappings on the left side of the head. I must examine the other cheek. The head is lying on its right side and must be turned over.

A strong rope is attached to the head and runs through a block and tackle by which it can easily be raised. This I do, but when I lower it again, it always lies on its right side. I ask the FACTOTUM to raise it and, as he lowers it, I endeavor to turn the head to the left side. With my first attempt, the heavy head lands on my hand but rolls back to the favored right side. Forgetting my damaged hand, I try again and succeed in wrestling the head over on to its left side. I gather a little of the corrosion substance from this fresh source, place all of the samples in order and put them away.

Just then the photographer arrives. In detailing to him the photos desired by Demetria, we examine with the magnifying glass and then with the microscope the characteristics of the edges of the gold bordering the strip of the missing trappings. I follow the outline bit by bit and notice that

Figure 24. *An original inlay. Were it not for the corrosion in the scratches, the inlay would be barely visible. Note that the traces of green material (white in the photo) stop at the edge of the inlay and that within the area of the inlay white lines are much narrower — because they hold almost no corrosion substance.*

This explains and supports the description in the text about the radiative cooling of the horse and the attendant condensation of moisture which builds up the corrosion in the scratches. We examined the inlays and learned that they are much thinner than the surrounding metal of the horse and are therefore much less subject to the variations of temperature. When the body cools, the inlay remains warmer. The water in the rivulet evaporates as it reaches the warmer area of the inlay which is thus less affected by the action of corrosion.

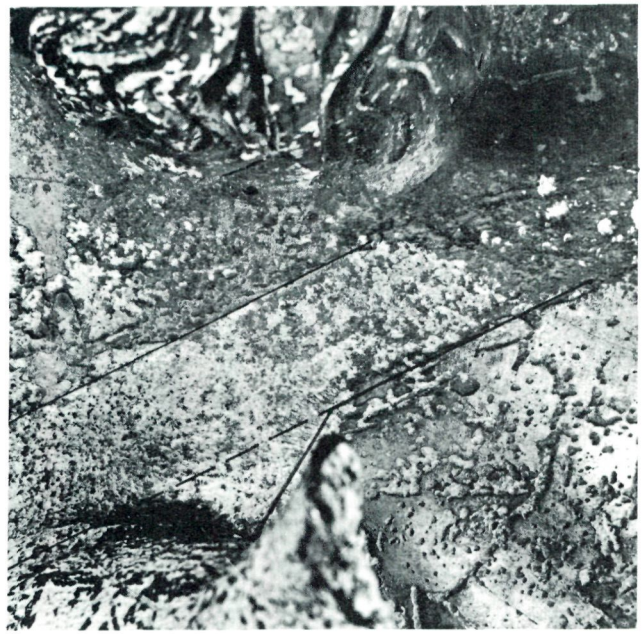


Figure 25. *Area behind the ear of the horse. The trace of the trappings is clearly visible as is the incision along its edge. Note also the triangular cut at lower left, believed to have been a slip of the chisel when the trappings were being removed.*

it is cleanly cut. When I reach the trace behind the ear, I notice that the cut no longer continues parallel to the trace, but deviates sharply (Figure 25). I have the impression that here the engraver's chisel slipped and that he then tried to correct his error as best he could. The border of the strip at this point forms a triangle with two of its sides outside the strip itself. I note that behind the other ear, the cut follows the strip perfectly. I notice, also, that the surface of the ear where the slip of the chisel occurred is particularly tormented and hardly designed to accommodate a harness. I ask the photographer to include details of this among the photographs. He takes numerous notes and promises to do the work quickly and expertly.

Despite the fact that all of this work has been going on in an air-conditioned room, I feel as though I'm in a Turkish bath. Perspiring as I was after carrying up the heavy box, I continued to sweat during my scrambling around the horse and during the struggle to turn its head.

The FACTOTUM comments about my appearance and the effects of the Sauna. I badly need a shower but content myself with splashing at the nearby washbasin. While looking for a clean rag with which to dry, I wander into a small room where the young FACTOTUM shows me a plastic sack containing some sand which was found inside the horse. He adds that mixed with the sand are a few pieces of partially burned wood. He says that expert foundrymen believe that the wood is residue from the fire which the artist must have lighted inside the horse for the goldplating operation. I examine attentively the contents of the sack. I remove a few pieces of the wood and put them carefully into a clean container.

Starting down the stairs, I at least don't have to worry about keeping my clothes neat. I hoist the box onto my shoulders, holding it with my right hand since the left has already swollen to the size of a ham. I reach the Piazza and by sheer luck I immediately find a porter. I consign to him the heavy box onto which are tied all of the pieces of equipment which I was unable to repack. I ask myself how I manage to get involved in transporting such heavy things in Venice where it is such a problem. I feel that I have earned the luxury of a motor launch. The boat moves slowly away from the wharf and, with an elegant salaam past the colorful mooring piles, it picks up speed. The light breeze dries my perspiration and I feel cool and well again. The driver examines my pitiful condition and possibly for this reason adds speed and heads farther out into San Marco basin. I stretch out in the stern of the boat, lift my legs onto the big box and turn to observe Piazza San Marco receding in the background.

"*So he saw it again, the most remarkable of landing places, that blinding composition of fantastic buildings which the Republic lays out before the eyes of approaching seafarers: the soft splendor of the palace, the Bridge of Sighs, on the bank the columns with lion and saint, the advancing, showy flank of the enchanted temple, the glimpse through to the archway, and the giant clock. And, as he looked on he thought that to reach Venice by land, on the railroad, was like*

entering a palace from the rear, and that this most unreal of cities should not be approached except as he was now doing, by ship, over the high seas"*.

The motor launch enters the Grand Canal and through a labyrinth of small canals to reach Piazzale Roma. There are no porters at the dock and I am forced to carry the heavy box across the piazza to the garage. There is the usual line at the check-out window and I keep worrying about the consequences if I go off forgetting the big box. I arrive in Bologna and am lovingly liberated of all the material which I succeeded in collecting.

But the next morning the GEOLOGIST complains that the samples are too skimpy for a thorough X-ray analysis. We argue about this — I maintaining that I can't go back to Venice for such a thankless task and he declaring that he cannot perform miracles. But then it occurs to me that we are not interested in knowing if certain chemical compounds are present but only if the substance collected from the trace of the trappings contains a trace of gold. Why not try to determine this by using the technique of the microprobe?

He immediately agrees, saying that it is the surest technique, but that unfortunately the only available apparatus of this type is in Milan. He kindly agrees to go there and make the analysis to determine the presence of gold and other metals. But first he will have to spend a few days preparing the tiny wafers of material so that it can be examined. He promises to keep me advised of his progress.

Meanwhile there comes to light an unusual coincidence which might be entitled "Is it possible to take part in any activity without getting involved with horses?".

A research currently in progress in our laboratory concerns itself with interplanetary material which enters the earth's atmosphere.

The space which surrounds us is crowded with the remains of a planet which, about the time of the formation of the solar system, underwent a process of disintegration, possibly brought about by the collision of two celestial giants which the laws of Kepler and Newton, far more inflexible than those of the Traffic Assessor of Bologna, prevented from passing one another.

The fragments of the crash revolve around the sun like tiny planets, some of which enter the earth's atmosphere. There is a continuous rain of these tiny rocks but we are unaware of it because they are so small that they wouldn't hurt a fly.

Every once in a while, however — say every other century or so — a truly enormous one crashes to earth. To have an idea of the dimensions of these giant stones one need only look at the moon on a clear night. Those large craters were caused when the surface of the moon was struck by interplanetary stones.

I am currently reading several old books on the origin of the solar system. There is always something to learn if nothing other than the evolution of the theories on the formation of material in interplanetary space. I came upon the works of a famous astronomer of the recent past who was one of the pioneers on the study of Mars. At one period of his life, as a hobby, he searched

* "Death in Venice" - T. Mann.

Figure 26. *The imperial coin of Emesia. The coin depicts the monument to the meteorite of Emesia. This is a photograph of an enlarged drawing made by a famous French astronomer.*

It is only since the begining of this century that astronomers have had access to equipment which permitted them to photograph celestial bodies. Previously, they looked through their telescopes and then endeavored to draw that which they saw. A good astronomer had to be a good draftsman as well. Our French astronomer apparently felt a little nostalgia for the past and chose to draw the coin rather than photograph it. In the text of this book I have said that the engraving is somewhat stylized. The chariot is on a level different from that of the horses; the hatchet-shaped symbols seem suspended in air; the form of the chariot is incomprehensible, etc. Looking more closely, one sees that the horses are not all identical. The forms of the chests differ, particularly between the second and fourth horses; the angle and size of the lifted legs vary considerably. One might even conclude that instead of being stylized, the coin reflects the clumsiness of the engraver, who sought only to show the size of the meteorite by displaying it with the horses.

out and studied meteorites, the technical name of large interplanetary stones which strike the earth's surface. Among the things which he tells about this activity is the story that is closely connected — or could be — with the origin of our four horses:

Varius Avitus, upon becoming Roman Emperor, assumed the name Heliogabalus, meaning "consecrated to the god Helios", or sun. He took this name not only because he was slightly insane (and did such things as fight a naval battle on a small lake of wine) but also because his birthplace was Emesia, a city of Syria. The people of Emesia worshipped a cone-shaped black meteorite believing it to be from the sun which they called Heliogobal.

The mighty Emperor had the stone brought to Rome and placed in a splendid temple built specially to house it. Historians report that he used the stone to satisfy a clownish whim: on occasion, he had the stone mounted on a chariot drawn by horses with himself as the most unusual charioteer. Standing in front of the horses, he grasped the reins and, walking backwards, drew the horses and chariot behind him. This permitted him to gaze continuously at the meteorite. And, since it was difficult for him to see where he was leading this strange procession, he required his high court dignitaries to participate, one of whom would walk on either side of the Emperor to guide and support him.

Getting to the point, an imperial coin of Emesia, the place where the meteorite was found, commemorates the cone-shaped

stone. The coin depicts what is probably a monument to the meteorite (Figure 26). But the most unusual coincidence is that the chariot on which the stone is mounted is drawn by four horses which have the same stance as our four bronzes. The only differing detail is that the chariot's horses do not make up two symmetrical pairs as do those of San Marco. But since on the coin the engraving is highly stylized — or so it appears — and rather small it would be unlikely that all details be represented.

What happened to those four horses? Of what were they made? Did the Emperor take to Rome only the stone or the entire monument including the horses?

Apart from these questions, the incision shows four horses hitched to a chariot which has no driver!

It is probable that the reproduction of the monument on the coin was to serve only to show by comparison the size of the meteorite. Because of the friction of the earth's atmosphere, any object of that size would have made a great blazing spectacle. Its trajectory made it appear as though it came from the sun. In those days these flaming bodies were thought to be ultimatums from the gods saying mend your ways, or else. I ask myself how the fall of such a terrestial body would be interpreted today in Italy. We would discuss it interminably and then decide that the infallibility of God does not necessarily include stone launching expertise — that his crude message is intended for some nearby country. There would then ensue speculation as to which other nation had been his target.

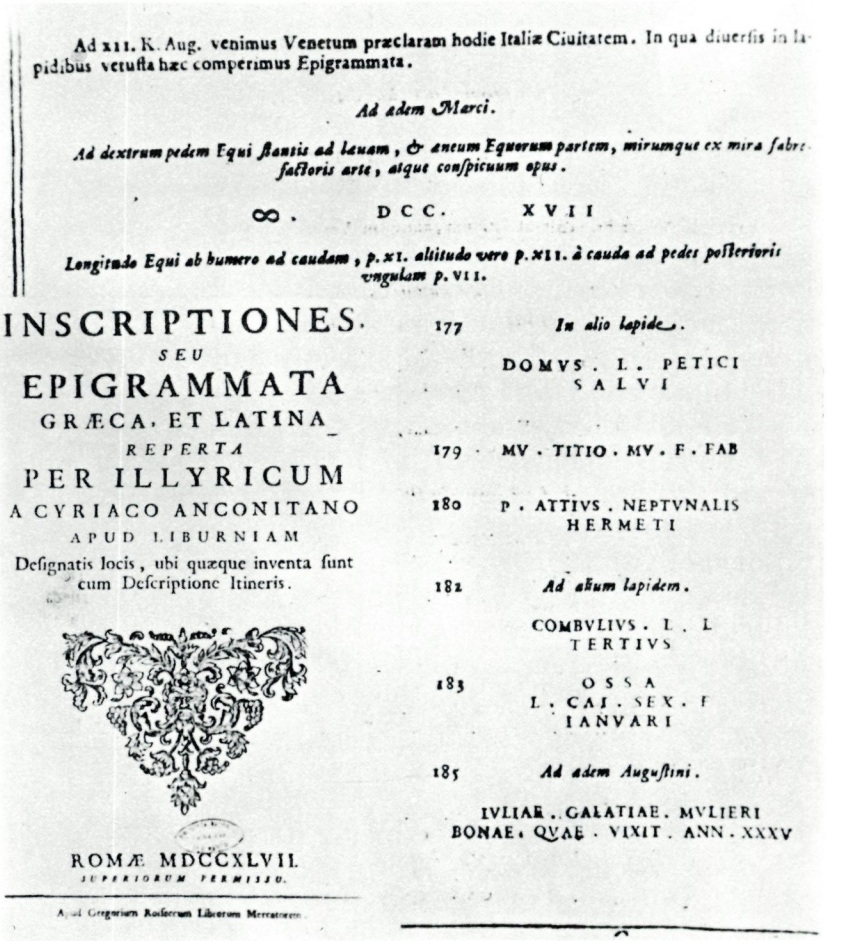
Turning back to our horses, Demetria reports that everything is proceeding nicely. She and her two assistants have been working with great enthusiasm and one part of the network of scratches has been constructed. I stand admiring their work and find pleasure in adding a few strokes to the drawing. Demetria is confident that she will soon be able to start assembling the sections of the mosaic.

I again take up the search for documentation about the horses but find it a useless effort. I cannot find a single date, circumstance, or anything that might be useful. We have come to the conclusion that the matter of the trappings is one of the most important to establish the symbol which the horses originally represented. We try by our exchange of ideas to clear up the problem relative to the origin of the horses. We agree that our chatter is superficial (in other cases I would have said academic) and not constructive. We are well aware that the archaeological aspects of the bronzes are beyond our competence. We also know that this type of research, even when conducted by experts, can only with difficulty establish beyond reasonable doubt the validity of the hypotheses. We must also be aware that all of our efforts may be meaningless because our opinions — and I admit having a fair amount of common sense — may end up playing the Cinderella in a contest with those formualted by others who have all the cards in order.

There is nothing to prevent our reading all that has been written about the casting of the golden horses. We want to know

Figure 27a. *Roman document. The bibliographic material which we managed to assemble contains a great deal of information about the horses but very little that we could evaluate. One document which we unearthed attracted our curiosity because it cites an incision on the hoof of the horses:*
∞ DCC XVII
We checked the hoofs and sure enough, on the right front hoof of each horse there is an incision, one of which has exactly the same sequence of numerals as above but grouped tightly together as in Figure 27b (a rubbing since the curved surface of the hoof makes it impractical to photograph). One of the incision is illegibile but from the other three we obtained ∞ DCCXVII, ∞ DCCX XXV, ∞ DCCLXXX. The symbol ∞, which today in mathematics stands for infinity, was often used by the Romans in the place of M (thousand). If so used in this case, we would have the numbers 1717, 1735 and 1780 which some scholars feel indicate the dates of repairs or restorations. But this does not hold because, although the document was published in 1747, it was taken from an original manuscript of Cyriacus Anconiatanus, who lived three centuries before and visited Venice in 1434! More probably they indicate wieght since each horse weighs about 1600 pounds and we know that the Romans used a unit of weight about equal to the presently-used pound.

Figure 27b. *A rubbing of one of the incisions on the hoofs of the four horses.*



Ad xii. K. Aug. venimus Venetum præclaram hodie Italiæ Ciuitatem. In qua diuersis in lapidibus vetusta hæc comperimus Epigrammata.

Ad adem Marci.

Ad dextrum pedem Equi ſtantis ad lauam, & antcum Equorum partem, mirumque ex mira fabre factoris arte, atque conſpicuum opus.

∞. DCC. XVII

Longitudo Equi ab humero ad caudam, p. xi. altitudo vero p. xii. à cauda ad pedes poſterioris vngulam p. vii.

INSCRIPTIONES
SEU
EPIGRAMMATA
GRÆCA, ET LATINA
REPERTA
PER ILLYRICUM
A CYRIACO ANCONITANO
APUD LIBURNIAM
Deſignatis locis, ubi quæque inventa ſunt cum Deſcriptione Itineris.

ROMÆ MDCCXLVII.
SUPERIORUM PERMISSU.

177 *In alio lapide.*
DOMVS. L. PETICI
SALVI

179 MV. TITIO. MV. F. FAB

180 P. ATTIVS. NEPTVNALIS
HERMETI

182 *Ad alium lapidem.*
COMBVLIVS. L. L
TERTIVS

183 OSSA
L. CAI. SEX. F
IANVARI

185 *Ad adem Auguſtini.*
IVLIAE. GALATIAE. MVLIERI
BONAE. QVAE. VIXIT. ANN. XXXV

more about the personality of the unknown artist.

To state the dilemma about the origin of the horses simply as "Are they Greek or are they Roman?" would be incorrect. From some of the more reliable material on the subject it appears clear that even if we were to conclude that the sculptor of our horses is of the school or inspiration of Greek sculpture, this would not necessarily establish the period when the horses were cast.

Nothing precludes the supposition that the four bronzes are a work of a Greek sculptor called to work in Rome. Demetria interrupts me, objecting to the term "called" which might be applied to an invitation a university extends to a professor to assume a chair of study. I rethread my narration and state that the Greek master sculptor is "transported", or as she prefers "transported in chains" to Rome where he could have sculptured a Roman subject with Greek hands.

The dilemma should be posed in different terms. Greek origin should refer to the casting of the horses in Greece to represent a symbol of Greek history or mythology. If such were the case, the horses would have been designed or made by an artist of the 3rd or 4th century before Christ.

Roman origin implies nothing about the school of the artist; it refers to a Roman symbol and hence a birth date which could be anywhere between the time of Nero and the late Empire. Some experts on the matter, who believe the style of the horses is Greek, are nonetheless "Romanists" in the sense that they believe the horses were cast relatively late. There are "Romanist" purists who believe that they are Roman both by birth and conception.

The arguments must seem rather vague to the layman. They are based upon arbitrary comparisons with other monuments, on personal interpretations of historical events, or on the symbolic differences between Greek and Roman monuments in those days.

Amongst the various hypotheses offered to unravel this web, there is one that strikes us most. Opinion for opinion — convinced as we are that one is about as good as another — this is the one that we accept as most satisfying. Naturally, we cannot judge whether it is more valid than the others; we just know that we like it a lot.

It is the theory of a recently deceased German archaeologist*, and is based upon his critical examination of historical documents which have survived. Carefully sifting out the historical records (in some cases these would better be called chronical than historical) he was able to establish that in Constantinople before the arrival of the "Western Barbarians", there were two, rather than one quadriga of horses, and indications are that they were both gilded!

One foursome was mounted on the Hippodrome of Constantinople. A writer of the day cites this quadriga only in describing a spectacular suicide. At a certain point in his narration where he mentions the place where the suicide was to occur — a high platform which would be ideal to achieve a good shattering on the pavement below — he says " . . . near where there are the four fiery steeds with their necks slightly curved

* Editor's note: Dr. Johann Friedrich Crome, who died in 1964.

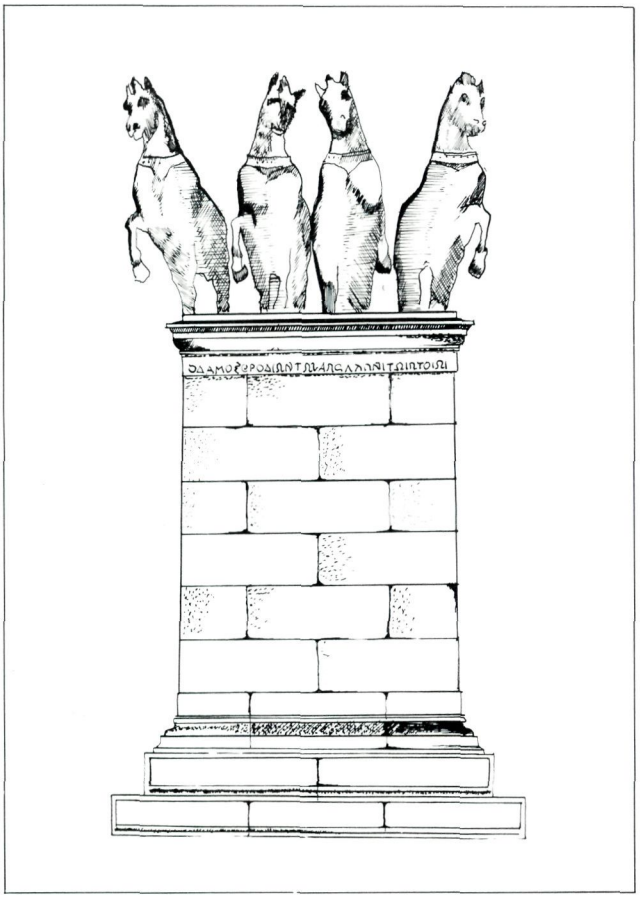


Figure 28. *The pedestal at Delphi. A drawing by the German archaeologist depicting the monument at Delphi erected by the city of Rhodes. Clearly visible is the inscription in Greek: " To Apollo from the people of Rhodes ". Note that the two inner horses are almost kissing while the outer two are about to leap, giving the impression of speed and agility. This is far different from their grouping today on the Loggia of San Marco (see Figure 1). On the pedestal they are a true quadriga in the accepted concept of the ancients. On the Loggia they are simply four golden horses. There are many indications that the monument at Delphi looked exactly as pictured by the German archaeologist (see Figure 29).*

towards each other and eager to leap into the race . . .". We know that these four horses had been brought to Constantinople from the Greek island of Chios by an emperor who succeeded Constantine.

The other foursome, the quadriga which was probably among the most precious works of art in Constantinople, was yoked to the Chariot of the Sun. We know only that it was in the square in front of the palace of the Emperor.

According to the German archaeologist, these are the same four horses which are today on the Loggia of San Marco in Venice. He excludes the possibility that the latter might have been the ones on the Hippodrome. He states that the four horses yoked to the Chariot of the Sun in Constantinople had been previously grouped harmoniously together on a pedestal in Delphi.

The quadriga was there in Delphi as a votive gift from the people of Rhodes to the Delphic Apollo, who in the ancient Western world was the most authoritative substitute for the Sun God himself. The German archaeologist was able to find in Delphi the pedestal that, according to him, supported the quadriga of Rhodes. On the pedestal (in Latin) there are the words: "To Apollo from the people of Rhodes".

The German archaeologist 'reconstructed' how the quadriga, composed of the actual four bronze horses of S. Marco had to be mounted on the Delphic pedestal. His reconstruction includes also the points of support of each hoof atop the pedestal (Figures 28, 30).

The perfect match of logical and har-

monious composition of the quadriga with the dimensions of the pedestal gives his theory an objective support that is difficult to ignore. (Consider, for example, the fact that the horses of San Marco are much larger than actual living horses.) It satisfies both geometrical and artistical canons. The quadriga is mounted so that it appears to be leaping towards the observer. The space taken up by the horses is exactly half of that available. The other half must have been destined to accomodate the chariot of the Sun as in Fig. 31.

He concludes that the quadriga which was on that pedestal was the famous golden quadriga erected in the city of Rhodes to the Sun, the god of the island of Rhodes.

For the people of this romantic island of the Mediterranean the Sun was the most revered of the gods. And this was only natural since they believed that their island was created by the Sun God himself.

The legend says that on the day that Zeus assigned portions of the world to the various gods, he forgot about the Sun God who was off doing his thing about creating the day. When he returned that evening and discovered that all the lands had been distributed, he asked Zeus to give him that island which he had seen beneath the surface of the water as he was passing overhead in his chariot. When Zeus agreed, the Sun God caused the water to evaporate and the island of Rhodes — for roses — emerged from the sea.

When the inhabitants of the island decided to build a new city destined to represent their power and their fortune, they

Figure 29. *Design on a Greek vase depicting a quadriga, hitched to the Chariot of the Sun.*

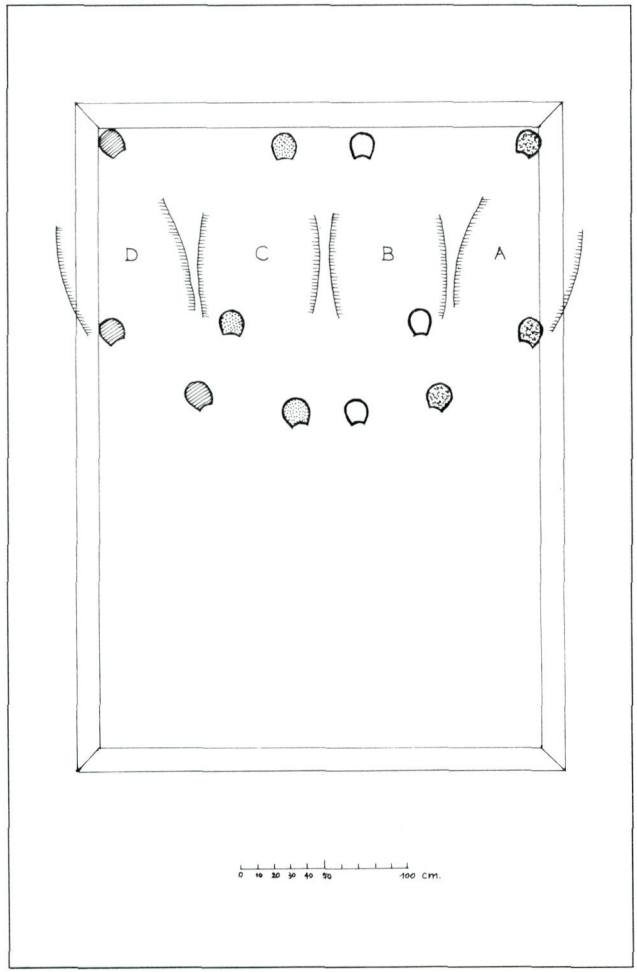


Figure 30. *A top view of the pedestal at Delphi. Utilizing the measurements of the horses of San Marco, the German archaeologist was able to establish what he believed were the points of support of each hoof atop the pedestal.*

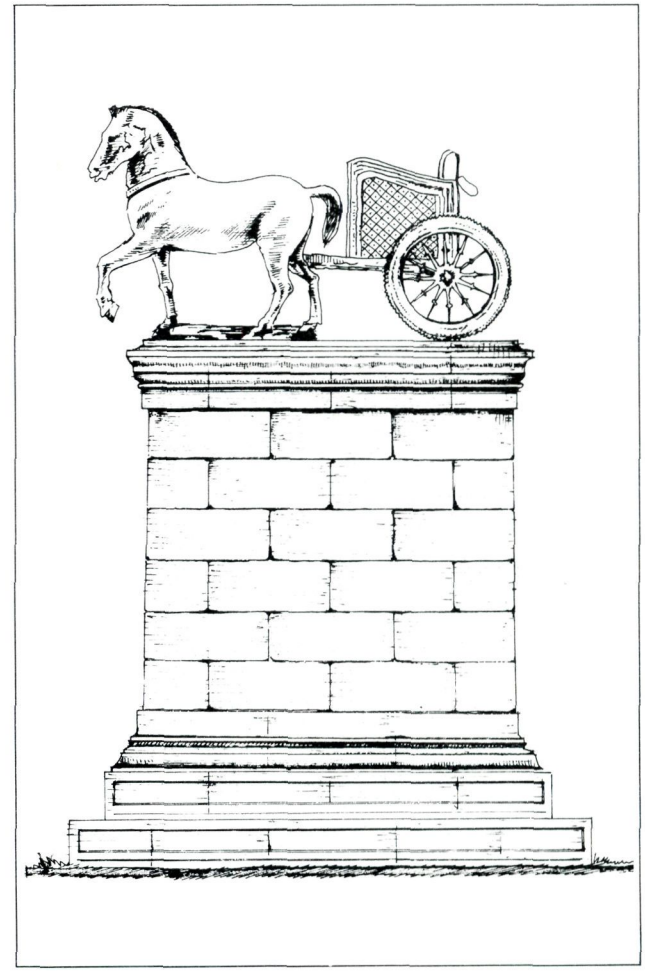


Figure 31. *Reconstructed pedestal at Delphi with the German archaeologist's conception of the placement of the quadriga and the chariot.*

named it Rhodes and erected for their creator the Sun God, a monument representing him driving his solar quadriga. And this had to be gilded because for them the Sun was gold and the gold was the Sun.

The master sculptor of the solar quadriga of Rhodes, which according to the German archaeologist was brought to Delphi, then to Constantinople, and is now in Venice, was none other than Lysippus, one of the greatest artists of ancient Greece.

We know very little about him although his work embraces a long period since he began very young and worked until he was quite old. He started as the sole heir of the great classical Greek tradition and, as he matured, he developed his own esthetic vision to become the distant precursor of the Hellenistic style.

He was an exceptional teacher and trained a group of apprentices who later did honor to his school — so much so, that one of them was responsible for the Colossus of Rhodes, the seventh wonder of the world.

Lysippus made an incredible number of statues in marble and bronze of the most varied subjects. Pliny tells that he had the habit of dropping a coin in a crude piggy bank after he finished each work. When Lysippus died the little bank was broken open and they found more than 1500 coins.

Lysippus was Alexander the Great's court sculptor. The features of the young "Ruler of the World" — of the world that then counted — were so close to the classical ideas of beauty and regality that a Greek sculptor of the day could not have found a better model. But Lysippus' skill revealed itself outside the channels of tradition as well. His statue of Socrates is not one of the usual "government-commissioned" busts of illustrious men. It goes far beyond. It pays homage to the creativity of Greek thought. In the funny, ugly features of the philosopher, his chisel masterfully shaped the unmistakable signs of a superior light of intelligence. I am sorry to be a layman and must remain one. I wish that I were able to declare with an authority which I do not have that I have never seen in any statue, ancient or modern, as effective an expression of genius — genius with a capital G.

All of his works are presumably lost. At least there is not a single work that can be attributed to him with certainty. We know him through faithful reproductions made by good copyists.

Some of his works made the trip the four horses are thought to have made. One of his giant bronze statues was taken to Rome and then to Constantinople. It was there when Dandolo's crusaders arrived. With the exquisite artistic sense which characterized them (or rather characterized the culture of the time) they melted it down to fabricate useful weapons. The same thing happened to a horse standing in the Hippodrome of Constantinople.

Lysippus lived in the second half of the 4th century B.C. in the period when all Greek art began to decline. The theater, painting and sculpture languished. But Greek genius was anything but dead. In fact, it was during this "decadent" period that there were laid the indestructible foundations of mathematics which, along with

other contemporary marvelous scientific achievements, guided and still guide humanity along the paths of knowledge.

It is very comforting to believe that the object of my excursion into the world of art has such an illustrious father and that it was conceived to represent a people's gratitude for a happy event in their history. In fact I would be much annoyed at having to accept the possibility that our (by now they are ours) horses had been cast to represent a Roman quadriga with Nero at the reins. Nothing could be more squalid! Among other things, Nero was a terrible driver. When he took part in chariot races everyone in the stadium laughed because of his spectacular tumbles. He would then stop the race and repeat it until he was able to finish victoriously.

The skill of the sculptor of the horses does not seem to be among the elements that help to determine his identity. In all of the material published on the subject, there is not one purely artistic judgement that might confirm or exclude the possibility that Lysippus, one of his students, or another artist made the bronzes. From an acquaintance who claims to understand sculpture I learn that it is a difficult task. There are no references to help and the motives which inspired the work are unknown. He adds that then as now there were excellent copyists. Another man whom I consulted, perhaps the least expert, said that to judge the real value of an unknown artist by examination of a single work of art is like evaluating the class of a tennis player simply by watching his play without seeing the ball.

Something develops, however, which makes the hypothesis of the Roman quadriga — with or without Nero — come back like a bad dream. During one of my frequent visits to Venice someone shows me a paper whose author examines the meaning of a particular characteristic of the eyes of the four horses.

The sculptors of antiquity represented the expression of the eye by a pupil in its center made as a simple round cavity. Often there was no pupil at all. But then in the 3rd or 4th centuries A.D. a technique was developed in Rome to give the statues a more lifelike human expression. The trick is ingenious. The circular cavity of the pupil is replaced by a half-moon or bean-shaped cut which causes a particularly effective play of light.

Our horses, notes the author of the publication, have eyes with half-moon pupils! This element is too important to ignore.

We are reluctant to passively accept its meaning — that is, that the sculptor lived after the 2nd century A.D. That would, of course, eliminate Nero but the Roman war symbol would remain.

We ponder how best to analyze this new technical detail and we decide that the only secure proof that the half-moon features are the work of the sculptor of the horses would be a perfect similarity between the eyes of twin horses.

I exclude out of hand the possibility that we could ascertain this through a comparison of photographs. Photographs might not reveal a slight difference between the two pupils. A geometrical reference com-

mon to both is lacking and cannot be created in loco.

I evolve a method of comparing the eyes photographically, not directly, but through impressions or castings. In that way the half-moons would be small bulges in a little shell. I would then fill the shells with water, arrange them like two spirit levels and photograph them.

As I am explaining to Demetria the meaning of free surfaces of water as geometric references, she has an inspiration. "It is useless to tax your brain further" she says, "There is a much simpler test. If we make an impression of one eye we can see if it fits the eye of its twin. We will have the answer instantly". The idea is brilliant and we debate how to carry it out.

The task requires the use of a self-hardening resin and a certain technical and manual dexterity. It is not unlike what a dentist does when he makes a mold of teeth. But it certainly is not a job for me. Demetria concedes that I might be able to spread the paste on the horse's eye but she excludes the possibility that I would be able to remove it after it dries. She means in one piece. We decide to lay the problem aside for the moment and examine the results of the Milan analysis of the scrapings from the trace of the harness. This too holds promise because that section of the unplated surface (behind the ear) is an element which certainly must be considered. It is likely that the trappings were applied at a subsequent time.

But if the study of the trappings doesn't add anything to our research, we may still get something worthwhile from the castings of the eyes. When informed of our desire to have these castings, the BEARDED ONE promises that he will take care of the matter as soon as he has time.

These discussions have not delayed the work on the graphic interpretation of the network of scratches and we finally arrive at the first reconstruction of the design. The work requires patience and a great deal of precise drawing. But when Demetria discovers that the separate drawings do not line up with each other to form the mosaic, we realize that during the period when the complete view was being prepared, someone inadvertently moved the projector and this threw off the reference lines. The projector was set up in the library of our Lab which is habitually open to everyone. It's entirely possible that someone bumped the projector, being unaware of its presence when it was not lighted. I cannot rid myself of the feeling that that someone was I. Demetria and her friend are sure of it. Despite the fact that many hours have been lost, Demetria is not discouraged and she is ready to start all over again. Cheerfully, she says that only one drawing is involved. Her spirit is a manifestation of not only the constancy of her character, but her enthusiasm about the results of the first drawings which appear to confirm the validity of our hypothesis. We secure the projector to ensure against chance displacement, and the painstaking work of reconstruction begins again.

I must go to the United States for a week to present the results of a laborious

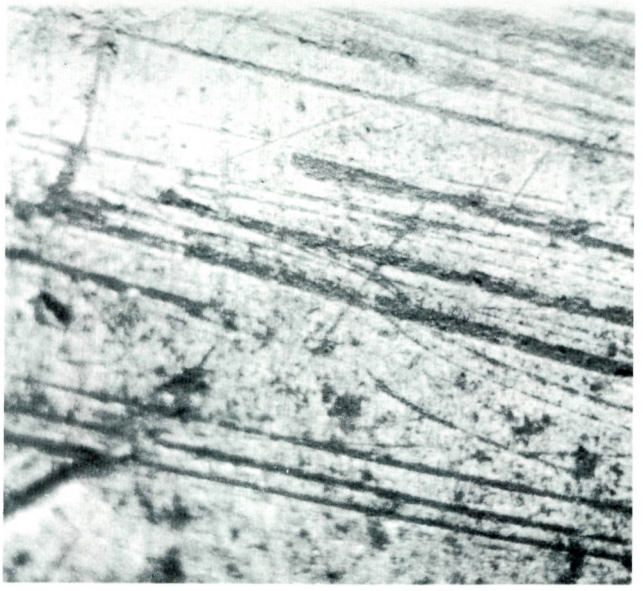
original research which has been brought to a happy conclusion in our laboratory. With the help of my co-workers, I feverishly work at preparing for the trip — assembling charts, graphs, slides, copies of manuscripts, etc. I abandon temporarily the research on the horses.

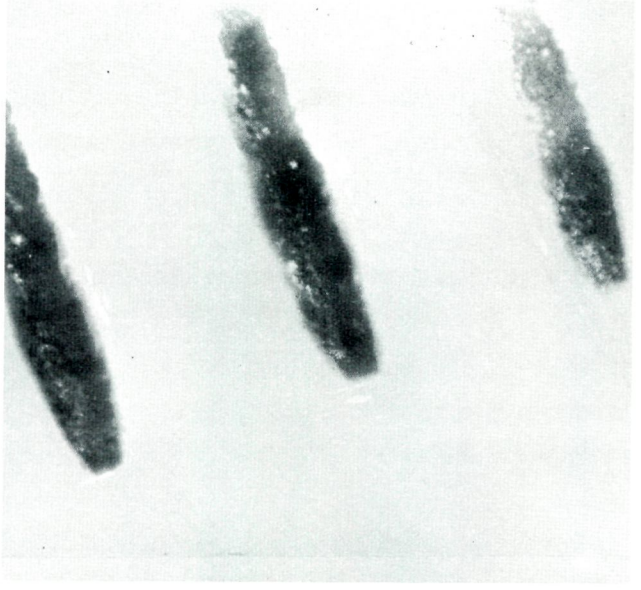
The tour of American laboratories is intense, with warm welcomes from friends and their families, and impersonal but professional attitudes of constructive criticism about the report that I am presenting. I am rather satisfied. I say "rather" because an American scientist never accepts blindly what he is told. He asks pointed questions, explores details of the report, asks if you have tried this or that, if you have taken into account the findings of so-and-so published in issue X of year Y on day Z. He does this in your interest and his to understand better and help you understand better. In some of our scientific circles, criticism of this type is looked upon as a personal attack. The efforts which our nation must demonstrate to progress in the field of scientific research must eventually pass along this same road. The liberal criticism, the continuous stimulus to do well, is not an American monopoly, but is open to all progressive nations. For example, England. Last year I went to an institute of an English university to present a work on a subject about which the institute had done avant-garde studies. The chairman (a gentleman of the sort who would not find the right words to tell you that you were wearing one black shoe and one yellow) took me by the arm and led me to a blackboard. He placed a piece of chalk in my hand, carefully lit his pipe, sat down with his fellow workers, and with a mocking smile said, "All right, you might as well get started; our knives are ready. But be careful with the weak points because that is where we will attack".

This is an attitude which in the course of time, I have learned to appreciate and consider as proof of esteem.

After a stop at the National Science Foundation with which our laboratory has dealings, I reach my last and favorite stop — the home of a famous research scientist. I call it my home in America because I have lived there so much and have lost the so-called guest complex.

After dinner other research scientists arrive and we talk about work. At a certain point I tell them the story of the horses and elicit lively interest. They eagerly follow all details and they suggest analyses with special instruments — offering assistance of all sorts. The discussion goes on to the matter of restoration about which they know that, until now, I am not interested. I report that the physiochemist in Rome, his colleague in Padua, and the Professor of Metallurgy of Novara are experts on the subject and have conducted studies to determine the degree of stability of the gold leaf so as to determine the best method of restoration; they have determined that the green corrosion products extend from the scratches under the layer of gold in some places and that there are many spots where the gold leaf no longer rests on the bronze surface but on the substance of corrosion; simply washing away the green might have serious consequences





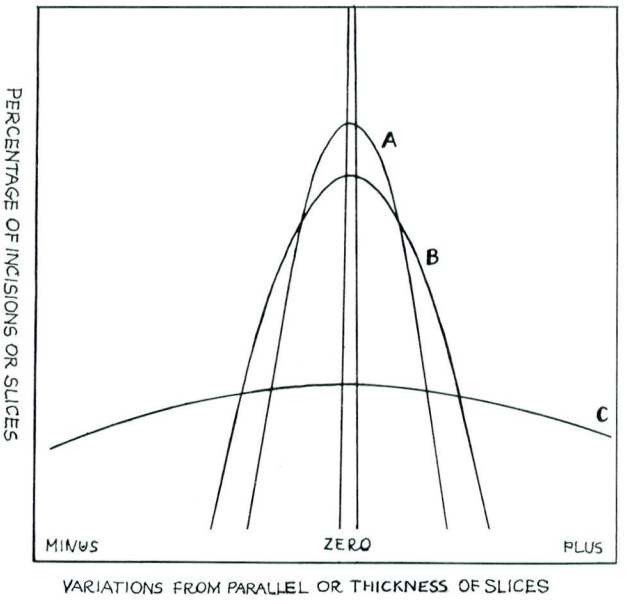


Figure 32. *Microphoto of an area with tightly spaced scratches showing how neatly they parallel each other.*

Figure 33. *Microphoto of the beginning of three adjacent scratches. Note the sharp outline of the point where the burin began its incision and the exceptional parallelism.*

Figure 34. *Graph described on pages 71 and 72.*

because there is the danger that part of the gold would wash away as well. Some scientists argue that this same thing should happen when it rains. I answer that the physiochemist of Padua is studying this very aspect of the problem.

Some of the group are acquainted with special resins. Oftimes words are improperly used with precision even by experts. By resins in this case they do not mean natural products like shellac, dragon's blood, amber, myrrh, and the balms our grandparents used, but rather those products of modern chemistry that have gigantic formulas and are purposely "constructed", molecule by molecule, with advanced industrial processes.

In the little town of my host is the headquarters of one of the largest industries in the world. It is so well known in America and abroad that no one knows the name of the city where it is located. It is as though FIAT headquarters were in Pavullo instead of Turin. Its name would indicate that it deals with electricity but in reality it deals with almost everything.

One department of this giant industry is highly specialized in artificial resins. My host, who is a consultant there, suggests that I take advantage of my visit to speak with the GREAT RESIN AUTHORITY. He makes a few telephone calls. Only out of courtesy will the great man see me. His hours are precious but he will expect us at eleven the next morning, which is already today because our discussion of the horses has kept us up until dawn.

The GREAT RESIN AUTHORITY is less optimistic than my colleagues. He asks me about the chemical composition of the corrosion substance. I explain that the physiochemist of Padua has discovered that the green deposits are the result of complex chemical and physical reactions. Some reactions form copper salts and others remove them. Copper carbonates are missing, for instance, indicating that once they are produced (which occurs in a reaction with the carbon dioxide of the atmosphere), they are removed from the horses' surfaces by the rainwater (which is a mild acid because of the pollution in Venice's air). The chemical composition of the corrosion substance is thus the result of these processes.

He understands the difficulties that the restorers are facing and he believes that some information on certain resins might be useful to them. At the end of our talk I have a file full of notes and technical publications.

I leave the United States with the usual contrasting feelings; gratitude to the country whose guest I have been and nostalgia for Italy. A nostalgia that is all the more intense for the distance.

I disembark at Rome's Fiumicino and Italy at once reappears as she is.

When I get back to the laboratory I find that a great part of the photographic material has already been mounted. But while that is going well, the basic research in the laboratory is another thing. My neglect of the recent past is beginning to make itself felt. In addition, our agreements with the National Science Foundation entail a whole series of revisions and a new framework for all current research.

The atmosphere (and I refer not to the

object of our research) is heavy and I am almost brutally pulled back to my work. I am so busy that they seem to have forgiven me for the time that I have "lost". I rapidly become interested in the conclusions and results of our recent labors. I exercise care with details: our work takes shape, is corrected, revised and discussed. Final drafts are prepared and part of the work is sent to the United States. Everyone is convinced that I have finished with the horses.

In my rare free moments I examine the photographs made through the microscope and, as I had feared, they came out badly. I study the beautiful photos done by the Venetian photographers and I wonder how the regularity of the lines — some with extraordinary parallelism — could be demonstrated objectively. I reject my first impression that they may have been made with a multi-pointed chisel because there is enough divergence to exclude that possibility. These lines merit a critical examination.

The regularity of the curves and parallelism can be expressed numerically. In an important nuclear techniques institute of Bologna there is a machine designed to follow the traces of nuclear events recorded in photographs. As it follows the traces, the machine registers the position of the points explored. Relative mathematical models provide information on the path of the lines and hence on the nuclear events.

My friends who have the machine say that the computer has a few idle moments each day and I am welcome to them. We make a drawing of the zone with the fine lines, photograph it and feed it into the machine. The pertinent mathematical program is fortunately available and the next day my friends at the institute give me the data tabulated by the computer. The results are astounding. In some portions of the curves the relation of the tangent to the curve is almost constant. This shows an extremely firm hand — one that can draw a portion of a circle with a constant radius. The parallelism of the straight lines is almost perfect.

To evaluate the skill of the artist's hand, we examine several of his groups of parallel lines. For comparison we use an analogous configuration from an engraving of a well-known modern artist. We assume that both artists engraved the groups of lines intending them to be parallel. This is not generally a valid supposition because the artist does not think in geometric terms but according to a vision of the final result that he alone knows. But when the lines are drawn at an almost microscopic distance from one another, the assumption becomes acceptable because the artist would tend to avoid having the lines intersect.

The two configurations studied — that of the sculptor of the horses and the one of the modern engraver — both confirm this assumption: 15 to 20 lines in a space about a half centimeter wide do not touch.

The computer is able to furnish numerical information on how closely parallel the lines are.

A few hundred numbers in a column would mean very little to the reader and so I have endeavored to illustrate this information on a chart (Figure 34). Curve A is that

of the sculptor of the horses, B that of the modern engraver and C that of an ordinary draftsman. To interpret the curves as a measure of skill, it is enough to know that the narrower and higher the bell-shaped curve the greater the parallelism of the lines and hence the surer the hand that made them.

The long line in the center that runs off the paper represents a hypothetical almost perfect parallelism: minuscule width of the curve and almost infinite height.

The results from the computer show that our great artist and the modern engraver do excellently. The difference between the two is negligible. A comparison of the two with curve C, that of the mediocre draftsman, shows that the two artists belong to a class quite apart.

Demetria believes that not everyone will understand this explanation. For those who have the same acquaintance with mathematics as Demetria, I offer an example which may capture the spirit of this sort of analysis.

Let us suppose that we have to slice a ham so that the slices are very thin (as is desirable with Italian prosciutto) and as nearly as possible the same thickness. If we put the ham into a modern mechanical slicer, the slices will be practically equal. The "skill" of the slicer might be represented by the narrow curve which runs off the paper. The thickness of any given slice will be practically the same as that of all slices. Now let us give the prosciutto to a delicatessan man. He certainly will not be able to do what the slicing machine did, and any given slice will be a little different in thickness from the average slice. But it is unlikely that the degree of variation will be very great. He makes mistakes but they are little mistakes. His skill could be represented by lines A or B.

But if we undertake the slicing ourselves — even if we pride ourselves as being efficient around the house or in the kitchen — our skill with the knife is likely to be less than that of the salumiere. The slices that we produce will vary greatly one from another. It is also probable that some of them will be as thick as the sole of a shoe. The bell-shaped curve representing our skill would be very low and wide.

CHAPTER FIVE

The reconstruction of the drawings is taking shape and the most convincing part of our research is emerging from Demetria's work. The light and shadow of the lines reveal the horse's features with impressive fidelity. If our drawings could include as well the extremely fine lines, the shadowing effect would be even more evident.

When I see the completed drawings mounted against a gold backdrop and I see how they reproduce in an artistic synthesis the vague picture with which we started, I cannot help but be pleased. The details of the head and neck are followed to perfection. With his burin, the artist almost redesigned the features of the horse.

But my satisfaction is not like that which I have experienced on other occasions (a few!) when I have finished a research in my own field. I believe that I understand why. The most difficult part of research is not the doing of it. To put together the pieces of a problem, study the most sophisticated theories, read and reread articles, put together again and again the right instruments, scribble out increasingly proper models — all this is an activity with even its amusing aspects.

The hard work begins when the research is completed. One then has to examine his conscience — justify the procedure used and the methodology followed. And the worst about this is that it must be in writing. It is a sort of self-criticism and a painstaking effort to find the holes and weaknesses in one's work.

And that effort is always directed to those few individuals who constitute the international scientific community. It is to them that the researcher — without being aware of it — directs his work. It is their judgement which will determine whether or not his contribution will leave a mark, however small, in the great book of human knowledge.

I feel uneasy about this business of the horses because I am not convinced that I have yet arrived at a phase where I can put together the pieces to examine my conscience. I try, but cannot define some parameters. I can't find the correct terminology. Some aspects of the research seem incomplete. I wonder if I should continue the research so as to come up with other details to confirm in other terms that which has already convinced that part of me called common sense.

I confide in Demetria who bluntly tells me not to be ridiculous. There is no need, she says, to convince the tortured minds of physicists: there is nothing to discuss because the results speak for themselves and only a sectarian could object.

I think aloud — that the methodology used in our research is substantially that used in physics generally, even though our problem was not one of physics. I should therefore like to examine the results and draw conclusions as I usually do.

I consult with physicist colleagues who counsel me to steer clear of it. It is a mined field! If I were to try to argue that the interpretation of a figurative composition in terms of "artistic taste" is simply a series of

very rapid mental processes condensed and concentrated, which, on the basis of a long series of experiences that all humanity has had (transmitted from generation to generation through complex biological messages), evaluates what is under observation, and this interpretation is comparable to the conclusions from logical analysis of physical data based upon physical laws, I would run the risk of being branded, at the very least, as having a "mechanistic vision" of "artistic taste".

They advise me not to create unnecessary problems but to leave this sort of work to philosophers of science.

I find comfort in Demetria who, as I said before, knowing little or nothing about physics, understands my concern. She understands it but does not share it.

She declares that the phenomenon which we investigated is something which one can see with the naked eye and that we are able to examine it "live". It is therefore proper that the result be expressed in terms of a correct "vision" of the phenomenon itself. Other research projects in our laboratory have always seemed absurd to her because they dealt with things that are not visible.

Perhaps that is the reason I am creating this problem for myself, she adds.

Without losing my composure, I try to explain to her that some phenomena can be "seen" in different ways and one way is as good as another.

She doesn't agree. She reminds me of the time a student worked month after month on a glass apparatus connected to various electronic instruments. To her enormous surprise she learned one day that the student was doing his dissertation on the atmosphere of Mars.

She points out that the investigation of the horses is entirely different. The problem is different and physics has very little or nothing to do with it. What we intended to do we did with satisfying results. We should accept them as they are.

She believes that my uneasiness derives from the simplicity of the research. She insinuates that deep down what really annoys me is that the results can be understood by anyone. I try to justify my attitude and to explain the student's apparatus to study the atmosphere on Mars.

The next day in an effort to demonstrate that she is not alone in her opinions, she leaves on my desk a paper on which she has written in a beautiful hand "Translation of a passage from Duhen: how Duhen describes an experience in physics":

"You enter a laboratory and go to a table covered with instruments, an electric battery, some silk-covered copper wires, little basins filled with mercury, strange bobbins, a little steel rod to which a mirror is attached. An observer sticks the metallic leg of a peg with an ebonite head into some little holes. The steel rod oscillates and in the mirror attached to it you see a round spot of light appear on a plastic ruler; the observer scrutinizes its movements. This must be an experiment, you say to yourself; by watching the way the luminous spot comes and goes the physicist is observing in its smallest details the movement of the little steel rod. You ask him what he is

doing; do you think he will say I'm studying the oscillations of this piece of steel to which this mirror is attached? No! He answers that he is measuring the electrical resistance of a bobbin. If you look astonished, if you ask him what the movement of the light means and what relation it has to the phenomena he and you saw at the same time, he will answer that your question would require explanations of excessive length and he will immediately send you a textbook on electricity".

I realize that for the moment it is just as well to let things lie as they are. The results of the investigation of the horses are all there grouped in a disorderly way. It is clear that the reconstruction of the drawings is the most spectacular element and it seems to annul the others — or, who knows, maybe to include them.

Demetria is satisfied with my apparent resignation, but she does not realize that it is instead doubt and uncertainty. To convince me, she makes a few more comments on the scientific aspects (which she thinks are for me the most important ones) of our work. She says that we really started out with the idea that the scratches were made by the sculptor himself and that all we did was attempt to prove what we thought. "Is this how scientific research is conducted?", she adds sarcastically.

I seize the occasion to regain lost territory. I assume a professional stance but I do not succeed. I have never been able to achieve the professorial tone of voice, much as I've envied it in others.

I explain to her that it is normal in science. Research is always dominated by preconceived ideas. We call them hypotheses or working hypotheses. If we sometimes think we are free of them, it usually means that they are present in our subconscious. In any case they come to life with the very first steps we take on the new ground we are exploring.

Clearly the hypothesis, once formed, will guide our research. The danger is that it influences us by making us evaluate favorable elements too highly and ignore those which might weaken the hypothesis.

This is the reason why one must examine his conscience in the way I stubbornly insist upon doing. This self-examination does not have to do with results, which are as they are, so much as with the method adopted every step of the way. That is why the critical examination should not be directed to an individual thought but to the collectivity.

It is obvious that she is little impressed by these "sense of duty" considerations and so I bring the discussion down to a more earthy level. I point out that our work will be judged not only by experts, but by public opinion, by everyone. And it is these non-experts who generally have the most pitiless reactions.

How often someone devotes himself to a task which in perfect good faith he considers important and then after all of his labors, he is mocked and the whole thing crumbles in his hand. I try to explain that the embarrassment of such an occurrence lasts a long time. I could even tell her about the sadness of old scientists who have spent

Figure 35. *Photo showing structure of network of incisions on the chest of the « laboratory » horse.*

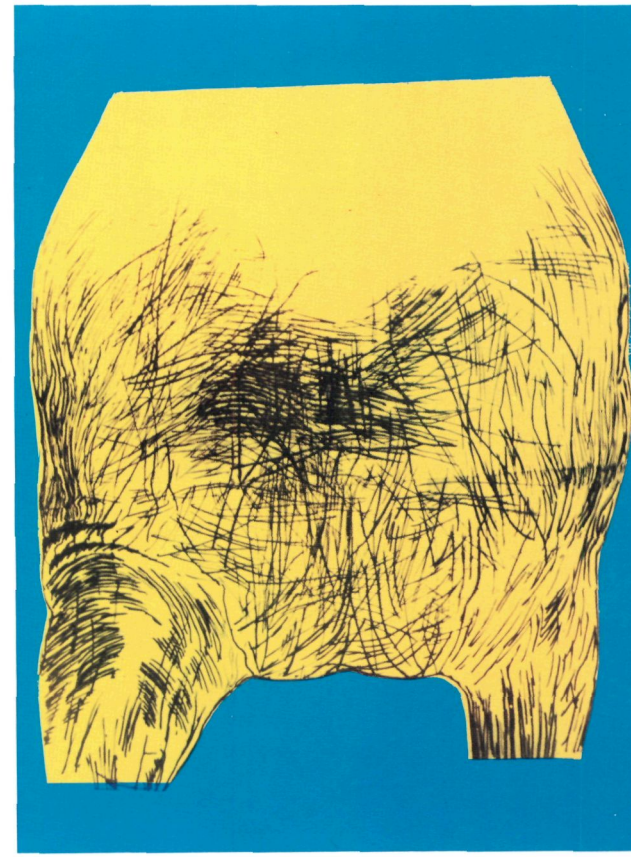


Figure 36. *Graphic reproduction of the scratches shown in Figure* 35.

Figure 37. *Photo of the chest of another horse on the Loggia of San Marco.*

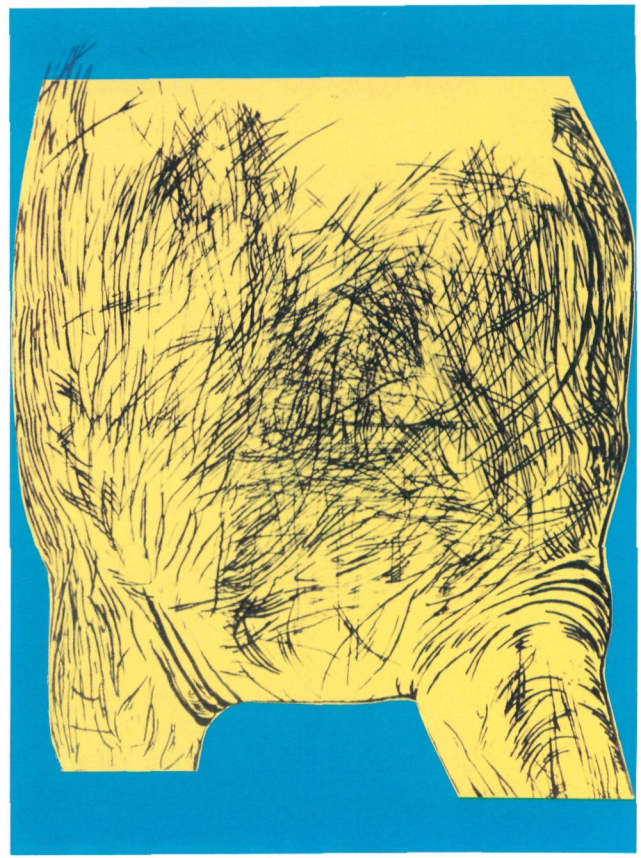


Figure 38. *Graphic reproduction of scratches in Figure 37.*

Figure 39. *Partial reconstruction of the original network of scratches on the heads of two different horses. Since the scratches on the brow were almost completely filled with corrosion the details of the fine network in this area were revealed through very large blowups. The eye has been added to the drawing merely to serve as a point of reference.*

Figure 40. *Our reconstruction of the network of scratches on the neck. Note that the incisions parallel the mane and the deep curve of the mouth (in the lower figure). The lines which we have necessarily made to show the rippled mane are merely an embellishment of the drawing.*

Figure 41. *Reconstruction of the network of scratches around the mouth of a horse. Note the delicate and precise manner in which the incised lines follow the curvature of the mouth and nostrils.*

their entire lives trying to refute Einstein's theory of relativity. But I do not think she would understand. I tell her, instead, about an incident which could happen to anyone. In fact it happened to me.

It occurred back in the years when I was a student in the most beautiful and chaotic city of the world.* To get my hands on a little money I worked part-time for a firm which needed a boy who could do more than add and subtract.

At two o'clock one blistering August afternoon, I was heading for work. The city was almost deserted. As I turned into my street I noticed a crowd of people in front of the building where I worked. As I drew nearer I saw that the people were anxiously looking up at a window from which a half naked child was leaning. The building had a labyrinthian complex of stairs and hallways. I noticed that some of the good people were ringing all of the door-bells at once.

I recognized immediately the apartment. I rushed into the building passing the porter who had been awakened from his siesta (would that I had stopped to talk with him!). I ran up the stairs planning my action. As I reached the proper floor, I crashed against the door which to my great surprise gave way before me in a cloud of plaster and dust taking with it the door frame and casing (obviously of war-time construction). There on a sofa lay an old, apparently senile, man (later I learned that he was only deaf) and the baby. He was wearing a canvas harness secured by a long strong rope tied to the leg of a heavy piece of furniture.

I prefer not to repeat the comments of the crowd, nor the reactions of the porter who had had time to tell them about the baby's harness. I tell Demetria of the daily humiliation I suffered for the next two months — for the period which I continued to work there. The baby's father, the owner of the apartment, wanted me to pay for the damage to the door. I was not bothered by his pressure and obviously I did not pay him. What bothered me was the ironic smile on the face of the local bartender each time I passed, the cutting remarks of the porter, and the pitying glances of the tenants of the building. The attitude of my fellow workers was no different.

My story has some effect. The fear of being ridiculed is the key that opens many doors. She agrees that the results of our work must be presented to experts.

I sit down to write an article about our research. With her help, I rewrite the introduction seven or eight times. I find difficulty getting into the body of the article — the artistic portion of the research — without saying that the authors know nothing about art. But with a bit of literary gymnastics I succeed in doing so. My concluding statement is that a judgement of the importance of this research is humbly left to qualified scholars.

After repeated polishing the article satisfies me. I have cut out much of the technical detail and the English seems fine (perhaps because it is like the English of someone who doesn't speak Italian). But when the manuscript is finished I realize that, good planner that I am, I have no idea to whom

* Editor's note. He refers to Rome, of course.

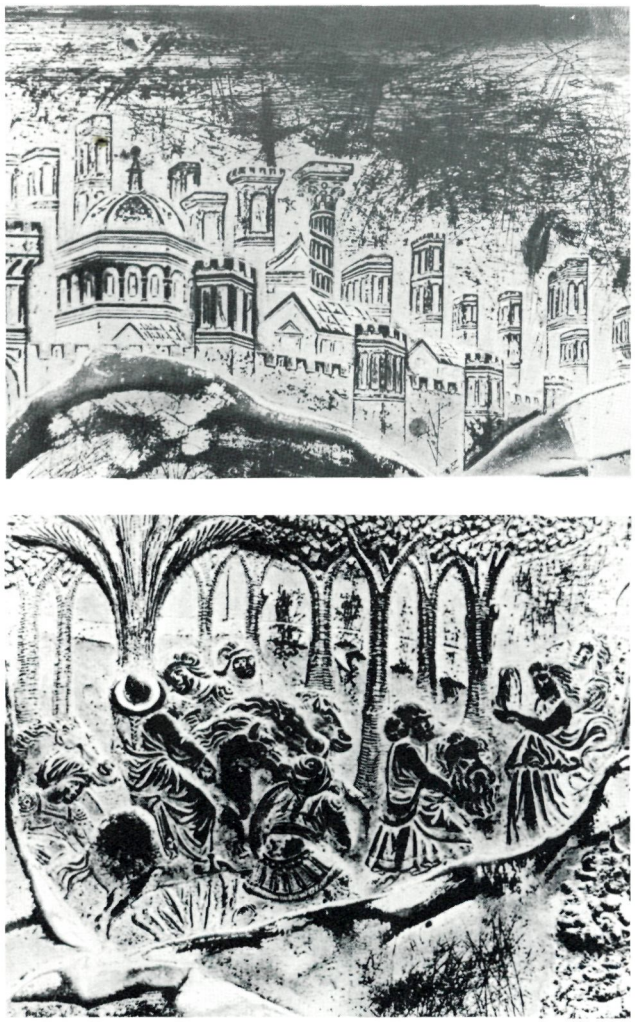


Figure 42. *L. Ghiberti. Panels of the Doors of Paradise. Note the shading on the flat areas (sky and background).*

to submit it.

I race (only one flight of stairs this time) up to ask the counsel of my authoritative friend, the GREAT ART CRITIC.

I find him as he likes to be found, surrounded by papers, photographs, and open books — in the pose of a tired intellectual immersed in his creative work. He firmly believes that the occasional visitor will be so intimidated that he will tiptoe back out without saying a word.

But I know my man. I pull him away from his meditations and put my problem to him. Rather condescendingly (he knows that I am irritated by this manner) he lists the names of some international art journals. "This one is too conservative; no one there will even read your article; that one doesn't deal with matters of this sort; this one . . . a waste of time . . . " etc.

He has no time to read the article but when I show him the photographs of the network of scratches, the condescension disappears. I see that they interest him, but he strives to deny me the satisfaction. He suddenly realizes that he has given me too much time, announcing that he has serious work to do, that he is sorry that he can entertain me no longer, etc.

At the door I ask him the name of the best-selling, most prestigious international art journal. Without replying he pulls from the shelf a fat brown magazine and hands it to me. It is published in England. I leave him without saying goodby since he is again entranced with his Raphaels.

I send the article to the famous magazine and within a few weeks I receive a highly

flattering reply. The editor is high in his praise of the "fascinating" article which is well worthy of publication.* He thanks me for having chosen his journal for so delightful an article.

I am elated! "In a jujube soup" as they say in Rome.

Along with the compliments the editor reports the comments of a German scholar who read the article. He was reminded of when, after the last war, Ghiberti's doors on the Baptistery in Florence were cleaned of the centuries of filth and restored. Looking at the photographs of the Ghiberti panels, he discovered ("Lo and behold", I quote him) that the gilding there shows the same sort of scratches as on the horses of San Marco. He adds that Ghiberti, too, faced the problem of reducing the reflection of certain portions of the gilding. The scratches are never on the figures in relief (finely designed by Ghiberti in an alternation of volumes and voids) but only on the flat surfaces like the sky or flat walls!

My friend the GREAT ART CRITIC possesses all the literature on Ghiberti. As he reads the letter from the editor and the comments of the reviewer (whom he describes as a famous scholar on the Quattrocento) his usual air of condescension disappears. He abandons his work, goes to a bookshelf for several large volumes which he places on the table. He finds the photographs mentioned in the letter and he sits down with a magnifying glass. It is easy to find the scratches; they frame the central figures in the various panels. They shadow the sky and the trees in the background. They fill, with varying density, the empty spaces in the scenes. (Figure 42 and 43)

There is no doubt about the purpose of the "graffiti". Ghiberti was well acquainted with the effect; he used it to reduce the reflection of the flat portion of the panels so that the observer would not be too dazzled to see the central figures. My friend suggests that the great artist, a careful student of the techniques of the ancients (I am shown pages of Ghiberti's "Commentari") had probably discovered the trick of the scratches and then used it. With the glass the GREAT ART CRITIC examines reproductions of other works of Ghiberti. He discovers that the effect of shadowing the gilt surface, first used outside, must have pleased Ghiberti so that he used it on bas-reliefs meant for indoors as well. He finds as evidence a bas-relief on the baptismal font in the Baptistery at Siena. The scratches are finer and denser than those found on the doors of the Baptistery of Florence (because of different distances from the observer?) and their effect is even stronger. A nearly continuous shadow surrounds the central figure. (Figure 44)

I wonder why the restorers didn't notice, as did the German scholar, that the scratches are distributed in such a way that they couldn't have been done by accident.

Michelangelo called Ghiberti's work "the doors of paradise". How much did the shadowing caused by the scratches count in this authoritative judgment? The editor concludes his letter stating that a new line of research in the field is opened.

* Editors note: March 1975 issue of Burlington Magazine, London.

Figure 43. *L. Ghiberti. A panel of the Doors of Paradise.*

How wonderful these foreign art historians! How easy to begin a conversation with them! I cannot help but compare their attitude with that of editors of scientific journals in our field: what a contrast!

Demetria is as delighted as I, and she confesses that she is glad that I insisted on doing it my way.

I have hardly finished basking in the letter from the English editor when an entirely different incident confirms yet again that gilt objects in the sun appear just as the great artists that we have studied saw them (we beg indulgence of Renaissance scholars if, in our ignorance, we allow ourselves to compare our unknown sculptor with Ghiberti).

Much of the photographic material used in the project was given to us by a nationally famous Bolognese firm. And I must add that the handsome photographs published herein are either their work or that of the Venetian photographers. The modest ones we did ourselves.

A good part of the well-done photographic material required many proofs. To decide on the best we spent hours with the director of the firm and with one of his coworkers, a man sporting a splendid nineteenth century moustache and, more important, a quick mind. We saw each other so often that we became friends.

While we are working on our horses, MOUSTACHE comes to Venice on a trip with his son who hangs on every word as the father plays the learned guide, showing him the Moors, the Basilica, the Horses and other works of art in the Piazza. The father

explains as he photographs. The little boy understands everything. When the father points his lens at one of the golden lions atop a pole (it is the lion with the sword), he directs the child's attention to the lion. The little boy is puzzled and says that the shiny object up there looks more like a ball than a lion, although not a perfectly round ball. And then he adds "No, papa. It looks like the sun".

The sun is shining on the golden lion. MOUSTACHE looks again and notes happily that it is not the generation gap. Under those conditions, in that light at that moment, the lion is visible only to those who know that it is a lion.

The reflected sunlight is so glaring that the child cannot distinguish the outline of the gilt object. Is it possible that innocent eyes see, as do creative artists, what the eyes of experts fail to recognize? I try to show off a little of my "classical" education to Demetria by reminding her of the fable of the Emperor's golden clothes. The frightened multitude could not see what the innocent child observed. I admit that deep down, I, too, am one of the frightened. I may not applaud the beauty of the emperor's clothes, but I do not have the courage to say he is naked.

MOUSTACHE'S account arouses my curiosity. I try to steal from Demetria several articles which deal with gilt objects, both ancient and modern, displayed in Piazza San Marco. She catches me and loses her cool. She says that gilt objects scratched and unscratched are growing about us like mushrooms and if I want to collect them all I

Figure 44. *L. Ghiberti - Baptismal font. The Baptistery of Siena.*

might as well change my profession. She adds, with veiled sarcasm, that to distinguish the good mushrooms from the bad takes more than physics. It takes a lot more!

Perhaps her attitude is justified. I am already too deeply involved with gilt objects. But I am aware that this horse business is contagious. Even the publisher of our book, a serious fellow, did a little on-the-spot research in Greece. He sent me back a photograph of a single bronze horse from a lost quadriga, a good Greek work. It was cast around 450 B.C. What is its alloy? Who cast it?

I stifle these questions and return with Demetria to examine our progress. Our feelings of great satisfaction come not so much from our successful research as from the close relationship that we have established with the unknown sculptor who, many centuries ago, devoted his talent, skill and courage to a work of art so complex — an artist who, above all, had the cleverness and determination to overcome the incredible difficulties as they arose.

Once the last battle with the sun was won, his four horses were installed on a high pedestal as symbols of something which we do not know and may never know.

The GEOLOGIST friend returns from Milan with the results of the analysis. Here, too, we are pleased because our hypotheses seem exact, although not quite as we had formulated them. The results show that the trappings were applied after the gold plating operation. Silver is present in the corrosion substance deposited along the strips. It probably comes from a gold-silver electrochemical corrosion. A replay of the sequence of events appears relatively easy: the horses were entirely covered with gold, including the strips where the trappings were subsequently placed. I can accept the possibility that when the horses were removed from their original pedestal and placed elsewhere to represent something else (probably yoked to a chariot), the trappings were applied. So that they could be fixed solidly to the bronze surface, the gold leaf was stripped off the area which they would cover. The trappings were probably a silver alloy. We do not know when or by whom they were removed and probably never will. No writer has mentioned missing harness and we can assume that it was already gone when Dandolo took the horses from Constantinople. If one day an archaeologist were to declare that the horses were cast in Greece or in the East where they were displayed free under the sun, and only later taken by the Romans and yoked to a chariot, we would certainly agree.

After some time I meet again with the other menbers of the commission and we compare data. Everything fits together nicely and everyone seems to agree on the conclusions. Restoration measures are discussed. Unprepared as I am in this area, I listen to what the others have to say. The chemist of Rome has conducted experiments to determine the chemical and physical characteristics of the corrosion substance. His findings seem to provide a valuable basis for a decision as to how to restore the horses. He has found that the green substance contains a high percentage of water-soluble

salts and he has proven that when the water evaporates entirely from the horses' surface, the corrosion substance becomes dry, extremely fragile and porous.

I tell the group about my trip to the United States and I pass to the physiochemist of Padua the information on the resins. He is familiar with developments in this field but expresses interest in a special new silane resin created by the firm which I visited in the U.S. Many of us are convinced that magic formulas will not be necessary because relatively simple solutions seem possible. We all assume (although we do not say so) that we will discuss the matter further after the summer vacations. Our goodbyes are especially warm — like those of students saying goodbye after the last day of school.

Vacation time is here. Hot coffee gives way to iced coffee in the mid-morning snack. Pants and T-shirts in atrocious colors appear on the streets. Our laboratory begins to have a demobilization atmosphere. We discuss plans for vacations, such as can be afforded. The BEARDED ONE says that he will make several trips so that his kids can get a little fresh air. He remembers his promise about doing the impressions of the eyes of the horses and says that he will take care of that during his vacation. A week later he calls me from Venice. It took him fifteen minutes to do the job. He reports that the eyes of the twin horses have half moons carved differently from one another. He did only three because, despite my repeated praise about his talented hands, his legs are not designed for climbing dangerously out

Figure 45. *Photo of the casting of the corresponding eyes of the twin horses.*

over bronze monuments. He returns a few days later and delivers the molds. The difference between the half-moons is so apparent that I abandon the idea of doing careful measurements and comparisons (see Figure 45). My ideas become even more confused. I ask the opinion of a sculptor who is familiar with casting techniques. He says that it isn't at all certain that the half-moon technique was a 3rd century innovation. He thinks that the circumstance is far more complex than it appears but that the presence of the half-moons should not cause the imagination to run wild. He doesn't think that the difference between the two eyes is necessarily proof of their later origin. A sculptor can make minor modifications in the mold before casting and it is entirely possible that the difference between the eyes of the twin horses was effected at the time of casting. He adds, however, that bronze, and particularly a bronze like that of the horses, can be worked like "biscuit dough". In other words, the half-moons could have been done any time after the casting.

The information about the eyes proves exactly nothing and the light which we glimpsed through the mystery of the horses darkens again. However, the picture which we have put together is still valid. How long it will stand up is another matter. Perhaps we ourselves have put in motion the mechanism which will soon cancel it from our minds.

EPILOGUE

After a few days I go to see the BIG BOSS and I show him the reconstruction of the network of scratches. He says that the conclusions are so obvious that he regrets having involved me in a project so banal. His other remarks clearly indicate that, at least for him, the business of the horses is closed.

He goes to the blackboard and with his usual clarity defines for me the terms of a new problem. He particularly emphasizes — and this is so unlike him — the fascinating aspects of the project; this time it is physics.

I know why he is doing this. He has seen through me. I can detect from his first words that he is confident that he can take my mind off the horses.

But even if his flattery touches my most sensitive chords, I believe — I don't know how — that I will be able to resist him.

He doesn't know that I have already sent to a highly specialized research institute a package containing the pieces of wood found inside the horse.

He knows perfectly well what physics can do with an old piece of wood. It can establish its age.

. . . The law of causation is neither fair nor false; it is rather an heuristic principle, a guide. I think it the most precious guide we have to orient ourselves in the confused muddle of events and to indicate the direction scientific research must take to achieve fruitful results. Just as the law of causation takes over the soul of a child as soon as he awakes and puts in his mouth the tireless demand "why", so must it guide the scientist all his life, incessantly posing for him new problems. Science, in fact, does not mean restful contemplation of knowledge already achieved, but constant work and constantly progessing development toward a goal to which we may aspire, but which we can never attain.

MAX PLANCK

. . . you can easily understand how these things that shortly before were black can suddenly become white like marble; how the sea, when gusts of wind agitate it, turns into shining, marble-white waves. You can therefore say that when the matter that constitutes a generally black body is disturbed, and the order of its atoms is changed, and some atoms are added and others taken away, it can suddenly seem white and splendid.

But if the waters of the sea were made up of little blue particles, in no way could they become white. However you mix the blue particles, never will they turn to the white of marble.

LUCRETIUS, De rerum natura,
Book II, 757 1st century BC
(*home-made translation of a passage which in Latin is far more beautiful*)

Opinion the color, opinion the sweet, opinion the bitter: in truth nothing other than the atom and the void.

DEMOCRITUS

The puzzle about the origin of the four horses and the identity of their creator was for us so engrossing that, overcoming our initial incompetence (which gave us some worrysome moments) we went on to explore all the paths which, one by one, opened before us.

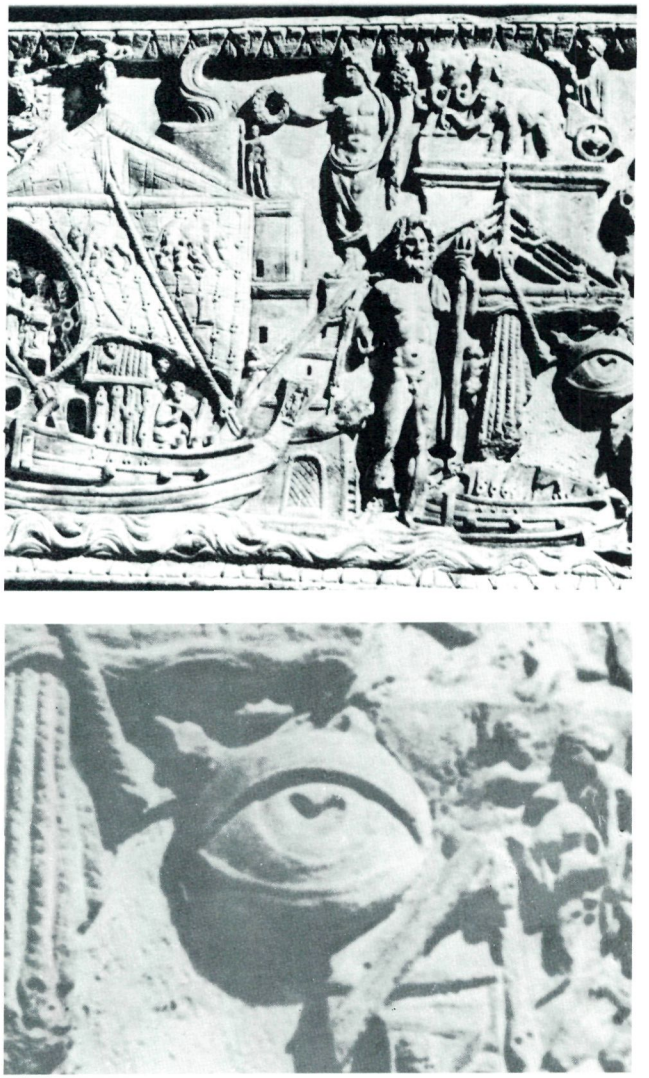
Our inability to distinguish beforehand the through-roads from the dead-ends brought us into by-ways that we never knew existed. The times that we stumbled left no bruises and we have forgotten them. Overcoming one of the many stumbling blocks, we found ourselves in a strange and fantastic world with many pitfalls and mysterious doors, all so complicated that we were incapable of weaving it into our narration on the four horses.

But the matter which carried us so far afield directly concerns the puzzle of the four horses. Those readers who have managed to read this far have every right to know about it. They should not be deprived of these further elements of information which may lead to a solution of the puzzle. This is why we warmly dedicate this separate little tale to them.

The subject of this new and unusual experience is so vast that it could become another book. But that would be too much. We decided that we will try to deal with it briefly, concisely and, if possible, clearly. We will put it into the style of a school theme to be done as homework which, as everyone knows, encourages the student to write as little as possible.

THE THEME:

"Given the eyes shown in Figures 46, 47,



Figures 46 & 47. *Bas relief of the ancient Roman port of Ostia and an enlarged detail of the apotropaic eye.*

Figure 48. *Photo of one eye and a portion of the head of a horse of San Marco.*

48, 49 and 50, formulate the greatest number of doubts about the theory that the half-moon or bean-shaped eye was introduced into ancient sculpture as an aesthetic variation of the form of the human eye for the sole purpose of improving the expression."

DEVELOPMENT OF THE THEME:

Necessary Premises:

1. Consideration of Figures 46 and 47
2. Definition of "badons"
3. Formulation of approximate theory about their behavior.

The adjective "apotropaic" comes from the Greek and means literally "that which sends back, which rejects". The apotropaic eye is an eye which, according to ancient beliefs, sends back or rejects evil. Thus it is exactly the opposite of the "malocchio", or evil eye. In a free Italian translation it would be the "bonocchio", or good eye.

The features which the ancients gave the apotropaic eye are clearly evident in the Ostia bas-relief (Figures 46 and 47). The eye appears to be suspended in mid-air without relationship to the other elements of the scene in the relief. Actually, it has a well-defined meaning and function. It is there to protect the catch of the fishermen. The fact that it is there indicates that fishing has been good around Ostia. No one would bother to seek protection for an unfruitful business.

To understand the meaning and function of the "bonocchio", it is necessary to first learn about the evil eye, the "malocchio". It is not easy to do this, as I discover when I go to a university library and start searching through the subject card file. From

the start I realize that something does not work. Either it doesn't lend itself to classification, or the people who arranged the cataloguing know little or nothing about it. Under "evil eye" one is referred to "amulets", from amulets to "superstitions", from superstitions back to "evil eye". Try a different approach and you end up with "magia".* Get out all of the books listed and you discover that you are off the track because the material therein is unrelated to what you are looking for.

Superstition is considered the manifestation of nervous obsessions and collective anguish, while "magia" extends from complex items of psychology to the product of minds affected by maladies whose names end in "oia" or "ia" and which we laymen call madness.

I note that while I am intently studying with a magnifying glass a series of little black and white symbols that seem to have been taken from the private collection of a maniac, two students nearby (they have open before them a book on Comparative Psychology) look alternately at the little figures (leaning forward to do so) and at the attentive expression on my face. I must confess that at the moment I feel like dropping the whole business, horses, eyes and this weird study and going back to my easy usual little problems. But my momentary feeling of embarrassment and other periods of doubt pass and I go on.

I continue my reading of available texts and articles on the evil eye and at times I think that I am losing my mind. Although I am in the library every evening for almost

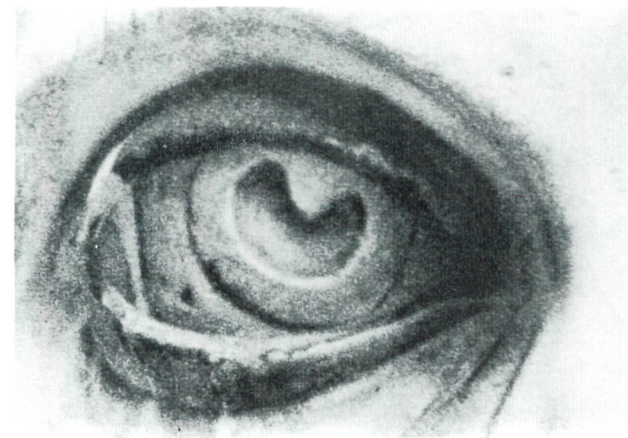


Figure 49. *Head of Emperor Gallien.*
Figure 50. *Eye of Emperor Constantine.*

* Editor's note: "Magia" has in Italian a much wider meaning than magic and includes the belief in an activity of the supernatural — even in these modern times.

a year, I do not read everything available. Frankly, I have no desire to. Aside from the fact that most of it, including the most fundamental portions, are either misplaced or are in German, a language which I handle poorly, there is no indication that anyone tried to arrange the material in a frame which is contemporary, simple and logical.

I am able to extract from the finer works a few key points for my own use. I end up with a rough picture so that I can emerge, somewhat messy, from the swamp into which I had ventured.

The evil eye is not, as I had believed, and as someone as ignorant as I may still believe, a perfidious, evil influence or action of supernatural beings with magical powers. It is a real eye, complete with lid and brow, placed correctly in a living, human face. It is the eye of one who in Italy is branded the "iettatore" (in some parts of Italy — the most industrialized areas — he is called "menagramo" but these regions count for little in the cultural evolution of the subject).* The evil eye has nothing special about it to distinguish it from any other eye. And, it could not be otherwise because the "iettatore", according to the experts, cannot be recognized by his eyes as many believe, but only by his deeds.

The mechanism of the evil eye appears to be founded on well-defined physical concepts which date back to the atomic theory of Democritus. In ancient Greece and other scientifically advanced countries it was believed (and possibly still is believed) that envy and similar feelings towards successful individuals were actually transmitted by the eye — that the eye sent out tiny particles of matter (the chemical composition not being defined) which penetrate the object, usually a human being, and do him damage.

These particles emitted by the evil eye behave very much like the elementary particles of modern physics. What Democritus considered the building blocks of all bodies, were particles of the same substance which joined together to form matter and that the chemical composition of the matter depended on the way they joined. These building blocks are for us today electrons, protons, neutrons, etc. From here on by analogy we shall refer to the elementary particles emitted from the evil eye as "badons".

One defends himself against the evil eye by taking defensive action against its carrier, the "iettatore", or by adopting protective measures against the "badons". Protective measures may be either passive or active. Passive measures consist mainly of shielding those parts of the body that the "badons" might penetrate. Active protective measures are based on the use of some means to reflect or diffuse through physical action the particles (badons) emitted by the evil eye.

The most effective form of active defense was probably conceived by logical minds which took into account the way "badons" are transmitted (even in ancient times it was believed that they travelled according to the laws of propagation of light). This defense consists of extending the hands in front of the body with the fingers spread apart and pointing at the "iettatore". Some accompany this action with the words "tie,

* Editor's note: The "iettatore" is one believed to be a person who exercises his evil practice deliberately, while the "menagramo" is analogous to our "bad luck Charlie".

tie" — (take that, take that), a useless element of passion that contributes nothing at all to the effectiveness of the physical defense procedure which is basically to present an infinite variety of differently oriented surfaces to deflect the particles themselves (skin cannot be penetrated by badons).

This posture has an element of active defense because the "badons" striking the finger tips (which defend the entire body because they are in front of it — the farther forward the better) are deflected in all directions including back to their origin. This means that they strike back at the very eye that emitted them — a highly apotropaic action that is greatly feared by the "iettatore". In the process he is bombarded by the very "badons" that he projected and is literally struck by his own evil influence. Nothing could be more terrifying because his eye reflects only a portion of the returning "badons" and some are absorbed into the surface of the eye itself.

If one takes into account that some "iettatores" do not look the part (in fact some do not even know that they are "iettatores") the need for special equipment to provide reliable and long-lasting defense can be understood. Such equipment includes objects designed to have the same effect as the defense described above but without the user having to be constantly on the alert.

One can readily understand that it is not feasible to go about with one's hand continuously opened before the body, or to be incessantly ringing little bells or jangling keys (according to the ancients these were also very active measures of defense because the sound waves of bells and jangling keys scatter the "badons" in all directions). It is therefore advisable that one equip himself with permanent, single-purpose defense objects — amulets! If they are properly designed or selected, amulets will disperse the arriving "badons" and even drive them back to the evil eye!

For best results one should procure and wear in a prominent place such articles as tridents, coral branches (ineffective if polished), crystalline gems with as many facets as possible, small ivory hands carved with many fingers (at least six), and a long list of other items.

The amulet continuously protects the wearer — even the improvident and the innocent. Still practiced in some parts of our country is the custom of placing a strong amulet around the neck of the newborn babe even before its first post-natal bath!

Other strange objects which the superstitious wear or produce in an emergency such as pouches containing odd matter, tiny dwarfs, animal teeth, etc., are not true amulets, but talismans. These are supposed to act directly on the psyche of the "iettatore" either by distracting his attention, by calming him or intimidating him. (He can be intimidated very effectively by eagles, owls, fierce animals or serpents).

If one considers that the "iettatore" is most provoked by envy, one can — with imagination — understand the significance o- many talismans and other means of passive det fense. I am not up to pursuing this subject af greater depth because, amongst other things, I am not qualified. If I gave the impression

that I understand all that I have written, that was not my intention. Nor could I understand all of it since the world of superstition is as large and diverse as the creative fantasy of man.

It is a world which can be humorous when it is represented by a Prince Capistrelli, a noble and moving figure of an "iettatore" endowed with nitro-glycerine powered "badons". (The Prince is a protagonist in some of the novels of Achille Campanile.)

It is also a world that contains practices — unfortunately widespread and disconcerting — that are so vile as to offend the whole of society. Leopardi said that this would last "*so long as the multitude is ignorant, that is, so long as it remains the multitude*". It is difficult to argue against this logic. The roots of this great evil are probably in man's nature. Latent in all of us is the baby who wants the light on as he goes to sleep.

Our sketch of the subject helps us understand the anti-evil characteristics that the ancients attributed to the half-moon eye. Let us examine the apotropaic behavior of the normal eye and that of the bean-shaped eye when dealing with the "malocchio" and its "badons".

The normal eye has an apotropaic effect — that is it functions as a "bonocchio" — only if the "badons" strike it from a certain central angle. If the "badons" arrive from the side the normal eye does not function apotropaically. The "badons", although reflected, do not return to bombard the "iettatore".

The true apotropaic eye (the one pictured in the Ostia relief) has a completely different structure. It is a sort of telescopic mirror. The half-moon shape ("meniscus" in geometry) tends to imitate the circular luminous sector (which is reflective) that appears in the normal eye under light. Therefore it has the characteristics of both the "bonocchio" and of an aesthetically normal eye.

The borders of the meniscus have the same dihedron structure as the mirrors placed on the moon to send back to earth the Laser light beam transmitted from a station in the United States. (This permits a precise measurement of the distance between the earth and the moon.)

The half-moon eye has a much, much wider angle of apotropaic reflection than does the normal eye, thus limiting the angle from which the "iettatore" may operate without risk of being bombarded by his own rebounding "badons".

OBSERVATIONS AND DISCUSSION:

The ancient Greeks and Romans were incredibly superstitious. With the Greeks it was more intelligent and more scientific. The Romans just babbled.

To the Greeks of the Classical era (the period when the theory of the evil eye must have been formulated), the evil eye was the answer to questions everyone asked about certain phenomena or events. The law of chance was unknown (the light of Democritus' genius was quickly extinguished) and therefore the Aristotelian method of research was applied even where it was not valid: (given an event or action, find its cause).

The Romans believed in anything and

practised everything. They imported from aonquered lands new gods, customs, beliefs cnd amulets. Their superstitions on the whole were not based on the principle of cause and effect, but were dispersed through a series of rites, practices, representations and wholly irrational beliefs. It is hard to accept that a people who used their brains only to construct roads, bridges and palaces and to compose that structure of musical logic which we call Latin, had sufficient imagination to conceive the apotropaic eye. The fact that they called it apotropaic is in itself evidence that this prime defense against the evil eye was imported from Greece or the East. (Its creator must have known at least as much about geometry as Euclid.)

The apotropaic lunula eye appears in Roman sculpture for the first time in the Ostia bas-relief. Its meaning is now clear. Fishing has been good and the reaction of the evil eye (envy) is feared. The time is 180 A.D.

During the third century A.D. the eye with the curved pupil (half-moon and otherwise) exploded as a means of expression in Roman marble sculpture. As a formal means of expression it had already been used for some time in terracotta and bronze. I quote a famous archaeologist, ". . . since the time of Hadrian, the pupil and iris in marble sculpture are no longer expressed in color but by carving as had always been done with terracotta and bronze . . .". (For example, Figure 52)

But nothing of Roman bronze sculpture remains from the Republic or the early Empire. One belief is that the Romans, famous

Figure 51. *Etruscan bronze of the IV Century B.C. The eyes were "worked" after fusion. There is evidence that the now-empty sockets of ancient bronze statues once held eyes of materials other than that of the statue.*

for weapons and coins, found it difficult to give up bronze for something "useless". Only a fragment remains — the head of Marcus Brutus (?) of the 3rd century B.C. The eyes have pupils carved not as a half-moon, but something similar. We have discovered, also, that the eyes carved in stone were common in Etruscan art of the 3rd century B.C.

The carved marble eye (done with a drill) was especially effective in 3rd and 4th century Rome in expressing a common motive — pain and suffering. Not physical suffering as expressed in the classical Greek period through movements of the body, but spiritual suffering. The new eye form was used effectively by Roman sculptors to render the anguish of imprisoned barbarians, the spiritual suffering of the poor and rejected, the melancholy of old people.

But this practice of carving the pupil (with forms that vary within certain limits) served also to express power and pride of the great.

By tradition and for vanity, all Roman emperors commissioned sculptors to carve a flattering likeness by which they would be remembered. (By analogy today we hear about almost anyone recently departed: "He was such a good man".) The sculptor saddled with the task often found little inspiration (aside from presumption and awareness of power) in the personality of those champions of megalomania.

We find the half-moon apotropaic eye in two statues of Roman emperors. But these were exceptional individuals and the sculptors had no need to exercise their fantasies to create an appropriate expression. Instead, they must have worked hard to achieve the expression of the "light" which people of the period believed inspired these two great personages: Gallienus and Constantine.

Gallienus was a young emperor of great moral and intellectual gifts. He reigned with courage and intelligence and initiated a dialogue (as one would say today) with the barbarian enemies who were continuously in revolt against the Roman Empire. Among other things, he put a halt to the persecution of the Christians. After his death, brought about by the customary palace stabbing, he was eulogized.

We all know something of Constantine. He was the official defender of Christianity; he transported the capital from Rome to Byzantium, which then took his name (not because of his megalomania, since he wanted to call it Nova Roma or some other banal name).

Gallienus looks like Alexander the Great; the same expression of pride, but softened by Latin piety. The eyes turned towards heaven give him an inspired look, the look of a man who is called upon to perform nobly. The apotropaic pupils do not alter the kind beautiful features of his face.

This cannot be said of the statue of Constantine. I have no idea how he looked when alive. Maybe he was ugly on his own and the half-moon eyes do little for him. But let us read the appraisal of an expert. "This statue places the sovereign high above common mortals; it is almost a religious statue... It is animated only in the eyes where

magical power, the spiritual content the artist wanted to give the face, is expressed".

The half-moon eyes give both of these emperors the magnetic look (with associated elements of protection and challenge) that their admiring populace attributed to them.

Possibly the emperor's involvement with Christianity may have influenced the sculptors in choosing the eye form. The apotropaic eye could thus represent the distinguishing attribute of the charismatic leader, defender and protector of a helpless community. We should bear in mind that in primitive Christian symbolism pagan motifs were often mixed with sacred ones. Christian iconography includes a multitude of representations of the Madonna and Child where Jesus is shown with a coral branch amulet at his neck.

In the late Empire half-moon eyes disappear and statues of emperors and famous persons once again (except for some rare cases) are given the normal eye of ancient sculpture.

Another Roman statue provokes thought about the meaning of the apotropaic eye: Marcus Aurelius' horse on the Capitoline Hill has the apotropaic eye while those of the Emperor are normal. If the half-moon eye was introduced to achieve a more human expression in the sculptured eye, I wonder why the sculptor of the Capitoline bronze sought to humanize the horse and not the rider. And what a rider! He was perhaps the greatest and wisest pagan emperor of Rome.

We should remember that in the East horses were, and perhaps still are, given

Figure 52 a & b. *Details of paintings on Greek ceramics of the IV Century B.C. Above — an eye on the shield of a Greek warrior. Lower — eye on the prow of a Greek ship.*

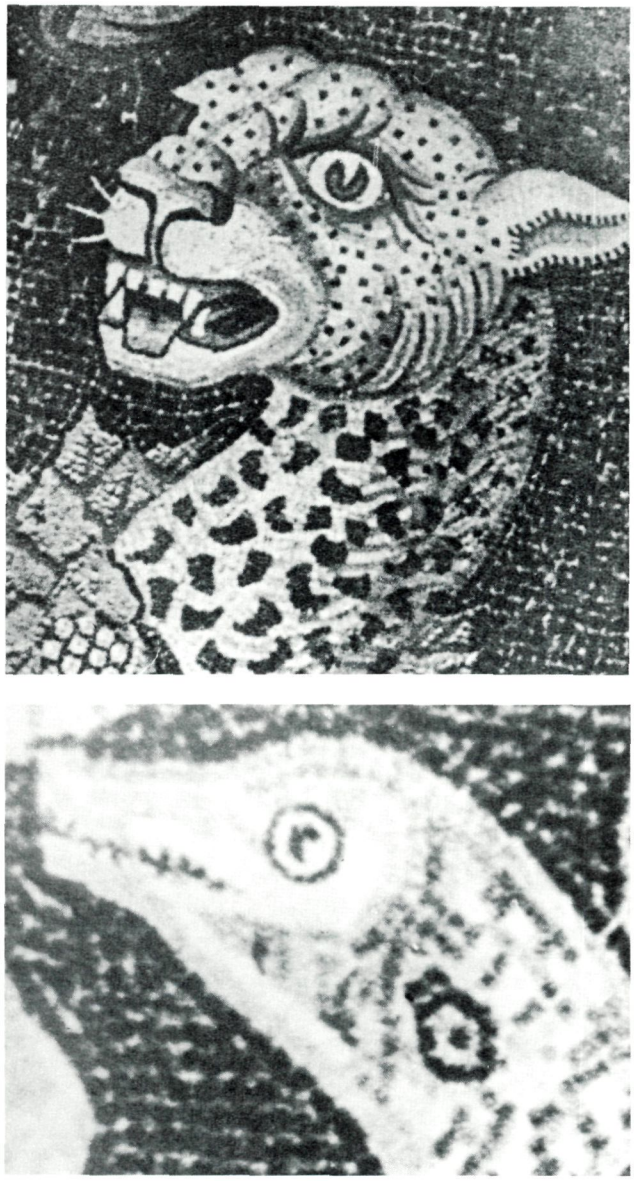


Figure 53. *Eyes of a panther and a serpent. The half-moon structure is clearly visible in these features of a Greek mosaic of the III Century B.C.*

amulets to protect the rider. Turkish war horses had tiny reflecting stones attached to the harness "to protect the riders from the evil eye". There is no reason to doubt that the horse's apotropaic eye in equestrian statues is a symbol of permanent defense of the great knight against the attacks of the evil eye. This is not as fanciful as it might seem at first glance. We should remember that superstition took on the most absurd forms in ancient times. The shields of Greek warriors bore a symbol against the evil eye — exactly in the center of the shield. In the war scenes drawn on ancient vases the shields of the warriors (who are on foot) are decorated with lions, owls, serpents, fierce dogs — all symbols against the evil eye — and with normal eyes for the same purpose. (Figure 52a).

These warriors and knights, although courageous, skilled in arms and ready to fight man-to-man, felt helpless against the mysterious powers of the evil eye. They relied upon the amulets to help out in that area.

Eyes were also painted on ships' prows (Figure 52b). And I have discovered that the ferocious animals described above are represented with the half-moon eye in ancient decorations, and I wonder if this is not the fundamental element which gives them protection against the evil eye (Figure 53).

A re-examination of the apotropaic eye of Ostia discloses a structural difference from the eyes of our four horses. In the eyes of the horses the central point on the upper edge of the half-moon does not exist. A dying horse represented in a bas-relief (prob-

ably of the time of Hadrian) has an eye exactly like the one in Ostia. Anyone who flies ITAVIA (the domestic subsidiary of Alitalia) will see it in the large photograph behind the ticket counter in the Rome terminal. But the Roman boat on Trajan's column has a normal anti-evil eye on its prow.

CONCLUSION

The theme did not require the solution to the puzzle of the eyes of the four horses. It asked only that one formulate doubts about a certain theory. Formulate, not arrange in order.

We would like to believe that we have presented herein a series of facts, discoveries and associations that might excite the curiosity of anyone studying the origin of the horses.

Let us suppose that the horses were Roman. Not of the time of Nero because the carved eye came later (3rd to 4th century), but more or less contemporary with the statue of Marcus Aurelius.

But the bronze of the Capitoline equestrian statue has no inlays — a fact that indicates that it was cast with a good alloy. That means that in the 3rd century A.D. they knew how to cast bronze. And if all of these circumstances were true, why would our four golden horses (which certainly are not the work of a novice) have been cast with the dreadful alloy that we have discovered it to be?

As another interesting element that will further muddle the research (or possibly clear it up) we offer the following:

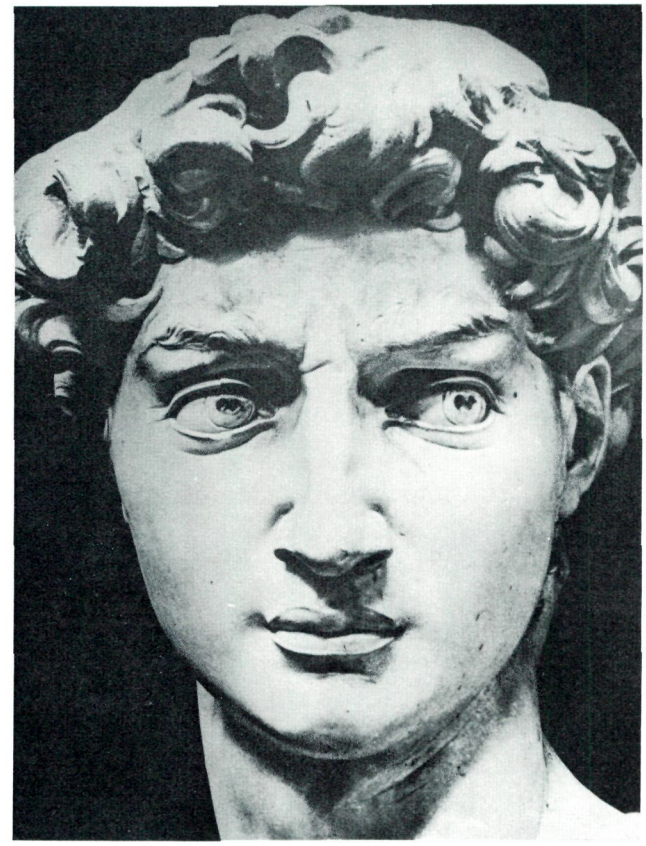


Figure 54. *The head of Michelangelo's David.*

Figure 55. *Apotropaic eye on a fragment of vase of the 20th century B.C. recently excavated in Crete.*

The most famous statue in the world, considered by many to be the greatest masterpiece of the Renaissance, has perfectly apotropaic eyes. It is the only one of many statues made by the great artist which has eyes such as these. It is the David of Michelangelo (Figure 54).

Not everyone agrees on what the statue meant for its creator. Some say that it was political, others that it was religious. Perhaps it was both. But let us re-examine the statues of Gallienus and Constantine. For both, inspiration comes from above. The same is true of Michelangelo's David. The apotropaic eyes give his face an expression fundamentally similar to that of the other two. Confidence in what he is about to do; calmly waiting for the enemy the awareness of the nobility of the cause his infallible sling is ready to defend — a cause that was the religion of the pagan heart of Michelangelo: the city of Florence!

EPILOGUE

An illustrious Italian historian becomes interested in the story of the horses and in the mysterious and fascinating problem of the eyes. He offers to introduce me to a friend who happens to be in Rome on business, the business of archaeology. The friend is one of the most noted in that field. He is an Italian who left Italy about the time that somebody thought that the greatness of the Roman Empire could be restored by just gilding the surface. Being a "second-class citizen", the archaeologist had difficulty finding acceptable living and working conditions. Greece provided them along with

a magical world yet to be discovered — and not just with pick and shovel!

The encounter is a cordial one. I listen to their comments about recent digs in Crete uncovering a long period of history. The two compete in deciphering some inscriptions which remind me of tattoo marks. Not only do they decipher them, they understand their meaning as well — for me the far more difficult accomplishment. I now understand the words of the principal of the oldest classical school in Bologna: "Greek is not difficult if you translate it with a Greek mind".

We pass to the discussion of the horses and their eyes. They agree with my reservations and supply some new ones. We talk of "malocchio" and "bonocchio". I ask the famous archaeologist for his opinion as to the origin of the evil eye superstition.

He picks up a photograph, cuts it in two with a pair of scissors and smilingly gives me half. It shows an anti-evil eye carved on a fragment of a vase which he found in his recent excavation (Figure 55). It is from the 20th century B.C., a date so far back that, for me, it has no historical meaning. In mathematics it would be dated "infinity with a minus sign". Minos and the minotaur were not yet born. Nor was Zeus.

The belief in the evil eye is thus as old as envy, as gossip, as character assassination. It is as old as man.

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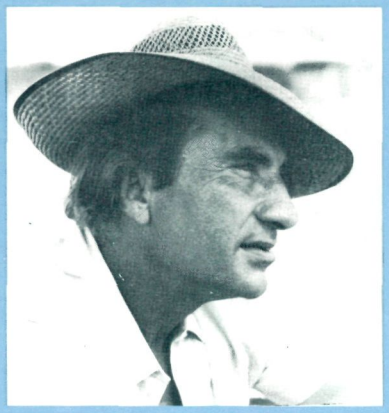

AN EXPERIMENTAL PHYSICIST WHO STUDIES THE ATMOSPHERE OF THE EARTH AND THE PLANETS AND WHO KNOWS NOTHING OF ART AND ARCHAEOLOGY, FINDS HIMSELF INVOLVED IN RESEARCHING THE STRANGE MALADY WHICH AFFLICTS THE FOUR GOLDEN HORSES OF THE BASILICA OF SAN MARCO.

A GIGANTIC WEB OF LINES WHICH COVERS THE GOLD PLATED SURFACE OF THE HORSES REVEALS THE GREEN AND BLACK OF THE UNDERLYNG METAL. THE PROCESS WHICH WOVE THIS NET SEEMS AN UNSOLVABLE PUZZLE.

CALLING UPON HIS KNOWLEDGE OF PHYSICS AND ASSISTED BY HIS COLLABORATOR, DEMETRIA, HE GROPES ALONG IN THIS UNUSUAL FIELD OF RESEARCH.

AT A CERTAIN POINT IN THE INVESTIGATION, HE DISCOVERS THAT THE ANSWERS TO THE RIDDLE WERE CONCEIVED IN THE MIND OF AN EXTRAORDINARY MAN WHO LIVED MORE THAN TWENTY CENTURIES AGO.

A FASCINATING BOOK, MADE MORE SO BY THE FACT THAT IT IS TRUE.

YOU WILL FIND IT DIFFICULT TO PUT DOWN.

PROCEEDS FROM THE SALE OF THIS BOOK WILL BE USED IN THEIR ENTIRETY FOR THE RESTORATION PROGRAM OF VENICE COMMITTEE, IFM.