



HOW ONE MAN SAVED THE
REPUTATION OF FLORENCE

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Mediocrity Averted

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*Honored proud man now become dust,
yet immortal seen across azure skies of Tuscany.
Whose vision brought forth an era of fresh light,
Creating a new birth to elevate mortal man
Beyond the dreams held high to greater
Heights of new discovery.*

1. My Story – La mia storia

I mio nome è Filippo. Sono di Firenze. Conosci la città? Sapevi che l'ho salvato dalla mediocrità.

Parli Italiano? No? Ah scusami. Non sapevo che non lo sapessi. Parlerò in inglese.

My name is Filippo though my close friends call me Pippo and I come from Florence, that beautiful city on the banks of the Arno now recognized as one of the treasures of Italy. For the last 700 years the world has marveled at its streets, monuments and the magnificent architecture we Florentines have brought into this world. In the Quattrocento or what you like to call the Renaissance we created a paradise for all of Italy and the world to admire attracting millions of visitors today. Do we have the right to be proud of this achievement? (Are you proud of your New York, your London, your Paris?) Of course, we have the right.

We accomplished what many considered an impossible task. We created the most magnificent duomo above our beloved Santa Maria del Fiore rising to the skies like a beacon above Florence as a testament to our God. Like no other creation it leaps up into the heavens as a sign of our power and creativity that will be remembered for centuries to come.

Today in your twenty first century, Florentines and the world continue to admire the cupola of Santa Maria del Fiore. It has graced the outlines of our city for centuries. It gave Florence the character and recognition it well deserves all because of the efforts of one man. That man with all humility is I, Filippo Brunelleschi.

Honestly, I single handedly saved Florence from certain mediocrity.
Ho salvato Firenze. I saved Florence.

You may want to know how one person saved the mightiest city on earth?

When I was born, the grandeur of a city was measured by the size of its cathedral? As a young man we were the laughingstock of Italy, for right in the middle of our cathedral there was a large empty void with no roof, for we had yet to find a way of creating a duomo to finish this memorial to God. Many had declared it impossible and had given up hope.

We felt we were the most important city in the world, but so did the cities of Milan, Piza and Siena. We had to show proof to our rivals. To our city the cathedral meant everything. It is an emblem reminding the world of our devotion to God. To have less of a cathedral than any other, diminishes us in the eyes of the world.

For this reason, we had to build the largest most impressive temple ever created to the glory of God and our city, but instead for almost 45 years all we had was a large hole in the midst of this unfinished church. The cupola that had been promised was nowhere to be seen, because our guiding fathers had not resolved how such a monumental structure could be created. We clearly had a problem that must be solved.

That was the predicament of our community when I was born. Our cathedral could not be used in the rain for lack of a roof. The Tuscan sun in the afternoon made it unbearable for mass or services. We were belittled by the world around us.

On one painful occasion, the archbishop of Siena, our rival city, came to visit us to celebrate mass. What an arrogant little man. His envy for Florence was more than he could contain in that jealous little mind of his.

He preached down to us from the pulpit and berated Florence: "Children, if you want to build a monument to God you must consider first whether you can finish what you start." He then looked up through the absent roof into the sky and then stared down into our puzzled faces with a malicious little smile. We were furious and embarrassed. The challenge was made. Florentines knew then something must be done to preserve the honor of the city and to respond to this hypocritical priest from Siena.

I will not burden you with unnecessary detail but will tell you, with all due modesty how I alone above all men resolved this seemingly eternal puzzle.

I was born in Florence in 1377. My father Brunellesco di Lippo, was a notary and civil servant who worked on behalf of Florence and the Opera del Duomo committee. This was the committee in charge of completing the cathedral Santa Maria del Fiore. My father insisted that my early education would consist of literature and mathematics with the hope I would follow in his footsteps.

Of course, this was never to be, because my father made an honest mistake. He remained involved with the Opera del Duomo Committee and on returning home every day would often tell me the many stories of how the Cupola was to be administered and

the technical problems they could foresee. Many times he took me hand in hand to visit the enormous construction site out of which rose a massive building destined for greatness. My interest was set afire.

By 1390 the Opera del Duomo began to raise the massive octagonal walls of the cathedral. My father Ser Brunellesco was aging and I, Pipo, continued to give these problems much thought. Throughout this time there was much debate over the support necessary for the construction of such a large dome. How could the weight be handled and how could such a large structure be built. To build such a dome would require all the forests of Tuscany to create the supporting structure used to hold up the stones of the cupola as it was built.

At age 22, I became apprenticed to Arte della Seta, the silk merchant's guild. This was the wealthiest and most prestigious of all the guilds. This guild consisted of jewelers and metal craftsmen. Many sculptors and artists such as Donatello and Leonardo Davinci (years later) first trained in such settings. Soon after my arrival I became a master goldsmith and sculptor capable of working in bronze. In those early days I even created a clock with an alarm, a device never previously seen until then. That same year I was asked to create small bronze sculptures of the evangelists and saints for the altar of the Pistoia Cathedral. This was my first real commission. My future looked bright, but my mind was always on the Duomo

My first competition took place in 1400 as the city now had cause to celebrate the end of the "Black Death," that had devastated Florence and the countryside in the previous year. The overly religious suggested the city fathers arrange this to appease a wrathful God. The Guild of Cloth Merchants decided to sponsor a new set of bronze doors for the Baptistery of San Giovanni. This was one of the most cherished buildings in our community as this is where every child in Florence was baptized. In 1401 I found myself in Pistoia, attempting to remain clear of the recent plague, but on hearing of this new competition I quickly came home.

The candidates for the commission were given four sheets of bronze and asked to create a scene based on Abraham's sacrifice of Isaac as described in Genesis. We were given one year to complete the trial panels. This was no easy task as it was fraught with many potential disasters that could ruin the entire effort. Michelangelo was known to request a Mass every time a bronze statue was poured.

At the end there were only two candidates left standing before the judges, Lorenzo Ghiberti, an unknown goldsmith, and myself. Lorenzo had no previous experience with the guilds and came of questionable parentage, both dubious marks against him. What he did do, to his credit, is ask the judges for advice before the competition. He ingratiated himself with all those that mattered and no doubt this helped him a great deal in the outcome. I myself refused to share my secrets with anyone nor did I ask for

advice. Why should I do so? I knew the extent of my talent and I was not in the habit of asking for opinions.

In the end after all considerations the judges and the people of Florence could not decide. The work of Ghiberti was elegant in the Roman classical style but mine was full of the emotion of the moment. The judges foolishly decided to ask us both to work together on this tremendous project. I myself considered this an affront and excused myself from the project altogether.

Was this an act of arrogance or stubbornness on my part? Was this an act of pride? Some have accused me of this. Despite the outcome all was not lost for the head of the jury was none other than Giovanni di Bicci de Medici (father of Lorenzo and Cosimo) who would later become my patron. I now could give my attention to the Duomo.

Rome Visit

In 1419, during my 42nd year, Florence's Opera continued to seek an architect with the skill to finish the cupola over Santa Maria del Fiore and erase the blot of humiliation brought by our inability to finish such a project. I would have to admit humbly, but without any uncertainty, they came to me begging for advice.

How could I in all honesty volunteer myself and not appear arrogant, though I knew I was the best and only choice for such a project.

I suggested a competition open to all artists and architects in the area of Tuscany. I knew a decision from the Opera would take years and so I chose to leave for Rome with my friend Donatello. I had much to learn before taking on such a task. I had to discover the mysteries necessary to create the impossible.

There were many secrets I would need to discover and so I chose to find them in the rubble abandoned in the temples and monuments in Rome. Could the answer be found in the remains of the ancients who had created the Rome of the Caesars? The Romans had left monuments and columns which were then strewn throughout the city. Christianity and the Church had no need for this pagan influence and had done all it could to suppress it or make it dissolve into oblivion, yet much remained.

The Pantheon, the focus of my attention, remained in all its glory. At that time this was the largest known dome in the world. It had been converted into a church consecrated to Saint Mary and the Martyrs in 609 at the request of Pope Boniface IV. Here before us was the most magnificent dome ever created in the known world. It was completed by the emperor Hadrian in the first century of the common era. It had now lasted over a thousand years, astounding all who walked under its shadow. While there, Donatello and I had the opportunity to see the details of the Pantheon but also of the many

classical Roman buildings that remained. We immersed ourselves in this study retaining many ideas for the future.

The Competition for the Duomo

When I returned from Rome with Donatello the competition had yet to take place. The Opera committee continued to deliberate yet could not reach a consensus. Another year had been wasted. In the meantime, I had a great opportunity to think more about this seemingly impossible project. Many details swirled in my brain, never ceasing, keeping me up at nights.

How do you raise thousands of tons from the level of the street to the tambour or drum which held the Cupola, 54 meters into the air? We would need a lift powered by oxen to lift the heavy stones to the tambour, but my concern was the time it took to do so. Every time you took something up you had to bring something down. Once the lift reached the top the oxen must be unhitched and reversed so that they could lower the lift. This was laborious and added precious time to the whole enterprise, not something our merchants appreciated, but this was how it had always been done. The question in my mind was could there be a better way? Remember, I was answerable to the most enterprising merchants ever known in Florence who valued money and time above all. Somehow, I had to please these men.

During this time in history to create an arch or a dome you must first construct a frame that would hold the blocks of the arch in place as it rose into the sky. The blocks that were part of the arch were created as wedges or triangles that once laid on top of each other curved inward. Without the support structure the stones would fall soon after they curved to the inside. Eventually both sides would embrace at the top with a keystone creating a sound structure. Once the keystone was in place the support could be withdrawn and the weight of the arch remained supported by the walls, if God was on your side, but not always. There were instances of catastrophic failures in which the entire dome caved in on the penitent gathering for mass. The weight of the Duomo was equivalent to that of 37,000 tons. In addition it rose 114 meters into the sky. To make such a support structure would require all the wood from the forests of Tuscany.

The day of the competition finally arrived and I frankly worried over my competitors. The many haphazard suggestions brought tears of laughter to my eyes. One wanted a supporting column in the center of the cupola that would forever block the view of mass from the inside. Another would fill the church with earth to support the cupola as it rose. When asked how it would be removed, he explained that coins would be mixed into the earth and at the end the poor would be given an opportunity to search for the coins and thus remove the earth.

When it was my turn, I described how I would create a dome without using supporting structures but gave no details. I explained how I had plans on what would be required

to lift the thousands of stones at a great savings to the Opera del Duomo, but I gave away nothing. Again I must remind you, I do not give away my secrets.

The judges were furious with me but remained very curious as to my design. They were unable to say no to me but could not decide.

At that time, in jest, I proposed a challenge. He who could make an egg stand on end would win the competition and build the cupola. With trepidation they agreed. I allowed all others to go first. Many tried but all failed. I approached the table with confidence yet cautious.

I grasped the egg and gazed upon it, turning it slowly. They stared at me wondering what magic I might conjure to win my bet. I cautiously slammed the egg on the table to flatten the bottom and the egg stood on end yet partly broken. I stepped back allowing them to see the egg standing on end. The audience immediately gasped and jeered, but I had won my bet. All my competitors criticized me, but I assume it was from jealousy. In the end, my nemesis Ghiberti was a finalist for the position, but this time the task was given to me alone.

To be frank, I was the one chosen not because of a cheap parlor trick but because I promised something unique and nearly impossible to achieve. I proposed to build the dome without scaffolding, which would represent a great savings to the guild. This had never been tried before and many believed me to be a lunatic for such an assertion. They expected nothing but my failure. The only ones to believe in me were the Medici and it helped they were financing the project.”

I was given the task of which I long dreamed of possessing. It took me 16 years to complete which were the happiest of my life. Today I stand back and see this monument to Florence in relief over the Tuscan sky. It is my crowning achievement.

How would you keep a dome without support from crashing in upon you as it rises? I also want you to consider how you manage to build eight curving walls in such a way to accurately let them bend and meet exactly 114 meters in the air without scaffolding or support?

So you want to know my secrets? This is my secret which I hold very dear to me. Of course, if I tell you everything now, then you would think you could also accomplish what I have done. I'm not sure I like the idea, and so with sincerest humility I will take this to my grave. Maybe someone will discover my secrets? Who knows?

Thank you for your patience. Until later.

Arrivederci Amici.

1. History of the Trecento:

Brunelleschi was a genius without compare, in this world of Florence amidst the new dreamers and creators that made the Renaissance come alive and blossom in such a way we still marvel at what they left behind. He was a special man made for a special age challenged by events and yet nurtured by those who believed in the creative genius of man.

To better understand the magnitude of this achievement one must know the challenges Florence and Brunelleschi faced. Unfortunately the trecento or the 1300s, were some of the most traumatic times ever faced by Florence. This era was dominated by war, civil unrest, plague, famine, and politico-religious rifts. The Guild republics, Florence being one of these, suffered immensely as a result of these events.

Political Rivalries

At that time factions were born out of the rivalries between the Holy Roman Emperor in his throne north of Italy and the Pope in Rome. Sides were taken in the form of the Guelphs and the Ghibellines. The Guelphs were a faction supporting the Pope whereas the Ghibellines were supporters of the Holy Roman emperor.

This becomes important in our story as the Ghibellines favored the architectural influence of the Germans and French with their flying buttresses and high peaked roofs whereas the Guelphs representing a majority of Florentines saw their future in the vision left from the classical Roman empire.

Plague of 1348

One of the most disastrous outbreaks of the Black Death occurred in 1348 at which time the population of Florence was tragically decimated decreasing from 120,000 inhabitants in 1338 down to 50,000 in 1351. If you were lucky or wealthy you could leave the city and move into the country. This is much like the exodus of the wealthy from New York in today's COVID epidemic.

The Wars

The Florentine economy came to a halt in the 1300s due to a combination of continuous wars necessary to counter Giangaleazzo Visconti from Milan. He had expanded his control first over Lombardy and later into Tuscany. He had set his sights on Florence and in 1402 the Milanese army advanced to the gates of Florence, Visconti became

suddenly ill and within weeks expired. The army decamped and returned whence they came. Florence was saved.

Plague of the Bianchi.

In the summer of 1399 a religious movement arose in Lombardy in the area of Milan and moved southward towards Rome attracting a multitude of pilgrims. They wore white linen robes and so were known as the Bianchi. The movement might have been a blessing had it not been for a terrible unexpected disease it brought with them. The thousands of barefoot penitents also carried the plague. One more time it gripped the city, tragically diminishing the population of Florence. By the time the crisis was over another 12,000 Florentines had perished of the 60,000 living in the city.

In the end these crises all affected the work on the cathedral which originally started in 1293. Due to the loss of the working force there were times the Opera del Duomo resorted to importing labor from elsewhere to maintain the construction.

2. Entering the Quattrocento:

By the turn of the new century Florence was still in a state of moral dilemma. It had survived two bouts of Plague in the last 50 years and lost most of its population. The effects of a newfound religious fervor were everywhere. Clerics and religious zealots insisted the Black Death was the terrible retribution for a century of sin and required a visible auto da fe. What better way than to create new monuments to God such as the completion of Santa Maria del Fiore and ask for his deliverance from future calamities?

Despite the carnage, Florence was blessed with a strong economy comprised of the textile industry and banking. It did not take long for these resourceful merchants to take part in restoring the fortunes of the city and naturally much of the art we see there today.

Florence was blessed with the presence of a family whose efforts greatly influenced the Renaissance and the political world internationally. This was none other than the Medici family whose wealth and influence were present at that germinal moment when the world began to evolve into the new dawn of the Renaissance.

The Medici were responsible for many of the outstanding Florentine works of art created during this period. Giovanni di Bicci de' Medici, the first patron of the arts in the family commissioned Filippo Brunelleschi for the reconstruction of the Basilica of San Lorenzo in Florence, in 1419. They came to know Brunelleschi well as he worked for them on San Lorenzo, the first church of Florence. Here is where all the principal members of the

Medici family are buried. San Lorenzo was later considered a milestone in the development of Renaissance architecture.

3. Construction of the Duomo

The renaissance is symbolic with the Cupola having been completed 60 years before Columbus arrived at the new world. It is described as an Arch with a point that at a distance could be compared to a bullet, a projectile or even the tip of a rocket. To accomplish such a feat required 40,000 tons of bricks. This engineering miracle resulted in two cupolas one within the other, each as wide as ½ football field and 10 stories tall. The duomo became the center of the city if not the area of Tuscany and eventually challenged all cathedrals in the Christian world.

The church existing where the Duomo now rests in all its majesty was known as Santa Reparata, an older metropolitan church dating back to the seventh century. By the 1200's it was badly in need of repair or reconstruction.

The Ghibelline and Guelph factions continued to do battle in the city for the hearts of the people and a voice in the architecture of the cathedral. Many negotiations took place to resolve this debate and It is interesting to note the negotiations were overseen by Ser Brunellesco, Filippo Brunelleschi's father. This architectural choice, in favor of the Guelphs in 1367, was one of the first events of the Italian Renaissance, marking a break with the Medieval Gothic style and a return to the classic Mediterranean dome.

The only problem now was finding the right person to create the dome and overcome the dangers of omitting the flying buttresses.

The Construction of the Church

Construction of the church originally started in 1292 with the work of Arnolfo di Cambio who was hired to build a foundation for a new front, new and wider walls and new and higher piers to reach above the old basilica.

The church was built in the accepted styling of a basilica of the era. It had a wide central nave of four-square bays with an aisle on either side. The entire structure is in the form of a Latin cross. The dimensions of the building are enormous with a building area of 89,340 square feet, the length is 502 feet, the width 125 feet. The height of the dome is an impressive 375.7 feet.

The structure of the dome itself is imposing. The impost, a projecting structure, rising to a height of 35.50 meters above the tambour, is about 54 meters above ground level. The weight of the dome is estimated as 37,000 tons. It has been calculated that over

four million bricks were used in its construction. It is the biggest dome ever built without supports.

1. My Inventions

Amici, buona serata. Welcome back, it is Filippo again, or is it I that have returned? I must say, I have yet to understand these temporal – spatial conundrums I find myself in, but here I am once again, at your pleasure.

I pray you are now aware of the serious obstacles I faced as I prepared to address my challenge. Our Republic looked on me hopefully yet with a skepticism that would have crushed a lesser man. My task was set, and it was now my turn to show the world the strength of my purpose.

First, may I ask you how do you raise materials weighing half a ton up in the air and move them side to side?

For over 3,000 years man has lifted heavy stones into the air to commemorate the lives of kings, pharaohs and victories over their enemies. These memorials were built without the sophisticated cranes you now have at your disposal capable of lifting as much as 19 tons, with a reach of 200 or more feet. Yet if we look closer at the work of the ancients a surprising fact is revealed. For example, the temple of Amon-Ra at Karnak has crossbeams weighing 60 to 70 tons each. The capital blocks of Trajan's column in Rome weighed more than 53 tons and were lifted to a height of 34 meters. This technology was lost in the haze of the Dark Ages and had to be rediscovered to accomplish the seemingly impossible task of raising the Duomo. It was I, Brunelleschi who was able to create the special technology to accomplish this task.

Brunelleschi and his Inventions

Part of my contract with the Opera del Duomo was to create the tools to make this project a reality. In the case of the cathedral the stones used must be lifted 52 meters (171 ft) above the ground to the level of the tambour. At the level of the tambour these same stones must also be moved sideways into the appropriate position with accuracy.

When I competed and won the contract, I was aware that the existing machines could not accomplish the tasks required to finish the work. I have been told and I agree that I alone possessed the genius to provide the inventions and designs, and at the same time oversee the construction to achieve the necessary results outlined in my plans. There are very few architects and builders in your era capable of such work.

I made careful arrangements to prevent making my drawings public or giving descriptions of my machines. Unfortunately these machines were visible to the public for several years and were admired by many engineers of the time. These were carefully studied and sketched by those who followed me. One young engineer was the apprentice, Leonardo da Vinci who visited years later. He was fascinated by my inventions and went on to design machines of his own. The sketches he created of my work were of such detail that some attributed them to Leonardo himself. This work with machines inspired him to design some of his own. I have heard that some of these may have even appeared in that notebook your Bill Gates purchased for \$30 million of your dollars. This is why I have kept my work to myself.

Filippo's three-speed hoist

I was able to respond to the competition with a clever lifting device which was a three-speed hoist. It brings back fond memories of my earlier training as a clock maker. To understand the key mechanics, please visualize what happens if you stand behind a cart resting on a stand and you pull the top of the wheel toward you. The wheel will turn in one direction. If you pull the bottom of the wheel toward you it will cause the wheel to turn in the opposite direction. I used this simple idea for my first device.

Using this concept I was able to create a hoist that could go up or down without changing the direction of the oxen that drove the capstan. I was able to construct a mechanism by which the main gear could be engaged at the top or bottom to move the hoist in either direction. This was accomplished by using a worm screw that allowed the repositioning of gears much like a transmission.

In addition by adding additional shafts and gears of different sizes I was able to arrange for the hoist to raise light objects rapidly and heavy objects slowly. This was very practical as it allowed the movement of food and diluted wine for the workers using the fast gear and heavier material with the slower gear.

This device allowed a significant savings in terms of time and money. Two oxen provided the power, and the efficiency of not having to unhitch the oxen and reverse them to lower the rope resulted in much faster trips to the top and back down. Over a period of the 16 years of work much time was saved by this incredible device. I guarantee to you that the Medici's who were the masters of time and money approved of such a remarkable invention.

The Castello

At the level of the Tambour large stones had to be moved horizontally with great accuracy. For this endeavor I created a machine called the "Castello." It stood 65 feet in height and could rotate 365 degrees. I truly believe this may be the predecessor of the tower cranes you use today at construction sites. The structure was in the form of a

capital T, with a vertical tower rising from the floor and a horizontal section at the top. The weight to be lifted was at one end of the horizontal beam and on the other side were attached counterweights that could be moved in and out depending on the weight attached on the lifting end. This coordinated movement allowed the entire structure to remain in balance. The lift was accomplished with a screw system since it was necessary to lift the stones just enough to clear the floor. This device allowed precise movement of heavy material weighing in excess of one ton. Without this machine the construction would have taken much longer and consequently increased the cost.

I only mention these key inventions as we are limited by my time with you, but there were many others. Without these devices the construction of the Duomo may have never occurred.

Challenges

I must also share with you the troubles I faced at the hands of peripheral personalities whose only motivation was their innate jealousy in response to my achievement. One of these was that bothersome Giovanni di Gherardo from Prato, also known as Acquettini. He was my deputy and had lectured at the Studio of Florence as a reader of Dante. He challenged me for my designs of the Cupola and ridiculed one of my inventions which happened to be a ship, the Badalon, used to carry the marble to Florence used in the construction. He went so far as to publicly post this vile sonnet to besmirch my reputation.

*O you deep fountain, pit of ignorance,
You miserable beast and imbecile,
Who thinks uncertain things can be made visible:
There is no substance to your alchemy.*

*The fickle mob, eternally deceived
In all its hope, may still believe in you,
But never will you, worthless nobody,
Make that come true which is impossible.*

What could I do after such an assault? I had no choice but to respond to the public of Florence. My response to Acquettini was as follows:

*When hope is given us by Heaven,
O you ridiculous-looking beast,
We rise above corruptible matter
And gain the strength of clearest sight.*

*A fool will lose what hope he has,
For all experience disappoints him.
For wise men nothing that exists
Remain unseen; they do not share*

*The idle dreams of would-be scholars.
Only the artist, not the fool
Discovers that which nature hides.*

*Therefore untangle the web of your verses,
Lest they strike sour notes in the dance
When your impossible comes to pass.*

Fortunately, nothing came of this bothersome pest and I continued with my work, not only with the Cupola but also with my other projects. I had little time for lesser minds.

I am sorry to say but my time is drawing to a close and I will leave you for now in the hands of our presenter.

2. The Secrets of the Duomo

The Duomo is one of the most studied historic structures in the world of architecture and its secrets seem to elude historians, engineers and architects even today. Until recently all attempts to determine how Filippo managed to achieve such a task have been unsuccessful. Brunelleschi managed to leave no essential details of how this was accomplished and even made efforts to hide the important features of the structure to prevent an understanding of his techniques.

Brunelleschi was awarded the commission and began work in August 1420. He brought the dome successfully to completion in 1436 without apparently ever disclosing his method of construction. Records of the Opera del Duomo include the written specs of 1420 which must have been written by Brunelleschi himself. The dome was built close to these specifications, but they give no indication of the techniques he used.

In the specifications he proposed building two concentric octagonal shells without any means of support. This was an outrageous suggestion at that time as it was deemed to be impossible. The two shells were to be tied together and made rigid by 24 ribs: eight major ribs, one rising from each corner of the octagonal base, and 16 minor ribs, two rising inside each segment of the octagon. All 24 ribs were to converge toward the center at the peak of the dome 375 feet from street level.

In the 1970s and early 1980s much speculation arose out of the academic community in regard to the techniques used by Filippo Brunelleschi. Recently Massimo Ricci, whose

family dates back to the era of the construction of the Duomo, has proposed Brunelleschi constructed this dome by the use of a technique known as radial methodology. This technique had been used since the early history of man in one form or another.

The radial method is what I would like to call “Brunelleschi’s rope trick.” He employed a system by which a rope is fixed to a reference point, passes through the central axis of the dome and reaches a working area such as a wall that is to be created. This system allowed for accurate positioning, orientation and inclination of every brick comprising the dome during every instance of the construction. This tool also permitted the positioning of every one of the eight sides of the octagon so that they join seamlessly. This let each side to rise independent of the other. Remember that the construction took place without scaffolding or supports. Massimo Ricci was able to take his hypothesis one step further by creating a smaller identical copy of the dome using the same tools available to Filippo Brunelleschi.

In his research one of the features that first caught Ricci’s attention was the methods used to establish a platform base for the construction of the dome. This was meant as a temporary structure, yet the evidence left behind in the form of holes for supports left in the walls at the base of the cupola suggest a very exacting process. It is likely they were meant to support a base on which much weight would be carried but could also serve as a precise and stable structure to be used as a reference plane for taking measurements as the dome was built.

To aid in the construction Brunelleschi attached chains from each opposing corner of the octagon creating a star like pattern later known as the “star of the cupola.” This was used routinely as a reference for plumb lines as the walls rose to the sky.

The internal vertical curvature of the duomo was a feature required by the Opera. It was to be a “pointed fifth” or commonly known at that time, “the quinto acuto.” This is what creates the bullet shape of the Duomo. This curve is created by making an arc using a radius equal to $\frac{4}{5}$ of the dome’s interior base diameter. Since the Duomo’s span measures approximately 45 meters, $\frac{4}{5}$ would be 36 meters. The center of the quinto acuto radius is placed $\frac{1}{5}$ the distance from the edge of the base of the dome. If ropes are placed on opposite sides the arcs formed meet at the top resulting in the bullet shape of the Duomo. In reality, this was the shape of the classic Gothic arch.

Brunelleschi used the platform he created and the star pattern resulting from the chains set across the void of the dome as reference points to use his radial methodology of construction. He simply used a length of cord attached to the reference point of the Quinto Acuto on the platform. The free end of the cord extending 36 meters marks the distance equal to the radius. The cord is pivoted so the end moves vertically up and down along the working profile to help define the curvature of the corners of the octagonal Duomo. Using this same rope he could define the entire curvature of the

dome as it rose to the oculus. The rope also extends through the center of the structure as defined by the chains forming the star of the cupola. This simple rope trick allowed him to monitor all of the vital parts of the dome.

Using this same radial methodology technique Brunelleschi was able to define the ribs of the inner and outer shells of the dome. All the ribs taper uniformly as they rise toward the apex where the oculus is found. Even today hooks are found at the level of the ribs from where the cords originate to define their construction. Again, as the construction rose plumb lines were dropped to confirm alignment with the star of the cupola.

The radial method was used for defining the walls between adjacent corners. The segments had to conform with the quinto acuto curvature so that as the dome rose each segment curved inward uniformly toward the corresponding central axis on all eight segments and met at the oculus.

Of interest, is that as the cord defining the wall is extended 36 meters through the center it creates a curve on the floor of the platform opposite to it. This arc is not a circle but actually a conchoid. There are eight of these conchoid arcs, one for each side of the octagon. The pattern resulting from these conchoids on the platform resembles a flower with eight petals and Ricci refers to it as the flower (fiore) of Santa Maria del Fiore.”

A critic of Filippo Brunelleschi (Giovanni de Gherardo da Prato also known as Acquetini the creator of the sonnet) who challenged Brunelleschi and spied on his work, left drawings in which he outlined the system used to create the curvature of the dome with the eight walls. It was in the form of an eight-sided flower as mentioned above. This helped to confirm the radial methodology used by Brunelleschi.

One of the best-known features of Brunelleschi's dome is its herringbone brick pattern. It is called spinapesce in Italian and “herringbone” in English, because the pattern resembles the spine of a fish. Bricks were laid flat in groups of three end to end. At one end of every group a brick was laid on its end pointing upwards. At the other end a brick was placed pointing downwards.

By interlacing the bricks in this manner the technique may have served two main purposes:

First, the system provided structural support during construction by bonding each new layer of bricks to earlier layers, thereby permitting Brunelleschi to build the dome without full centering and scaffolding. This gave greater support to the wall preventing it from tipping inwards and collapsing.

Next as the dome rose and its segments converged, adjacent lines of spinapesce locked the increasingly inclined, flat-laid bricks together, preventing them from sliding off while the mortar was wet.

The position and angle of inclination of the spinapesce bricks could be determined by the use of the radial method described earlier brick by brick.

As one visualizes the brick courses laid between adjacent corners of the octagon it resembles the concave curve traced by a rope or line held slack between two points at equal height. This curving of the mortar beds and brick courses is usually referred to as corda blanda or literally "slack-line."

It is most likely the corda blanda did more to allow the dome to be self-supporting rather than the Spinapesce. This occurs by ensuring that each course of bricks was always held in compression, which would not have been the case otherwise.

Recently a team of researchers from Princeton University and the University of Bergamo in Italy have shown by computer analysis that the herringbone pattern in the Duomo helped create the stability necessary for the construction of the Duomo. The herringbone pattern creates rows of plate bandes. These plate bandes are caused by the horizontal bricks pushing outward towards the vertical bricks and thus remaining in place and stable.

Today there are several reasons which may explain how Brunelleschi was able to accomplish this astonishing marvel of construction without the benefit of a supporting frame.

First there is the well know Spinapesce method of interlocking bricks, second the unintended corda blanda effect which effectively allowed the compression of each row of bricks and finally the plate bandes resulting from the way the bricks were laid. In addition his creative use of radial methodology was helpful in building a dome without supporting structures. Clearly in combination, the effects resulted in a type of construction never seen before. It allowed the impossible to take form in Florence to the delight of the world.

3. The Effects

Filippo Brunelleschi's death is celebrated every year in Florence with parades and colorful festivities. He is appropriately buried under the cupola to which he devoted most of his life and loved with great passion.

Personal statements left behind reveal a man who demonstrated a playful superiority over his critics. He refers to these with distinct sarcasm and even rage.

Was he arrogant? Yes, of course. Was he intelligent? No doubt his works show his brilliance. Was he a visionary? The world agrees that he indeed had a unique vision that continues to amaze. We have known of individuals like this who are geniuses in their own time and stand above the rest of their peers. We frequently acknowledge their foibles and give them a wider berth as they course through our world.

Today we recognize him as a founding father of Renaissance architecture. In his own day Filippo Brunelleschi became known as the man who renewed the Roman style, now identified with the architecture of the Renaissance. His works helped transform the artistic traditions of Quattrocento builders. He was able to bring together both Gothic and Classic elements. Florentines appreciated its "economy" as well as its harmonious proportions. They were enthralled with the introduction of "vaulting without supporting structures." The ability to create such a dome without support was considered miraculous.

He devised mechanical systems for delivering, hoisting and placing building materials that contributed greatly to the development and progression of machinery. His inventions helped influenced the evolution of patents in the years to come. These systems allowed a remarkable speed of construction and safety. In the 16 years he and his workers rose up and down the base and the cupola there was only one death. This was an outstanding achievement in an era when human life was expendable.

Today the monumental form of the cupola dominates the Florentine skyline. It surprises you often as you turn the narrow streets or breaks into view unexpectedly upon entering a piazza. It is seen throughout the city. It may even be seen from Pistoia, 15 miles west of the city when the skies are clear. There they have renamed one of their city streets to "Via dell'Apparenza," Street of the Appearance. To them it is more than just an architectural element or an engineering feat, but rather a miraculous apparition. It is the handiwork of God arising overnight in the Arno Valley.

He was an irascible man who challenged the system of the time but who knew his worth. He realized the value of his ideas and managed to protect them from disclosure much like the high-tech companies of today. There is no doubt he managed to elevate Florence to a higher plane among the cities of the Renaissance by the value of his architecture and inventions.

He may well have helped save Florence from mediocrity.

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