

The Spark of 1812

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by

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With contributions by the SIGMA Think Tank

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“Mastah Jeff’s son, carriage comin’,” the young black man said to the old white man crouched beside him, planting vegetables in the garden.

The old white man, dressed in a tatty plain linen blouse and britches, straightened up and lifted the brim of his floppy hat to see. His long hair was nearly white, with just a hint of the fiery orange it had been in his youth. He wiped sweat from his brow, leaving a muddy mark. “Thank you, Wormley. Only two days late. We shall soon see what this is about.” He raised his hoe and used it to help him stand, unwound to his full six feet, two inches, then handed the hoe to his companion. He stretched his sore knees and began the short walk from the garden terrace up to the driveway. As he reached the level of the driveway, he noticed that his man Burwell was already coming down the steps from the domed house to greet the carriage, followed closely by Isaac. No need to hurry ... his visitors would be greeted properly.

The carriage was a fine landau, its top up. It was looking the worse for the long trip; both it and the horses were splattered with mud and covered in dust. A short distance behind the first was a second carriage, not quite so fine, but just as dirty. The

first pulled up and Isaac took the leads, though the horses would not be inclined to bolt after their recent climb. Burwell dropped the carriage step and opened the door, standing erect to one side, playing his part to perfection.

The old gardener approached the scene as a short gentleman with the face of a serious parson, wearing a fine coat and trousers, stylishly long white hair, and with a top hat in hand emerged from the carriage and stepped down. Two more faces hesitated at the door, waiting to see how the ceremony would proceed.

The old man removed his floppy hat and bowed deeply. “Mr. President.”

The fine gentleman returned the bow. “Mr. President.”

Both men held their deep bows as the old man said, “Πόσο καιρό πρέπει να διατηρήσουμε αυτό ο κύριος Πρόεδρος φάρσα?”

The fine gentleman replied, “Αρκεί, ήδη, παλιό φίλο.”

They stood and embraced warmly, while the two remaining passengers stepped down. First was a tall, dark-haired gentleman in a black coat. He was followed by a shorter and younger man with curly hair, wearing a stylish cravat, who asked with a French accent, “I confess, that was Greek to me. Mr. Monroe, do you understand what they said?”

The tall dark-haired gentleman smiled and told his companion, “Monsieur du Pont, I believe you may relax. Mr. Jefferson and President Madison concur that this will be an informal gathering, just as I expected.”

Thomas Jefferson looked down at James Madison’s mud-caked shoes and splattered trousers, and noticed the other guests were in the same condition. “Your trip encountered some difficulties?”

Madison shrugged. “You really must see to these roads, Tom! Horses show little respect for office, I’ve found. When sufficiently stuck, all passengers must get out and push.”

Jefferson turned to James Monroe next, and shook his hand firmly. “James, how is our Secretary of War?”

Monroe shook his head. “I resigned from that post in March, Mr. President. President Madison hopes Mr. Crawford will take the position when he returns from France. I am doing this one last chore on my way home.”

“Well, then,” Jefferson said with a smile, “It is a good thing the war is over, is it not?” Then he turned to du Pont and embraced him. “*Irénée, mon cher ami, quel grand plaisir de vous revoir! Et votre père...comment se porte-t-il?*”

“My father is very well, Mr. President,” Irénée du Pont replied as he squirmed a bit, “and bids me to tell you he hopes to be back in this country soon.”

The second carriage pulled up and the servants repeated their routine. President Madison pulled Jefferson aside and whispered to him. “Tom, after one day trapped in a carriage with that lot, I feared my ears would soon bleed, and I arranged for a second. God protect us from inventors!”

Jefferson turned to look at the three men stepping down from the second carriage. “Colonel Stevens I recognize. Not this fellow though. And this last ... James, I considered us friends. You have brought Evans! Back in the first administration, when my duties included approving patents, I could not walk down a street without Stevens, Evans, Fitch, or Rumsey tugging at a sleeve.”

And then, with no more hesitation than a bracing breath, Thomas Jefferson smiled and strode over to meet his latest guests, who had lined up politely by their carriage. Jefferson extended his hand to the tall elderly gentleman in the plain coat. "Colonel John Stevens, my old friend! I was so sad to hear that Chancellor Livingston passed away. How is his partner, Colonel Fulton?"

Stevens hung his head. "You have not heard? Robert caught a chill trying to save a friend who fell through ice, and died of consumption, just this February."

Jefferson grasped Stevens' shoulders. "That is terrible news! Such a young and talented fellow! I shall miss his correspondence and demonstrations greatly. I had very much hoped he would one day build us a submarine boat."

Jefferson offered his hand to the next man. "Sir, I hope I do not slight you on the chance that we have met, but I do not recall the occasion."

The man took Jefferson's hand and bowed curtly. "Francis Cabot Lowell, Mr. President. I am a businessman from Boston. May I offer a gift?" He presented a package. "This is one of the first runs of our new mill, and I hope the dimensions I obtained for your table are correct."

Jefferson lifted a corner of the wrapping, to reveal plain cotton cloth. "A tablecloth, and am I to understand that it was made in Boston?"

Lowell shook his head. "My partners and I have taken up the manufacture of textiles in Waltham, where the Charles River offers a good drop. We spin and weave under one roof, using looms powered by the water. I am confident our mill has no equal on this side of the Atlantic."

Jefferson returned the bow. "Excellent, I may cover my table without enriching our recent foes. Well, then, Mr. Lowell, perhaps at some time during your visit you would care to see our modest looms here at Monticello?" Jefferson pointed to a small stone building near the garden terrace.

"Nothing would delight me more, sir."

Jefferson placed his fists sternly against his hips and turned to the last man, a jolly-looking fellow with a bulbous nose, round face, and an impish grin. "Well, the inestimable Mr. Oliver Evans! You, sir, are most welcome to be my guest at my little hermitage in the mountains ... provided you have brought no solicitors or legal writs."

Evans laughed and offered a hand, which was quickly accepted. "Mr. President, I'm here at your service. I recently had a solemn ceremony with my family, and burned all my patents. And to my surprise, I find I'm not only happier as a result, but my purse is fuller as well! Now, the last I heard, you had procured one of my ore crushing screws. Is it performing well for you?"

Jefferson nodded, and waved a hand in the direction of the workshops on Mulberry Row. "Quite well. We are now able to make our own very good plaster here."

Evans offered a package of his own. "Since you are giving up your cherished library, sir, I thought I might give you a small start on a new one. Two copies, one for the old, and one for the new. My latest book."

Jefferson accepted the package with a polite nod. "Mr. Evans, if this book is half as helpful as either of your previous books, I shall read it eagerly. I must say your last book did as much for steam engines as your first did for grist mills, and did your country a fine service." He turned in a circle to address his guests. "Gentlemen, I must assume

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you are weary from your ride. Mr. President, the octagon room is yours, as usual. Mr. Monroe, will you be staying with us here, or at Ash Lawn?"

"Here, if it is not too much trouble."

Jefferson smiled. "I am, as always, honored to welcome you. Burwell and Isaac here will show you to your quarters, and provide you with whatever you require. I shall see that your drivers and horses receive some well-earned care. When you are comfortable, I suggest we meet in the tea room." Jefferson turned to summon Wormley, but noticed the young gardener and an assistant were already standing by waiting to take the horses.



Burwell collected his tray and left the tea room, leaving the party to discuss business.

Custom dictated that the host should begin the conversation. After all had a quick sip of tea, Thomas Jefferson spoke first. "I confess that I am somewhat mystified as to the purpose of this meeting. President Madison was vague about the subject, except to suggest that he considered it important, and seemed to think that the matter would, for some reason, demand my meager talents. I had expected the remaining guests would be members of the government, yet instead we have men of manufacturing and invention."

Oliver Evans spoke, not noticing that the President was about to. "It was implied to me that we were to inspect your library and pass final approval on the purchase for Congress. Never having had the pleasure to compare your legendary collection to that of Philadelphia's Library Company, I sprang at the opportunity."

Madison leaned back in his chair and smiled. "At times, a little subterfuge is useful. Gentlemen, I defer to Mr. Monroe."

James Monroe put down his cup and composed his thoughts for a moment. "I shall be blunt. We blundered into this war unprepared. The British offended us greatly, true enough, but they did so in the absolute certainty of their superior military strength. They did not think we would declare war because they were sure we would lose. There is an old saying that you must kiss the hand you cannot bite."

"Well," offered Evans, "I would say the nation agrees. We showed them otherwise. A hearty bite indeed! I was proud to supply iron wares to Chauncey and Perry."

Madison shook his head. "The nation may agree, but wiser heads know better. We went to war so unaware of our own weakness that we thought we could match them. Frankly, we were lucky we did not lose. The terms of the treaty are *status quo, ante bellum*. Nothing changed. Are you gentlemen aware that the British withdrew the Orders of Council of 1807 just two days before our declaration of war? We achieved most of what we wanted before a shot was fired, yet we did not know this because of the time it takes to sail the news across the Atlantic. And for the same reason, our greatest victory was fought after the peace was concluded. Now I am traveling back to

Montpelier to gather replacements for my possessions lost when Washington burned. Gentlemen, Mr. Monroe and I saw, with our own eyes, just how poorly our defenses held against a relatively small force of British troops. That we should lose our capital, unable to muster a defense on our own soil, is deplorable.”

“But Baltimore, New Orleans ...” Evans objected.

“Mr. Evans! You interrupt the President,” John Stevens scolded Evans.

James Monroe waved a hand. “That, gentlemen, is one of the reasons he was invited, and I would encourage all of you to speak your minds. Each of you were selected because you have never shown any hesitation to express your views when you believe you are right. Mr. Lowell, for example, memorized the design of an English manufactory, and then, despite blockades and embargos, managed to make it home in one piece, where he convinced investors to build a large and elaborate fabric mill in the middle of a war, from plans smuggled out of England in his head. Had the British suspected his motives, I expect he would yet be locked in the Tower of London, or worse. Colonel Stevens has never been shy in advising the government how it should conduct its business, especially where steam power is involved. Monsieur du Pont, having survived the French Revolution and kept his head, came here and decided we know nothing about the manufacture of gunpowder, so set out to build us a powder mill as good as any in Europe. My generals tell me he succeeded. And then there is Mr. Evans, willing to bring suit over a matter of patent infringement against a sitting President, the very man who had granted the patent in the first place. Finally, of course, there is our host, who in 1776 told the King of England that we no longer cared for his Divine Guidance.”

Jefferson laughed. “And may I add, Irénée’s father and I have been close confidants for many years. Without the help he provided to Chancellor Livingston, we should not have gained the Louisiana Territory. I hope, and I am sure, Irénée will show us the same willingness to express himself as boldly as does his father, and speak for his father on matters of economics. Colonel Stevens, I am equally sure, will be able to speak for the late Chancellor Livingston and Colonel Fulton. And now the picture becomes clearer.”

“To you, perhaps, Mr. Jefferson,” Evans said, “but perhaps you would illuminate a poor wheelwright’s apprentice? If we are not here to approve the library, then *what?*”

“With pleasure, my good sir, although I must say you are the only wheelwright I have ever known who could cite Boyle and Charles and calculate the force of steam and the strengths of boilers.” Jefferson looked at Monroe. “What Mr. Monroe desires is to pool your thoughts and see what can be done with your infernal machines to make it impossible for any foreign navy to ever sail into our harbors and rivers and burn our cities. I expressed my own notion of this at the start of the war, but in retrospect, my proposal was too rash to repeat. I invite better alternatives, which I expect are many.”

Jefferson looked to du Pont. “The easiest member of this squadron of thinkers for us to recognize would be Monsieur du Pont, as clearly gunpowder will be at the heart of any war machinery. But Colonel Stevens, could you please tell the others about the work of Colonel Fulton? While he was in France I followed his work on torpedoes and submarine boats quite closely, thanks to his affiliation with Chancellor Livingston there, and we had frequent communication since his return. I suggested to him that we really should establish a corps for the Navy, similar to the Army’s Corps of Engineers,

specifically to design new ships and weapons of the sort he proposed. Nothing ever came of it.”

Colonel Stevens set his cup down. “I shall try to be civil, as Mr. Fulton and I became bitter adversaries in recent years due to his monopoly in the waters of New York. But now, with his passing, I should acknowledge his considerable worth. You may know, if you read the newspapers, that the steamboat the Chancellor and Fulton launched on the Hudson in 1807, which they called the *North River Steamboat* but which the papers insist is the *Clermont*, was only the barest glimpse into the Colonel’s talents. His main interest while in France was developing explosive devices designed to be used underwater, called torpedoes, with the means to deliver them. The summer he launched his steamboat, he demonstrated one form of his torpedoes against a brig of about two hundred tons. I watched him blow it to splinters and sink it in twenty seconds, all by placing a powder charge under the hull.

“More recently he experimented with another sort of torpedo, in essence a cannon fired at close range under water. I witnessed several of these tests, and can tell you that the effect is far worse than fire above the water line. The blast shatters a hole three feet across, and would send any enemy ship to the bottom in minutes.”

“How close must you be?” Jefferson asked.

“Under twenty feet. Fifteen is better. So, yes, one would need a special craft to employ it.”

Jefferson nodded. “The *Demologos*, his steam-powered warship?”

Colonel Stevens shook his head. “He considered it, but the *Demologos* is simply a very sturdy floating battery, sixteen guns of thirty-two pounds, and with a hull five feet thick of the same sturdy oak that the Constitution and Constellation are made of. But, of course, the *Demologos* is powered by a steam engine. While she is not fast, she can maneuver without regard to the wind, and in the tight confines of a river or harbor should have any sailing ship at a dreadful disadvantage, turning to fire broadsides against ships unable to turn at will. Had the British come face to face with a squadron of these in the Chesapeake, they would have found their T crossed like a Chinese character, and Washington might have gotten a good show rather than a roasting. Alas, she was alone, and in New York’s harbor, alongside the defenses I designed. I will note that the British left New York alone.”

James Monroe gestured encouragement with his right hand. “Now, good sir, please tell them about your own clever experiments.”

“You are too kind, sir, as it was my son Robert’s idea. Just this last December, a day or two after the treaty was signed, we demonstrated an elongated explosive shell fired by a twenty-four pound rifled gun, with a most satisfying effect. In fact, it might make an interesting enhancement for Colonel Fulton’s torpedo cannon.”

Monroe laughed. “I forgot that one! I meant *your* floating battery.”

Stevens smiled. “Ah, that one. Once we knew what destruction the shells would wreak on a wooden hull, we immediately wondered what countermeasures could be applied. Unlike Colonel Fulton’s, my own craft has yet to be built. Mr. Evans, may I borrow your saucer?”

Oliver Evans passed the saucer, placing his cup on the table. Burwell swooped in with fresh saucer, placed the cup in the saucer, wiped up the ring with a napkin, and left without a word.

Colonel Stevens chuckled, holding up his own cup for Burwell to see, then placed it on the table and picked up his own saucer. Burwell was there in a second with a replacement, while Colonel Stevens placed the two saucers together, face to face and lip to lip. “This, gentlemen, is the form of my design. It is also a floating battery, although mine is intended to be anchored to the bottom by a swivel and chain in the center. Gun ports are positioned at regular intervals around the periphery. Within is a modest steam engine, driving a pair of my propulsive screws, arranged to thrust on the tangent, so that the vessel may be rotated at will. It is intended to fire one gun at a time, then rotate to bring a fresh one to bear, so that it can fire nearly continuously in any chosen direction, or multiple directions should the need arise. And to make it invulnerable to return fire, the sloped topside structure is to be covered with iron plate.”

“Iron ... is that sturdy enough?” Jefferson asked. “And would it be too heavy?”

“Cast iron would shatter, I expect,” Stevens replied, “but a modest wrought iron plate fastened over an oak structure, and angled as this simple model suggests, will deflect cannon shot easily. Robert and I have tested it. And I can assure you that the resulting structure weighs far less than it would if made of the same thickness of oak as the *Demologos*.”

Madison turned his gaze to Jefferson. “Tom, you and I attended that demonstration Colonel Fulton put on at Kalorama, and I know you corresponded with both him and the Chancellor. Your opinion?”

Jefferson considered the saucer model for a moment. “This is inspired, but, of course, limited. The same year Colonel Fulton demonstrated his torpedoes in New York, I recommended that we acquire gunboats for every major harbor.” Jefferson offered a sheepish grin, and shrugged. “It seemed like a good idea at the time. And yet, they seem to have made little difference to the defense of Washington, and the main defense at Baltimore was Fort McHenry. Gunboats blocked the harbor entrance, but I am unaware that they participated in any firing. As far as I can tell, all the Chesapeake Bay Flotilla accomplished, outgunned seven to one, was to frustrate the British in trying to catch them. This resulted in the destruction of several towns, before they finally scuttled the lot and salvaged the guns in the attempt to defend Washington. We all know how that turned out. I see my short-sightedness now, and I hope we will not be equally short-sighted in this discussion. Tell me, Mr. President, are you receiving fervent calls for the construction of more forts to defend our harbors?”

“Oh, indeed I am. Every town with a harbor sufficient for a row boat wants its own McHenry.”

“Mmmm.” Irénée du Pont rubbed his chin. “Speaking for my father, as an economist, I presume one can readily calculate the cost of one such fort, the cost to supply it, and maintain a garrison? And that most members of Congress can perform simple multiplication? Has anyone considered what taxes shall be needed to pay for all these forts? What say you, Mr. Monroe? Were you still Secretary of War, would you sink treasure into very sturdy, but expensive, fortifications bristling with guns, which can only defend a mile or two about them, and when it is likely that none will ever have the opportunity to fire a shot in anger? If so, I shall gladly supply the powder, which I shall sell at a price to offset my wasted taxes.”

James Monroe shook his head. “I can think of but a few harbors worth the cost. Even at Baltimore, the fort did nothing to stop an army from landing and marching on the

city. My generals told me they were surprised when the British infantry withdrew, but they believe they did not wish to attack our lines without their fleet defending their flank. In truth, the fort did little damage to the British ships, as they simply withdrew beyond the range of its guns, and as a consequence could only fire on it with mortars and Congreve rockets, at extreme range. This resulted in spectacular but harmless air bursts, and a wonderful poem by a Mr. Key. The fort did suffice to prevent them from supporting their infantry, but the circumstances were particular. The troops manning the earthworks and facing the British Marines ought to have a verse of their own, as they suffered more danger but missed the fireworks.”

Jefferson nodded. “I am not noted as a military man, but I have read a little on the subject, and I believe those generals who say the days of castles and fortresses are behind us. A fortress is a refuge. It cannot sally forth and engage the enemy. I presume you all play chess? The most powerful pieces can cross the board. The king is a cripple, barely able to hobble.” He pointed to the stacked saucers. “I very much like this armor. I very much wish it were not chained in place. Colonel Stevens, why did you not make this a ship of maneuver, as Fulton did the *Demologos*?”

Colonel Stevens stared at his saucers. “As you say sir, it seemed like a good idea at the time. I was thinking as an artilleryman, envisioning a fortified gun emplacement able to fire in all directions, as you will find in some military books, but fortified better and able to be arrayed for raking fire at will across a channel. I do have another design for an iron clad ship of maneuver, based roughly on my steamship *Philadelphia*, and intended to fire the elongated explosive shells. Certainly, it makes sense to do this. We need not limit ourselves to fixed defenses, even floating ones. We can take the battle to the enemy.”

Monroe raised a finger. “We can move a strong force to any river or harbor the enemy threatens, instead of leaving nineteen parts in twenty of our forces useless in their own ports, unable to assist their outnumbered neighbor. How fast do you think a steamer with iron armor can travel, Mr. Stevens?”

“The *Demologos* can make about five miles an hour, although she was not built for speed. I think we might manage seven or eight with a sleeker hull. My steamer *Philadelphia* can make that.”

“You could manage twelve, if you had better engines,” Oliver Evans offered. “You all recall when Fulton’s river steamer, the *New Orleans*, made the trip from Pittsburgh to her namesake, back in 1811? That trip took, I think, about two and a half months, and that was downstream. Upstream I think she could do no more than three miles an hour, and could reach only as far upstream as Natchez. But you have heard the news, I am certain, of the boat built by Daniel French, the *Enterprise*? And I should hope you do not consider me too immodest if I say her engines, while adapted to their purpose by the esteemed Mr. French, are essentially of my design. She launched from Pittsburgh with a load of military supplies for General Jackson this last December, and made it to New Orleans just the day after the final battle. A mere nineteen days, as I recall, along more than two thousand miles of twisting river filled with snags, shallows, and sand bars. Jackson liked the boat so much he has kept it busy down there. When he’s done, mark my words, she’ll make it *back* all the way to Pittsburgh, as well. Strong steam, gentlemen! Those ancient Boulton and Watt engines, such as Fulton used on the

Clermont, or the cheap copies Nicholas Roosevelt built for the *New Orleans*, suckle as a babe!

Mr. Lowell, silent until now, cocked his head. “Eh?”

“What Mr. Evans means to say,” Colonel Stevens explained, “Is that Bolton and Watt engines work on the principle of the *condensation* of steam. The actual force on the piston is provided by the atmosphere, acting against the suction produced when steam filling the cylinder condenses to liquid water. What Mr. Evans has by all accounts perfected is engines that work on the pressure of steam itself, at several atmospheres of pressure.”

“I can do at least ten atmospheres,” Evans injected.

Stevens rolled his eyes. “If one can figure out how to hold steam at high temperature and great pressure, one can make a small engine work harder and on less fuel than a huge one operating on the atmosphere alone. James Rumsey understood this. I have long advocated this, although I have had difficulty in running more than one atmosphere of pressure. Even Mr. Watt knows this. The difference is that Mr. Evans here, who has made himself a master at forcing iron to his will, and keeping steam in its place, has figured out how to actually build engines which *do* this. I believe he must have now built fifty or a hundred, and I have seen many of them in operation. They work exceptionally well. In this regard he has my entire respect. I can dream up new engines. Oliver can *build* them.”

Evans face beamed “I told you so,” but said nothing as he leaned back in his chair.

The President nodded. “And that is the other reason Mr. Evans was invited. You may also notice that Eli Whitney was *not*. All of you have shown the ability to move a complex project quickly to completion. And, with my apologies to Colonel Stevens, who may not be quite so good at ‘forcing iron to his will,’ I have watched him do so to *men* for many years.” The President turned his gaze to Stevens. “Whatever you lack in skills with a hammer, sir, you make up for as a man who knows what needs building, with the skill to make political machinery move. Your turnpike projects alone justify your presence here.”

The President glanced at the clock. “Now, gentlemen, that you have learned the true intent of this journey, to throw you all in the cauldron and stew your brains for a few days until we have a brew with which to see the future, perhaps we should adjourn to the library so that I can honestly say we did what my formal report will say was our purpose here.”

Oliver Evans was the first out of the door.



Thomas Jefferson noticed the crestfallen visage of Oliver Evans as the inventor surveyed the library. Over half of the shelves were empty; the books already carefully packed in crates. “My apologies. Had I known that an approval committee wished to see

them first, I would have delayed packing them. However, I will gladly open any crate you wish to inspect. The crates are organized by subject, and each has a list of its contents on the lid.”

Evans spied Diderot’s *Encyclopédie, ou Dictionnaire Raisonné des Sciences*, and headed straight for the shelf, as Stevens, du Pont, and Lowell each browsed a wall. Madison and Monroe, already well familiar with the library, watched the others with amused smiles. Approval of the acquisition for the new Library of Congress was a foregone conclusion.

“A bag of flour is a consumable commodity,” Jefferson said loudly enough for all to hear. “Bread, wine, these are not meant to be held for long. A harness, a carriage wheel, a coat, these are also common commodities, to be used for a few years, and then be replaced when they no longer serve. But a building, a mill, a forge, these we consider capital, an investment intended to produce value for us for a very long time. Books, gentlemen, are not common commodities. Books are capital.”

The others turned toward the speaker and nodded approval. Jefferson watched Evans study the shelves, taking down a volume, leafing through it, then finding a new treasure and doing the same. After a few minutes, Jefferson walked quietly over behind him. “You seem to be enjoying yourself, Mr. Evans.”

Oliver looked up with a smile. “I love a good library. I am used to one of the best, the Library Company of Philadelphia. I know you know it well.”

Jefferson nodded. “I do indeed. During the Continental Congress, when I wrote the Declaration, if I were missing, my delegation knew exactly where to find me, exploring the library. It was that library that inspired me to build my own. When I was sent to France, I explored every bookstore I could find, and sent home books by the case. The one in your hands is but one of hundreds I purchased there. Many of them were bought expressly because I knew they were in Dr. Franklin’s library.”

“Ah, here, Boyle’s Law.” Evans pointed to a page. “I remember when I first saw it. I was searching for basic principles of natural philosophy that I could apply to help me calculate the work that could be done by steam. But you mentioned another?”

“It was published but a few years ago, by Gay-Lussac, describing the work of Jacques Charles. Where Boyle addressed the relationship between pressure and volume, Charles demonstrated a similar relationship between volume and temperature. In your book on steam power, you seemed to be using both. In fact, you were using them combined, in a very clever fashion, considering volume, pressure, and temperature as a whole.”

“Well, honestly, I did not read Mr. Lussac. A Frenchman?”

“Oui.” Jefferson removed a volume from an adjacent shelf, and thumbed for the relevant paper.

Evans continued. “I’m afraid I can only manage a few words of French. But I recall becoming very excited to hear about the principle, during a lecture at the American Philosophical Society, shortly after the turn of the century. It made immediate sense, and I began using it the following day. I don’t recall if I jotted down the names, in my excitement to record the principle itself.”

Jefferson put the volume back in its place. “If you don’t mind my asking, you said you were a wheelwright’s apprentice, and I was wondering what other formal education you have had.”

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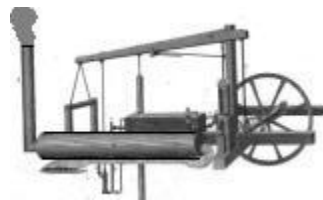
“Well, I can tell you I never attended William and Mary, or Harvard, or King’s College.” Evans nodded his head toward Jefferson, Lowell, and Stevens, in turn. “I learned to read, write, and cipher when I was a boy. And I learned to work iron, wood, and leather, to make rivets, make glue, and make grease. We prepared our own paint. We had several lathes to make spokes and hubs. But the most important thing I learned as a wheelwright was that I did not care to spend my life repeating the same dreary tasks over and over, because some master wheelwright said it had always been done that way. My mind was always on finding an easier, better, faster way to do things.

“One day, on a dare, I invented a way to make wire pins for a carding comb and insert them quickly in their place in a leather holder, three thousand a minute. It was a very successful invention, one I would expect Mr. Lowell is using in his fabric mill, but that is when I also discovered that if you show your ideas to someone else, without obtaining a patent, you’ve lost them. So I suppose you could say my school was creating machines in my head, and learning from my mistakes.”

“I think,” Jefferson said with a smile, “that you have attended a much finer college than the one that tried to devour me. I was lucky to escape William and Mary with my wits intact. It is very clear to me that you have availed yourself of two of the most remarkable institutions of learning in the United States, and that both of them were founded by Dr. Franklin and his circle of friends, back in the early part of the last century. They called themselves the Leather Apron Club. Few of them had more schooling than you. And that is why my present avocation is to build an Academical Village, a place for men like you to come and study.”

Evans smiled. “It might interest you to know that Daniel French and Henry Shreve are no more educated than I am. They just read my engine book. It was French who built the *Enterprise*, the steam boat that raced down to New Orleans a few months ago, and Shreve was her pilot. My son talked to Captain Shreve before he even began the trip, and he says Shreve has ideas for a better engine already.”

“I should like to meet them some day,” Jefferson said, as he dipped a pen in the inkwell of a nearby rotating bookstand. Evans noticed that Jefferson was holding a copy of Evans’ new book. Jefferson placed the book beside a list, and copied the title and author onto the list, with a notation as to the proper position in the group, then walked to the shelf and placed the book in its new home.



The servants busied themselves clearing the supper table as the party chatted amicably. Thomas Jefferson noted the stains on the new tablecloth. “My apologies, Mr. Lowell, for spoiling your wares so quickly. I hope we can clean it well enough. My girls are more used to linen than cotton.”

Lowell smiled and shrugged. “That cloth took under five minutes to produce. How long would it take on your own looms?”

Jefferson’s jaw dropped, and he said nothing. Lowell smiled.

President Madison tapped his glass for attention. “Gentlemen, now that your appetites are sated, perhaps we can revisit the subject of defense. Tom, you had a topic you wished to bring up?”

Jefferson nodded. “Indeed. I never received any clarification from Colonel Fulton as to why he seemed to have abandoned the idea of delivering torpedoes using submarine boats. Colonel Stevens, do you know the details?”

“Certainly, sir.” The colonel leaned forward to raise his wine glass, which precipitated a quick toast to Colonel Fulton. “Before our relations soured, we discussed it in depth over a particularly nice *haut Medoc* he brought back with him from France. I presume you all recall the *Turtle*, the little underwater barrel built during the Revolution?”

“I do indeed,” the old sage replied. “George Washington and I encouraged Mr. Bushnell to build it. I confess a certain vanity in hoping to see the idea succeed.”

Stevens continued. “Colonel Fulton did make a much improved craft, the *Nautilus*, while in France. It was a bit over twenty feet in length, about six abreast, with a crew of two or three men. He attempted to propel it with a hand crank driving a propelling screw. He could submerge it to a depth of twenty five feet, and stay under as much as four or five hours, thanks to a sphere of compressed air it carried. But the best he could manage over half a mile or so was about two knots on the surface, just a little faster than a common rowboat with the same crew. When submerged, it was even slower. On his attempts to attack British ships, they spotted it on the surface before it could fully submerge, and simply moved away. Finally, it developed chronic leaks and he abandoned it. Apparently, this led to some misunderstanding with Napoleon, and he left for Britain shortly thereafter, using an assumed name.”

President Madison looked disappointed. “This explains why his demonstration at Kalorama made no mention of submarine boats. Instead, he suggested rowed torpedo boats, armed with harpoon guns with which to affix ropes to the enemy, and thus pull torpedoes into contact with them. His proposed tactics specified an uncomfortably close attack, *en masse*. He seemed convinced that small boats could do this with little danger, although I recall he recommended sloped covers on the boats to discourage boarders. It seemed a foolhardy tactic to me. Is there any hope for using steam power in a submerged boat?”

Stevens shook his head. “Not if totally under water. The air supply Fulton carried for breathing would be consumed in seconds if used for such intense combustion. I suppose one might travel slightly submerged, with pipes protruding to take in air and exhaust the smoke, but with no advantage of surprise. One would need an engine that needed no ... what is the name for the vital part of air?”

“Oxygen,” du Pont offered. “Antoine Lavoisier, my old master at the Armory, named it.”

“Well after my good friend Joseph Priestly discovered it, and demonstrated it for him, I think,” Jefferson added.

“Yes,” du Pont admitted. “Lavoisier also discovered that the balance of air seems to be almost entirely a gas he called ‘nitrogen,’ which he believed was the same as that evolved from niter. So Priestly’s dephlogisticated air is nitrogen, with some smoke.”

“Hah!” Jefferson clapped his hands in delight. “So I was right! Clover *does* extract something from the atmosphere to replenish the soil! The effect is similar to

adding niter. But the niter connection presents an idea. I believe someone long ago suggested an engine that runs on small charges of gunpowder. The book is packed away already, or I would look this up. Would this be possible, at least to power a submarine boat for short distances under the water?"

Oliver Evans leaned back in his chair, studying the ceiling, and lost in thought. John Stevens began patting his pockets to see if he had a pencil and paper.

Francis Lowell scowled. "Who was that madman in England? Cayley? Yes, Sir George Cayley. He believes he can build a gunpowder engine for a flying machine."

Irénée du Pont put his hand to his forehead and closed his eyes, searching his memory. "I believe I heard, while I was at the Armory, that Thomas Paine also toyed with the idea of gunpowder engines."

"Then we should look in to this, for Paine was certainly no madman." Jefferson turned to address his butler. "Burwell, could you check my cabinet and fetch us some pencils and paper, and perhaps my drawing instruments as well?" He turned back to the party. "This does, however, suggest an alternative which I think may already be proven possible by what we have discussed today. Consider that we have established that Colonel Fulton has made a submarine boat which is practical except for its means of propulsion, allowing that leaks are a matter for good shipwrights to correct. He mastered the buoyancy and control. Furthermore, he has two very deadly weapons capable of destroying a capital ship, providing the boat can come close enough without being destroyed. Now, then, we consider Colonel Stevens' idea of affixing iron over a wooden shield to protect a boat. Could such a boat, run with her deck nearly awash, with an angled cover such as Fulton suggested for his torpedo boats, or perhaps even simply a flat deck, not repel any fire from cannon or swivel guns? Perhaps it would still be vulnerable to plunging fire from mortars or howitzers, but I should think a small moving target would be exceedingly difficult to hit except with direct fire, which would simply glance off."

"This sounds a bit like the contraption Silas Halsey built last year," Monroe noted. "It proved more danger to him than the British."

"Powered by human flesh, I presume," Jefferson continued. "But say we incorporate one of Mr. French's engines, and give this torpedo boat some speed. Adjust the buoyancy so the deck is almost awash so it presents little target, with pipes as needed for chimneys and air, and race to battle, at ten or twelve miles an hour. We care not a whit for stealth, but instead charge in boldly; confident our quarry can neither escape nor harm us with her guns. Sweep down the side of the first ship in the line of battle, under her guns, discharge one of the cannon-torpedoes into her point-blank, leaving a hole the size of a card table below her water line, and continue on to the next victim. I picture a boat with perhaps twelve such cannon, six to a side. Two such boats, and a little luck, would have put the British fleet at Baltimore on the bottom in one pass, and then we could have continued on out to sea and would see how long a blockade line stayed around. The main risk to the crew, I believe, would be to their ears, when shot bounced off the iron plates."

Everyone in the party laughed. Burwell, just coming in with the drawing materials, tried very hard not to.

The technical discussion soon swirled to a storm of brains. Madison and Monroe watched with detached amusement as the five inventors huddled over one end of the

dining table, sketching and arguing. In quiet tones, the President and his former Secretary of War speculated about the utility of torpedo boats and submarines in the upcoming campaign to finally put an end to the outrages of the Barbary Coast pirates, already too far along to afford a delay. Monroe whispered that they might prove useful in defending the neighbors of the United States from continuing European military interventions.

“No, not a paddlewheel,” Stevens objected. “A wheel would stick above the water line and would be subject to damage. I much prefer a short Archimedes propelling screw, like a four-armed windmill, at the stern. I use a pair, rotating counter to each other by way of cogs in the drive.”

“I have heard of your ‘smoke-jack fly’.” Jefferson studied the sketch of the propeller. “Colonel, I should show you my design for the mould board plough. I believe we can make your propelling screw even better if we give it a subtle twist. Make it a screw of least resistance.” Jefferson then pointed to a circular detail on the hub. “But could you tell me what this detail does?”

Stevens glanced at it. “Oh, for experiments I adjust the angle of the arms of the screw to determine the most effective match to the engine.”

“Well,” Evans concluded after a moment’s thought, “if it is to be a propelling screw, then let us not use Mr. French’s engine. That one is particular to paddlewheels. But I can make you one to turn a shaft easily enough.”

“And another thing, Oliver, your boilers.” Stevens put his hands on his hips. Now, I know you build them well, and have yet to have one explode, but have you ever considered the effects if one did?”

Evans nodded. “Indeed. This is why I build them for at least ten times the greatest pressure I ever intend to use.”

“As well you should. I have seen the size of your boiler at the Fairmount pumping station, and I expect it might as well be a hogshead of gunpowder if it should ever burst. But now consider that this boat is going to go, as John Paul Jones stated, ‘in harm’s way.’ No matter how well you build your boiler, I should not care to be anywhere within this ship if a thirty-two-pound iron shot moving at six hundred feet a second passed through the boiler. Also, your boilers take, I believe, around half an hour to come to a boil? Why, the enemy would be on you and the crew would still be huffing and puffing on the fire.”

Evans grunted indignantly. “I suppose you suggest we use that leaking, hissing tube contraption you like, the one you stole from Jim Rumsey? God, man, what did he have in that thing? It must have been a hundred feet of iron pipe!”

“Two hundred,” Stevens admitted. “I should say that Nathan Read also likes tube boilers. But I think Rumsey’s only held twenty quarts of boiling water at any time, not five hundred gallons, so the effects should it rupture were far less serious. I used copper pipe in the boiler of my little boat in 1804, and it ruptured with my boys aboard. Neither was hurt. And by your own calculations, a small cylinder can stand pressure far more easily than a large one. Finally, a tube boiler will make steam nearly as fast as you can make a fire.”

“Mr. President,” Lowell asked, “did you consider inviting Congressman Read? A good Harvard man, as I recall.”

“He seems to have moved somewhere just past the edge of the earth,” Madison replied. “Maine.”

“I thought Rumsey’s boiler was brilliant,” Jefferson injected.

Evans leaned back, hand on his chin to consider this for a moment. “Well, then, for a military ship, I can see it. Iron pipe, though, not copper, which I fear would fail instantly if it ever were run dry at any point. Still, so much pipe! I use pipe, of course, but I try to keep it to a minimum. Do you know what it takes to make pipe? First, you have to set up a rolling mill and slitting machine to make a skelp, a flat iron bar as wide as the circumference of your tube, and if you are making a pipe two hundred feet long I would like to see the furnace you intend to use to heat it.”

Stevens held up three fingers. “Actually, it was three pieces of pipe, joined to make two hundred feet.”

“Ah, even so, a very long furnace,” Evans snorted. “Now you heat that skelp up to a cheery glow and run it through a rolling mill with contoured rollers to begin forming the round. And then, finally, dress the edges clean, you heat it to just shy of white hot, stick a round mandrel in it, and set the crew brushing on flux and wailing away with hammers to weld the seam. This is every bit as much effort as making, say, sixty musket barrels. Or three reeeceally long ones. This seems to me a tremendous investment of capital to build such furnaces for a very small demand. And then, how do you join the tubes?”

“Well, that is still a problem,” Stevens admitted. “Rumsey threaded the ends, and made couplings rather like long nuts, but they do tend to leak. He tried sealing them with solder. I’ve tried making my own, and leaks are a bedevilment.”

“Solder?!! What fool tries to use solder on iron pipe?” Evans shook his head in disbelief. “Braze it, man! Copper and zinc, perhaps a pinch of bismuth, and a bit of charcoal on top to keep the ... ah, oxie-gen away. And do it on fresh, clean metal, with a dab of borax to make it flow into the joint, not as some feeble patch on the surface when it is too late. And I’m guessing you fools used a straight thread, like some press screw?”

Stevens nodded affirmation.

“You will *never* get it tight.” Evans turned around, walked to a corner of the dining room, found a chair, and hunched over with his forearms across his knees, muttering to himself.

Lowell, Stevens, du Pont, and Jefferson continued work on the design for the iron steamer, aided by several books from the library. Jefferson had a rotating book stand brought in to facilitate keeping several references open at once. Many sheets of paper were sacrificed before something started to take shape.

“A mouthful of soggy splinters!” Evans blurted out. “Of course!”

All turned to eye the man, wondering if he had taken a bit too much wine. Then Jefferson laughed. “Is that what they say in Philadelphia these days, instead of ‘eureka’?”

Evans got up and hurried back to the dining table. “I’ve been sitting over there wondering how to make pipe. That came to me clearly enough. You just have to want it enough, and you set up the rolling and slitting, the forming rollers, to all go in one pass. And I expect we would dress the edges on that pass as well. Then back in the furnace, which need not be as long as I thought, and into the damnedest big monster of a trip hammer you would ever care to see, the hammer and anvil made with just the size of

grooves to make the tube. I would guess about two hundred pounds to the foot would suffice. Throw on a shot of flux, and I think I can rig a machine to do that in a simple operation. Then *wham*, you get your welded seam in a single mighty blow, or perhaps a few blows down the length. A ream could knock out the burrs, if you care enough.

“Now, figuring out the machine, that’s the smaller problem. *Paying* for it, that’s the problem. With such a machine, I expect I could make a mile of pipe a day. But to make it worthwhile, I need to *sell* a mile of pipe a day. Who needs that much pipe?”

“And then it struck me. Thank you, Colonel Stevens, for reminding me of the new water works in Philadelphia. Now, you gentlemen from Washington left for the new capital just before we installed the first water works, the one that fool Ben Latrobe built. I will say this for the man: as a steam-powered water works engineer, he is a splendid *architect*. You will never find a prettier pump house than the one he built for that plaything at Center Square. You would like it, Mr. Jefferson, as it features a dome I expect he stole from you.

“In any event, to carry the water throughout the city, they dug up the streets and put in hollowed-out logs made of pine or spruce. Some complained of the taste, but I myself found it rather pleasant, while it lasted. But soon enough they found that the plaything was too small, as I told them it would be, so in 1812 they began construction on the new pumps and reservoir at Fairmount. It has two pumping engines, one made by me, and the other a fair imitation of a Boulton and Watt, also made in Philadelphia. Either will pump over three million gallons a day into the reservoir atop the hill. Mine is cheaper to run and more reliable. But now comes the problem.

“You see, now there is more pressure with the new reservoir, but even so, the old log pipes can only handle a million gallons a day. Not enough. And the old wooden pipes are running so hard, once in a while you take a draught of water, and wind up with a mouthful of soggy splinters!”

“The Watering Committee is seeking a replacement. I expect they will use cast iron for the main pipes, but every house will need smaller ones, and the present options are wood and lead. Wood has that soggy splinter problem. Lead, I expect, they will one day find will rot our brains. But if I could produce iron pipe at a good price, there is a market ready for it. New York, too! And then every city in the nation!”

Mr. Lowell smiled. “But Oliver, won’t you then get a mouthful of rusty water?”

Evans shrugged. “Rust is common enough in well water.”

Du Pont cocked his head to one side for a minute. “There is a piece of armor in the Royal Armories Museum in England, I think from India. It is coated with zinc, which seems to protect it from rust. I wonder, could there be a connection with the use of zinc in Alessandro Volta’s electric piles? The experiment should be straightforward.”



The following morning the meeting resumed over breakfast. Thomas Jefferson brought a copy of the new book Evans had given him. As the plates were cleared, he brought it out.

“My dear guests, last night, before bed, I read the most amusing thing I have seen in a very long time. My problem is, I cannot discern if it is prophesy, or fantasy. The title is *Patent Right Oppression Exposed, or Knavery Detected*, and it is by a hitherto unknown author, one Patrick N. I. Elisha, Esquire, a man whose delightful sense of satire encourages me to read more.” Jefferson directed his gaze to Evans, who was positively beaming.

Jefferson opened the book to a marker, cleared his throat, and began to read. “The time will come when people will travel in stages moved by steam-engines from one city to another, almost as fast as birds can fly, fifteen or twenty miles per hour ... A carriage will start from Washington in the morning, the passengers will breakfast at Baltimore, dine at Philadelphia, and sup in New York the same day ... Engines will drive boats ten or twelve miles an hour, and there will be hundreds of steamers running on the Mississippi.”

There were titters of laughter from several at the table, but not all.

Jefferson continued. “Two sets of railways will be laid so nearly level as not in any place to deviate more than two degrees from a horizontal line, made of wood or iron, on smooth paths of broken stone or gravel, with a rail to guide the carriages so that they may pass each other in different directions and travel by night as well as by day; and the passengers will sleep in these stages as comfortably as they do now in steam stage-boats.”

Jefferson paused to study each of his guests to judge their response, and noticed that Evans was doing the same. The President and Mr. Monroe were still suppressing laughter. Lowell and du Pont seemed attentive. Stevens looked dead serious.

“And it shall come to pass, that the memory of those sordid and wicked wretches who opposed such improvements shall be execrated, by every good man, as they ought to be now.”

Now even Madison and Monroe seemed more serious. Jefferson directed his attention to Stevens. “Colonel, would you care to express your views? Prophecy, or fantasy? What say you, sir?”

“Mr. Jefferson, fellow guests, just this February, and after years of trying against total indifference,” he directed a sidewise glance to the President, “I obtained a charter to build and operate a railroad in New Jersey.” He looked directly at Evans. “And I should say that Mr. Patrick Elisha is no prophet. I believe the speed he anticipates merely states what is *easily* foreseen, and that it will be possible, in time, reach treble that, and more. A mile a minute is not beyond the realm of possibility, in due course. I have ventured that there is no reason why a hundred miles an hour might not be achieved.”

Evans nodded agreeably. Several audible gasps were heard from the others.

“Mr. Evans,” Lowell asked after a sip of coffee, “there is a curious detail in the passage Mr. Jefferson just read. Do you think you can enlighten us as to why this Mr. Elisha would be so very specific as to the rails being even within two degrees of horizontal? This prediction seems out of place for some crazed visionary, and more like a statement by a man who has actually attempted the feat.”

Evans choked on his own coffee, and dabbed his mouth with a napkin. “Oh, I should think Mr. Elisha should be quite upset to be insulted as a ‘visionary.’ I have been

accused of that, myself, by none other than Benjamin Latrobe. Perhaps it is he whom Mr. Elisha so soundly criticizes in that last passage. For, you see, Mr. Latrobe prepared a report back in 1803, concluding that it was impossible to use a steam engine to propel any useful boat or carriage, as the engine, boiler, cistern, fuel, and other necessities would be so ponderous as to preclude the carrying of passengers or freight. Alas, enough people read his poppycock that it discouraged investors for some years. What else can be expected of a fellow who knows only the engines of the past, the large ones by Watt, the huge and ancient Newcomens, fit only to sit in one place and pump water, or who thinks boilers should be made of *wood*? But, by the time the American Philosophical Society published that report, in their 1809 Transactions, our own Colonel Stevens and his friend Colonel Fulton had already built and had operating perfectly good and practical steam boats. Furthermore, the engine on Colonel Stevens' Phoenix was built by Latrobe's partner, Nicholas Roosevelt, who then also built the engine for the *New Orleans*, and piloted it down some two thousand miles of the Mississippi. And who was among the few passengers on that first voyage? Why his dear wife, Lydia, the daughter of Benjamin Latrobe! Of course, since then, steamers have gotten even better. So I expect Mr. Elisha, knowing these facts, rightly supposed Mr. Latrobe to be a man blind to the future, able to see only the past, and prone to accuse as delusional anyone able to see what is clearly possible."

"Ah," Lowell replied. "Spoken from the heart, clearly. But you left unanswered the matter of the two degrees."

"My apologies for the sermon." Evans thought for a second. "From my own experience, Charles Peale and I built, about a decade ago, a small working steam model of a machine we called an 'agricultural traction engine.' This machine was not intended as a carriage, but rather to pull such implements as ploughs."

Jefferson's eyebrows shot up.

Evans continued, "However, if one simply changed the wheels from those meant for soil to wheels meant for rails, I should think it would easily pull one or more stages or wagons, also on rails. Where is that model now? I vaguely recall leaving it at the shop of Coleman Sellers for his boys play with."

"Ah-ha!" du Pont interrupted, "Yes, I believe I have seen it there. You mean to tell me that little thing actually runs?"

Evans smiled, "Indeed it did, and I hope it still does, if the boys have not broken it! But to answer Mr. Lowell's question, while the model did run very nicely, it had the rather amusing habit of tipping over on uneven ground. I'm sure the defect could be easily remedied, but that year I had so many irons in the fire I simply put that one aside. Perhaps Colonel Stevens should like to see it on his way home."

"Absolutely! I was about to attempt to build something very much like it myself, and, knowing your talents, I expect a partnership with you could save me several years. I have been turned down by the Erie Canal Commissioners to fund a test. Perhaps with your model, we could undertake a demonstration of our own, at little expense," Colonel Stevens said with a nod, then turned to Jefferson. "Sir, may I read that passage?" Jefferson handed him the book.

Lowell leaned back in his chair. "There is much talk up in my part of the country of building canals. This we have known how to do for ... how long would you say, Mr. Jefferson?"

Thomas Jefferson's mind was far in the future, but he snapped back upon hearing the question. "Canals ... thousands of years, certainly. Diderot shows locks that have been in use for hundreds of years, back to the Middle Ages. Yes, Pierre du Pont and I have discussed the advantages of building numerous canals here, to promote trade. General Washington was quite enthusiastic about them. Some of you may know that James Rumsey supervised the Potomac Canal Company, all the while tinkering with his boiler and engine."

"There are, so far, no rail roads, while canals are certain. But it is certain that they are slow," Lowell continued. "A few years ago, I would have considered this rail road idea madness. Yet I am now convinced that they *can* be built, and I am wondering if they might not be far easier than canals. Three things have changed my mind. First, my own experience in building a complex mill makes me more inclined to listen to inventors, particularly those who can build engines that pump three million gallons of water a day. Second, if Mr. French can build a steam boat that can run Fulton's off the Mississippi, then I think steam on rails cannot be so far behind. Finally, I know from my time there that the British have a handful of men doing this very thing, inspired by a machine built by a fellow named Trevithick. I would dearly love to see us beat old John Bull at this endeavor, and I have no doubt that the men to do it are at this table."

Stevens closed the book and put it down. "This Mr. Elisha should have had a long talk with Chancellor Livingston. The Chancellor was quite interested in building the canal from the Hudson River to Lake Erie, which is gaining more support by the day. Back just before the war started, he and I corresponded on this matter at some length. I found myself unable to win his support for building a railroad instead. Among his worries was the problem of collisions, when one engine and its carriages encountered another coming the other way, or simply stopped on the tracks. I notice that Mr. Elisha has anticipated this problem in suggesting separate tracks for each direction, and I concur. I am certain that much thought should be addressed to this concern. And yet, the very same issues exist for canals, except that collisions between barges pulled by mules are more comical than disastrous. Most canals are just wide enough for one barge, with one tow path, except for a few wide ponds where barges wait their turn and may pass, and so one must have strict rules as to who may enter the narrow sections. Surely, any railroad can do what canals have long done."

Irénée du Pont sat with his chin braced on a hand. "How does one build a canal past a continental divide?"

"An astute question, sir." Colonel Stevens leaned forward. "The Erie canal proposes to do this. The plans I have seen call for a total of fifty locks, most used to climb to the lowest passage available. That passage is lower than the surrounding mountains, and so can be fed by streams from even higher up. But it is important to remember that these are only streams, not rivers, and the locks can operate only as often as the streams provide water to fill them. This is one of the ways in which I see railroads as having a tremendous advantage."

Evans nodded his agreement. "My son and I built an engine works in Pittsburgh back in 1810, and I have made that arduous trip by stage several times. Apart from the rigors of our recent journey, that country is also full of men of dubious reputation, inclined to covet your purse. I count the stage operators among them. I have heard some talk by those hoping to build a canal parallel to the Potomac, from Washington to

Cumberland, and then make a similar passage through the mountains to the Ohio River. It is inconceivable to me that they could complete such a task before railroads pass them by. We no longer live in the Middle Ages, and should not limit ourselves to their modes of commerce. I, for one, would never attempt the Pittsburgh trip by a mule-towed barge even if the canal were present. Life is too short. But I would gladly make the trip in a day by railroad. Perhaps canals will suffice for cotton bales and coal. But thanks to our host, Chancellor Livingston, and Irénée's father, our nation has recently grown to reach the Pacific Ocean. Lewis and Clark's map shows us a maze of mountains, so tall and ragged as to make those around us appear as no more than bumps, which bar the way of any sensible canal to the Pacific. To ignore railroads for such vast expanses is sheer folly."

"Canals may suffice for cotton or coal," Stevens agreed, "but flour or other foodstuffs are apt to spoil on any route over a hundred miles or so."

"I am content with either approach," du Pont confessed. "When I discussed setting up my powder mill with my father, *gunpowder* was not the most important product on his mind. He was aware of General Washington's difficult task of blasting a canal through solid rock at the Great Falls of the Potomac. This practice was, to the best of my knowledge, unknown in Europe then, and it excited him, as he believes strongly that the United States will need many canals, many of which must pass through rocky obstacles. Thus, from the start, it has been my goal to also provide *blasting* powder. But as I am certain rail roads will face the same obstacles, I shall help to remove those obstacles just as happily. My father knows naught of rail roads, but he knows very well the value of transportation of goods to market, and were he here, I believe he would be intrigued by this new possibility. I should dearly love to provide the powder for *both*."

James Monroe had been following the conversations with one ear, but staring at the table as if deep in thought. Finally, he spoke. "Canals will do us little good in defending the country. Let us say we run canals not only east to west, but north to south. We have had discussions in Washington about using these to move troops, cannon, and supplies. This has never seemed satisfactory. Not only do barges pulled by mules travel slower than soldiers march, but the time they spend in the locks, and the limitation of one barge passing a lock at a time, weigh heavily on any general considering moving his troops to counter an amphibious assault. Furthermore, any route from north to south must encounter many rivers and runs. As I understand canal craft, each must be crossed with a large aqueduct, a robust stone bridge carrying the whole canal and towpath, which could easily be destroyed by the enemy and would be months or years in repair. To return to our assignment, if rail roads shall indeed work as well as Colonel Stevens and Mr. Evans clearly expect, then they will be just as clearly superior for moving men and materiel. I should be delighted with even *ten* miles an hour."

Monroe unconsciously rubbed the old injury he received to his shoulder in the Revolution. "I weep when I think of the number of men who died by the road when Washington and Rochambeau moved their armies down to Virginia to lay siege to Cornwallis. Then they scoured the country for enough shovels to build the earth works. They were victorious at Yorktown because they made the sacrifice to be where they were needed. That single victory won the Revolution. We owe it to our children to be sure we give our armies mobility and supplies by the fastest means available. To have moved the army down from New York in a day"

President Madison waited for Monroe to finish. “Colonel Stevens approached me about rail roads before the war. I confess I was as dismissive of the idea as most. But what Mr. Monroe says moves me greatly. We could have saved Washington by more timely movement of troops. I admit I am not yet sufficiently convinced of their practicality to declare that we must abandon canals and build rail roads instead. But looking back, I believe Colonel Stevens suggested a rather modest cost for a demonstration, some tens of thousands of dollars, compared to several millions for any long canal. I believe this demonstration is an entirely reasonable expense for the government to undertake, either for national defense, or for the encouragement of commerce.”

“Trenton to New Brunswick, in my home state,” Stevens stated bluntly, “if I may choose the location.”

“I trust I shall soon receive a new proposal, since you have obviously given this much thought.” The President turned to Oliver Evans. “Mr. Evans, I had a stray thought just now as Mr. Monroe was speaking so eloquently and wisely. Your agricultural traction engine ... please give some thought and let me know if you think it can be adapted to this. Would it be possible to build one covered with the armor we discussed for a steam torpedo boat yesterday, and could you mount cannon on it? It would be better, too, if it not tip over.”

Evans smiled broadly and reached in his pocket for a pencil and a scrap of paper.



President Madison and James Monroe waited for Thomas Jefferson on the Southwest Portico after breakfast. The spring morning was cool, the air scented with a mix of flowers and plowed fields, and the Virginia hills were bright green with budding leaves, accented with redbud and dogwood blossoms. Closer in, Jefferson’s own impeccably-tended gardens were magnificent. Wormley and three other servants tended a bed forty yards away, just beyond the fish pond.

“Pardon my delay,” Jefferson apologized as he exited the mansion. “Monsieur du Pont had an odd request. He wondered if I had any zinc and oil of vitriol, and then asked if he could borrow the blacksmith forge down on Mulberry Row for an experiment in practical chemistry. I directed him to a modest stock of chemicals I have stored in the cellar.” Jefferson pointed toward the slave quarters and workshops. “There he goes now, with Evans in tow. I suspect we shall see neither for the rest of the day.”

“Quite alright, Tom,” the President replied. “Spring is always such a pleasure, but compared to the smell of charred timbers in Washington, this is doubly delightful. But we can enjoy it while we talk business. What is your impression of the meeting so far?”

“I believe we may have sparked something quite remarkable here,” Jefferson replied, “although I expect everything we have discussed so far was inevitable, in twenty years or so. It has given me many things to consider for my University, though. Evans

was just looking at my drawings for it. He told me the one thing he admires about Benjamin Latrobe, and architects generally, is that we draw so clearly. He urged me to teach mechanical drawing there.”

“So will you?” Monroe asked.

Jefferson nodded. “I think there may be a greater need, though, for schools to train tradesmen in the skill. He tells me that half of his workers cannot work to a scaled drawing. He must draw everything at full scale on a large chalk board for them to understand it.” Jefferson stared down Mulberry Row, lost in thought.

“Tom, is something bothering you?” Madison asked.

“Eh? Oh. Sorry. I was just thinking of Bannaker’s letter.”

“Who?”

Jefferson shook his head. “You two probably would not know him. He was on the surveying team for the city of Washington. A negro, born free in Maryland. Among his jobs was making the astronomical observations to fix the starting corner of the city.”

“A negro?” Madison exchanged glances with Monroe. Both looked bewildered.

Jefferson nodded slowly. “He sent me an almanac he had prepared. Tables of ephemeris for the calculation of solar eclipses. I sent him back a brief letter, thanking him for the proof of the intelligence of men of his color. Even then, I had trouble believing it, and suspected he had help with it. This has troubled me ever since. I have long suspected that negroes have difficulty planning, and yet I also admitted that the problem might be caused by their owners, myself included, doing all in our power to discourage them from anything but following orders.

“So I have been doing an experiment. John Hemmings is my best carpenter and joiner. He can take one glance at my scaled drawings and make a compound miter cut for a hip roof gable better than any white man I know.”

Monroe raised an eyebrow. “Hemmings ... he is more white than negro, though?”

Jefferson shrugged. “Yes, but I doubt it matters. I did not limit my experiments to the Hemmings family, but they make good examples. You both know how smart Sally is. Smart enough that she left for Poplar Forest with the rest of my family when she learned visitors from Washington were coming. You also know Burwell is as well-spoken as any man, and I’ve found he can run the house very well when allowed to. I let Edy Fossett run the kitchen. The only time I dare enter is to wind the clock. What I have learned is that the owners of slaves are blind to any evidence they choose not to see. When I wrote the Declaration, I stated that all men are created equal. I did not write that lightly, but I will confess that I lingered for a while upon those words, and asked myself if I really meant it. At the time, I was considering the rights of Man, and not each man’s innate talents, but those words have haunted me ever since. I am now convinced that negroes are as smart as any race, if given the chance.” Jefferson fell silent again.

When he could stand the silence no longer, Madison gave his old friend a nudge. “What bothers you, Tom? This is more than just the old moral problem of slaves.”

“I see trouble ahead, James. You remember when we corresponded while I was in France? The poor woman I met on the road? Starving, working hand to mouth for a few sous. In my pity, I gave her three days wages for acting as my guide for an hour. I saw trouble then, for France, and I hope it has now finally run its course. Twenty-five years of turmoil, more than ten thousand beheaded: they guillotined Lavoisier, and almost did the same to Pierre du Pont, Rochambeau, and Thomas Paine. How much was lost?”

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“Surely you do not think that will happen here?” Monroe spread his arms in joy. “I have never seen the nation so unified. The Federalists have collapsed entirely.”

Jefferson stared into the distance. “The Federalists are not gone. To buy the Louisiana Territory, I ignored the Constitution and put us deeply in debt, two things I swore I would never do. I sent Adams’ ships to fight pirates in the Mediterranean. Then I changed my mind about manufacturing. I fear I have become a proper Federalist, and you two with me. But at least it has brought unity. And so in our unity we lull ourselves into contentment, just at the moment when we could avert our future suffering. Consider the mechanical marvels of our age, and what they will do.”

“Steam ships? Rail roads?” Monroe shook his head. “I see prosperity, providing they work.”

“You missed two. Eli Whitney’s cotton engine. It has made cotton profitable. New plantations are springing up around New Orleans, and they are hungry for slaves to grow cotton. Cotton which we formerly sold to the British, but now can sell to a mill in Massachusetts. I suspect it will be the first of many. And we shall have the steam ships and rail roads to carry it cheaply to market. All very prosperous, unless you are someone’s property, in which case it is a demand for your labor and the labor of your children. I had hoped we would soon find some way to let this peculiar institution fade slowly into the twilight, but I fear our recent inventions have simply stoked the fires to keep it burning. Our progress these last two days may only be making it worse.”

“Perhaps, Tom,” Madison acknowledged, “but as I have heard you say, that is a problem for the next generation. Our job today is to provide for our future security.”

“You miss my point, sir. How many states will the Louisiana Territory produce? We have eighteen now, and more are certain. I have done the calculations for the future growth of our population, and expansion into the new territories. The increase we can expect in just two generations will throw your eyes wide open.”

“Tom, please, not another lecture from the Tables of Mortality, on such a beautiful spring day,” the President pleaded. “James and I can calculate how fast our numbers will double, even if it seems hard to believe.”

“Incredible as the numbers are, they are a mathematical certainty,” Jefferson continued. “We shall be flooded with new states. Any new ones down around New Orleans will not let slavery go easily. Yet the northern states are drifting away from it. The Quakers are becoming quite vocal in their objections.

“You remember how hard we worked to find compromises for the Continental Congress, and how hard you and the others worked at the Constitutional Convention. I don’t need to remind you how delicate the balance was for compromise between the states with few slaves and the states with many. Recall the crass arguments as to whether a slave is a person, two thirds of a person, or not a person at all? With new states, the compromise will fall apart, and the balance will tumble. The time to find a solution is *now*, while we have this wonderful unity, and not later when we shall have greater divisions than we have ever seen.”

“So, what do you propose we do, Tom?” Madison asked. “Draw some line across the western territories and say that every state north of it is free, and south of it is slave?”

“Heavens, no!” Jefferson cried with alarm. “That would be the death of the Union! It might be an easy political expedient for a few years, but in time it would inevitably slice us in two. A geographical line, coinciding with a marked moral and

political principle, once conceived and held up to the angry passions of men, will never be obliterated, and every new irritation will mark it deeper and deeper.”

“What else, then?” Monroe wondered. “Pass a Federal law to free the slaves? Perhaps say that no person born a slave after ten years from now will remain a slave after reaching the age of twenty?”

Jefferson shook his head. “You know as well as I, that would require an amendment to the Constitution, and it would never pass the required two thirds in the House and Senate, much less ratification by three quarters of the states, not when we depend on them so completely. No, not so long as there is profit to be made by owning slaves. Even the revolution in Haiti, with cruelty and barbarism on both sides that challenges credulity, has not changed the equation. The owners only crack the whip harder, and pass laws against ever teaching slaves to read, lest they read about slave revolts. This is the terrible trap, the wolf we hold by the ear, and the three of us understand it better than most because we are ensnared by it. No, the problem we must address, and we may have just the people here to do it, is to find a way to run a plantation that is *more profitable than using slaves*. You two are concerned with a military threat. My fear is that, not now, not in ten years, but maybe in thirty or fifty, *slavery* is our military threat. I have seen a civil war unfold, watched a country tear itself apart.”

“This is not France, Tom.” Madison objected. “We have no King. You cannot think it will come to a civil war! Slavery is a matter for each state, not a national one.”

“You choose not to believe it. *Representation* is a national issue, and *representation will be the cause*,” Jefferson replied. “We just concluded a war fought over a matter of insult and honor, interference with trade, and the impressment of a few thousand sailors. How easily we slipped in to it, with the belief that we would win! Can you not see a war over insult and honor, loss of property and prosperity, and the enslavement of *millions* of people? Would you be willing to wager those calling for war would expect a quick and cheap victory, the way it started in France? I think they will have a far worse fight than they can ever imagine.

“If nothing else, consider new states, dependent on cotton, with plantations much larger than ours, run by a few white men, but worked by several thousand slaves. What is to stop a slave revolt if it ever started? Surely, one day slavery must end, and we must find an alternative, which I expect will be farming machinery. Better we should seek another way, and do it *now*.”

“I have less than two years left in my administration, Tom,” the President confided. “I will follow the precedent of Washington and yourself and serve only two terms. I think this discussion should be with our next President.”

Jefferson smiled, and turned to look at Monroe. “Any one I know?”

Madison nodded. “Breathe not a word. Nothing is official as yet, but he should win easily. He asked for some time off to place his affairs in order, as he will not be his own man for eight years, with a little luck, and God willing.”



Oliver Evans and Irénée du Pont arrived for supper with a length of rough grey pipe, looking entirely more pleased with themselves than the appearance of the product would seem to justify. Evans laid it carefully in the center of the table.

Thomas Jefferson bent over to inspect it, and then lifted it to judge the heft. “A pipe. At first glance, I thought it might be cast from zinc, but I had too little in my meager supplies to account for it. You have found a way to cover iron with zinc?”

Evans nodded eagerly. “Yes, it was Ernie’s idea.”

Irénée du Pont put his hand on his forehead in mock angst.

“I showed your smith how to make the pipe. Ernie carved out a few bricks to make a long crucible for the zinc, and cleaned the pipe with the vitriol. You must work quickly while the zinc is hot, for it sublimates into the air and makes a white powder.”

Jefferson looked up the bore of the pipe. “You missed a spot.”

“You had too little zinc,” Irénée objected. “But it serves as a control to test my hypothesis. Ollie and I shall begin a test tonight, if we may have the use of a watering trough, and will soon see if the exposed iron sections resist rusting. If it works as I expect, the zinc and iron form a Cell of Galvani.”

Jefferson nodded eagerly. “Yes, yes! Iron instead of copper or silver! As I recall, the two metals are immersed in a caustic solution, and a metal wire is applied between the ends. There would seem to be a mild electricity, too weak to move an electroscope’s leaf, but sufficient to make a frog’s leg twitch. The zinc is the more active metal, and is consumed.”

“Yes, and more.” Irénée withdrew what appeared to be a stack of coins wrapped in oiled cloth from his jacket pocket. “Last night I mentioned Alessandro Volta’s electric pile. These have become all the rage in France, the subject of much study. One stacks the cells of Galvani together, to increase the potency. This is like pressure. The simplest way to make these is to make up disks of cloth or paper saturated with a caustic paste, and place them between disks of the metals. Here I am using copper pennies and some of the zinc left over after we made the pipe. It is still very mild compared to the pressures of Dr. Franklin’s sort, but most investigators are certain the two are the same in essence. I hope you do not mind, sir, that I used some of the copper wire I found with your chemicals.”

“You are most welcome to it,” Jefferson said with a nod. “I had it drawn by a coppersmith in Williamsburg back in the days of Dr. Franklin, so that I might dabble with electricity. I have been meaning to find the time to explore this new sort.”

Irénée carefully unwrapped and unwound the two copper wires, one soldered to either end of the stack of disks, then touched them to his tongue, and reacted with a jerk. Then he touched the wires together for an instant. In the candlelit room, a faint blue spark was visible. “Yes, still fresh. Would each of you gentlemen care to try? There will be a shock, similar to those I am told Dr. Franklin used to amuse his guests with, but harmless enough.”

Jefferson tried it first, and noted that the shock lasted as long as the wires touched his tongue, unlike the quick static shocks Franklin’s experiments produced. One by one the guests confirmed the effect.

James Monroe bent over to study the pile. “How long can the wires be?”

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Du Pont shrugged. “As far as I know, nobody has yet tried a distance at which the effect does not carry. I believe there was a test done in England, a distance of over two miles, using Dr. Franklin’s sort of electricity. It is fast, too. The test proved it is faster than sound, either instantaneous or so close to it that the difference could not be discerned.”

Monroe laughed. “Forgive me, but I just had the most absurd idea. Cruel, really. Imagine a rail road, or a canal, with a long stretch of single track or channel. One must govern its use. So imagine a signal system. One puts a pile such as this, and if I recall Dr. Franklin’s demonstrations, a moveable contact to interrupt the wire, at one end of the canal, and some poor soul at the other end with the two wires in his mouth, a pencil in his hand, and a piece of paper in front of him. One taps in a code, such as is used with a shutter signal, at one end, and the poor man on the receiving end writes down the code on the other, no doubt reflecting all the while that it is better to give than to receive.”

Everyone laughed except President Madison, who stooped to study the device, silent for a moment. At last he straightened up. “I have no idea if it would work, or how one would contrive to make the wires, but picture the wires able to reach across an ocean. On one end, diplomats come to an agreement. On the other end, you avoid a war, or a bloody battle after the war has ended.”

The room was silent for a minute, as the men exchanged glances.

Jefferson studied the device, his arms crossed, then left the room. He returned a few moments later with a small wooden box containing a magnetic compass. “I have always wanted to try this.” He held the compass up against a wire from the pile, and motioned for du Pont to come over. “I have long wondered if an electric flow is magnetic. Dr. Franklin’s discharges are too quick for this test. I expect the compass needle to point toward the wire. Sir, if you would be so kind as to touch the ends together?”

At the first touch of the wires, the compass needle swung slightly, but not toward the wire. It seemed, instead, to be attempting to *avoid* the wire.

Jefferson gasped with astonishment, then changed the orientation of the compass and motioned for du Pont to make contact again. After several attempts he stood up and declared. “The magnetism is clearly there, but seems to go *around* the wire instead of into it. How peculiar!”

The men experimented for half an hour, until interrupted by a black woman in a stained apron at the northeast door of the dining room, hands on her hips, and clearly out of patience. “Mastah Jefferson, you all gonna eat, or am I gonna send yo *boeuf à la mode* down to Mulberry Row? I do de-cla-ah! Grown men and their toys!”



Thomas Jefferson’s “cabinet” was not a storage compartment, but an office, a room two corners short of being an octagon, on the south corner of the mansion. In one window was a cage, and in the cage a mockingbird watched the proceedings with great

interest. Over the years the cabinet had seen many interesting projects, and several mockingbirds, come and go, but in the spring of 1815, few topics held Jefferson's attention as much as his "Academical Village," better known as the University of Virginia.

"Then on either side of the Rotunda, a row of academic halls."

"No chapel?"

Jefferson shook his head. "This choice has cost me support, but I am steadfast in my belief that freedom of thought will be better served without an affiliation with any particular denomination. I have observed that if a clergyman is given a seat on the Board of Visitors, he will always call into question the godliness of any area of study not offered at his seminary. I also think it best if this university does not have set requirements for conferring degrees. I have spent my life studying what I choose, with the exception of my time at William and Mary. My greatest joy there was the study of science, in which I was blessed by a close friendship with Dr. William Small, and was directed as we saw fit, not according to a set *curriculum*. My greatest curse while there was their expectation that I ought to become a priest."

Colonel Stevens turned his hands up in supplication. "So, you expect students to come for as little or as long as they like, study what they will, then depart?"

Jefferson looked up from the plans, and fixed his eyes on Oliver Evans. "What say you, wheelwright? Would such a plan work for you?"

Evans put his hand on his chin, and turned his eyes to the ceiling for a moment. "Let me see. No Greek. No Latin. I might study a little German if it helps me understand my workmen. Perhaps French, as there did seem to be some worthwhile books and pamphlets from there before the ruckus, and I hope there shall now be many more. Courses in natural philosophy and mathematics. Newton's 'Fluxional Calculus.' Knowledgeable men presenting lectures on every new topic of natural philosophy one can imagine. Unlimited access to a great library. This sounds very much like Philadelphia, to me!

"But I am not a young man. I am an old man with too many ideas to ever follow them all up, and this week I seem to have acquired three more: an armored traction engine, a rail traction engine, and a pipe forge. But what I would give for a hundred smart young men, educated as I just described, and also taught just what practical ways one may manufacture with iron, copper, bronze, brass, leather, and wood! Young men who can calculate the power of a steam engine." Evans looked down at the drawings and put his arms across his chest as if he wished to embrace them. "Young men who can *draw* this clearly."

"No Greek or Latin?" James Madison asked dismissively. "Will you then ignore the wisdom that has been the foundation of great universities for a thousand years?"

"Hah! Well, then, show me an ancient Greek text on steam-powered traction engines and I shall gladly learn it! And perhaps they did know these things, for they certainly could cut and move some mighty stones. The 'Gyptians, too, and then I shall learn their hieroglyphs. But if you mean should I study, in Greek, how to make a ramp, a lever, a pulley, a wheel, or a screw, I knew all these things by the time I was fourteen, and did not need Greek or Latin to do so.

“So, for setting up an engine works, it matters little to me if a young man can read Greek or Latin. Far better that he knows how to cut iron, to gauge the roughness of a shaft in millionths of an inch ...”

“Wait,” Jefferson interrupted. “You must mean thousandths. Are you using millionth in the sense of the Latin use of *mille*, as in the French millimeter?”

“No, no, and there you are letting your Latin get the better of you!” Evans shook his head emphatically. “I can tell the difference between a thousand dollars and a million dollars. One dollar is a thousandth of a thousand dollars and a millionth of a million dollars. And when I say you must know how to measure the roughness of a cylinder or a shaft to a few millionths of an inch, that is exactly what I mean, otherwise it will tear any packing you use to shreds. And if I say you must be able to measure the diameter of a cylinder or a piston or a shaft to within a few thousandths of an inch, that is exactly what I mean.”

“How can you ...” Stevens started to ask.

“One of my men has become adept at modifying watches for the purpose,” Evans continued. “And I have perhaps already said too much, and can only beg that you honor the poor man’s inventiveness, as the device as yet has no patent protection.”

James Monroe picked up a hair that had fallen on one of the drawings. “I cannot even imagine a device which could measure a hair. To even measure a *thousandth* of an inch!”

“Tut, tut,” Evans objected. “Makers of astronomical instruments, including James Watt, have known these tricks for a century and more. A simple caliper with a graduated scale can, with care, be scribed in hundredths of an inch. A simple vernier scale allows it to be read to a thousandth. And a screw with a pitch of a tenth of an inch, with a knob graduated in a hundred divisions, can be read to a tenth of a thousandth using a vernier, or just a good eye. We use such a screw on the ends of rods of various lengths to measure bores quite precisely. My men are adept at contriving measuring equipment. Were there more engine works, I’m sure we could sell instruments such as these profitably, although if you tour any good mechanician shop, you shall see all manner of little gimcrack gadgets they use to gauge and measure.”

“I have seen such tools,” Irénée du Pont agreed. “We have a machinist shop in Brandywine. And I have seen Mr. Sellers use something like them in Philadelphia.”

Mr. Lowell nodded. “Our machine men at the Waltham mill each have their own special measuring tools.”

“I was about to say this”, Evans continued. “No university I have ever heard of teaches what the men in my Mars Iron Works, or the men in my son’s new engine works in Pittsburgh, know how to do. Oh, yes, these men sometimes cast iron and work it the age old way Mr. Diderot shows in his Encyclopedia. But they also can cut and shape it with the skill to make a cabinetmaker jealous, and it seems that every month they invent some new way to do it even better. These men are not common blacksmiths, working with hammers, chisels, and files. Now, they *have* mastered the smith’s arts, particularly the hardening of iron and steel, so that they may fashion little bits of it into cutters. But then they mount those sharp little bits into machines, where they *cut* iron with the utmost delicacy. You should see them turn an iron bar on a lathe, cutting threads. The first time you see the chip curl off the work, you can’t take your eyes off it, so magical is the effect. They can turn, grind, and polish a shaft to near perfection, the surface as smooth as a

mirror. They can bore a cylinder with almost no taper at all. They make cogs as fine as a watch but as sturdy as an anvil. They can form a cam to an exact profile to make a valve cock open and shut just so in a piston stroke. And the parts all slide so nicely ... ah, think of a lad and a lass.”

“Mr. Evans,” the President asked, “are you suggesting that Mr. Jefferson’s university should be a school for tradesmen?”

“With all respect, Mr. President, and Mr. Jefferson, I am suggesting that men who design engines, engineers, must know what tradesmen can do and what metals they may do it with. Otherwise,” Evans, with a sly grin, turned to look at Stevens, “they might try to make a high pressure steam engine with a piston of cork, because they have experience with Champagne. An engineer need not *possess* these skills, but it is quite necessary that he know *of* them. He will not learn these from ancient texts. The oldest useful steam engine, and just barely useful, is the Newcomen, and that is only a century old. It was a Newcomen installed at the Schuler Copper Mine that I first heard of as a boy, that inspired my fascination with steam.”

Jefferson turned to Madison and Monroe. “The engine Josiah Hornblower brought over from England. You met him at the Continental Congress.”

Evans nodded enthusiastically. “The very one, and bless Josiah’s old heart, for as sloppy and wasteful as that contraption was, it captured my imagination. And as soon as I heard how it worked, I knew it should work on the *pressure* of strong steam, and not on its condensation. The Newcomen, now about a hundred years old, and the Watt, about fifty, are so behind the times that they might as well have been made by the Romans. I do not say that they are not worth study, just that if we only look back to the way things used to be made, we’ll end up like Mr. Latrobe, unable to imagine any better. Please, Mr. Jefferson, if we are to have iron clad steam torpedo boats, railroads running a mile a minute, and signals across the oceans, teach these things at your university. Turn trade arts into industrial *science*.”

“The man is making sense,” Stevens admitted. “Mr. Jefferson, when you were Secretary of State, and reviewing patents, you must have known all of the American steam inventors.”

Jefferson nodded. “John Fitch, James Rumsey, Nathan Read, Oliver Evans, and yourself. Alas, poor Mr. Evans submitted his steam engine patent application too late for my consideration, just as I managed to delegate that task to others, but I already knew him from his mill patent. Colonel Fulton became enamored with steam just a little later, but I knew his endeavors well. Chancellor Livingston was my ambassador to France, your partner on a steam endeavor.”

“And Josiah Hornblower, while not a steam inventor, taught Nicholas Roosevelt to build engines.” Stevens held up his hands showing nine fingers. “I can count them on two hands. Of those men, five are now dead, and we are down to one hand.” Stevens held up four fingers. “Fortunately, thanks to Mr. Evans’ fine book on steam engines ...”

“*Hah, you finally admit it!*” Evans injected.

Stevens gritted his teeth only a second, and continued, “... we know of at least two more steam men, to which we can add his son George and my sons. Oh, and Aaron Ogden now fancies himself a steam boat man, although my sons and I have been teaching him a lesson or two.”

The President raised an eyebrow at the mention of Ogden. “Governor Ogden? Ah, so perhaps that is why he turned me down when I appointed him as a major general?”

“The very one, Mr. President. Curious, isn’t it, that the community is so small, and so many are also leaders, men of politics. So that gives us ten, a paltry number if we are to make these ideas a reality. Imagine if Mr. Evans and I were set upon by highwaymen on the way home. Why, you’d lose the most experienced two, and a fifth of the men who now know enough about steam to do anything useful. There is too much work to be done by so few.”

Mr. Lowell raised a finger. “If I may offer an observation, shortage of labor generally, and skilled labor especially, is an American problem.” Lowell extended his hand toward the windows of the office, and Mulberry Row beyond. “Hence, slavery. When I was in England, stealing the plans for their looms, I noticed they treat machinery very differently than we do here. The English have plenty of skilled workmen, perhaps even too many. When trade slowed due to the embargos, they had difficulty keeping them employed. At least with slaves, when work is slow they are still fed. The English will simply dismiss their workmen and let them starve. The situation was already becoming dangerous when I left, and I strongly suspect it figured in their repeal of the Orders of Council. In any event, it is my opinion that the English see machinery merely as a tool to allow the workman to do a better job.”

Jefferson nodded gravely. “I noted the British labor unrest before the war. I ... let’s just say I saw it as their vulnerability. As much criticism as I took for our own embargo, it hurt the British more. Had we realized how much, and waited just a few weeks longer before declaring war, we would have known the Orders of Council had been rescinded.”

“In America, we lack enough workmen,” Lowell continued. “We see machinery as a way to allow our limited work force to do more work. You may think this difference in approach is a quibble, but as a businessman I think of this as a Greek mechanic would see a lever, to multiply the work one man may do.”

Evans nodded enthusiastically. “Exactly the purpose of my automatic flour mill. Why have a dozen men shoveling, raking, scooping, bagging, dripping sweat and tracking dirt on the grain and flour when a machine can let one man run it, and produce a cleaner product?”

“Indeed, Mr. Evans, and our new looms as well, except that we find a young *woman* can run one! Now I look at the future and I imagine the United States in a few years, each person’s labor multiplied by machines,” Lowell continued. “Each person’s *prosperity* multiplied by machines. For even those people still laboring the old way will benefit from cheaper grain, cheaper cloth, and cheaper transportation, making each item they buy more economical.”

Lowell turned to Jefferson. “Sir, this university of yours can also be seen as a lever of sorts, one to multiply the knowledge of the few inventors and forward-looking businessmen, to make more like them, to make this future possible.”

Jefferson bent his head and bit his lip for a moment. At length he spoke. “I used to be known as a man who believed we should concentrate on agriculture, and leave the wretched life in factories to the British. We could import all the manufactured goods we needed cheaply enough, and rely on our bountiful land. And I must say, for myself, I still prefer the life of a country farmer. But, in recent years, I have changed my opinion. I’ve

bragged to Pierre du Pont, among others, of our efforts here to manufacture our own goods, and thus be rid of high-handed British trading practices. I take particular pride in our looms here at Monticello. Yet, Mr. Lowell brought a gift of cloth made with such speed, I wonder if our little looms are not a foolish waste of effort.”

Lowell smiled and nodded vigorously.

“This, in turn,” Jefferson continued, “makes me wonder what other fields of endeavor might benefit from machinery. Farming, in particular. Over the years, I have invented or bought a number of implements to improve the economy of farming. In 1794 I designed a moldboard plough I call the ‘plough of least resistance’. Mine was wood. Now they make the same pattern in iron. I cannot say farmers notice the difference, but I do think every plough-horse that sees me gives me an appreciative wink.”

“I saw some of your equipment down on Mulberry Row,” Evans acknowledged. “I was most impressed by the threshing machine, in spite of the fact it is powered by horses. I have heard of them, but they are quite rare. And you have a very nice grain drill. I saw your comments regarding my mill patent, with the comparison of my grain elevator to your grain drill, so I was interested to see it.”

“I hope you don’t hold that letter against me,” Jefferson apologized.

Evans smiled and winked. “I should hope I am too reasonable to take offense at an honest difference of opinion. Besides, you seemed to like my hopper-boy.”

“It is quite clever,” Jefferson acknowledged. “It is also obvious that the design of your mill, however it may borrow from ancient inventions, does work as a whole machine to excellent effect. I expect that almost every mill being built today is of your design, and I hope, despite the expiration of your patent, that you continue to profit from it.”

Evans shrugged. “There is good money in being the most respected supplier. I make money selling the parts and supervising their setup, and waste far less time in the company of lawyers. Ah, with apologies to present company.” He glanced at the other Virginians.

“Which brings me to my next topic,” Jefferson continued. “Mr. Evans, you had some experience farming as a young man, and you are an expert miller. Since you say you have built an agricultural traction engine, I presume the idea of farm machinery still interests you?”

Evans eyed Jefferson with suspicion. “Yes sir, although I fear I may have just volunteered for another invention.”

Jefferson tried to look innocent as he stepped to a shelf and took down a rolled drawing. “The farms around here are swarming with farmers who tinker with their own inventions. Alas, most of these are cantankerous contraptions that do not work very well and which are prone to break the first time they meet a stone. This is one of them. I chose this one because I think it has the most potential to be useful if it could be built more practically. And I know you, above all people, will be sensitive to the man’s invention rights.”

Jefferson unrolled the drawing. “This came to my attention a few years ago, from a farmer named Robert McCormick, over in Rockbridge County. It is a reaping machine. I think he has made little or no progress on it in the last five years, and probably could use some advice.”

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Evans studied the drawing. “It seems simple enough. A crank driven by one wheel slides a toothed bar against a fixed one, so that it shears as scissors do. Ah, but if this is meant to harvest grain, I see a problem. If it is drawn by a horse, the grain will be trampled.”

Jefferson nodded. “Indeed. So my question is this ... could it be *pushed* by your agricultural traction engine?”

Evans’s face exploded into a wild smile. “Absolutely! But, if I may say so, my traction engine should easily have the power of a large team of horses, so it should be a waste if that were all it did. Now, let me think a little, the way I did when I designed the mill. How else could it save labor? It seems to me that this just cuts the grain and lets it fall to the ground. We must scoop it up and not run it over, so perhaps we add a cradle and some sort of guides here ...” Evans picked up a piece of paper and began to sketch, “... or perhaps a belt. And I see no reason why we cannot convey the grain to a small threshing machine, right on the reaper. I think we could even blow away the chaff. Put the wheat into bags, ready for the mill, and expel the straw to one side ready to be scooped into a wagon. No! We should put the straw straight into a wagon!”

“What, you won’t mill it as well, right on the machine?” Lowell teased.

Evans shook his head. “Alas, there’s that drying step after grinding, the one the hopper-boy does. Otherwise, I probably could.”

Jefferson turned to President Madison. “James, I take back all the unkind things I said about Mr. Evans, and thank you for bringing him.” He turned back to Evans. “Sir, do you know it takes three hours of labor, working as most farmers presently do, to produce one bushel of wheat?”

Evans shrugged. “No, but I’m not surprised. That’s why I left farming and set up my own wretched factory.”

“*Touché*,” Jefferson acknowledged. “I think you may have just dropped the labor by two thirds. Which brings me to reconsider my previous beliefs, that the life of the farmer is the best possible. I fear I have already packed the latest census information, but I’m certain it will show that about nine persons in ten are engaged in farming, from which we may conclude that most farmers and farm laborers subsist on their own labors, with little surplus, and it takes about nine farm laborers to feed one person otherwise engaged.”

Several of the others nodded at the simple math.

“If machines such as this can be made for most crops, then three farm laborers could replace nine!” Jefferson observed, with eyebrows raised, and a glance down Mulberry Row. “Mr. Evans, when you speak of horse-power, exactly how is that calculated?”

“It describes the work done by a draft horse, in typical situations such as pulling a plough,” Evans explained. “I use Watt’s estimate that a horse used to pull buckets of water from a mine can lift three hundred and thirty pounds of water up one hundred feet in one minute, and sustain that pace for at least four hours.”

“So, my fine steam inventors,” Jefferson asked, “how many horses will one traction engine represent?”

“My big Columbian engine at the Fairmont water works runs at about fifty horsepower, although it was designed for a hundred,” Evans replied. “It would probably

make too large a traction engine to be practical. Ten to twenty horsepower is more reasonable, I think.”

Stevens hugged Evans. “Precisely my need! We really must discuss rail traction engines at the nearest opportunity.”

“How much fuel does such an engine require?” Jefferson asked.

“The Columbian takes ten cords of wood a day,” Evans admitted. “But that is running about twenty hours or more a day. Mind you, it serves more than sixty thousand people. It runs well on coal, too, of course, and probably corn stalks or dried manure for that matter. A smaller engine should take less wood in proportion to its power, if run at the same pressure. And unlike a horse, when not needed, the engine does not eat.”

Jefferson smiled. “So much to consider. Cutting that much wood is a significant amount of work, but then I must consider that such an engine might also run a saw.”

“Come up to Philadelphia, sir, and I shall show you a steam engine sawing marble, with twelve blades going at once.”

“And if my railroad is built, it will haul far more wood or coal than it takes to run it,” Stevens injected.

Jefferson laughed. “So, Mr. Evans, may I presume that a ten horse power traction engine ... may we call it a tractor? Could a ten horse power tractor pull ten ploughshares?”

Evans shrugged. “From my own days behind a plough, I should think maybe five, but twice as fast as a single horse can pull one. And the ploughman can ride the ... ah ... tractor. I like the name.”

Jefferson stood with his hands on his hips. “How many crops do you gentlemen suppose could be cultivated by machines? Cotton? Corn? Certainly not fruit or berries.”

“I’ve thought of using something like a comb to pick blueberries,” Lowell offered. “This should speed the picking greatly. I would not rule out the use of machines to speed the planting and harvest of almost any fruit. But, of course, fruit tends to spoil on the way to market.”

“That would change if you could get it to market faster,” Stevens stated. “And smoother ... railroads should be much gentler on tender produce than wagon roads. I imagine it should be possible to transport fruit on ice, where it is available.”

“Make your own ice,” Evans said with a twinkle in his eye.

“Just how would you do that?” Madison asked.

Evans turned to Jefferson. “Did Dr. Franklin ever tell you of an experiment he did using ether?”

“The sweet oil of vitriol!” Irénée du Pont exclaimed. “The distillate of grain spirits and vitriol. There may be enough vitriol left. Shall I prepare some?”

“Is this the experiment where he showed you can cool a thermometer by dabbing it with ether?” Jefferson looked to the other Virginians. “I do believe we had a demonstration one evening in Philadelphia. Several of the ladies almost fainted from the vapors. I should think this is an impractical way to make ice.”

“Mind you, I have only thought of this,” Evans apologized. “It was the same year I made the model tractor, built the amphibious dredge, and wrote my engine book. I mention it in the Postscript. I had too many irons in the fire to build it then. It should work but it needs proving. I thought of it while designing a steam engine that uses a condenser to save the water to use again, a provision that saves cleaning the boiler. One

essentially runs the engine backwards. If you used the cylinder and piston to make a vacuum pump, driven by an engine or water wheel, one could cause rapid boiling of ether in a closed reservoir, cooling it, quite dramatically I think. Then, on the compression stroke, force the vapor into another tank where the compression should heat it. Charles' Law, was it Mr. Jefferson? Let it cool until it condenses, and then pump it back into the evaporation tank. No fumes. Although, again, sealing leaks could be a bedevilment."

Madison glanced at the other two Virginians. "Are you two thinking what I am thinking?"

"Iced cream!" Jefferson and Monroe replied in unison, both smiling broadly.

"I might be tempted to invest in this invention myself," Madison acknowledged, followed by nods from Jefferson and Monroe.

"I should learn to keep my mouth shut," Evans declared with a shake of his head. "I shall need five of me. No, ten, as I already needed five of me before this trip."

"A frightening thought," Jefferson observed. "I was planning to ask if you would teach at my university, yet to do so would take you away from what you do best. We must give some thought about how to do both."

"I don't suppose you will have a modern iron works in one of these buildings." Evans looked over the drawings for the university.

Jefferson scratched his chin. "I had not planned on it. Perhaps if you, Mr. Stevens, Mr. Lowell, and Monsieur du Pont would each instruct for a few months a year, we could send young engineers to learn your trades for a year or two, as part of their education. Not quite apprentices, but some form of cooperation between the university and your companies, to both promote their education and to provide you with bright young minds."



Out on the west lawn, far from anything breakable, Irénée du Pont set up his demonstration. He placed six small paper cylinders within a ring of bricks. Each cylinder had two wires protruding. The wires from one end of each cylinder were twisted together with a single longer wire, which lay on the ground and led back to a box of glass jars fitted with curious brass hardware. The other wire from each paper cylinder ran, propped up on twigs so as not to touch each other or the ground, to one of six nails driven into a rough board. Beside the board lay a long stick. Another wire affixed to the stick also ran to the jars. The jars, in turn, were connected by more wire to a contraption that looked a bit like a spinning wheel, except for the large glass disk on it. Another small jar mounted on the spinning device was wired to the wheel. Within that jar was a small flag of gold foil.

Du Pont bowed to Jefferson. "Sir, I would gladly spend a month exploring your cellar, for you have the most delightful collection of toys." He turned to the rest of the company. "You gentlemen will, of course, recognize the Franklin generator, and perhaps

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also his battery of Leyden jars. A few of you may even recognize his powder caps. I have been working with these at my mills.”

Everyone but Lowell nodded in recognition.

Du Pont turned to Lowell. “Some time before the American Revolution, Dr. Franklin found that an electric spark, created within a tube of gunpowder, will ignite it. I thought about this when we were discussing the possibility of an engine fueled with gunpowder. I cringe at the idea of attempting to feed small charges of loose powder by some contraption into an engine. One little flash, and it is likely the chain of containers would send fire right back to the keg. The effect would be essentially the same as one of Colonel Fulton’s torpedoes, and any man with such a machine in a submarine would need to be a thousand times braver than am I. But then I thought of Dr. Franklin’s electrical caps. With these, there is no need for loose powder, and relatively little danger of a stray spark igniting one.”

Du Pont picked up the stick with the wire and turned to Evans. “Ollie, would you kindly turn the generator, and let me know when the gold leaves are spread at least a quarter inch?”

Evans nodded and stepped to the machine. In a few seconds he had it spinning, and the leaves of the electroscope were spread. “The charge is ready.”

Du Pont touched the wire on the end of the stick to each nail in turn, about a second apart, and with each touch, a paper cylinder exploded with a loud report.

Smiling broadly, du Pont turned to his audience. “The little voltaic pile I made here proved too feeble, but I can do this with a larger voltaic pile back at my mills. I leave it to you mechanical men to rig a way feed these caps into a small ‘gun’ mounted to the cylinder of an engine, and to operate contacts to a voltaic pile.”



The carriage bearing Lowell, Evans, Stevens, and du Pont disappeared around the bend. James Madison let out a heavy sigh. “Peace at last! I’m sure they will chatter and argue the whole way. I’m off for Montpelier as soon as Isaac can hitch my team.”

James Monroe shifted his gaze to the other two Virginians. “Do you think we gave them enough paper? With a week and a half to reach Philadelphia, I dare say they may invent flying machines before they arrive.”

Jefferson stared longingly after the carriage. “I hope we can do this again next year,” he said earnestly. “*I pray we have done it in time.*”



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Historians now look back on the first Monticello Conference and recognize its importance. Had it not occurred, how many of the great American inventions would have appeared decades later, or else have been created in other countries?

Most experts in engineering history insist that, on his own, Stevens would have had considerable difficulty in producing a working locomotive, and likely would have been beaten to market by the British. But with Evans' help, the twenty-six mile Camden to New Brunswick line was up and running a year after the historic conference, with a slow but serviceable Evans locomotive. Of course, within weeks it was out of service, as the original iron-capped wooden rails lacked durability. However, John Stevens' son Robert suggested a design for iron rail, and Evans quickly designed a rolling mill to make it. The line was back in business in months, and Robert's rail design is in use to this day.

Evans, concerned with tip-over, employed a wider rail gage than the emerging British models. The British foolishly used existing carriage jigs with a width that dated back to Roman chariots. The Evans locomotive was nearly a foot wider. The wider gage not only made the Evans locomotives more stable and the carriage rides smoother, it meant American trains could carry heavier loads, and were safer at higher speeds. Consequently, the fledgling British locomotive industry was quickly overshadowed by the more robust American designs, except for a few specialized applications where width was an issue.

Evans moved to Charlottesville, Virginia in late 1816, where he set up a new iron works dedicated to the production of agricultural implements. Inspired by Jefferson's habits of healthy food and daily exercise, Evans lost weight and improved his health. Friends from Philadelphia commented that they could barely recognize him.

The moment the first locomotive shipped to Stevens, Evans built another pair, equipped with wheels for use on dirt, for Jefferson and Madison. Partnered with Robert McCormick, Evans built the first McCormick harvesting machine at the Virginia works in 1817, with the first two going to Jefferson and Madison. The reaper was followed by a threshing combine in 1819. Jefferson, Madison, and Monroe bought the first three, with Evans tractors to power them.

The new equipment suffered the inevitable setbacks, but Evans was there to correct them, and by the second harvest the advantages of the machines were obvious. This attracted the attention of plantation owners all over Virginia and Maryland, and in North Carolina a season later. While the equipment was too expensive for small farmers for many years, the economic success of mechanized farming was too good to ignore, even by the most stubborn slave owners. As new implements were developed for other crops, the machines inevitably spread. The new equipment caused a noticeable drop in the practice of slavery in these states within a few years.

The day the University of Virginia opened for business, in 1818, two new and improved tractors became the pride and joy of the College of Engineering. The Steam Engineering department received one, and the Agricultural Engineering department received the other. The Department of Civil Engineering was added two years later, and exploited the design to build steam-powered earth-moving equipment. In 1821, the new Electrical Engineering department began experiments with electromagnetic power generation using an Evans fixed-location steam engine. In honor of the discoverer of electromagnetism, we now call the unit for electrical current the "Jefferson," or "Jeff", for short.

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In 1819, Evans received a bonus from his cooperative education partnership with UVA, when the very first young engineering “co-op”, working late at the Mars Iron Works, caught a disgruntled apprentice attempting to set fire to the factory. The factory was saved. Evans lived to the ripe old age of 82, inventive to the last. Now remembered as the Father of the American Industrial Revolution, he towers in our minds above later inventors such as Perkins, Ericsson, Westinghouse, Tesla, Edison, and Verne.

Stevens attracted the young John Ericsson, a capable teenaged Swedish engineer enthusiastic about Stevens’ ideas for steam ships and propellers, and took him on as an apprentice. Ericsson “took the bit in his teeth” when unleashed on the ironclad warship design, and is credited with making it practical. Emboldened by the success of the new Stevens ironclad warships in their first trials at the new Naval Engineering Academy, President Monroe announced the “Monroe Doctrine” in his third State of the Union address. In 1822, he dispatched the Navy to intercept a British fleet intent on making a show of force off the coast of Puerto Rico. The American Navy was still mostly wooden ships under sail, and Commodore Bainbridge suffered the three ugly, smoking, graceless Sea Dragons and their unarmed collier in his task force only because his Commander in Chief insisted on it.

The still-experimental iron boats were commanded only by junior officers, under Lieutenant David Farragut, an audacious young man who had his first command (a boat captured by the USS Essex during the War of 1812) as a midshipman at the improbable age of 12. When the British made the fatal mistake of firing on the Americans, Farragut ordered his iron boats submerged until their decks were barely visible, offering almost no target. The black monsters raced ahead to meet their opponents, without any need to consider the wind, firing turret-mounted rifled cannon loaded with Stevens’ elongated exploding shells. The flat-firing and highly accurate projectiles skipped off the water and struck near the waterline, causing crippling damage at ranges of up to a mile. When inside a hundred yards, the Sea Dragons blasted the hulls of their hapless wooden opponents *below* the waterline with self-propelled Fulton torpedoes driven by powerful gunpowder engines, from which we record Farragut’s famous quote, “Man the torpedoes, full speed ahead.”

Small arms fire from Ericsson revolving machine guns, firing Du Pont electric cartridges similar to those which propelled the torpedoes, raked the rigging of any British ship the main armaments were too busy to engage. The British wisely struck colors while they still had enough ships to take on survivors, assuring plenty of men made it home to tell the tale. The news of the stunning victory of iron and steam over wood and canvas spread quickly, and within two years every Navy worth its salt was scrapping their old ships for ironclads.

Steam development exploded as University of Virginia engineers became the brains of American industry. By 1830, railroads extended east and west, north and south, from the Atlantic to the Mississippi. In 1841, the final spike was driven in the Transcontinental Railroad, which extended all the way to the Oregon coast.

By 1851, every slave state had laws stipulating that no one would be born into slavery, and the practice was finally outlawed by 1862. Owners found slaves to be expensive and unnecessary. Freed slaves were not generally welcomed in the states in which they had been owned, as evidenced by Virginia’s Fugitive Slave Act. Jefferson’s experiment in repatriation to Liberia was a notorious flop. Instead, most freed blacks

moved to western territories, where they were better accepted, especially as many of them were experienced steam mechanics. The resulting demographic shift made most western territories relatively racially balanced, and made it impossible for any new state to vote itself slave.

James Madison retired to his Virginia plantation, Montpelier, where he established a company to make the refrigeration equipment suggested by Evans. Evans licensed his refrigeration ideas to his friend Jacob Perkins, who proved the concept worked, and built practical refrigeration machines for Madison. Partnered with local dairy farmers, Madison introduced the first commercially-produced ice cream, based on his wife Dolley's recipe, and endeared her name to lovers of this delicious treat for almost two centuries now. The rail refrigeration cars to transport it to markets nationwide spawned a revolution in the transport of perishable foods.

One can go on to the spin-offs that developed later, such as Michael Faraday employing multi-stage Perkins-Evans refrigeration pumps to successfully liquefy methane, oxygen, nitrogen, and hydrogen in useful quantities. This, in turn, led to the development of liquid-fueled rocket engines by Verne a few years later, and launched the space program just before the turn of the century. The list goes on.

But how are we to know what might have happened if this pivotal meeting had not taken place? This is all pure speculation, of course, but perhaps the best-considered and best-written is the controversial alternate-history novel by the famous science fiction author Samuel Clements, better known by his riverboat-based pen name, Mark Twain. Based on his own research and keen insights into human nature, Twain concluded that people of Jefferson's time were not quick to adopt new technologies, and that prior to this meeting, these inventors had extreme difficulty convincing investors that they were not half-mad "visionaries" (oh, my, how the meaning of that word has changed!). In Twain's view, the adoption of new technology, particularly agricultural mechanization, by three of the most respected men in the nation, and especially considering their influence among Virginia planters, was the single most important development of the conference, and seminal to the changes which followed. Also, in Twain's fictional world, the University of Virginia did not have a College of Engineering for decades, so there were no graduates to implement the new technology. Jefferson's writings prior to the meeting make no mention of a College of Engineering.

In Twain's chilling novel, *The War Between the States*, this critical change in agribusiness never took place. In 1820, the representation problem Jefferson feared came up when several territories, particularly Missouri and Maine, were up for statehood. Twain speculated that the little-known Missouri Compromise of 1820, which simply negotiated a temporary measure for maintaining the balance of slave versus free states with the hopes that the new experiments in agriculture might make slavery obsolete in a few decades, instead drew a line in the sand. In Twain's story, a latitude was selected above which new states would be free, and below which they would be slave, the very measure Jefferson predicted would cause deepening divisions that would break the Union. The recorded votes for the actual compromise were, in fact, close, so it is not unreasonable that the passionate arguments Madison made before the House and Senate were crucial to the outcome.

In Twain's novel, while steam did take off for transportation and industry, though more slowly since in his world the Monticello Conference never took place, agriculture

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remained mired in its antiquated ways, and totally dependent on slavery. Instead of gradually dying, the institution grew dramatically, fueled by cotton. The nation divided just as Jefferson foresaw, resulting in the southern states seceding in 1862. This triggered a civil war, brother fighting brother, *by far* the worst military catastrophe ever to befall the nation.

Most readers have difficulty believing Twain's story, insisting that the Luddite philosophy of the planters, the stubborn refusal to adopt technologies that we know to be so sensible and profitable, strains credulity, as does the willingness of citizens of the free states to make war against their neighbors for simply withdrawing from the Union. Most readers refuse to believe that our ancestors could have been so pig-headed, and unable to avoid the danger. But many scholars of those times insist that Twain got it right. Our ancestors really *were* that pigheaded, and what happened at Monticello launched a change in thinking that otherwise might have ended up as Twain described.

This should lead us to ask what new technologies of today are being overlooked, and at what consequence. Food for thought!

The author wishes to acknowledge several of the characters in this story as co-authors. Wherever possible, they have been paraphrased or quoted verbatim.

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