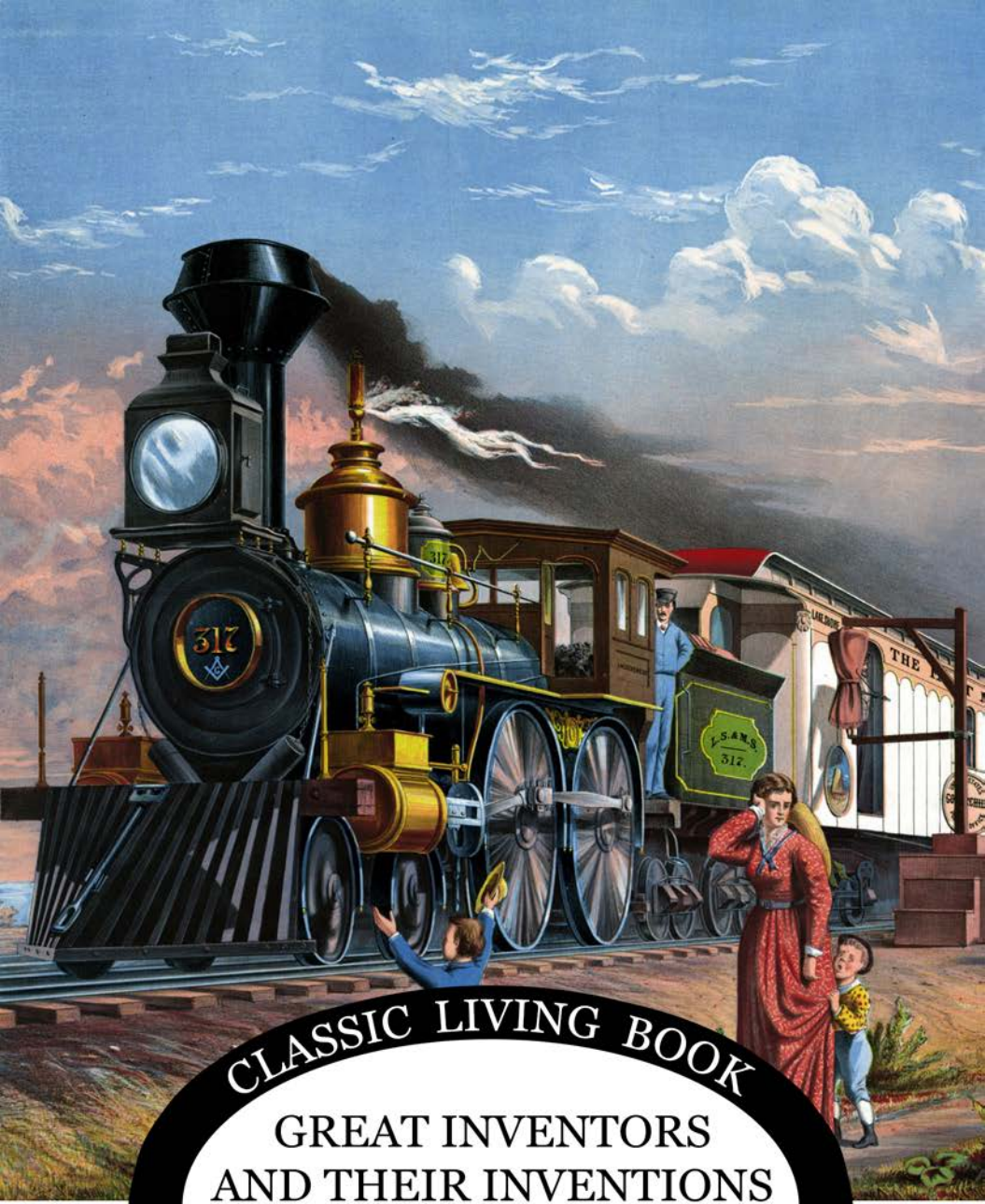

CLASSIC LIVING BOOK

GREAT INVENTORS AND THEIR INVENTIONS

Frank P. Bachman

COMPLETE AND UNABRIDGED

Great Inventors and their Inventions

FRANK P. BACHMAN

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JAMES WATT AND THE INVENTION OF THE STEAM ENGINE

Until a little more than one hundred years ago, the chief power used in the production of food, clothing, and shelter was hand power. Cattle and horses were used to cultivate the fields. Windmills and water wheels were employed to grind corn and wheat. But most tools and machines were worked by hand.

JAMES WATT

Men had, for many years, dreamed of a new power which would be more useful than either work animals, sails, windmills, or water wheels. This new power was steam. Yet no one had been able to apply the power of steam so that it would grind corn and wheat, spin and weave cotton and wool, or do any useful thing at all. The man who succeeded in giving to the world this new power was James Watt. Steam now propels ships over the Atlantic in less than a week. It speeds express trains across our continent in ninety hours, and it does a thousand other wonderful and useful things.

CHILDHOOD AND EARLY EDUCATION

James Watt was born in 1736, at Greenock, Scotland, not far from Glasgow. His early education was received at home, his mother giving him lessons in reading, and teaching him to draw with pencil and chalk. His father drilled him in arithmetic and encouraged him

WATT AND THE TEAKETTLE.

in the use of tools. When at length James went to school, he did not at first get along well. This was due to illness which often kept him at home for weeks at a time. Still, he always did well in arithmetic and geometry, and after the age of fourteen he made rapid progress in all his studies.

Even as a small boy, James was fond of tinkering with things. This fondness was not always appreciated, as is shown by a remark of an aunt: "James Watt, I never saw such an idle boy; take a book or employ yourself usefully; for the last hour you have not spoken a word, but taken off the lid of that kettle and put it on again, holding now a cup and now a silver spoon over the steam, watching how it rises from the spout, and catching the drops of water it turns into. Are you not ashamed to spend your time in this way?"

Much of his time, as he grew older and stronger, was spent in his father's shop, where supplies for ships were kept, and where ship repairing was done. He had a small forge and also a workbench of his own. Here he fashioned cranes, pulleys, and pumps, and learned to work with different metals and woods. So skillful was he that the men remarked, "James has a fortune at his fingers' ends."

The time at last came for choosing a trade. The father had wished James to follow him in his own business. But Mr. Watt had recently lost considerable money, and it now seemed best for the youth to choose a trade in which he could use his mechanical talents. So James set out for Glasgow to become an instrument maker.

Learning Instrument Making

He entered the service of a mechanic who dignified himself with the name of "optician." This mechanic, though the best in Glasgow, was a sort of Jack-of-all-trades, and earned a simple living by mending spectacles, repairing fiddles, and making fishing tackle. Watt was useful enough to his master, but there was little that a skillful boy could learn from such a workman. So he decided to seek a teacher in London.

There were plenty of instrument makers in London, but they were bound together in a guild. A boy wishing to learn the trade must serve from five to seven years. Watt had no desire to bind himself for so long a period. He wished to learn what he needed to know in the shortest possible time; he wanted a "short cut." Master workman

after master workman for this reason turned him away. Only after many weeks did he find a master who was willing to take him. For a year's instruction, he paid one hundred dollars and gave the proceeds of his labor. The hours in the London shops were long. "We work," wrote Watt, "to nine o'clock every night, except Saturdays." To relieve his father of the burden of supporting him, he got up early and did extra work. Towards the end of the year he wrote, with no little pride: "I shall be able to get my bread anywhere, as I am now able to work as well as most journeymen, though I am not so quick as many."

Jack-of-all-trades

In order to open a shop of his own, Watt returned to Glasgow. He was opposed in this by the hammermen's guild. The hammermen said that he had not served an apprenticeship and had no right to set up in business. They would have succeeded in keeping him from making a start, had not a friend, a teacher in the University of Glasgow, come to his aid, providing him with a shop in a small room of one of the college buildings.

Watt soon became a Jack-of-all-trades. He cleaned and repaired instruments for the university. Falling into the ways of his first master, he made and sold spectacles and fishing tackle. Though he had no ear for music and scarcely knew one note from another, he turned his hand to making organs. So successful was he, that many "dumb flutes and gouty harps, dislocated violins, and fractured guitars" came to him to be cured of their ills.

All the while, Watt spent his leisure time in reading. The college library was close at hand, so there was no lack of books. Chemistry, mathematics, and mechanics were studied. By learning all he could and by doing everything well, Watt came to be known as a man "who knew much and who could make anything."

Captured by Steam

Coal and tin mining had for a long time been important industries of Great Britain. Shallow mines were easy to work. Men and women carried out the coal or tin ore in buckets, by winding stairs. Or a windlass was used, turned by hand or with the aid of a horse. Water was taken out in the same way. As the shallow mines became ex-

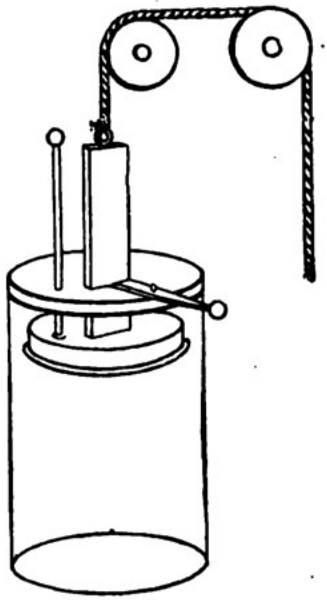
BRANCA'S STEAM ENGINE OF 1629.

hausted, deeper ones were opened. The deeper the mine, the harder it was to lift out the coal or tin ore. Into these deeper mines also came quantities of water, flooding many of them. Unless a machine should be invented which could be run at a small cost, to pump out the water and to hoist the coal or tin, these mines would have to be closed. The need of such a machine led to the invention of the first successful steam engine.

Watt first heard of the steam engine in 1759. The idea captivated him, and he began to read how others had tried to make successful engines. Finding that the best books on steam and "fire engines," as they were then called, were in Italian and German, he took up the study of these languages.

In an Italian book he read about Branca's steam engine, invented in 1629. Branca's engine was little more than a toy, no use being made of it, except to pulverize saltpeter and do other simple things of like sort.

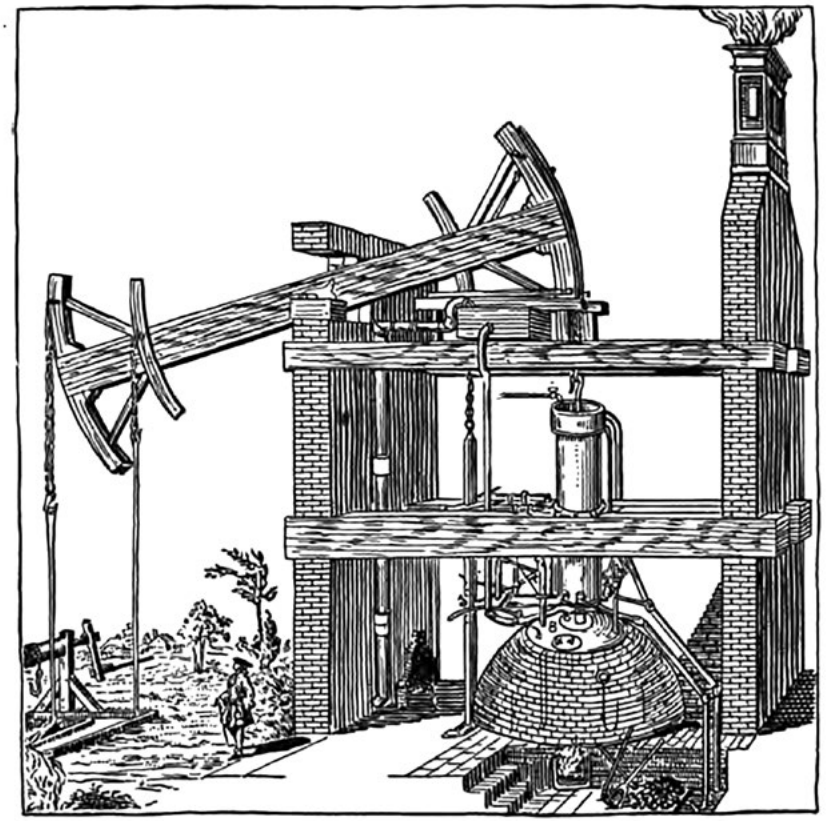
In a German book he read about Papin's engine, which was invented in 1690. In Papin's engine steam was admitted into the cylinder. The steam was then allowed to condense, that is, turn back into water. This formed a vacuum, or space without any air in it, under the piston. The weight of the atmosphere, which is about fourteen pounds to the square inch, on the upper side of the piston, forced it down, and the descending piston raised a weight fastened to the rope.



PAPIN'S ENGINE.

Papin never went further than the making of a model. But his idea of using steam to make a vacuum, and of using the pressure of the atmosphere to force down a piston was applied a few years later with some success by Thomas Newcomen.

Newcomen made his first engine in 1705. Although big and awkward, a number were used in England to pump out the water at the mines. But they could not be used in deep mines, as they could lift only six or seven pounds for each square inch of the piston. They worked slowly, making only about fifteen strokes a minute, and they were expensive also, a single engine burning fifteen thousand dollars' worth of coal in a year.



NEWCOMEN'S ENGINE.

Finding the Trouble

Watt had been thinking about steam for four or five years before he saw one of Newcomen's engines. Then it was only a model of one, brought to him from the university for repair. When he had repaired the model, he started it to going. It made a few strokes and stopped. There was no more steam. The boiler seemed big enough, so he blew up the fire. The engine now ran all right, but it required much fuel and used up quantities of steam, though the load on the side of the pump was light. Most men would have thought nothing of this, and would have sent the model back to the university. But that was not Watt's way. Everything he did not understand was for him a subject for study, and he never stopped until he understood. So he set to work to discover why the engine used so much steam.

Steam was used, you will remember, to make a vacuum in the cylinder. Watt found that to drive out the air and water, enough steam had to be let into the cylinder to fill it four times. Why was this? First, the cylinder was exposed to the air, which chilled it. The cold cylinder itself, before it was warm, changed considerable steam into water. Second, cold water was poured into the cylinder to condense the steam, and this made the cylinder cold again. Watt estimated that three fourths of all the steam used was thus wasted in heating and reheating the cylinder. Here was the trouble with Newcomen's engine. Watt saw that, to remedy this defect, a way must be found to keep the cylinder always as hot as the steam which entered it, and the vacuum must be made in the cylinder, without cooling it.

Making the Invention

Watt spent much time and money in making experiments, but nothing he tried succeeded. "Nature has a weak side," he was fond of saying, "if we can only find it out." So he went on day after day, following now this and now that false hope.

"One Sunday afternoon early in 1765," writes Watt, "I had gone to take a walk in the Green of Glasgow. I was thinking upon the engine and about how to save the heat in the cylinder, when the idea came into my mind that steam was an elastic body and would run into a vacuum. If connection was made between the cylinder and a tank from which the air had been pumped, the steam would pass into the empty tank and might there be condensed without cooling the

cylinder. I then saw that I must get rid of the condensed steam and of the water used in condensing it. It occurred to me this could be done by using pumps."

With a separate condenser in mind, to get rid of the steam after it had done its work, without cooling the cylinder, other important improvements were thought of. In Newcomen's engine, the upper end of the cylinder was open to let the air act upon the piston. Watt now planned to put an air-tight cover over the end of the cylinder, with a hole for the piston rod to slide through, and to let steam in above the piston to act upon it, instead of the air. This change made Newcomen's atmospheric engine into a steam engine. In Newcomen's engine the power was the pressure of the atmosphere upon the piston, and this power acted in one direction only. In Watt's engine steam was the power, and the piston was shoved both up and down by it; hence Watt's engine was called a double-acting engine.

"All these improvements," says Watt, "followed in quick succession, so that in the course of one or two days the invention was . . . complete in my mind."

The next step was to make a model, to put the invention into working form. Making the drawings was easy, but to carry them out was hard. A lack of good workmen was the chief difficulty. There were no skilled mechanics in those days, nor self-acting, tool-making machines; everything had to be made by hand. Blacksmiths and tinners were the only men that could be hired, and they were bungling workers even at their own trades. After eight months of racking labor, the model was ready to start. It worked, but despite all Watt's care, it "sniffed at many joints." The condenser did not work well; the cylinder leaked, and the piston was far from being steam tight. To add to Watt's troubles, his "old White Iron man," a tinner and his best workman, died. The cross-beam broke. Nevertheless, Watt saw enough to know that he was on the right track.

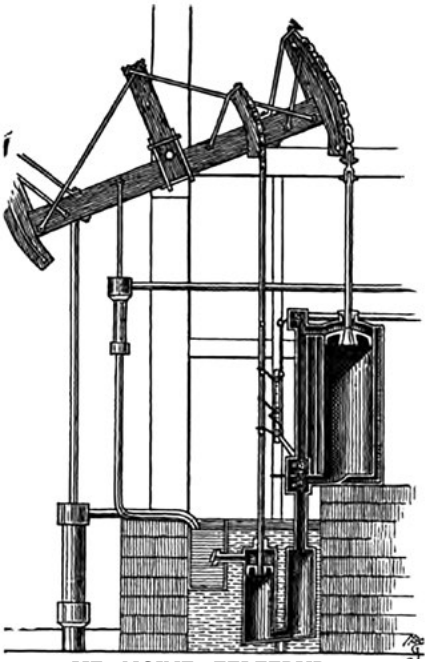
Beelzebub, the Trial Engine

Watt's great need was money, for it was necessary to build a trial engine to show the value of steam power. He finally, in 1767, secured a partner who promised, for a two-thirds share in the invention, to pay a debt of five thousand dollars owed by Watt, and to bear the expense of further experiments. The partnership was formed, and Watt

turned to the plans for the trial engine.

As the trial engine neared completion, Watt's "anxiety for his approaching doom kept him sleepless at night, for his fears were even greater than his hopes." Alas! the trial engine did not work well. The new condenser acted badly. The cylinder was almost useless. The piston, despite all that could be done, leaked quantities of steam. The whole machine was a "clumsy job." From the way it wheezed, and snorted, and puffed fire and smoke, the engine was named Beelzebub. Months were spent in Wales, overhauling him, but he behaved only slightly better on second trial. Beelzebub was far from being a practical engine, and he was left for the time to rest and rust.

There is little wonder that Watt was downhearted and wrote to his friends: "Of all things in life, there is nothing more foolish than inventing." "I am resolved . . . if I can resist it, to invent no more." "To-day I enter the thirty-fifth year of my life, and I think I have hardly yet done thirty-four pence worth of good in the world."



THE ENGINE BEELZEBUB, 1767.

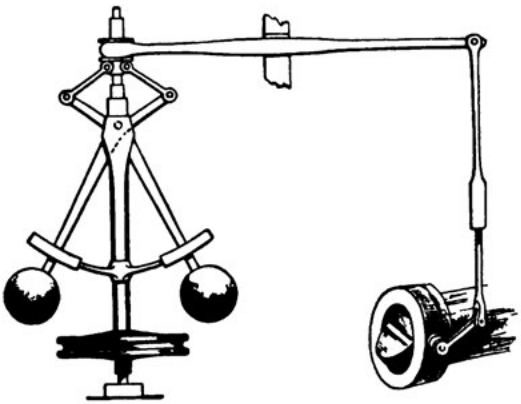
Completing the Engine

Watt had by this time spent ten years and several thousand dollars upon his invention, but it was still only a dream. Brighter days were, however, at hand. Matthew Boulton, owner of the largest hardware factory in the world, at Soho near Birmingham, and who had working for him the best mechanics in Europe, became interested in the fire engine. In 1774, he became Watt's partner.

Meanwhile, old Beelzebub was shipped to Birmingham. The best mechanics of Soho set to work upon him. One by one the separate

parts were repaired and improved. In a few months, he was ready for trial. Beelzebub puffed as much smoke and fire as ever, but with all his bluster and noise,—thanks to good workmanship, he went surprisingly well. Everyone who saw Beelzebub run felt sure that the invention would prove a success. Even modest Watt wrote to his father: "The fire engine I have invented is now going, and answers much better than any other that has yet been made, and I expect that the invention will be very beneficial to me."

Though success was promised, much remained to be done to make the engine practical. It was found, for example, that if the load Beelzebub was pulling, for some cause became lighter, he would run too fast; if the load suddenly became heavier, he would run too slow.



WATT'S ENGINE GOVERNOR.

Some way had to be found to make him run faster when there was need of more power, and to run more slowly when less power was needed. Two heavy balls were fixed to swing around an upright rod. When the engine ran fast, the upright rod turned fast, and the balls swung out and so acted as to admit less steam. When the engine ran slowly, the rod turned slowly, and the balls swung down and let in more steam. By the use of this contrivance, or the governor, Beelzebub was made to run at about the same speed, and when started and set to work, became his own engineer.

Other inventions were made, and the separate condenser, piston, and cylinder were improved. Thus, after years of thought and labor, the steam engine at length stood full grown and ready for all kinds of work.

Making the Business Pay

To make an invention is one thing. To get people to use it and so make it profitable is another. It is difficult to say which is the harder.

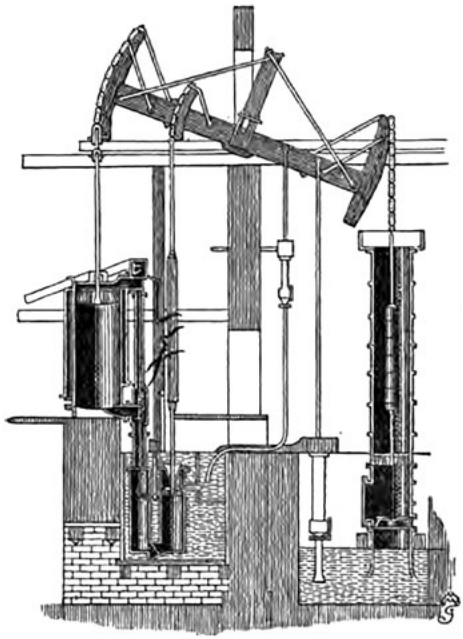
In any case, Watt's troubles were not over.

All the time that Watt was working on his invention, mines were being flooded with water and had to be given up. Among the first orders for engines was one for a mine in Cornwall. Watt made the drawing with care, and the workmen did their best, for much depended on the first engine.

The engine was ready by the middle of 1777, and Watt went to set it up. The people were eager to get a look at the monster. Mine owners came from far and near to see it work. Many were doubtful, and some even wished that the engine might fail. But to the surprise of all it succeeded. It pumped water as they had never seen water pumped before. The size, the speed, and "the horrible noise of the engine," wrote Watt, "give satisfaction . . . and the noise seems to give great ideas of its powers." In a few days the mine was dry. It was the deepest mine in the district, and orders for engines began to come in. They came so fast that in the course of the next four or five years almost all the mines in England and Scotland were supplied.

Boulton, Watt's partner, felt from the first that the greatest field for the steam engine was in mills and factories. When orders for pumping engines fell off, Watt went to work on a factory engine. The first factory engine was built in 1782, and was for a corn mill.

The use of the steam engine in mills was opposed by the millers. They saw that to put steam engines to grinding corn and wheat would do away in many places with windmills and water mills. The working people also were stirred up. They were led to believe that if the steam engine was put in mills, it would take work away from them.



A MINE ENGINE.

"It seems," wrote Watt, "the meddlers are determined to be masters of us. To put a stop to fire-engine mills, because they come in competition with water mills, would be as absurd as to put a stop to canals, because they interfere with wagoners. . . . The argument that men are deprived of a livelihood would put a stop to the use of all machines whereby labor is saved. Carry out this argument, and we must do away with water mills themselves, and go back again to grinding corn by hand labor."

So strong was the opposition that Watt and Boulton decided to build a flour mill, to show what could be done. They built one at a cost of sixty thousand dollars, and put into it their newest and best engine. The mill attracted much attention. But it was not allowed to run long. So bitter was the feeling against the steam engine that the mill was set on fire and burned to the ground.

Though the mill was a total loss, it served its purpose. Orders for factory engines came in apace,—orders from France, from Italy, and from America. The advantages of steam power were now apparent. Water mills were stopped in the summer by the lack of water, and in the winter by frost, while steam mills worked on, by day and by night, in all kinds of weather, and in all seasons.

To bring the world to appreciate the value of the steam engine was thus a hard struggle. Down to the year 1785 every penny made from the sale of engines, amounting to more than two hundred thousand dollars, was put back into the business. Besides, large sums were borrowed. So great was the need for money that even the patents were mortgaged. Time and again it seemed as if all would be lost. More than once Watt and Boulton felt that this would be a blessing. The mine owners, for instance, refused to pay for the engines which had saved them thousands of dollars. Dishonest persons stole and used their patents. They were continually annoyed by rumors that a better engine was on the point of being completed. Efforts were even made to get Parliament to take away their patents.

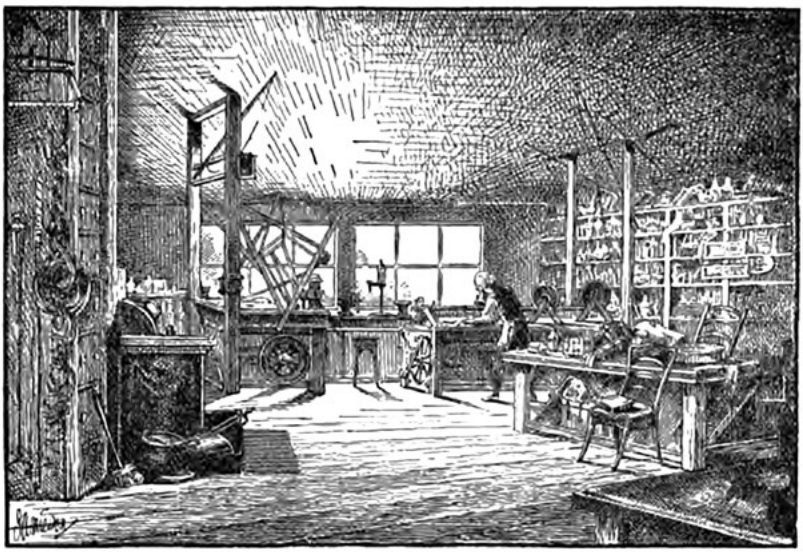
"We are in the state of the old Roman," Watt wrote, "who was found guilty of raising better crops than his neighbors, and was ordered to bring before the assembly of the people his instruments of husbandry, and tell them of his arts. He complied, and when he had done, said, 'These, O Romans, are the instruments of our art, but I cannot bring into the forum the labors, the sweats, the watchings,

the anxieties, the cares which produce the crops.' So everyone sees the reward which we may yet probably receive from our labors; but few consider the price we have paid for that reward, which is by no means certain."

Difficulty after difficulty was, however, battled down. Parliament refused to take away the patents. Persons who used them without right were punished. The mine owners were forced to pay what they owed. The business, after long waiting and untold distress, began to pay.

Old Age at Hearthfield

The partnership between Watt and Boulton came to an end in 1800. Watt was now well-to-do. Relieved of business cares and worry his health improved. He built a beautiful country home at Hearthfield. From there he made trips to different parts of Scotland, Wales, and England. To Hearthfield came old friends and the greatest men of England to visit him. Inventing continued to give him the greatest pleasure. A room was fitted up in the attic of the house, and there he would work for days at a time. This room remains just as it was in 1819.



WATT'S WORKROOM AT HEARTHFIELD.

On a monument erected to Watt's memory in Westminster Abbey are these inspiring words:

NOT TO PERPETUATE A NAME
WHICH MUST ENDURE WHILE THE PEACEFUL ARTS FLOURISH
BUT TO SHOW
THAT MANKIND HAS LEARNT TO HONOR THOSE WHO BEST DESERVE
THEIR
GRATITUDE,
THE KING
HIS MINISTERS, AND MANY OF THE NOBLES AND COMMONERS OF THE
REALM
RAISED THIS MONUMENT TO
JAMES WATT
WHO DIRECTING THE FORCE OF AN ORIGINAL GENIUS,
EARLY EXERCISED IN PHILOSOPHIC RESEARCHES,
TO THE IMPROVEMENT OF
THE STEAM ENGINE
ENLARGED THE RESOURCES OF HIS COUNTRY; INCREASED THE POWER OF
MAN
AND ROSE TO AN EMINENT PLACE
AMONG THE MOST ILLUSTRIOUS FOLLOWERS OF SCIENCE AND REAL
BENEFACTORS OF THE WORLD.