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THE AMERICAN WATCH WORKS.

BY H. C. HOVEY.

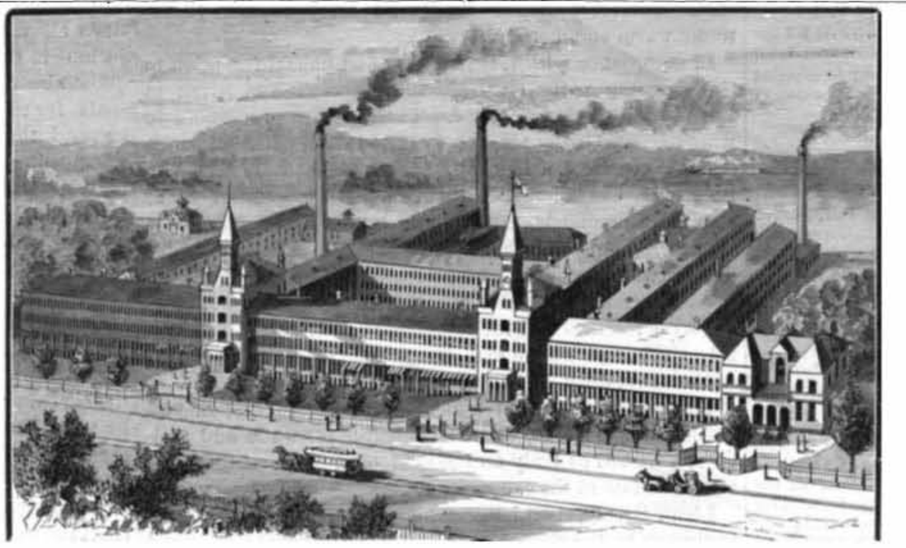
A watch is a machine. It used to be supposed that its delicate parts could only be made by manual skill; and in a large portion of the world this notion still prevails. The idea that a machine can be made by machinery, much of which is automatic, is essentially American. In its application to the watchmaking industry it originated with Aaron L. Dennison, a Boston watchmaker, who began his experiments in 1848. In company with Edward Howard and Samuel Curtis, a small factory was started, in 1850, at Roxbury, Mass., which was removed four years later to Waltham, ten miles from Boston, a place already famous for the first cotton mill started in this country.

After struggling with numerous unforeseen obstacles, these pioneers in a new industry failed financially; and their property was bought, in 1857, by Royal E. Robbins, for Appleton, Tracy & Co., the name being subsequently changed to Robbins, Appleton & Co. In 1858 the property was bought by the American Watch Company. The original stock capital of $200,000 has been increased to $1,500,000, with an equally large surplus. The number of hands has grown from 75 to 2,400. And in place of the small factory existing in 1857, there was built a much larger one, that in turn gave way to the immense structure now in use, and that has been wholly built since 1878.

A few figures will perhaps convey an idea of the magnitude of the Waltham Watch Works in their present form. The factory itself is a brick building, with numerous long wings, several towers, and inclosing three ample inner courts, besides an elegant suite of offices at one end and an observatory at the other. The total length of the front is over 700 feet. The floors cover nearly five acres. There are 3⅛ miles of work benches, mostly made of cherry plank, 2 feet wide and 2 inches thick. There are 4,700 pulleys; 8,000 feet of wall rods; 10,600 feet of main shafting, and 39,000 feet of belting, varying in width from 2 inches to 2 feet. All this machinery is driven by a Corliss engine of 125 horse power.

When Mr. Robbins took hold of what was then regarded as a forlorn enterprise, only 5,000 watches had been made in all. Now over 2,500,000 have been made thus far at this one factory, of which 500,000 were made during the last eighteen months! The present capacity of the works is 1,250 watches daily, which by recent improvements will soon be increased to 2,000. There have actually been sent

(*Continued on page* 102.)



VIEW OF THE WORKS AT WALTHAM, MASS.

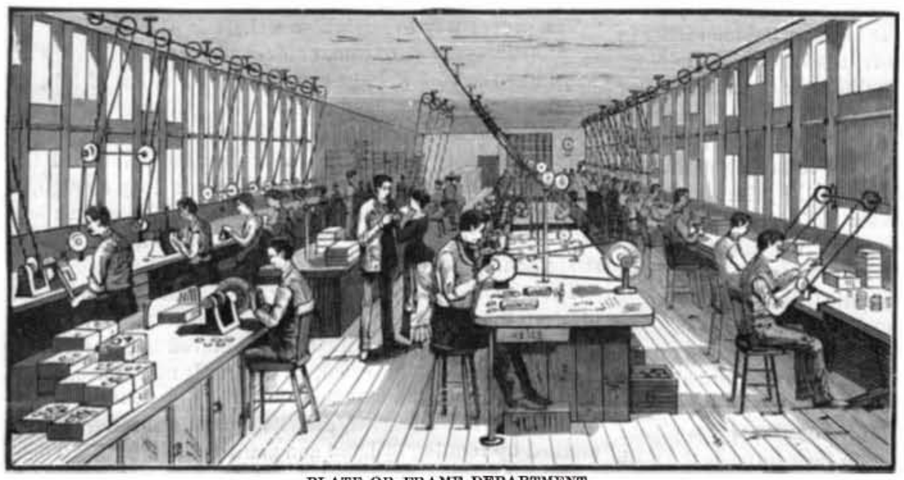
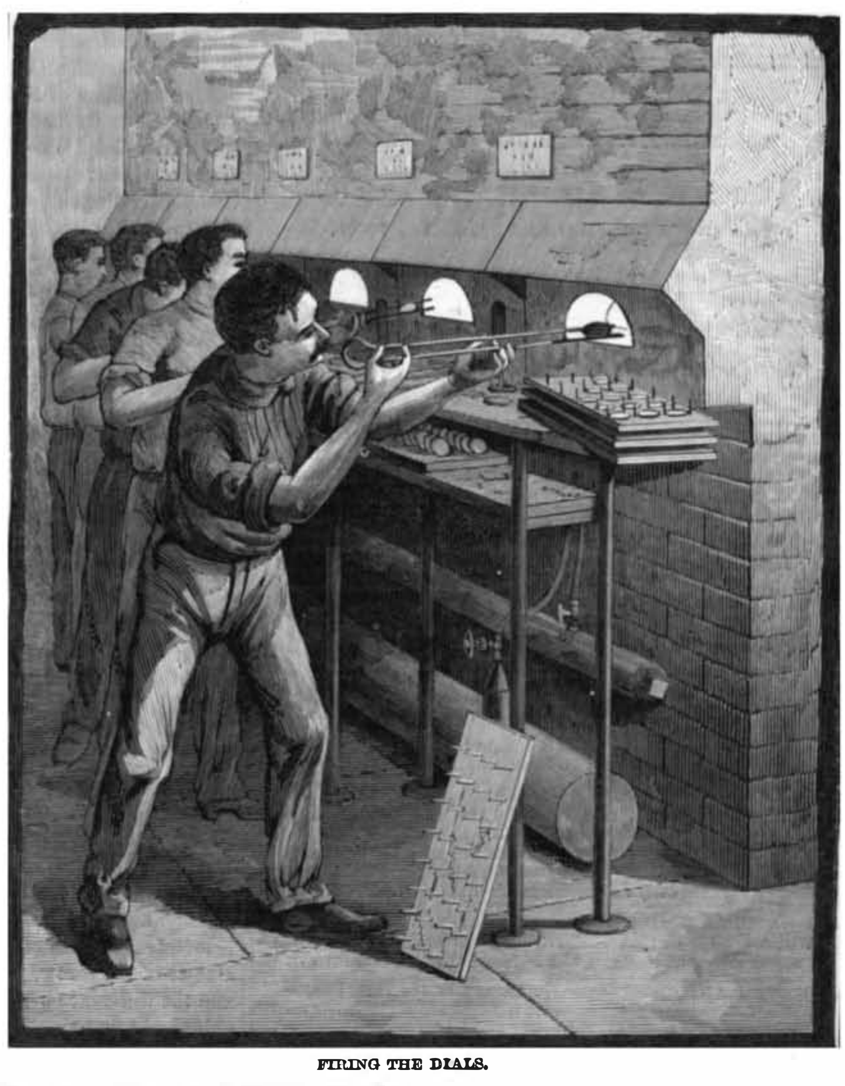


PLATE OR FRAME DEPARTMENT.

BALANCE MAKING ROOM.

GAUGING HAIR SPRINGS

JEWEL MAKING.



FIRING THE DIALS.

AMERICAN WATCH MAKING, AS CONDUCTED AT WALTHAM, MASS.

THE AMERICAN WATCH WORKS.

(Continued from first page.)

out 30,000 in a single month, and 30,000 watches are needed all the time in the finishing rooms to enable the hands to work to advantage.

Out of the American Watch Company all the others have originated, namely, those at Elgin, Rockford, Aurora, and Springfield, Ill.; at Springfield, Mass.; Lancaster, Penn.; Nashua, N. H.; Columbus, O.; Fredonia, N. Y.; Marion, N. J.; besides others that have failed and others just starting. Taking no notice of cheap, inferior goods, there are made, on an average, 3,650 watches a day by nine first-class factories. According to Mr. Robbins' estimate, the value of a year's product of gold and silver watches in this country exceeds $16,000,000; and the business directly and indirectly furnishes employment for 100,000 persons.

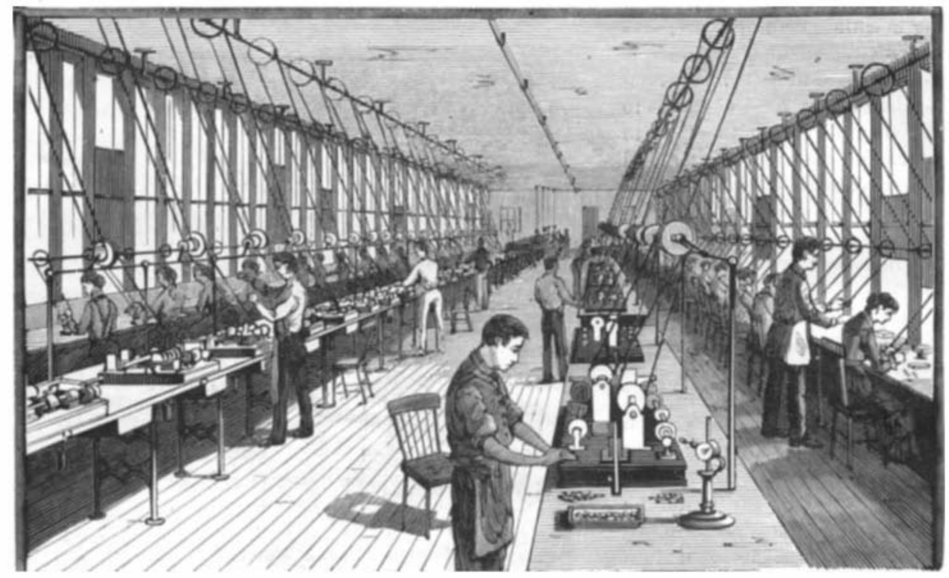
The factory at Waltham is located on an expansion of the Charles River, and is environed by parks maintained at the company's expense. The rooms are thoroughly ventilated, and all the sanitary arrangements are excellent. Consequently the operatives are a remarkably healthy, cleanly, and bright set of people, mostly young persons, whose unimpaired eyesight and steady nerves qualify them for the delicate work before them. Intelligence and integrity are also required in a business involving the handling of quantities of precious metals and jewels.

For certain kinds of work female operatives are preferred, on account of their greater delicacy and rapidity of manipulation; and it should be added that women get the same wages as men for doing the same kind and amount of work. All the apartments are lighted by large windows by daytime, and for night work there are 200 incandescent electric lamps and 3,500 gaslights, requiring over 22½ miles of piping. There are 38 furnaces using gas as fuel.

There are 25 distinct departments, each having its foreman, and all in telephonic communication with the central office. Mr. Ezra C. Fitch is Superintendent, recently at the head of the salesrooms, at No. 5 Bond Street, New York. G. H. Shirley is Assistant Superintendent, E. A. Marsh is the Master Mechanic, and D. H. Church Master Watchmaker, through whose kindness the writer had access to the various departments.

Most of the foremen and a number of the hands have been in the employ of the company for from twenty to twenty-five years. The "Foremen's Association," of which Mr. H. N. Fisher is President, meets once a month to discuss matters relating to the advancement of the work. Probably few persons realize how many distinct operations are required to produce a single watch. The managers themselves did not like to make a statement until at my request the question was laid before the foremen: "How many distinct mechanical operations are required in order to construct one of the grade of watch movements described as an 18 size, full plate, stem-winder, jeweled 4 pairs?" Each foreman made a list of the operations in his own department, and the startling sum total was 3,746; and the number would be considerably larger for some of the higher grades.

It is evident that the mere *finish* of a watch is no test of its excellence. The greatest pains are taken by the American Watch Company in perfecting the original model. Every variety of design and appliance that human ingenuity can devise is sought for; and a retinue of special artists, draughtsmen, and inventors is continually busy to make each part and process as economical and accurate as possible. The various machines are thoroughly and exquisitely exact. They are all made in the extensive machine shops belonging to the company. A great hue and cry has been raised in Europe against machine-made watches, as if necessarily clumsy and defective; whereas the reverse is true. In the anxiety to secure a high finish, many a hand-made watch is polished to death. The aim of the American Watch Company is to secure actual interchangeability of pieces. It may be too much to say that the corresponding parts of all their watches are identically alike. But they will come within one ten-thousandths of an inch of it! *e. g.*, a jewel hole should be two ten thousandths of an inch larger than the pivot that works in it. A few turns of the polisher would make a change. Hence microscopic measurement has to be resorted to in fitting pivots to jewels. But ordinarily, in assembling parts together, no measurement is necessary, but they are used exactly as they come from the machines. Furthermore, automatism in tools is the coming necessity for cheapening labor. The American Watch Company already uses many automatic and semi-automatic tools, and is constantly inventing more. The work thus secured is so nearly perfect that should any part of a watch fail in actual use the owner need only send on the number of the movement to enable the factory to supply an exact duplicate of the part. The order could be sent by postal card, and filled by return mail. To facilitate this a systematic record is kept; and this is so well done that any watch ordered could be located at any stage in its manufacture; and the same could be done for 1,000 or for 10,000 watches.



SCREW MAKING ROOM.—AMERICAN WATCH CO.

The "movement" of a watch is made up of two plates and the wheels, etc., between them. It may be as well, before going further, to refresh the reader's memory as to the general mechanism of a watch. The plates are known as the pillar plate and the top plate. On full plate watches the most peculiar thing is the barrel bridge, the object of which is to allow room for the main spring. A three-quarter plate is flush and the top plate not cut through, the main spring being narrower than in the former. All American watches have what is called a going barrel, instead of the fusee, preferred in the English system, though long discarded by the Swiss as superfluous. The going barrel contains the main spring, and drives the center wheel and pinion, which revolve once an hour, carrying the minute hand. The third wheel and pinion are simply intermediate between the center wheel and the fourth wheel, which carries on its staff the second hand, revolving once a minute. The fourth wheel also drives the escape wheel, so called because it only lets one tooth escape at a time, bringing the machine to a dead stop five times every second. They used to make all watches with 14,400 beats to the hour (or 4 to the second); this is called "slow train," and is now obsolete except for one-quarter second or "stop watches." The English standard was advanced to 16,200 beats to the hour (4½ to the second). The Swiss and American standard is 18,000 beats to the hour (5 to the second), called "quick train." Experiments have also been made up to 21,600 beats to the hour (or 6 to the second), called "fast train;" but results are not satisfactory. Experience has proved the "quick train" watches to be the best timekeepers.

The factory watches are all "lever escapement," universally accepted as best for pocket timepieces. The lever consists of a pallet and fork, and receives an oscillatory movement from the escape wheel. The balance, to which the lever imparts motion through the medium of the roller jewel passing alternately in and out of the fork, regulates the whole machine. It consists of a comparatively heavy wheel running on an axis with finely adjusted pivots, and with the least possible friction; and a hair spring attached at one end to the balance wheel and at the other to the balance cock, which is fastened to the top plate. The value of the hair spring is to determine the speed with which the balance wheel vibrates (*i. e.*, five beats a second). The balance is bimetallic, to correct the contraction or expansion of the hair spring, so that the watch may run true regardless of temperature.

THE CASE MAKING DEPARTMENT.

The minute and hour wheels are located under the dial, and are driven by a system of gearing. The cannon pinion fits friction tight on the center staff, being so put on to enable the hands to be set. The cannon pinion drives the minute wheel, and the minute pinion drives the hour wheel; the proportion being such that while the former revolves once an hour, the latter revolves once in twelve hours. Most of the watches now made are wound up by turning the stem of the case, and the hands also are set by a similar device, dispensing wholly with the watch key.

The safety of all this complicated movement from any injury that might result from the breaking of the main spring is secured by a safety-pinion screwing on to the arbor of the center wheel by a triple left hand thread. Should the mainspring break, the recoil would merely unscrew this pinion, and thus release the whole movement without any consequent damage.

A volume would be needed to describe all the 3,746 operations required for the construction of an ordinary watch. But a general description of the main departments may meet the demands of the present article.

The Plate Room is where they manufacture the pillar and top plates. The material used is generally brass, although nickel is used for some of the more costly watches. The plates are rough punched by the Scovill Manufacturing Co., at Waterbury, Conn., and brought in this form to Waltham. Eighty operations are required for the pillar plate alone. These include facing off both sides; punching for dial feet, which are guides through all subsequent operations; turning for diameters; drilling, countersinking, burring, recessing, tapping, stoning, numbering, finishing both sides; putting in the pillars and turning and drilling them; making and inserting the click stud; cutting recesses for the lever arm, the barrel, and the various wheels; putting in the minute wheel pinion, and drilling and cupping the train holes. The pillar plates are then distributed in sets of ten trays, ten boxes to a tray, ready to receive the other parts. The top plate also goes through a like process, being punched, recessed, milled, pierced by screw holes, numbered, drilled, tapped, and stoned, potance put in, and the plates distributed. The parts being assembled and screwed together, several operations are performed, after which they are taken apart and finally distributed. During this process, at various times, the plates have to be boiled in soapsuds to clean them from dirt. The *barrel bridge* is also punched, trimmed, stamped thrice, milled, recessed, and distributed. The *balance cock* is trimmed, flatted on emery wheels, turned to thickness, the star wheel regulator

THE AMERICAN WATCH CO.—THE PINION ROOM.

put on (an improvement on the arm regulator); it is stamped, burred, drilled, tapped, beveled, etc., and finally they are strung up by hundreds to be sent to the jeweling room.

The ratchet cap for the winding wheel is turned, drilled, recessed, etc., finished, and sent to the gilding room. Thus there are 157 operations in the plate room alone, as I made out my list going from bench to bench, only a portion of which are indicated above, but each requiring great care and precision. My first intention was to go through each department with equal thoroughness; but the task would have taken a month, and the results would have required many explanations to make them generally intelligible to any but experts. Hence in describing remaining departments I shall give salient points instead of detailed processes. *The Press Room* is in charge of N. P. Mulloy. The first thing that was exhibited was a sort of cabinet, in whose glass jars and tiny drawers are myriads of parts of watches, each sort labeled, *e. g.*, regulators, yokes, forks, cam clicks, lever springs, winding wheels, train wheels, gold and steel balances, hour hands, minute hands, second hands, etc., everything in short that can be made by *punching.*

The effect is striking of seeing so many objects of a kind massed together, *e. g.*, 10,000 second hands in one jar—the result of one day's work in that line, the monthly order calling for 160,000. The counting is done by weight. A box of center wheels, was weighed in my presence, and found to weigh 146¾ oz. A single ounce was then weighed, and the wheels were counted and found to number 136. Consequently it was ascertained that there were 19,979 wheels in the box. Some idea of the multiplicity of operations in this department may be had on learning that there are over 200 different sorts of hands now made! Many parts made here, and in other departments, are so small as to be almost microscopic, and measurements have to be made by a fine gauge micrometer. Curious to see the working of the instrument, I measured a single hair, finding it to be $\frac{6}{1000}$ of a centimeter in diameter. Many operations have to be verified to within $\frac{1}{2000}$ of a centimeter, *i. e.*, to $\frac{1}{10}$ the thickness of a human hair!

Visitors always notice with interest the double row of iron tumblers whirling oddly in every way, used for brightening by attrition the steel works which are too minute to be polished by hand.

The Pinion Room, in care of Martin Thomas, who has been in the employ of the company for 23 years, has another cabinet of jars, boxes, and drawers, with pinions of every sort and in every stage. Probably as much is involved in perfecting the pinions as in any other department of watch making. Everything must be as exact as possible. The process begins with cutting the wires to be used in lengths of 18 inches. Then these are cut automatically to the right lengths, roughed out, and pointed. Five or six turnings follow, and then the leaves (or teeth) are cut. It has long been known that these should be epicycloidal in form; but under the old system it was difficult to effect this with desirable exactness. Drawings on a large scale could be made with mathematical precision; but it was another thing to reproduce them in almost microscopic miniature. And then, it is said, that many workmen had a singular prejudice to these peculiar teeth, fancying than to resemble bishops' miters! Here the superiority of machinery over handwork is visible. Machines have no prejudices nor æsthetic notions, and are as able to shape a little pinion exactly as the great wheels of the largest engine. The cutters and polishers of the machine for making the pinions are themselves kept true and in perfect order by a machine invented for giving the exact epicycloidal form. The final result is that, when all the parts of the watch are assembled and set in motion, the action is perfectly smooth and continuous, an end that cannot be secured in any other way. This statement holds good for all grades of watches made here, the cheapest as well as the most costly.

After the leaves have been cut, the pinions are hardened and tempered, polished and finished ready for use. Seven barrels of flour a month are consumed in making dough for various uses, besides many barrels of pith, and quantities of rouge and Vienna lime. At the time of my visit pinions for 100,000 watches were actually going through the works.

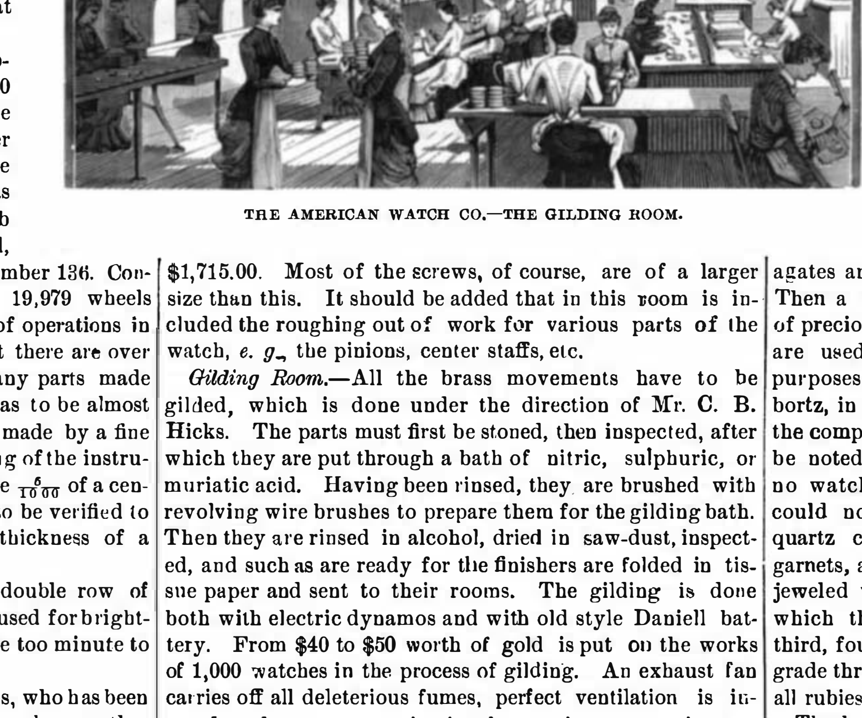
The Screw Department exhibits the perfection of automatic machinery more visibly than any other. The foreman, Mr. C. H. Mann, assured me that, were it not for the necessity of hand finishing some of the finest work, there would not be needed more than a dozen workmen to make the daily average of 100,000 screws. There are twenty-four of these automatic machines, each making from 3,000 to 4,000 screws a day, not including night work. There is also an automatic pin machine that makes 20,000 pins a day for use in fastening hair springs. All these machines were invented and made here. The material used for screws is mostly the finest of Stubs steel; but some of them are made of brass and others of gold. Most of the wire is purchased of the proper size and supplied to the machines, which then make the screws, after which they are hardened and finished. The process for common work is to put several hundred screws on a block to be ground off on laps.

The finest quality, however, have to be finished and blued singly, and all counted, because done by the piece. To illustrate the possibilities of this department, Mr. Robbins assured me that from steel wire, costing the company but $5.00 they could make 247,000 screws, weighing one pound, worth $1,715.00. Most of the screws, of course, are of a larger size than this. It should be added that in this room is included the roughing out of work for various parts of the watch, *e. g.*, the pinions, center staffs, etc.

THE AMERICAN WATCH CO.—THE GILDING ROOM.

Gilding Room.—All the brass movements have to be gilded, which is done under the direction of Mr. C. B. Hicks. The parts must first be stoned, then inspected, after which they are put through a bath of nitric, sulphuric, or muriatic acid. Having been rinsed, they are brushed with revolving wire brushes to prepare them for the gilding bath. Then they are rinsed in alcohol, dried in saw-dust, inspected, and such as are ready for the finishers are folded in tissue paper and sent to their rooms. The gilding is done both with electric dynamos and with old style Daniell battery. From $40 to $50 worth of gold is put on the works of 1,000 watches in the process of gilding. An exhaust fan carries off all deleterious fumes, perfect ventilation is insured, and every precaution is taken against any poisonous effects from the various chemicals used.

Balance making begins with a plain steel blank made of best steel. According to the foreman, J. L. Keyser, there are 85 operations in all required for making an expansion balance. The principal steps are as follows: First the center hole must be drilled, after which the disk is turned to a true diameter. It is then forced into a recess of a low brass capsule, and a ring of high brass is inserted between them. Having been prepared with a borax flux, it is heated sufficiently to melt the high brass on to the steel. It is then faced off to a definite thickness, turned, and rolled to condense the brass. The back is ground and the face recessed; after which the steel is punched, leaving the arm. Drilling, tapping, and finishing follow. Finally, the screws, 22 in number, are put in, being of different sizes, weights, and metals to conform to the varying strength of the hair spring.



THE AMERICAN WATCH CO.—MAKING ESCAPEMENTS.

The Escapement includes the roller, roller jewel, pallet with its two jewels and arbor, fork and guard pin, screws, escape wheel and pinion—thirteen pieces in all—requiring the most exact precision. The mechanical principles involved are such as have been determined by repeated experiments, but cannot be easily explained without voluminous detail. This department is in charge of Mr. H. N. Fisher.

The escape wheel cutting is done by an automatic machine carrying six cutters, three steel and three sapphire. Fifty wheels are cut at a time, and it takes six cuts to make each of the fifteen teeth. The machine stops when they are done. Each wheel is then set on its pinion and topped, to make it sure that it will run true in the round.

The garnet pallet stones are placed 30 or 40 together, on a steel block ground, and finished on one side and then on the other. The edges are finished the same way. They are then stacked on a graduated plate, and marked with a diamond to be broken off to a length. They are then put in a grooved plate, set at the desired angle for the impulse force. All are finished with diamond dust on ivory laps. The polishing is done with an oscillatory motion, so as to give less bearing for the escape wheel. Jewel pins are shellacked into a spindle, in rectangular slips, turned with a diamond to remove corners, then ground with copper laps, and polished with shell laps charged with diamond dust. One side is flattened for one-third its length, and than they are ready for setting.

Matching the escapement is done in the watch, which is regarded as preferable to the old method of doing it by the depthing tool.

The Jewel making department is under the direction of Wm. R. Wills. The first object exhibited was a cabinet containing agates and other materials for making polishing laps. Then a safe was opened containing about $50,000 worth of precious stones. To some extent Brazilian diamonds are used for splinters to drill with. But for general purposes African diamonds are good enough. Diamond bortz, in the rough, costs $1.50 a carat, or $225 an ounce; and the company requires about 12,000 carats a year. It should be noted, however, that, contrary to the popular notion, no watch jewels are made of diamonds, because they could not be drilled. Glass also is never used, nor quartz crystal. The stones used are rubies, sapphires, garnets, and occasionally crysolite and aqua marine. A full jeweled watch takes 19 jewels, called, for the pieces to which they belong, balance, end stone, escape, pallet, third, fourth, and center jewels. Every watch has the same grade throughout, *e. g.*, one will have all garnets, another all rubies, etc.

The balance jewel, however, in all watches is either ruby or sapphire. There are 40 different grades of garnets; but the only sort used here is the hard violet from Bohemia and Germany. The process of making diamond dust is, first, by means of a crusher, and then a steel mortar held down by heavy weights. The result is a powder one-fifth diamond and four-fifths steel. After separation the dust is used in that state for diamond saws only; but, for polishing, it is graded by successive precipitation from olive oil. The jewels, having been sawed into thin slabs, are next rounded to size, shaped, drilled, and faced. The jewel hole is opened to a certain size, varying from 0·005 to 0·020 of a centimeter, in order to fit the pivot—a process requiring the finest possible finish and polish, regardless of the quality of the stone. There were made, in the month of June, 350,000 jewels, employing 255 hands, of whom 175 were males.

The Hair Spring is a tiny thing, but has a department of its own under Mr. Thomas Gill. The material is steel wire 0·022 of a centimeter in diameter, and spun for this special use. It comes in coils, and the first thing done is to draw it through ruby and sapphire dies down to 0·018 of a centimeter. Next, it is rolled flat between hardened steel rollers, and afterward drawn between pairs of diamond dies, from which it comes out 0·027 of a centimeter wide and 0·908 thick. It is then cut into lengths of 14 inches, which are wound in little boxes, three in a box, these wired together in pairs, face to face, and hardened and tempered. They are then separated, cleaned by acid, and blued. The spring is now attached to a brass collet in the center, and to a steel stud at the outer extremity. Gauging the hair spring is a delicate operation. The gauge is a dial plate, 7 inches in diameter, beneath which is a spring of known strength attached to the center staff and jeweled. This dial is accurately divided into 2,000 divisions, each 0·01 of an inch wide. The hair spring is put on the end of the staff, where it is held by friction; the stud being attached to an arm held by an outer ring revolving about the dial, which is stationary. One revolution is made each way, and the strength of the hair spring determined by an index hand attached to the staff. It is seldom equally strong both ways, the variation amounting to from 5° to 10°; the average strength is about 1,000°. It takes so many degrees of strength in a hair spring to run a certain weight of balance and make the requisite number of beats per hour. All balance wheels are weighed; the average being 8 grains. One degree on the dial equals about 4 seconds of time an hour, and in the balance 0·01 of a grain makes the same difference. An exact record is kept of the weight of the balances, which goes with the work till it is completed. The last step is the actual timing and toning the hair springs in watches; after which they are laid away to be used according to their numbers. Each hair spring belongs to its own balance and each balance to its own watch, but they *do not meet each other till the watch is done.*

To show how greatly raw material can be enhanced in value by skill, it is worth mentioning that out of one pound (troy) of fine steel wire, worth from $2.70 to $5.40, may be made 17,280 hair springs, worth $7,152 at lowest wholesale prices.

The Dial Making Room is under Mr. Charles Moore, who has been with the company since 1859. The dial has a copper foundation, which is pressed and pierced at one operation. Next, the dial feet are brazed in. Pulverized enamel is laid both on the back and the face, and then fused on, or "fired." Having been smoothed they are fired a second time, inspected, and sent to the Painting Room, of which E. L. Hull is foreman. Here the face is spaced into 12 equal divisions that are indicated by lead pencil marks. Two circles are drawn likewise, to mark the length of the letters or figures. Dabs of paint go on where the hours are to be; enamel paint being applied by a camel's hair brush. When dry, the tops and bottoms are cut off to the proper length, then by suitable tools straight spaces are cut through, leaving the heavy lines of the "hours," and the surplus paint is carefully scraped off. Painters then draw in the hair lines of the hours, and put on the name of the company. The "minuters" next, by the aid of an accurately graduated machine, paint on the minutes. After inspection the dials go back to the third firing. A circular cut is then made through the enamel on both sides, and the intervening copper is burned out with acid, thus making a hole for the seconds dial, which has been undergoing operations similar to what has been described. After the edges of the hole and of the "seconds bit" have been ground and polished, the bit is soldered to its place.

Time regulation is, of course, very important. Two superior clocks are kept for this purpose; one for mean time, and the other for a constant rate. The Watch Company want to keep as near to the standard time as possible; but for practical purposes the main thing is to fix a uniform rate for adjusting their watches. Hence they are not content with Harvard time, because they evidently think they can do a little better; Harvard running its excellent sidereal clock for mean time rather than for constancy in time keeping. The Waltham observatory has a transit instrument, and an astronomical clock electrically connected with all the rooms where the timing of watches is an object. A chronographic record is kept, and a daily record of errors and variations of temperature and barometrical pressure. The clocks themselves are kept in a dark room whose temperature is maintained at 70° Fahr. all the year round. The barometrical pressure is regulated by an air pump for the constant timer, which is kept in an air tight case.

The Case Department is managed by Mr. Daniel O'Hara. Silver cases only are made at Waltham; the gold ones being all made at New York. The silver comes in bars, which are first rolled down and pressed into shape. Then the material goes to the turning room, where the pieces are snapped together and fitted. After the turners are through, the jointing and soldering are done. Now the cases are milled through for the joints, and the caps put on. In the opening room the winding crown is put on, and the joints fixed so that the case will open at right angles. It next goes to the springing room to receive the lifting spring and catch spring. The case is then taken apart for polishing, and the backs are sent to the engraver and engine-turner. It is now matched up again, and the pins put in, and finally polished; when it is backed and glassed ready for delivery. There are 150 operations needed to manufacture an ordinary watch-case. The department produces 650 silver cases a day, employing 400 hands. At the time of my visit they had on hand $90,000 worth of silver, and about $10,000 in gold for joints, etc., to guard which three large vaults have been constructed. The washings of aprons and hands, and the sweepings of the floors, and the cast-off garments of the workmen, are all saved up to be reclaimed in the refining room; and thus a large amount of metal is saved monthly.

While, as has been stated, it is the object of this article to treat the watch as a machine, rather than as merchandise, it ought to be stated, in conclusion, that the American Watch Company, besides its salesrooms at No. 5 Bond Street, New York, and at 403 Washington Street, Boston, has its agencies at Chicago, London, and Sydney. Most of the watches made are sold in this country; yet their excellence is appreciated abroad, as is proved by their increasingly large exportations.

Having inspected the shops at Waltham, a new delight was felt in looking at the finished watches as displayed to the public. My attention was especially directed to a newly invented case having no springs nor hinges, all parts screwing together, thus making the watch secure from dust and moisture. Also to fine timers with chronograph attachment, a Swiss invention for marking any particular moment, to within a quarter of a second, without interfering with the general movement. By pressing a spring, the sweep second hand is arrested; by another pressure it is made to fly back to 12; and by still a third pressure it is made to go again. The explanation is that the attachment is thus first lifted clear from the movement and temporarily detached, being afterward, by the same pressure, thrown into gearing again by means of a heart cam.

In reply to my inquiries, the following statement was made by Mr. Robbins, showing the augmentation of value of material by applied skill, movements only being considered:

A watch movement	18 size,		weighs	1 oz. 19 dwt. Troy.
" "	14 "	¾ plate,	"	1 oz. 13 dwt.
" "	8 "	"	"	1 oz.
" "	14 "	full plate,	"	1 oz. 9 dwt.

From these, and others taken at random, the conclusion was reached that the average weight of a watch movement is about 1½ oz. of metal, being nine-tenths brass, one-tenth steel, worth 3½ cents, brass being worth 30 cents a pound and steel being worth 62 cents a pound. These finished movements are worth, at manufacturers' prices, from $3.50 to $100 net.

Justice to the writer requires me to add that this article lays not the slightest claim to merit as from an expert, and quite possibly is in need of indulgence for errors of a technical sort. Yet for the general reader it may possess a certain interest and value of its own, as an impartial description and an unsolicited tribute to the science, perseverance, and skill characterizing one of the finest, most praiseworthy, and truly wonderful of our manifold American industries.

Photographs of Metallic Objects.

Although many persons will prefer to have a plain print of such an object as a medal or a piece of plate, there are others who may think that a photograph showing a metallic luster, and consequently very nearly resembling the original, is more satisfactory; and as it is very easy to make an excellent reproduction of a bright metallic object by transferring a transparent photograph to a metal or metallized surface, we propose to give some practical directions which will enable any person to make such reproductions.

The negatives for such pictures must be taken with uniformly dark backgrounds, as any light places would naturally show the metallic luster of the backing, and the effect of the picture would consequently be completely spoiled. In short, the background should be uniformly black, and ought to be reproduced on the negative as clear glass, or something very near to it.

As far as our experience goes, the best reproductions of metallic objects are made by developing a carbon print directly upon a metal plate—copper, either gilt or silvered, being most convenient. The prepared copper plates, which are sold at a moderate price for use by the engraver, are extremely convenient, as they may be had in a great variety of stock sizes, while the prepared surface is smooth, and in a good condition for being gilded or silvered. It is not worth while for us to give directions for gilding and silvering, as such work is done at a very low price by the trade platers and gilders, who abound in Clerkenwell. The commercial "brown" tissue is a good color for general work. As vigorous reproductions are generally required, it is well to use a rather weak bichromate bath for sensitizing—say about two per cent; and in other respects the mode of working is precisely that recommended for making carbon transparencies on page 359 of the present volume, the metal plate being used instead of glass.

The direct method on metal renders it necessary to use a reversed negative; and when an ordinary negative is to be printed from, it is necessary to transfer the carbon print from the support upon which it is developed, and this transfer may either be made upon a plate of metal or upon a sheet of metallized paper. When the carbon print is to be transferred after development, it is best to develop it upon a flexible support, as directed upon page 332, and to transfer it to the metal plate or paper—gilt or silvered—in the manner directed for ivory on the one hand, and for canvas on the other hand.

As many of our readers are not so far practically acquainted with the process of carbon printing as to be in a position to make an occasional print with a tolerable certainty of success, it is satisfactory to know that excellent metallic pictures may be obtained by making a transparent picture upon glass, in such a way that the image shows unreversed when looked at through the glass, and backing up the transparency with a piece of gold or silver paper. Transparencies made by the gelatino-bromide process of Mr. Wellington (page 79) are excellent for this purpose, but collodion, gelatino-chloride, collodio-chloride, or, indeed, transparencies by any other process, may be used.

M. Geymet recommends a somewhat complex process of transfer with collodio-chloride, which we may summarize as follows: A stout paper is coated with a moderately thick layer of plain gelatine, such a layer as would be produced by drawing the paper quickly over a solution of one part of gelatine in four of water, and this is coated with collodio-chloride, and printed as directed by Dr. Liesegang on page 772 of our volume for 1883. When toned and fixed the print is placed in water at a temperature of about 80° Centigrade, and as soon as the edges of the collodion film become loosened by the dissolving of the gelatine, a clean glass plate, which is about half an inch smaller each way than the print, is laid on a table, and the collodion print is laid down smoothly upon it, and after all inclosed air has been expelled by stroking with the hand, the loosened edges of the film are turned over the edges of the glass. It will now, in all probability, be easy to strip the paper away, leaving the collodion on the glass plate; but if the gelatine should not be sufficiently softened for this, the back of the paper must be treated with a sponge saturated with hot water. When the paper has been removed, the same sponge serves to clear away all traces of gelatine from the film. A sheet of white paper is next taken and laid upon the film, care being taken to insure contact all over by stroking it down with the hand or with a squeegee. The edges of the collodion film, which were previously turned over the glass, are turned back on the paper, and the paper, now carrying the film, is slowly stripped off the glass.

All is at last ready for transfer to the final support, whether this be gold paper, silver paper, or a metal plate; but this support should have been previously gelatined by having a solution of six parts of gelatine in one hundred parts of lukewarm water poured over it. The surface thus gelatinized is allowed to dry, but should be dipped in water immediately before the final transfer is made. The collodion film (now supported by the paper) is laid down on the final support, and the paper backing is next smoothed down with the hand so as to expel all air bubbles, and the whole is allowed to dry. It is now easy to strip off the paper covering, and the picture should be varnished with an amber and chloroform varnish.

If it be desired to imitate the appearance of an old and tarnished metal object—say antique bronze—a little green and yellow aniline color should be added to the gelatinous mixture used in making the final transfer.—*Photographic News.*

A New and Startling Invention.

Under the above heading the N. Y. *Mail and Express* describes a new railway improvement which certainly has the merit of novelty. It is believed to be the invention of Major Bundy, the editor of the above journal, notwithstanding he credits its authorship to a citizen of Connecticut. The frequent attempts of railway trains to pass each other on the same track have been attended so uniformly with disastrous consequences, that it has become to be the general belief that the feat is impossible, and that engineers will do well to desist from further efforts to accomplish it. To the ordinary mind it seems inevitable that if two trains approach each other on the same track, and do not slacken their speed, a collision must ensue. But there is a man in Connecticut whose mind is not ordinary. Of course, we do not mean by such a statement to insinuate that the Nutmeg State possesses only one man gifted with extraordinary mental endowments. The woods there are full of them, but so far as heard from, there is only one who has exercised his genius in solving the problem of how to enable two trains to pass on the same track without collision.

The plan of this ingenious person is very simple, as all really great plans and ideas are. He proposes to place on the front of every locomotive going in one direction a long inclined plane, upon which are two rails. These come close to the track at the forward end of the plane, and at the hinder end are connected with other rails that run along the tops of the cars, and down to the main track again on another inclined plane in the rear. When the train provided with this attachment meets another on the same track, the latter simply goes over the former, its weight making the connection of the front of the inclined plane and the rails of the main track perfect, and acting at the same time as a brake on the speed of the train underneath.

If this invention had been made a few years sooner, the number of double track roads in the country would not now be half as great as it is. A single track, with occasional switches for heavy freight trains, Major Bundy says, would answer all purposes, and the cost of constructing railroads would be decreased 25 per cent. The system will, of course, be adopted immediately on all single track roads, and within a few years the sensation of riding over or under another moving train will be so common as to pass almost unnoticed. This is a great country.

Power for the New Orleans Exhibition.

Director-General E. A. Burke has accepted the following proposals to furnish engines for the World's Exhibition:

	No. Engines.	No. H. P.
Cummer Engine Company	1	180
Cummer Engine Company	2	300
W. A. Harris	1	650
W. A. Harris	1	150
E. P. Allis & Company	1	500
Brown Engine Company	1	400
Robert Wetherill & Company	2	600
Armington & Sims Engine Company	4	500
Westinghouse Engine Company	2	400
Taylor Manufacturing Company	1	200
Smith, Meyer & Schuer	1	200
Novelty Iron Works	1	200
Buckeye Engine Works	1	125
E. M. Ivers & Son	1	100
Lane & Bodley	1	75
Jerome Wheelock	1	280
Hooven, Owens & Rentschler	1	500
Total	23	5,360

Flight of an Exploded Boiler.

A Lynn, Mass., correspondent, referring to a recent remarkable flight of a boiler illustrated in these columns, reminds us that, about two years ago, there was a notable boiler explosion of a similar character in that city. The flying portion formed a large part of the whole boiler, describing a circle high in the air, and landing 900 feet from where it started.