

cial type of boiler. Reverting, then, to tube surface, we have to consider how it shall be used. The first essential is that both sides—in other words, the whole surface—of each tube shall be fully heated, and not one side only. The next is that care shall be taken that an ample supply of water shall invariably be provided to take up the heat. If we have a long tube of small diameter, say an inch, and a very fierce heat, so much steam may be made in the bottom of the tube that all the water above will be blown clean out of it. Then water will rush in from below or above to fill the space, and this in turn will be ejected. We could name more than one water tube boiler which behaved in this way when hard pressed. The makers called the action "circulation," but it was not circulation in the legitimate sense of the term; a boiler worked in this way will soon be burned out and cannot fail to prime heavily. This "gulping" action is exceedingly injurious, and to be strenuously avoided. Bearing in mind the stipulation that the whole surface of each tube shall be heated, it will be seen at once that it is expedient that the tubes should be short. It is also evident that they must either be vertical or very steeply inclined. Any approach to the horizontal will result in disaster unless the tubes be very short and at least 2 in. in diameter. It may be taken as a rule that the fiercer the heat, the more closely should the tube approach the vertical.

Experiment goes to show that so long as a tube is made of metal not too thick, and abundantly supplied with water, it is quite impossible to burn it. We have already in a former impression cited Mr. Maxim's experiments in this direction. Years before Mr. Maxim thought about flying machines, Mr. Pope carried out experiments with tubes made of common tin plate soft soldered. These were buried in a blacksmith's fire, and everything possible was done to destroy them, but fire capable of putting a welding heat on a 3 in. bar could not melt the soft solder on the tube. We may take it for granted, then, that we cannot produce too hot a furnace. In this direction, no doubt, torpedo boat builders have proceeded a long way, and when 70 lb. or 80 lb. of coal are burned per square foot of grate per hour the temperature is very high. But something still higher can probably be got with petroleum. The maximum temperature to be had with proper arrangements and oil fuel will probably suffice to melt fire bricks of good quality much like sealing wax. If, now, there is practically no limit to the rate at which water will take up heat, it seems to be not at all improbable that an evaporation of 20 lb. or 25 lb. of water per square foot can be had. The notion that the water will be driven away from the tube surface and assume the spheroidal condition has no foundation in fact. But very great care must be taken to prevent the clinging of steam to the surfaces. An evaporation so rapid means, as far as the tubes go, only 5 lb. of boiler, and allowing 5 lb. more for the rest of the boiler, and other 5 lb. for water, we have 15 lb. per horse power, or for 500 horse power 12,000 lb., or say 5 1/2 tons, instead of 13 1/2 tons; and allowing a ton for fire bars and funnel, we still have a boiler which gives us 100 to 120 horse power for considerably less than a ton. That such a boiler can be produced we have no doubt. That it has yet been made we doubt, although results of trials made in the United States seem to show that engineers have got within measurable distance of it at the other side of the water, and on a comparatively small scale. The boiler of the Yankee Doodle is said to have 300 square feet of surface, and to weigh only one ton under steam. Fig. 14 *ante* illustrates it. It will be seen that we have made a tolerably liberal allowance of steam per horse per hour, and certain very excellent performances accomplished in this country are more to the credit of the engine than the boiler—a fact not to be forgotten.

If our readers will examine the designs of any express boiler, or will set about scheming one themselves, they will quickly find that there is a great deal of surface—in other words, a great deal of steel plate—that is of no use for generating steam. Not only does this weigh, but it takes up room which can ill be spared. Let us suppose that we use vertical tubes 3 ft. long; under them come the feeders, say 1 ft. in diameter, and above them the receiver, say 2 ft. in diameter. As the feeders must be below the grate level, there is less than 3 ft. left between the grate and the bottom of the receiver, and even then the whole boiler is at least 6 ft. high. The steam receiver and separator over the fire is the great offender. If it could be suppressed or put in another position, considerable advantage would be gained as regards height. It is held, of course, that it is essential in order to get dry steam. If it satisfied this condition, and if nothing else would satisfy it, then we must perforce have it. But it may be shown that the horizontal cylinder of considerable diameter, lying along the top of the boiler, is not necessarily the only expedient by which dry steam may be got, and that, in point of fact, unaided it will not give dry steam at all. There are various ways in which steam may be dried without the use of an unwieldy and heavy cylinder holding a great deal of water. It is true that each steaming tube must deliver a very large quantity of water mixed with steam. The steam can scarcely fail to fill the whole diameter of a 1 in. tube, and in any case its upward rush will entrain much water. If the tubes deliver against a flat plate, the concussion will knock much of the water out of the steam, and various devices are available for getting rid of the remainder.

It must not be forgotten that all we have just written applies to a very special and peculiar type of generator, in which a great deal is sacrificed for the sake of getting the largest possible quantity of steam out of the smallest and lightest possible boiler, and it is not to be expected that such a boiler can compare in economical efficiency with others. If we took an ordinary railway locomotive boiler and cut most of the barrel and tubes off, we should have a very efficient generator left, but it would not be very economical. Let us suppose, for example, that we burned 80 lb. of coal per square foot per hour in the grate: that the boiler tubes were 12 ft. long; and that a certain weight of water was evaporated per hour. If, now, we cut away all the barrel, save enough to leave tubes 2 ft. long, then the evaporation would still be nearly 75 per cent. as great as before. There would be a loss in economy of fuel, but there would be an immense saving effected in weight and in space. Furthermore, the reduction in

the length of the tubes would permit us to reduce their diameter, and the economy and efficiency of the boiler would both be helped by that alteration. There is, indeed, no reason to suppose that an express boiler must be dreadfully uneconomical; but, on the other hand, any attempt to make it thoroughly economical will end in failure, unless indeed it is intended to use the boiler only for very short periods, in which case the spaces for the discharge of the products of combustion may be made contracted, but only by incurring the risks of sooting them up and ruining the draught.

There are, we have no hesitation in saying, possibilities in view which, made use of properly, will give us boilers of hitherto unrealized lightness and smallness. The principles to be observed are very simply stated. The first is that the heating surface, and indeed the whole boiler, shall be as far as possible tubular. The second is that every inch of surface not used for generating or drying steam shall be regarded as waste. The third is that great care should be taken to secure a regular discharge of steam from the heating surface. If the steam has any chance of hanging or clinging to the metal, disaster will follow. When we come to work with enormous temperatures, there is no time for the correction of an error. If, for instance, a tube should boil itself dry, in less than five seconds it would be white hot and would burst. Fourthly, special arrangements must be made for getting the water out of the steam. To comply with all the requisite conditions is very far from being a simple matter. So much has been done, however, that more can no doubt be done, and we do not despair of seeing a boiler which, complete, shall only weigh about 15 lb. per horse power, and nevertheless shall be sufficiently durable to

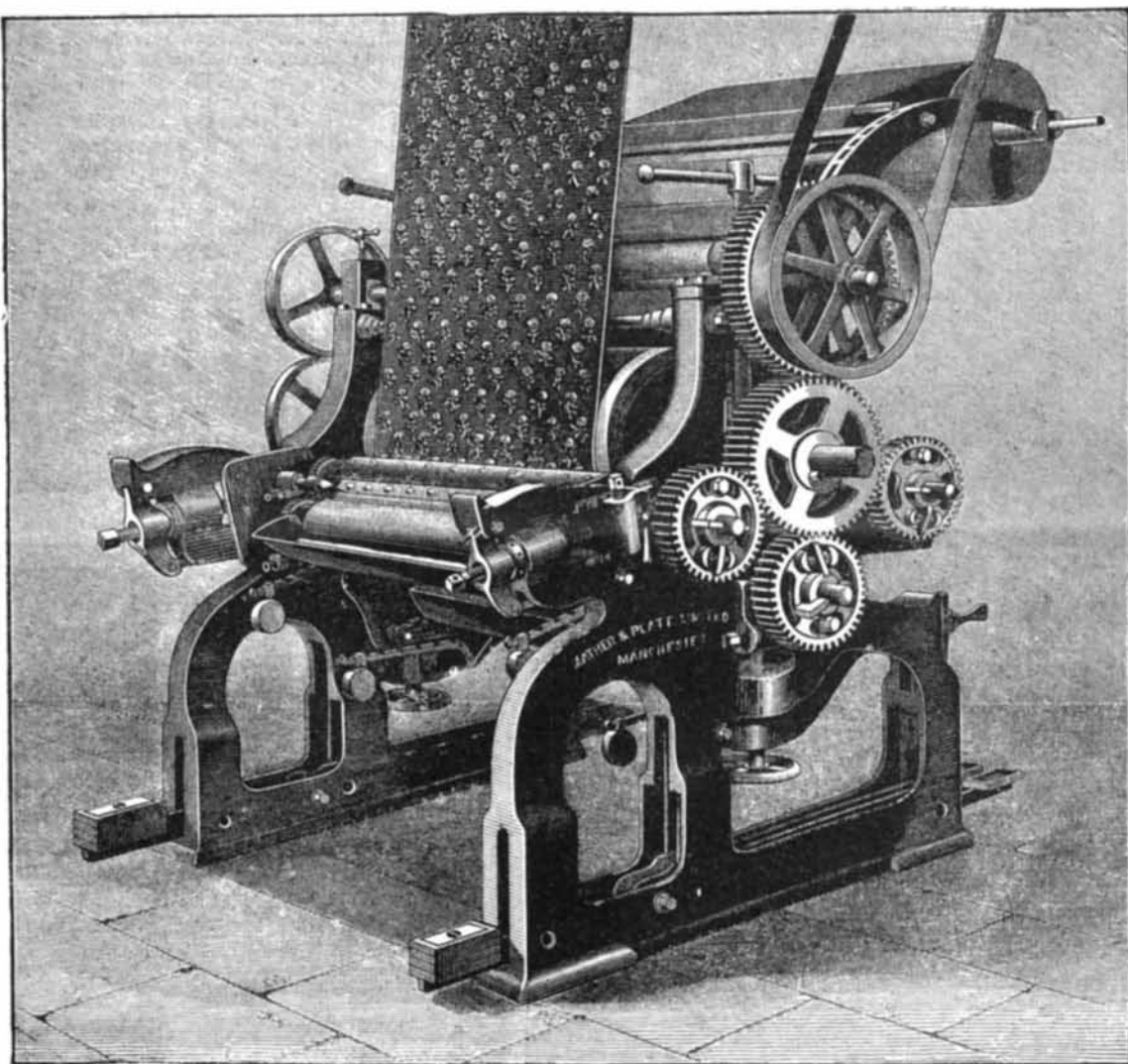
raised or lowered by screws. When the box is put in the machine the support is dropped, the color box put in and adjusted to exact position by means of the regulating screws. The furnisher is held in brass or gun metal bearings, fixed on the ends of the color box, and is driven by means of a toothed wheel, gearing into a similar wheel fixed on the end of the mandrel carrying the engraved copper roller. Thus it works generally at the same speed, or in some cases faster than the printing roller; many people are of the opinion that the furnishing roller should run about one-third slower than the printing roller. When it is required that the furnisher should travel in the opposite direction to that in which the pattern roller is going, a small toothed wheel, called a stud or stud wheel, is placed between the wheels on the ends of the furnisher and the print mandrel. This is nearly always done when printing colors contain large quantities of solid matter in suspension, such as all the pigment colors, and several other colors, that are liable to "stick in the engraving"—very often because it has not been there at all.

The engraved copper roller or shell is forced on to a wrought iron mandrel, which fits the bearings on the printing machine. The mandrel has a projecting tongue or "tab" which runs from one end to the other, and it fits a corresponding groove in the printing roller; thus the latter is prevented from turning on the mandrel.—*The Dyer and Calico Printer.*

#### THE SWORD OF ETHAN ALLEN.

By JOHN R. WEATHERS, Washington, D. C.

THOSE interested in the early events of our country, and especially those who are thrilled with patriotic



THREE CYLINDER CALICO PRINTING MACHINE.

satisfy all legitimate demands that can be made on a torpedo catcher.—*The Engineer.*

#### CALICO PRINTING MACHINERY.

By JOHN WATERSON.

ALTHOUGH the two cylinder vertical engine is the one which is the most popular for driving the calico printing machine, the three cylinder engine appears to be regarded as the best for this purpose. The general appearance and arrangement of the printing machine can be seen from the extremely good illustration, representing Mather & Platt's three color machine. In any printing machine the frame should be strong and massive, in order to stand the great pressure put upon it without springing, and it should be well bolted to an absolutely firm and unyielding foundation. The side blocks, holding the bearings of the printing rollers, should be long, and plenty of adjustment allowed in all the moving parts.

Every part of the machine should be thoroughly well made and finished and the fitting accurate. As the pressure on the bearings of the rollers is heavy, they must be kept well lubricated—tallow, or tallow mixed with finely powdered plumbago, being the best lubricator. When the bearing becomes too warm it is a very common practice to hang a continuous loop of cloth on the end of the roller that projects out, and immerse the lower end of the loop in a vessel of cold water. The revolving roller turns the continuous band of cloth and thus a fresh part, impregnated with cold water, is constantly brought into contact with the heated roller; hence the bearing is kept much cooler.

The color boxes are supported underneath the printing roller on wooden or iron stands, which can be

emotion at the stories of valor and devotion found in the history of the American revolution, will be pleased, I am sure, to know that the old sword of Colonel Ethan Allen is still preserved. The writer saw it recently in the National Museum, of this city.

The sword is an old-fashioned blade about twenty-seven inches in length and slightly curved. The handle is made of horn or bone, and is some seven inches long, making the total length, from tip to tip, about thirty-four inches. The mounting is of silver, marked with gold, but the latter is partially worn off. A dog's head of silver forms the end of the handle, and from this to the guard runs a silver chain. On one of the silver bands of the venerable leathern scabbard is the name "Ethan Allen" engrossed in large letters; on another band, "E. Brasher, Maker, N. York"; while on a third band appears the name "Martin Vosburg, 1775." What connection this last name has with the sword, no one seems to know.

Colonel Ethan Allen, the original owner of this sword, and whose fame has made it valuable and renowned, was born in Litchfield, Conn., January 10, 1737. He was active, patriotic and brave, and hated tyranny. Soon after the noted battle of Lexington, Mass., in the American revolution, Ethan Allen was requested by the General Assembly of Connecticut to enlist men and capture Ticonderoga, a strong fort in the State of New York, then held by British troops. He immediately raised 230 "Green Mountain Boys," and with them took the fort in the early morning of May 10, 1775.

In describing the assault, and the part the illustrious sword played in the capture, it is, perhaps, best to quote from Colonel Allen's memoir.

"At the time of the assault," says the colonel, "a British sentry made a pass at one of the American officers with his bayonet, and slightly wounded him. My first thought was to kill him with my sword; but in an

instant, I altered the design and fury of the blow to a slight cut on the side of the head, upon which he dropped his gun and asked for quarter. This I readily granted him and demanded of him the place where the commanding officer kept. The sentry showed the way. The British commander asked me by what authority I demanded the surrender of the fort. I answered him, "In the name of the Great Jehovah and the Continental Congress!" The authority of Congress," continues the colonel, "being very little known at that time, he began to speak again, but I interrupted him, and with my drawn sword over his head, I again demanded the immediate surrender of that garrison; with which he then complied."

The fort, the garrison, and about one hundred pieces of cannon were the result of this easy victory.

Colonel Allen died in Burlington, Vt., February 13, 1789, at the age of fifty years, leaving his sword to his son, Captain Hannibal M. Allen. At the death of Captain Allen, the famous blade was retained by his widow, Agnes B. Allen, who became a member of the family of her sister, Mrs. Benjamin Hopkins. But upon the marriage of her favorite nephew, Hannibal Allen Hopkins, she made her home with him for the last twelve years of her life. At her death, in 1863, the sword became the property of Hannibal Allen Hopkins; who, dying in 1871, left it, in turn, to his widow. This widow died a few years ago at Lansing, Mich., and the coveted sword passed into the hands of her son, Hannibal Allen Hopkins, Jr., through whose courtesy it has been loaned to the United States government and placed beneath a beautiful case in the National Museum, of this city.

This precious relic is a silent reminder of the great struggle through which our forefathers passed, for the overthrow of political tyranny and the establishment of a home for freedom and untrammelled intelligence.—*Education.*

#### STUDY OF SNOW CRYSTALS.

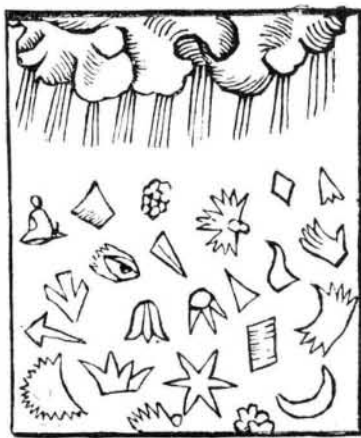
By Prof. Dr. G. HELLMANN.

(Translated for the SCIENTIFIC AMERICAN.)

In ancient and mediæval writings we find the form of the snow seldom mentioned. It was quite natural

that little attention was given to snow figures in ancient times, for the people of culture, who lived around the Mediterranean Sea, had rarely an opportunity of observing them. As might be expected, the earliest observations upon snow crystals were made by the people of northern Europe.

Albertus Magnus was probably the first one to call at-



OLAUS MAGNUS, 1555.

tention to the star-shaped form of the snow. The celebrated work of the learned Archbishop of Upsala, Olaus Magnus, which appeared at Rome in the year 1555, under the title of "Historia de Gentibus Septentrionalibus," contained a chapter on snow crystals, and likewise the first delineations made of them. On account of the great interest attending this first attempt to produce representations of snow crystals, a fac-simile is given. The author remarks in the text that the nearer one approaches the north pole, the greater is the abundance of snow figures. In one

day fifteen, twenty, or even more different forms may be observed.

He attempted to point out these varieties plainly in his drawings, but he undoubtedly allowed much play to his imagination, for hardly any of the figures correspond with those forms which actually appear in nature.

Although Olaus Magnus first called attention to and delineated the variety of snow figures, he overlooked the hexagonal form, which lies at the foundation.

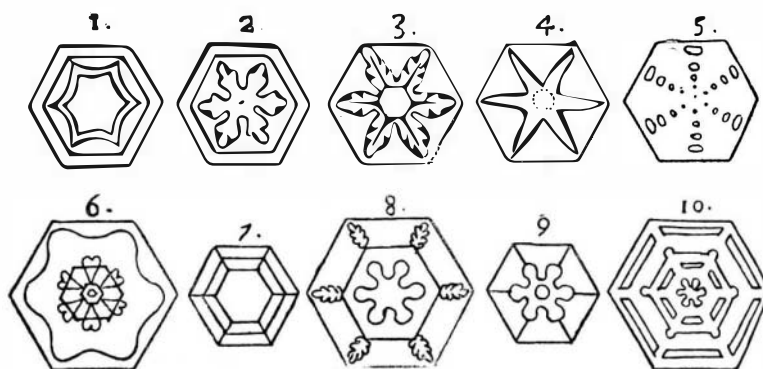
Kepler published, in the year 1611, the first book on snow crystals, "Strena seu de Nive Sexangula." Its purpose consisted not so much in describing new forms of snow crystals as to call attention to their hexagonal form. "Cur autem sexangula?" asks Kepler. He sought to establish various hypotheses which could not be maintained, assumed for each substance a peculiar forming or shaping power, and left the real solution of the problem to the chemist, who should say whether any salt or what kind was contained in snow.

The French scholar, Fabri de Peiresc, expressed his opinion, in the year 1623, that snow originated from seed, as plants.

The observations upon snow figures published by Descartes, in the year 1637, show a slight advance.

The Danish mathematician and physicist, Erasmus Bartholinus, published in 1660 "De Figura Nivis," which contained drawings of snow crystals. For the first time somewhat complicated forms are represented. Bartholinus certainly erred in his drawings, as he failed to draw the secondary rays parallel to the principal rays. We are not informed whether this scholar used optical help in his observations.

The English physicist, Robert Hooke, was the first to investigate the structure of ice, hail, and snow, by means of the microscope. His famous work, "Micrographia," contains a selection from more than a hundred forms observed by him. He has happily avoided the error in drawing of Bartholinus, for the conformity to law was known to him ("the branchings from each side of the stems were parallel to the next stem on that side"). In the year 1675 we obtain for the first time information in regard to snow crystals in the Arctic regions, through the German traveler Friederich Martens, of



D. ROSSETTI, 1681.

Fig. 43 i. 730.



Fig. 44 i. 730.



Fig. 45 i. 730.



Fig. 46 i. 730.

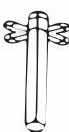


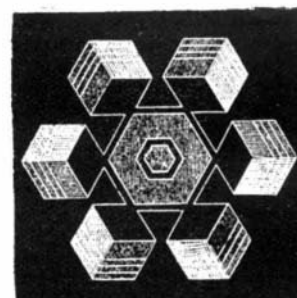
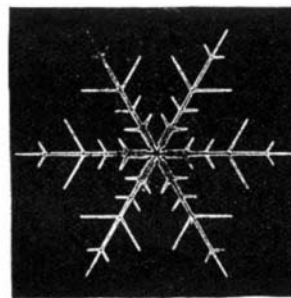
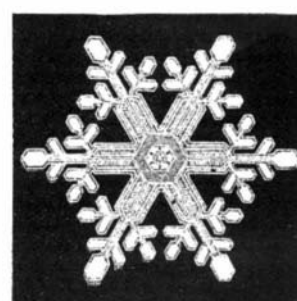
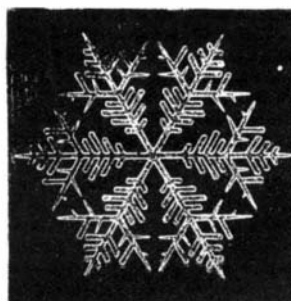
Fig. 47 i. 730.



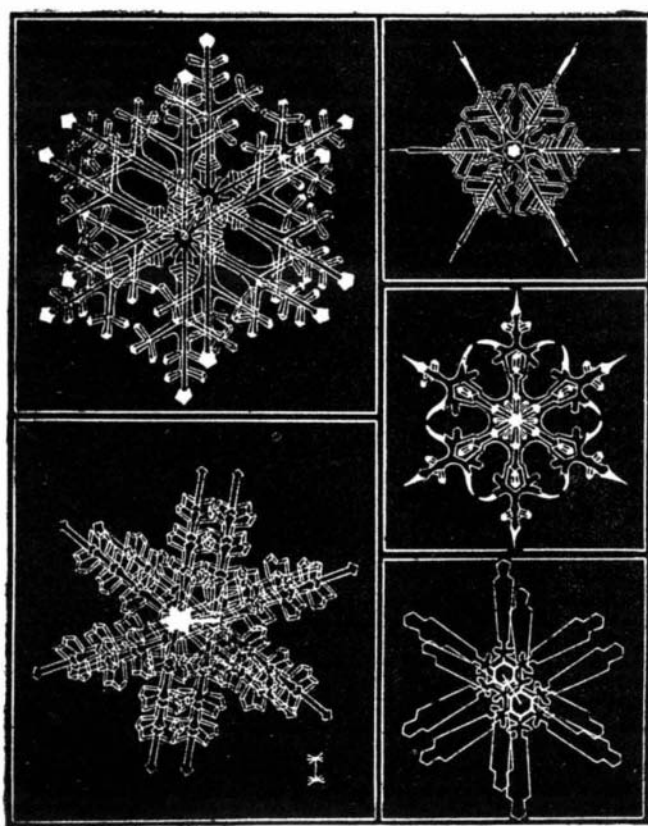
Fig. 48 i. 730.



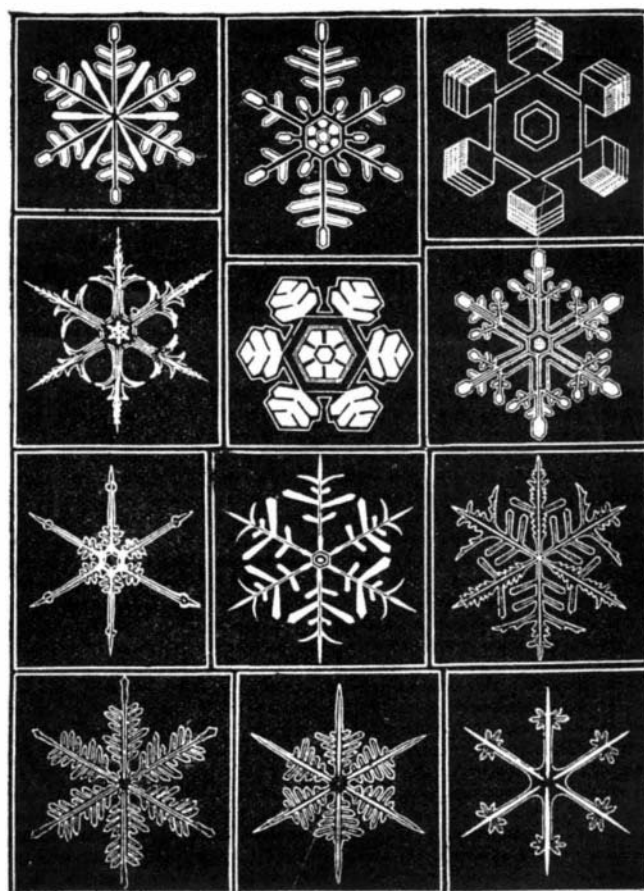
W. SCORESBY, 1820.



DRAWINGS BY J. GLAISHER, 1855.



DRAWINGS BY J. GLAISHER, 1855.



DRAWINGS BY J. GLAISHER, 1855.