

catechism. Though greatly extended in scope, it is still animated by the same cardinal principle. Each sect must defend itself by teaching its own dogmas to the youth, and, though every State college were to be abolished, there would be still as great a reason for maintaining all the denominational colleges. How long it would be before they would degenerate to the condition of mere sectarian propaganda, as before the revival, no one can say, but there would be a strong tendency in that direction. Freed from the competition of State colleges, their zeal in the teaching of science would soon lag. Not having ready access to the public means and resources of instruction, such as the State archives, maps, authorities, explorations, surveys, statistics, and to the avenues by which the State knows and readily regulates the great industries of the people, the church colleges would very soon see that there is an actual incongruity in their assuming to direct the scientific and industrial education of the people. It is the chief business of the church to look after the spiritual well-being of the people and not to fit them to carry forward the complicated machinery of modern civilization. Religion is the lubricator of this vast system, and the church is the agent by which it is applied. When the church departs from this sphere, she forsakes the true idea of the primitive church. When she leaves her spiritual kingdom and assumes to direct in the construction of steam engines, in the handling of theodolites and compasses, in the management of cotton-gins, in the measurement of the angles of crystals, and the distances to the stars, she may very reasonably be held to be out of her sphere. She has the privilege, of course, of doing all these things, and there was a time when she had good reason to do them, and was urged to do them, as the only capable agent; but that time has passed, and it can hardly be considered to be her duty to do them in the nineteenth century, when other agents equally capable have arisen, endowed with that special duty and function.

One of the boasted advanced steps of the nineteenth century is the separation of the church and State. In the mere manipulation of the governmental machine this is fully realized in the United States, and in much of continental Europe. But the administration of the laws is not the State, nor, indeed, is the making up of the laws, nor both of these united. True statesmanship surveys the whole body politic. It foresees and often institutes national enterprises. It watches the external and also the internal influences that move the masses; it takes advantage of the shifting markets for the domestic products. It notes the rise and decline of the various industries. It applies stimulants when needed and repression when necessary. In short, the State is an all-prevailing, energizing, regulating, far-seeing organization of the people; the culminating expression of the modern democracy. It is this machinery, which in our day is very closely connected with the appliances of modern science, which is not free from the church, but which the church assumes still to direct. Instead, we claim that it is the right and duty of the State itself to look after its own interests, and especially its highest interests, and to take measures to qualify citizens not only to read their ballots, but to discharge all the duties of high citizenship. There is no limit to this duty short of the necessity of the State, as has already been admitted. That which constitutes a State—"high-minded men"—is its necessity, and that it is the duty of the State to provide, to the end that its multifarious industry may be under the guide of the highest statesmanship.

THE French Government has appointed a committee, presided over by Rear Admiral Bourgeois, to study the different applications of electricity to navigation.

THE Society of Telegraph Engineers and Electricians will hold a meeting in Paris on September 21.

## MAGIC MIRRORS\*.

BY M. BERTIN.

[Translated from the French by Marchioness Clara Lanza.]

**LADIES AND GENTLEMEN:**—The term Magic was formerly applied to those metallic mirrors employed by sorcerers, necromancers, astrologers and charlatans, and by means of which spirits were invoked and the future predicted. These mirrors, transmitted from antiquity to the middle ages, were used to a very great extent about the sixteenth century, and up to two hundred years ago they were constantly seen in Europe. Now they are found nowhere except in the far East. We are able to furnish any amount of information about this strange superstition, but it is not of these mirrors that I intend to speak.

There is another kind of magic mirror, so-called because it produces effects apparently marvelous but real. History will tell you nothing, however, about these mirrors, and they are not even mentioned in any book of physics. Their appearance in Europe is quite recent, and as they are exceedingly rare, there is not often an opportunity presented for observing them. It is of this scientific curiosity that I shall talk to you this evening.

These mirrors are an uncommon variety of metallic ones. The latter you know were the first invented by man. The Greeks and Romans had no other kind, except a few specimens of glass mirrors made at the factory in Sidon. But glass when not quicksilvered does not make a good mirror, and it was not until the thirteenth century that quicksilver was employed for the purpose. Up to that date metallic mirrors alone were used, and even now some uncivilized nations employ and manufacture no other kind.

The Chinese and Japanese, for instance, are an example†. Since they have been in constant communication with European nations, however, they have partially adopted our glass mirrors and send us their metal ones as objects of curiosity. Chinese mirrors are exceedingly rare, so rare, in fact, that there is not one to be had in Paris. This leads me to think that they are no longer manufactured. Japanese mirrors, on the contrary, are very common. This is perhaps owing to the fact that in Japan the mirror is not only a necessary article for the toilet, but also an object of national worship. The primitive religion of the country, which is still embraced by the aristocracy and called *Synthism*, worships the goddess of the sun as its principal divinity, and the Emperors of the nation are supposed to be her descendants. This goddess invented the metallic mirror, and presenting it to her son bade him preserve it religiously. In the palace of Mikado, therefore, the mirror chamber is as carefully attended to as that of the Emperor himself, and often receives greater attention. In the temples of *Synthism* the only object of worship is a mirror, kept in a box covered with several wrappings of silk. Although this religion has been abandoned by the greater portion of the people, who have since become Buddhists, the mirror, nevertheless, has always remained a precious article. The ladies keep it raised upon a tall easel, which brings the glass upon a level with their eyes when they stand upon tip-toe. When they wish to remove it they hold it carefully by the handle, sometimes thrusting the latter into a piece of split bamboo.

These mirrors are of bronze of various sizes and shapes, but always portable. One side is polished and amalgamated. It is also generally convex, so that the images reflected look somewhat distorted. The other side is flat or slightly concave and is always ornamented by figures

\* Lecture delivered before the *Association Scientifique de France*.

† This statement is not altogether correct. The Chinese manufacture glass mirrors, and very seldom, if ever, use metallic ones any more.

in relief of more or less perfect workmanship. Japanese mirrors usually are more beautiful than the Chinese.

Here, gentlemen, are a few. I cannot pass them among you, but I can show them to you perfectly well by means of the magic lantern. This one is the copy of a mirror brought from Japan by Professor Dybowski. This second one belongs to General Teissier. The designs are of the reverse or unpolished side.

Among these mirrors there are a few of a lesser thickness, which possess a remarkable property. Although they reflect ordinary images in a diffused light, if a ray of sunlight falls across the polished surface and is reflected upon a white screen, the ornamentation upon the reverse side will be transported to the screen. This is what we call a magic mirror.

The first that appeared in Europe came from China. The Chinese, in fact, have known of them for a very long time. One of their historians who flourished in the eleventh century of our era, mentions them with admiration. Another writer, who lived in the year 1300, gave us a supposed explanation of the phenomenon. The Chinese Encyclopedia contains an article upon the subject, which has been translated by our great sinologue, Stanislas Julien. These mirrors have always been rare, but persons who have lived in China assure me that they can sometimes be found in Chinese curiosity shops.

We are not sure that the mirrors were ever purposely made. It is probable, on the contrary, that they are merely the result of imperfect fabrication. In regard to the Japanese this is absolutely certain, for magic mirrors are unknown in Japan. Neither the manufacturer nor the person who sells them has any idea of their peculiar property. European *savants*, however, have found magic mirrors from Japan many times. In 1832 M. Prinsep described one in the *Journal de la Société Asiatique*, which he had discovered in Calcutta. In 1877 Mr. Atkinson, Professor in the Imperial University of Jeddo, observed that numbers of Japanese mirrors produced magical effects. This attracted the attention of M. Ayrton, Professor in the Engineering School in the same city, who immediately began to investigate the matter. After examining five or six hundred he affirmed that three or four out of every hundred were magic.

Partially magic mirrors ought to be very common, and I am quite sure if I had been permitted to examine the Japanese collections in Paris, I should have found several. I am indebted to General Teissier for two beautiful mirrors that he brought from Japan. One of them is decidedly magic. I will have an electric light thrown across it and then upon the screen. You will see a part of the design upon the back appear.

Although we can furnish no written testimony concerning these mirrors, several learned men however, especially those who had traveled extensively, knew all about them. In the year 1830 Humboldt came all the way from Berlin to Paris, in order to show the Academy of Sciences a mirror which he believed to be magic. The experiments were made at the Observatory. Unfortunately there are no traces of them to be found in the scientific reviews of the period, but we know that the whole affair was a *fiasco*. Our illustrious chemist, M. Dumas, who was one of the investigators, affirms that Humboldt's mirror could not be considered magic in any sense of the word.

The first magic mirror that appeared in Europe was owned by M. Monchez, the Director of the Observatory in Paris. On his return from China he brought with him several mirrors, one of which was magic and had been sold as such. This mirror was presented to the Academy of Sciences on the 22d of July, 1844.

In 1847 a second one appeared belonging to the collection of the Marquis de la Grange. Stanislas Julien gave a detailed description of this one, in which he stated that the reflection obtained was identical with the reverse of the mirror, but that the latter was not in relief. This

mirror, therefore, should not have been magic at all, or if it was, all our modern theory would be upset. Many attempts have been made to find this mirror, but up to the present time the search has proved fruitless.

A third magic mirror was presented to the Academy in 1847 by Person, Professor of Physics in Besançon. Person's report consists of twenty-five lines only, but it is extremely important, as it contains the whole theory of magic mirrors, which, until then was unknown.

Finally, in 1853, Maillard presented the Academy with a fourth mirror, which was not magic to any great extent. It is now in the Collège de France. I have held it in my hands, examined it carefully, and I can assure you that it is an exceedingly bad specimen. A great deal of imagination must be possessed by any person who can call the effects of this mirror magic.

This, gentlemen, was the last, and the excitement about magic mirrors began gradually to subside. Nothing more was heard of them till the year 1878, when MM. Ayrton and Perry, both professors in the Engineering School, at Jeddo, presented the Royal Society of London with several magic mirrors which they had brought from Japan. For the first time, technical observations were made concerning the construction of these mirrors. As to the mirrors themselves, the effects produced by them were truly marvellous. We were unable, however, to form any correct judgment upon them until last year, when M. Ayrton brought four to Paris. The experiments made by him proved very successful, and were witnessed by me with great interest.

Since then, the fame of magic mirrors has revived with double intensity.

A few days after M. Ayrton's séance I received a visit from my old pupil M. Dybowski, Fellow of the Academy of Physical Science, who returned from Japan after a professorship of more than two years at the University of Jeddo. Of course, you all know that after the revolution of 1869, Mikado's government founded large scientific schools in the capital. Unfortunately, they no longer "import" professors from Europe, but content themselves with such pupils as we turn out.

Like all Japanese, M. Dybowski was ignorant of the existence of magic mirrors. He brought with him, however, as curiosities, four mirrors of antique manufacture, which are called *Temple mirrors* in Japan, and considered to be superior to modern ones, as the fabrication has grown exceedingly defective of late, owing, probably, to the competition of European mirrors. We experimented together with these four specimens, one of which was found to be magic in a slight degree. This mirror has been the starting-point of all our subsequent progress. Of course, this was naturally the consequence of a sound theory, which, however, was not immediately established.

The oldest on record is that given by a Chinese author of the thirteenth century. According to him, "the cause of the phenomenon is due to the use of fine and coarse copper. If, in manufacturing the mirror, the image of a dragon is produced in relief upon the reverse, a similar dragon is engraved upon the polished side. This last is concealed by filling up the lines of the engraving with copper. The metal is then incorporated with a purer quality of copper, while the mirror is submitted to the action of fire. Finally, the surface is polished and washed over with amalgam." The author, however, does not seem to see that if the difference in the reflective power of the two qualities of copper was sensible enough to make the phenomenon appear, this variation must necessarily disappear under the application of the amalgam.

Brewster's theory does not differ notably from the Chinese explanation. He says the polishing effaces the engraving and renders it invisible in a diffused light, leaving upon the metal, however, variations of density and reflective power, which makes the image quite visible

when exposed to the sun. But Brewster was not aware that the surface of the mirrors was amalgamated, and we may safely say that he was wrong to attempt a solution of the mystery, without ever having seen a magic mirror.

Nevertheless, before rejecting his idea completely, let us seek to verify it. I myself have had an engraving made upon copper, then caused it to be effaced. When it was no longer visible in a diffused light, it was, unfortunately no longer visible when exposed directly to the sun. Perhaps I went badly to work, and very likely a more careful and delicate operator might have succeeded better. We might have explained in this way the effects of an extraordinary mirror mentioned by M. Ayrton, which, instead of reproducing the image engraved upon the reverse, disclosed to the astonished spectators the grotesque features of a Buddhist saint.

Brewster's theory, fortunately, was not known in France when public attention was directed upon magic mirrors. I say fortunately, because his opinion, being that of a celebrated man, might have led us astray. The first French physician who examined a magic mirror, Person, immediately discovered the true solution of the problem. In the first place, he found that the polished surface of the mirror was not perfectly convex, but only so in certain parts, corresponding with the lines of the figure upon the reverse. In the portions corresponding to the relief, it was almost flat. Rays of light reflected upon the convex parts diverge, and produce but a faint image. On the contrary, rays reflected upon the flat portions retain their parallelism, and produce an image which is very intense. This is why the ornaments in relief appear brilliant upon a dark background.

This irregularity of the surface depends of course upon the method of fabrication. When taken out of the cast, the mirror presents the appearance of a flat disk. Before being polished it is scratched in every sense of the word with a pointed instrument, to which it naturally offers more resistance in the thick parts than in the thin. This operation makes it at first slightly concave, and by the elastic reaction of the metal it becomes convex. This convexity is more sensible in the thin places than in those corresponding to the relief of the design. The mirror is finally polished with a whet-stone, then with charcoal, which must frequently destroy the irregularities which produce the magical effect. The surface thus becomes perfectly smooth, but generally one or two cavities can be found. The manufacturer fills these in with balls of copper which he has ready prepared and of all dimensions, and which he afterwards rubs and polishes until he thinks they are invisible to the naked eye. An expectation, however, which is but imperfectly realized, generally speaking. The entire surface is then rubbed by hand with an amalgam composed of equal portions of mercury and tin.

Such are the details of the manufacture of magic mirrors. It is easy to see that they quite agree with Person's explanation, but the latter has one objection. How, it will be asked, can the surface of the mirror be irregular without this being apparent in the images it reflects in a diffused light?

However, this objection is removed when we come to consider the facts attentively.

A mirror with a perfectly regular surface is an exceedingly rare object. Here, for instance, is a flat, metallic mirror employed in astronomical observations. The reflections it gives are very good.

Here also is a silver plaque which reflects in a manner equally perfect. If however, it is made to reflect an electric light, we can see clearly that the surface is not uniform, for we are able to perceive, so to speak, every blow of the hammer which it received during the process of manufacture. Here is one of those little round mirrors which we buy for a few pennies at the bazaars. It is excellent and extremely serviceable if you desire to comb

your beard, but detestable if you wish it to reflect light.

By means of these examples you can easily see that all our common mirrors are irregular and reflect light imperfectly, although forms can be reflected by them very well. These are true magic mirrors, only the image reflected is as irregular as the mirror itself, while that of the Japanese mirror is regular like the curves of the surface which produces it.

But are we quite certain that the flat and the convex parts of an irregular mirror reflect a sufficiently variable amount of light to make them quite distinct, one from the other. Let us see:

Here is a convex mirror, the summit of which has been planed off, making a flat mirror in the middle of a convex one. I will now reflect it upon the the screen by means of an electric light. You see the central portion is a very brilliant disk which shows that the flat mirror reflects the cylindric portion. Around it is a black circle in which there is no light at all. This is the space between the cylinder and a sort of funnel which contains the light reflected by the convex mirror. This light forms around the black circle a grayish ring of feeble intensity and quite distinguishable from the white central disk. The difference would be much more marked if the two lights were closer together.

Here I have another mirror which is flat. To the middle of it has been attached a convex lens. The whole has then been silvered. A reflecting light you see, shows us upon the screen, a large spot nearly black surrounded by a brilliant ring which has another ring around it of a gray color. The centre and the rings about it are produced by the reflection upon the central convex lens, across which comes the cylinder formed by the reflection upon the flat mirror.

The variation in intensity of the two reflections is enormous, particularly in the centre, which only appears black by contrast. For, of course, there is just as much light upon the central disk as upon the edges. We know that it is really luminous for we can cast upon it the shadow of an opaque body.

It has been, I hope, clearly demonstrated to you, therefore, that the curves upon the surface of the mirror produce inequalities of marked intensity when reflected. You have, however, a perfect right to remain in doubt as to Person's theory, because in all magic mirrors, these irregularities are very faint, being almost invisible to the naked eye. Although Person has endeavored to sustain his theory by direct observations upon the surface of his mirror, it was necessary to support it still further by means of new experiments.

An Italian *savant*, M. Govi, has undertaken this task, and in 1864 and 1865 presented two papers upon the subject to the Academy of Turin.

The first one contains several experiments made for the purpose of upholding Person and utterly demolishing Brewster. But Brewster was determined not to give in, and after having translated M. Govi's article for the *Scientific Review*, he followed it up with a quantity of remarks and objections which he certainly never would have made had he ever been fortunate enough to hold a magic mirror in his hands.

The stupidity of the illustrious Scotch physician had a very good result, for it incited M. Govi to seek new proofs and obtain a surer ground than ever for his opinion. In this way he conceived the idea of making the most important and most curious experiment which had yet been seen in regard to metallic mirrors. He thought that by heating the mirrors on the back, the warmth would take effect sooner upon the thin parts than upon the thick: that the former would become more convex, and thus the magic property would increase in such mirrors as already possessed it in some degree, and might possibly be produced in those which were not magic.

Here is General Teissier's mirror—you have already seen that it was slightly magic—I shall now have it heated

by means of a gas light placed behind it, and you will immediately see that the magical effects become more intense. It develops by degrees and produces nearly all the forms and images which are on the back, quite perfectly. You observe that the great quantity of small figures which are in but slight relief are not visible, while all the others of pronounced relief are clearly brought out. This fact is an important one. It shows us that we must look for magic mirrors only among those having ornaments in decided relief upon their backs. You must also know that they are not to be found among very thick mirrors. The experiment is still more successful with this Japanese toilet mirror.

The first experiments, after reading M. Govi's papers, were made by M. Ayrton and myself, as we desired to verify the investigation of the Italian *savant* before publishing them, and at the same time study thoroughly this very interesting subject, hoping that we might be able, perhaps, to reproduce the mirror in France instead of importing them from the extreme East. You must bear in mind that we had but one mirror at our disposition and that one but slightly magic. It belonged to M. Dybowski. We began by heating it as I shall show you presently. Here is the natural mirror which is hardly magical at all. You see the effect is produced in proportion to the amount of heat employed. Heat applied to several other Japanese mirrors bought in Paris or borrowed from collectors produced a magical effect upon them all.

These experiments were repeated by us very often. But it was not long before we discovered the inconveniences of the heating method. First of all, as it is extremely difficult to preserve an equal degree of warmth upon the entire surface. The image is rarely perfectly regular; then the mirror itself is somewhat altered. The reverse becomes covered with a bronze iridescence while the surface loses its polish because the heat destroys the amalgam which covers it, the mirror loaned to me was in a frightful condition when I returned it, but it was finally put in order again. The spots upon the back were removed by a coating of slightly acidulated water, and the amalgamation replaced by nickel plating which made a more perfect and durable polish. Before giving it back to its owner, however, we had numerous copies made from it, and it was one of these which I showed you a few moments since.

The disadvantages of heating made us wonder if the same effect could not be produced by a different method, and we thought of pressure. M. Duboscq solved the problem by means of this box. You see it is not thick, and is of the precise diameter of the mirror which is attached to the upper part by an iron ring and one of India rubber. The under portion is closed and provided with a spout and plug which it connects with the little hand pump well known as the Gay-Lussac. This pump inhales on one side, and exhales on the other. If we attach an India rubber tube to the spout, on the exhaling side the movement of the piston will compress the air behind the mirror. We will now try it.

The mirror becomes more convex and the image widens. The thin portions protrude more than the others and the magical effect grows more and more pronounced. It will be quite complete when the pressure attains two atmospheres. We have it now! You see, the effect is perfect. It is certainly much finer than anything M. Ayrton has shown us, although his experiments astonished us so much.

We can also produce an inverse effect, by attaching the rubber tube to the inhaling spout. The action of the pump will remove the air beneath the mirror, which will become less convex and you see the luminous disk contract. The thin portions corresponding to the outlines of the design will yield more than the others, become less convex and perhaps concave. They will reflect more light and we may see a new image appear which will be the exact reverse of the preceding. That is to say, that the parts in relief will appear black upon a white ground.

This is a *negative* form of the first, in which we saw the relief traced in white upon a black surface.

M. Dehoscq made many other experiments, one of which I will relate to you before I conclude.

I wished to go still further. I wished to have a cast taken of the mirror while it is magic, and make a galvano-plastic deposit in the mould so that we might have a magic surface instead of a mirror. We tried this three times. The plaster moulding was very successful and the surface magic, but the galvano-plastic deposit was a complete failure. If any one here among my audience can give me any advice upon the subject I would be most grateful.

Gentlemen, I hope sincerely I have been able to interest you in this new subject of magic mirrors. If I have succeeded in making my meaning throughout, clear to you, these mirrors will no longer be a mystery, and you will have seen once more how Science, by slow but sure efforts, is finally able to explain and reproduce phenomena, which at first sight seemed miracles, always provided that the phenomena are real and not mere phantoms of human credulity.

#### RECENT SURGICAL CASE.

The following case, which, in some respects, is similar to that of President Garfield's, may be read with interest for the purpose of comparison. The man was sent to St. Michael's Hospital, Newark, N. J., where his case was considered hopeless at the date of his entry. We are indebted to Dr. H. C. H. Herold for a copy of the following report:

George Freund, age 36, Germany, ex-policeman.—Admitted to hospital July 4th, suffering from bullet wound of chest. The wound was produced by a 22-inch calibre pistol, and situated an inch and three-quarters below and half an inch to the left of the left nipple. When seen half an hour after admission his pulse, temperature and respiration were all normal. On examining his lungs the percussion note was normal. On auscultation, rales were heard over both lungs, resulting from chronic bronchitis. He is subject to attacks of asthma. Heart sounds normal. Ordered one-quarter of a grain of morphine every two hours until sleep was obtained.

July 5.—Morning. Passed a very restless night, not seeming to feel the effects of the morphine. Temperature, 102; pulse, 120; respiration, 32, and very labored. It was ascertained on examination that he was suffering from an asthmatic attack. He has had no spitting of blood and no sign of any lung trouble. Ordered grains x of iodide of potash, three times a day. July 5.—Evening. Complains of great pain in the vicinity of the wound, extending toward the stomach. Temperature, 102; skin feeling to the hand cold and covered with a clammy sweat. Pulse, 80; quite feeble and compressible, intermitting at every second beat. Respiration, 30; not labored, having recovered from his asthmatic attack.

July 6.—Passed a very restless night; one-eighth grain of morphia given every two hours; temperature, 103; pulse, 110; respiration, 40; labored and sighing; slight hemorrhage from wound; all pain left him.

July 7.—Passed a quiet night, sleeping very well; only one-eighth grain of morphia administered; temperature, 101; pulse, 106; respiration, 18; slight hemorrhage from wound; expectoration of a sputa which looks very much like laudable pus.

July 8.—Slept quite well, taking one-eighth grain of morphia; complains of some pain in vicinity of wound; hemorrhage from wound ceased; has taken no food since admission, being sustained by stimulants, beef tea, milk, etc.; temperature, 102; pulse, 115, quite strong, intermitting at every fifth beat; respiration, 26.

July 9.—Very comfortable night, taking only one-