utmost deliberation in all such cases by the avoidance of errors fatal to your prospects and reputation.

Another common source of error and consequent loss is the neglect in the consideration of a subject of what may sometimes seem trifling practical details, but which often control the question of success or failure.

Thus, for example, it was seen at quite an early date that a hot air engine was theoretically a more economical motor (if questions of practical detail were neglected) than a steam engine. Immense sums of money and a vast amount of the highest inventive genius have been expended on the development of such engines for general use.

The small practical details of excessive bulk in the machinery, consequent friction, the use of very high temperatures, and the like, have, however, limited the application of the air engine to a very narrow field.

In like manner, theoretically considered, the magneto-electric machine, deriving its exciting field of force from permanent magnets, is manifestly more economical than a dynamo-electric machine whose exciting field of force is maintained only by a constant expenditure of active energy. Yet, as a matter of fact, this theoretical economy is more than balanced by the practical impossibility of securing great intensity of magnetic field with permanent magnets, so that the losses caused by the greater friction and electric resistance present in the larger and more complex magneto-machines, are greater than those involved in the constant generation of a magnetic field by the use of an electric current in the dynamo machines.

There is another source of error which embraces not only engineering problems, but so much more that we might hesitate to restrict it by calling it a fallacy in engineering, but which, nevertheless, it behooves the young engineer to guard himself against.

That is, the confusion between the ideas of *force* and *energy*.

This fallacy has been very popular of late in certain connections, and has received the implied indorsement of some of the most conspicuous of modern scientific teachers.

To enter into its full discussion would be beyond our present limits of time, but let me at least draw your attention to this important feature. *Energy*, whether existing in an active form, as in the motion of a projectile, a moving train, or a rotating machine; or in a potential form, in a lifted weight, or two substances capable of chemical combination, is not a final cause, but is simply an effect of the grand, mysterious, unknown final cause called "*force*."

In order that the projectile, or the train, or the machine should possess actual energy by moving, they must have received motion from something having potential energy. Suppose this were in the simplest form of a raised weight, then *its* potential energy calls for the existence of the *force* of gravity.

Suppose the potential energy existed in the more recondite form of possible chemical combination: here again we must have the pre-existent "*force*" of chemical attraction, and so on with every other imaginable instance. Wherever we find energy, we find the grand, unapproachable, cloud-wrapped mystery of "*force*" looming up behind it.

But, you may say, is not this *force* a known thing? We have many names of *forces*: "*the force of gravity*," "*the force of magnetism*," etc. Surely, scientific men know what *force* is!

Truly, some of them talk as if they did, and as if, like energy, it could be expressed as "*a mode of motion*." But not the ablest, and those who have really appreciated the question.

At the very opening of his grand work the "*Mécanique Céleste*," that greatest of scientists, La Place, says: "The nature of that singular modification, by means of which a body is transported from one place to another, is now and always will be unknown; it is denoted by the name of *force*."

Standing as it were upon the threshold of the celestial universe, and about to explain the grand laws of its mechanical arrangement by which the countless stars and suns and worlds sweep in their eternal and harmonious cycles, this great philosopher, with bowed head, acknowledges the incapacity of the human intellect to grasp the knowledge of *force*, which is yet the cause of all these motions and interactions whose laws and results he so fully explains.

With such an example as this, let us then avoid the fallacy of those who, through carelessness or want of consideration, confuse energy with *force*, and pretend to understand and explain the material universe on a purely physical basis, only because they ignore its great mystery, and acknowledge that, in the simplest phenomena of matter, we find a super-material and mysterious agency "*whose ways are past finding out*."

The correct discrimination between *energy* and *force* is something which is only now beginning to find its way into general scientific consideration.

Even Faraday had no idea of it, as we see from his paper on the "Conservation of Force," and many of the most popular of modern scientific teachers show that their ideas are very much confused in this relation; but the time is not far distant when this confusion will be cleared up and the true limits of energy defined.

When this is done we shall see that the idea of a material universe, in which matter is the origin of all and a sufficient final cause for existing phenomena, will be as absurd a hypothesis as that of a self-moving machine or of a self-created animal.

Beware, then, of this fallacy as well as of the others which I have endeavored to indicate to you, and rest assured its acceptance would be as disastrous to your best interests as would that of any of those foolish fallacies which have led so many into disastrous failure.

EXPERIMENT OF MM. LONTIN AND DE FONVIELLE.

By M. JAMIN.

THE Ruhmkorff machine gives two sorts of currents, the one direct and the other inverse, which succeed each other alternately and indefinitely at very short intervals. The direct current magnetizes the disk transversely. It is to be noted that in spite of the movement which the disk may have, this magnetization has always the same direction in space, but that it is variable in the disk. It does not adhere to the matter of the disk and cannot draw it along. But as soon as the direct current ceases there remains in the disk a permanent magnetization, which inheres in the matter of the disk and endows it with polarity.

NEW ENLARGING LENS FOR MAGIC LANTERN.*

To photography must be assigned a considerable share in procuring an enlarged field of usefulness for the lantern—the instrument said to have been invented so long ago as the thirteenth century, by Roger Bacon. It is no longer the toy, as in bygone ages, for the raising of specters, etc., but is daily gaining in favor with the public lecturer, who has discovered in it a ready means for the diffusion of knowledge. However, even in its present state it leaves much to be desired; for who has not witnessed the often-contorted and ill-defined pictures thrown upon the screen?

The practical application of the law of conjugate foci constitutes the principle of lantern construction, namely, the object or slide to be enlarged is placed in one of the conjugate foci of the lens, and the image or screen in the other; thus, for a larger image, the screen must be removed to a greater distance from, and the slide brought nearer to, the lens, and *vice versa*.

To obtain an enlarged picture of sufficient brilliancy, a lantern comprises three essential elements, namely:

1. A brilliant source of light. The illumination of the picture diminishes in the proportion of the square of the distance of screen or the size of enlargement. Thus, if at distance 1 the illumination equals one candle, then at distance 50 it is only one twenty-five-hundredth of that amount; in other words, if at distance 50 the picture is to appear as bright as it is at distance 1, we require 2,500 candles in place of one for the source of light. A case in point is when a three-inch picture is enlarged to twelve feet by means of a six-inch focus lens *without* a condenser.

2. A condenser to concentrate this light upon the picture or slide.

3. The lantern "front," or objective, to project an enlarged image upon the screen.

Years ago my attention was called to the necessity for a better lantern lens or objective, by one well known in the annals of photography. I refer to Mr. Latimer Clarke, the inventor of a stereoscopic camera known by his name, who employed the lantern for the purpose of amusing and instructing his children. I well remember being struck by the ingenuity of this gentleman in providing a plaster of Paris screen, made concave to suit the curvature of image produced by his lens. Though successful the dimensions of such a screen were necessarily limited; and hence his request for a better lens to project a well-defined image upon a flat screen of larger dimensions.

The problem presented for solution is by no means an easy one, and had it not been for a further incentive to the same end by another gentleman, still better known in photographic annals, the Rev. F. Hardwich, formerly Professor of Photographic Chemistry at King's College, the subject would, probably, have remained in abeyance—at least as far as I am concerned. The reverend gentleman, as far back as the year 1876, wrote me a first letter urging the importance of an improved lantern for public lecturers. In subsequent letters, in response to my application, he kindly furnished me with all the *desiderata*, and this has enabled me to complete my task.

I think I shall best meet the wishes of my audience if I give some of the valuable hints obtained, in Mr. Hardwich's own words, arranged under three heads:

First. The source of light, or the "*radiant*," as I shall term it. "The process I use is the oxyhydrogen or mixed gases; the perforation of the lime which shows the greatest intensity is about the size of a split pea. Then there is an outer circle of less luminosity, etc. I do not like to risk anything nearer than two and a half inches to three inches, if the thickness of the glass be considerable. I never had a fracture, but I take precautions for the sake of the lime cylinders as well as the condenser. First, I turn on the hydrogen only for three or four minutes, then enough oxygen to make the flame burn red for another three or four minutes, and after that the full amount of oxygen required for incandescence."

Second. *The Condenser*.—"The one I use does not bring the whole of the light to a focus. The lighted disk should be as white as possible. Quantity as well as quality of light is wanted in a new condenser. I have obtained the best results from the American or symmetrical condenser of four inches diameter and two inches solar focus (three inches equivalent), but I fully expect that you will go beyond it."

Third. *The Lens, or Objective*.—"For lecture halls a six-inch (equivalent focus) is a good size. The field should be flat, or nearly so. The practical point is a brilliantly-lighted picture of great size. A three-inch should be enlarged to (say) twelve feet. I cannot get beyond eight and a half feet; enlarged beyond that the pictures are not brilliant, especially at the edges, etc., etc. I noticed that in showing a spectrum on the screen to illustrate the rainbow the blue appeared green, and all the upper violet shades were destroyed."

Mr. Hardwich then recounts the difficulty experienced by him in procuring a good French lens, remarking that all the quarter-plate lenses sent to him to choose from were defective in flatness of field, the outsides being quite out of focus. He then became possessed of a half-plate French lens, which gave a flat field and admitted of much more latitude in the adjustment of the lime, an alteration in its position, further from, or nearer to, higher or lower, not sensibly affecting the disk, as compared with the quarter-plate lenses referred to. Tested for distortion upon a square border it proved to be of the hour glass description, and the picture looked as though it were projected upon a slightly concave surface. He then refers to the advice so often given, namely, "to pick out a French lens with a flat field," concluding, "and that is precisely the weak point, as far as my experience goes."

With this ample summary of requirements before you I proceed to make a few remarks in the same order.

First, the source of light, or radiant. Theoretically this should be a point—at any rate it should be as small as possible, but intensely white or luminous. The nearest approach to such a source is the lime light, or the oxyhydrogen light referred to above; but even this is not a point. How much inferior, then, are the various kinds of lamps or lamp flames used for the purpose! I say nothing about the convenience or even sufficiency of such appliances for the illumination of small screens in private rooms, for they are undoubtedly safe. I am here concerned with the *best* source of light or radiant, and until electricity—the light of the future—is brought to our aid the lime light must be considered the best. I do not touch upon the subject of the proper methods for the production of this light, such as the preparation and storing of the gases, the best lime cylinders, the safety jets, etc., with which I am not practically concerned. Moreover, I prefer to leave this part of the subject

in abler hands, such as Mr. Hardwich's or other chemists familiar with the matter.

Assuming that we are in possession of the best radiant, we require something more in order to obtain a well-illuminated image upon the screen. Fig. 1 illustrates my meaning.

FIG. 1.

Let L represent the radiant, which sends out light in all directions; the diagram only exhibits one-sixth of these radiations. It illuminates the slide, S, represented in position, but only that portion of it situated between R and R' falls upon the objective, O; hence that small portion only is feebly illuminated and represented upon the screen. Now contrast the condition of things represented in Fig. 2, drawn to same scale.

Here the entire pencil of rays shown in Fig. 1 is concentrated upon or illuminates the slide, S, by means of the two plano-convex lenses, A and B, the condenser, and the objective, O, now receives light from every portion of the slide, the whole of the image being brilliantly illuminated upon the screen.

I pass by the single-lens condensers generally supplied with "toy" lanterns, inasmuch as they are almost devoid of correction, and only collect or condense a comparatively small amount of light upon the picture; nor shall I refer to the more complicated forms of condensers composed of three or more single lenses, nor to achromatized (!) ones—condensers said to collect angular pencils of 90°!

The condenser represented in Fig. 2 is of four inches di-

FIG. 2.

ameter and of three inches equivalent focal length, the radiant being at the same distance from the first lens, and including an angular pencil of 60°. To collect 90° requires for the same aperture an equivalent focus of little more than two inches; and when I mention the fact that the lenses composing such a condenser exceed the former by about one-third in thickness, the radiant of necessity occupying a position only removed one and three-quarter inches from the first lens, these conditions are obviously impracticable. Other things being equal, the amount of light collected by condensers is inversely proportional to the squares of their foci.

The commercial condensers may be comprised under two heads, namely, the so-called "Herschel" form,* composed of a plano-convex, or a concavo-convex combined with a double convex, the flat or concave side facing the radiant, the lenses of four inches diameter and three and a half inches equivalent focus; and the symmetrical condenser of three and a half inches and three inches focus respectively, and of the same diameters. I am disposed to give the preference to the latter form, resembling to some extent the Ramsden eyepiece, though this admits of improvement, as I shall show further on.

The essentials, then, of a good condenser are "quantity and quality of light." The former points to diameter and focal length, the latter to perfection of the glass and correction of aberrations of the lenses.

The condenser constructed by me for Mr. Hardwich is of four inches effective diameter, and two and three-quarters inches equivalent focal length. Assuming the radiant to be at a *safe* distance of two and three-quarters inches from the flat surface of the first lens, this condenser collects an angular pencil of about 66°, i. e., about twenty per cent. more light than the shortest focus symmetrical. It is represented by Fig. 3, and consists of the two unsymmetrical lenses, A

FIG. 3.

and B. A is a plano-convex of flint three and five-eighths inches diameter, and B is a double convex of crown glass of four inches diameter. The lenses are mounted at a certain interval apart, with their deep sides facing each other. Approximate correction of chromatic aberration for central pencils is obtained by a proper apportioning of their focal lengths and the distance at which they are placed. Thus,

* I deem it right to state that the late Sir John Herschel never designed the forms of lenses called by his name as a "condenser." He proposed it as a "burning lens," the spherical aberration being approximately corrected only for the sun, or for parallel incident rays, as expressed in a letter addressed to the writer by the late Sir John Herschel, in February, 1867.

* A communication to the Photographic Society of Great Britain.