INTRODUCTION

CONCERNING the title of this study, two remarks are useful. We speak of invention: it would be more correct to speak of discovery. The distinction between these two words is well known: discovery concerns a phenomenon, a law, a being which already existed, but had not been perceived. Columbus discovered America: it existed before him; on the contrary, Franklin invented the lightning rod: before him there had never been any lightning rod.

Such a distinction has proved less evident than appears at first glance. Toricelli has observed that when one inverts a closed tube on the mercury trough, the mercury ascends to a certain determinate height: this is a discovery; but, in doing this, he has invented the barometer; and there are plenty of examples of scientific results which are just as much discoveries as inventions. Franklin's invention of the lightning rod is hardly different from his discovery of the electric nature of thunder. This is a reason why the aforesaid distinction does not truly concern us; and, as a matter of fact, psychological conditions are quite the same for both cases.

On the other hand, our title is "Psychology of Invention in the Mathematical Field," and not "Psychology of Mathematical Invention." It may be useful to keep in mind that mathematical invention is but a case of invention in general, a process which can take place in several domains, whether it be in science, literature, in art or also technology.

Modern philosophers even say more. They have per-

ceived that intelligence is perpetual and constant invention, that life is perpetual invention. As Ribot says,[1] "Invention in Fine Arts or Sciences is but a special case. In practical life, in mechanical, military, industrial, commercial inventions, in religious, social, political institutions, the human mind has spent and used as much imagination as anywhere else"; and Bergson,[2] with a still higher and more general intuition, states:

"The inventive effort which is found in all domains of life by the creation of new species has found in mankind alone the means of continuing itself by individuals on whom has been bestowed, along with intelligence, the faculty of initiative, independence and liberty."

Such an audacious comparison has its analogue in Metschnikoff, who observes, at the end of his book on phagocytosis, that, in the human species, the fight against microbes is the work not only of phagocytes, but also of the brain, by creating bacteriology.

One cannot say that various kinds of invention proceed exactly in the same way. As the psychologist Souriau has noticed, there is, between the artistic domain and the scientific one, the difference that art enjoys a greater freedom, since the artist is governed only by his own fantasy, so that works of art are truly inventions. Beethoven's symphonies and even Racine's tragedies are inventions. The scientist behaves quite otherwise and his work properly concerns discoveries. As my master, Hermite, told me: "We are rather servants than masters in Mathematics." Although the truth is not yet known to us, it preexists and

[1] See Delacroix, L'Invention et le Génie (in G. Dumas' *Nouveau Traité de Psychologie*, Vol. VI), p. 449.

[2] *ibid.*, p. 447.

inescapably imposes on us the path we must follow under penalty of going astray.

This does not preclude many analogies between these two activities, as we shall have occasion to observe. These analogies appeared when, in 1937, at the Centre de Synthèse in Paris, a series of lectures was delivered on invention of various kinds, with the help of the great Genevese psychologist, Claparède. A whole week was devoted to the various kinds of invention, with one session for mathematics. Especially, invention in experimental sciences was treated by Louis de Broglie and Bauer, poetical invention by Paul Valéry. The comparison between the circumstances of invention in these various fields may prove very fruitful.

It is all the more useful, perhaps, to deal with a special case such as the mathematical one, which I shall discuss, since it is the one I know best. Results in one sphere (and we shall see that important achievements have been reached in that field, thanks to a masterly lecture of Henri Poincaré) may always be helpful in order to understand what happens in other ones.

THE MATHEMATICIAN'S MIND