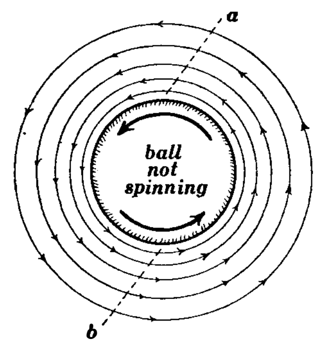
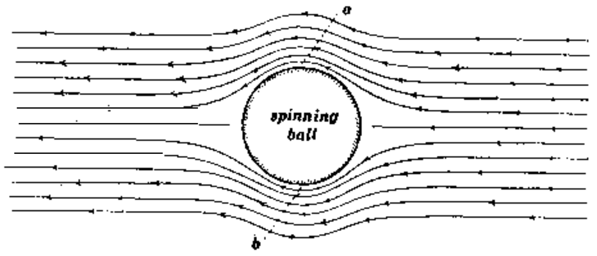
FIG. 11.



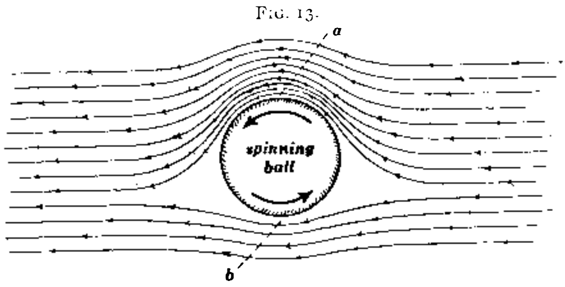
**Air whirl produced near a spinning ball—air everywhere at rest except in so far as it is affected by the spinning ball.**

FIG. 12.



**Air stream flowing past a ball which is not spinning.**

FIG. 13.



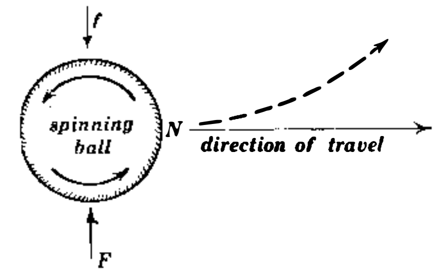
**Air stream flowing past a spinning ball. The velocity is high at "a" and low at "b"; consequently the air pressure is high at "b" and low at "a," thus producing the unequal forces "F" and "f" in Fig. 14.**

through gases: statistical physics. All correlations in this branch of physics must be sought for on the basis of statistical studies; the same thing never happens twice; and the old-fashioned idea of *cause and effect*, or the idea of *one-to-one correspondence*, or the idea of *law, in the sense of functional relationship* (as one may prefer to call it), gives place to chance and the laws of probability.

The older physics is sometimes called *macro-physics*, and the newer *micro-physics*, but this is distinctly misleading, because the largest-scale phenomena with which we deal in this world of ours belong to statistical physics—namely, weather phenomena. And the essential method in meteorology is the statistical method. Some little insight into atmospheric phenomena can be obtained by studying functional relationships, such as are expressed by Boyle's law of gases, the law of constant circulation in the vortex theory of fluid motion, the functional laws of radiation and absorption, and the functional relations of long-time and wide-space averages; but the thing which is now most needed in meteorology is the study and classification of storm types, the establishment of norms and probable departures therefrom, and, above all, the study of incipient stages of storm movements where very small variations may produce very large ultimate departures. If weather control is ever to be realized it must be by studying the possibilities of big consequences from small beginnings! Our Weather Bureau should employ, say, twenty of the most talented young men of highly-developed and rigorously-trained imaginative faculty, and set them to work studying storm data, averaging in time and space to discover norms, studying individual departures, and, above all, visualizing storm movements on a basis of the most minute study of details. No other method can ever lead to important results in meteorology.[2]

Consider a very smooth ball which is moving through still water without spinning. There is certainly no more reason why the ball should jump to the right than to the left. Therefore it must continue to move straight forward! That is good logic; but such a ball is no more subject to logic than is a sharp stick! The fact is that the ball does jump sidewise, and in a most irregular manner. This may be shown by dropping a smooth marble in a jar of still water. The marble goes nearly straight for several inches, and then suddenly jumps sidewise, as shown in Fig. 16. Similarly a smooth baseball jumps sidewise irregularly as it moves through the air, if the ball is not spinning.

FIG. 14.



**Unequal side forces "f" and "F" exerted on a spinning ball which is moving through the air.**

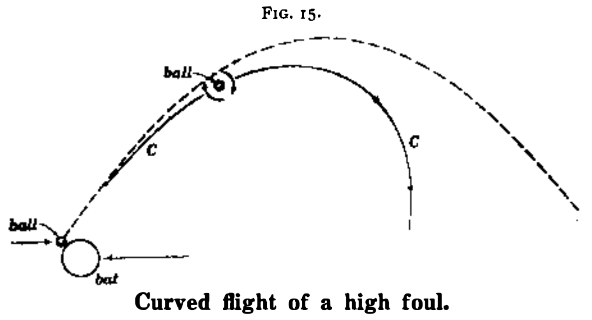
Fig. 17 shows how a rapidly moving stream of air splits when it flows past a ball, and the dividing lines, or *vortex sheets*, *aa* and *bb* between moving and still air are unstable. The result is that the stream of air *aa* (or *bb*) spurts upward and downward in irregular succession. When the stream *aa* spurts downward it produces an upward force or reaction on the ball, and *vice versa*. That is to say, the irregularities of the streams *aa* and *bb* cause a series of irregular side forces to be exerted on the ball.

The dynamic effects associated with a ball standing in a stream of air as shown in Fig. 17 exist also when a ball moves through still air. Therefore if a ball moves fast enough through still air to produce unstable vortex sheets, the irregular sidewise spurts of the air as it flows around behind the ball will cause the ball to travel in an irregular zigzag path.

The instability and consequent irregularity of a stream of rapidly-moving fluid is exemplified by the sensitive fluid. Every one knows how an ordinary gas flame suddenly becomes turbulent and produces a roaring sound when it is turned up too high (velocity of gas too great), and when a gas flame is on the verge of becoming turbulent the least disturbance is sometimes sufficient to throw the flame over into the turbulent form. A sensitive flame can easily be made by drawing out a glass tube to give a smooth nozzle about a millimeter in diameter, and burning a jet of ordinary illuminating gas at this nozzle. When properly adjusted, the flame responds to a hissing sound across a large room.

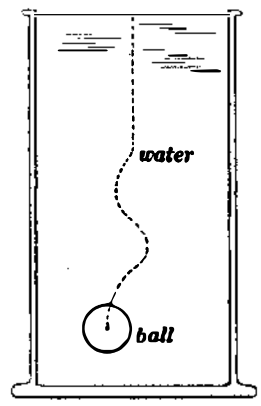
The hissing sound of a high-pressure steam jet is due primarily to an unstable condition of the jet near the nozzle, an unstable condition which is somewhat similar to the instability of the vortex sheets *aa* and *bb* in Fig. 17; and this instability leads to an excessively irregular and complicated whirling and eddying motion in the jet. Indeed, a jet of gas or steam is infinitely complicated! Everyone concedes the idea of infinity which is based on abstract numerals—one, two, three, four and so on *ad finitum*—and the idea of infinity which is based on the notion of a straight line; but most men are concerned with more or less persistent or steady phases of the material world, their perception does not penetrate into the substratum of utterly confused and erratic action which underlies every physical phenomenon, and they balk at the suggestion that the phenomena of fluid motion, for example, are infinitely complicated and erratic. Surely the abstract idea of infinity is nothing as compared with the dreadful intimation of infinity that comes from things that are seen and felt. We are immersed in an illimitable sea of phenomena every element of which is infinitely complex, and every minute detail is essentially erratic.

FIG. 15.



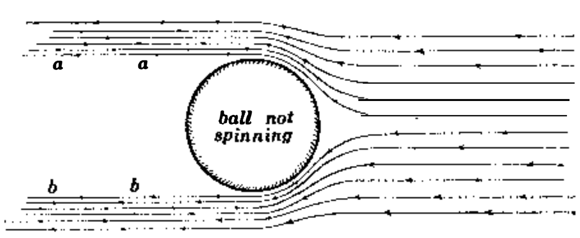
**Curved flight of a high foul.**

FIG. 16.



**Irregular path of smooth ball (not spinning) as it sinks in water.**

FIG. 17.



**Showing how a rapid stream splits when it flows past a ball.**

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[2] See a very brief article by W. S. Franklin in *Science*, vol. xiv, pp. 496, 497, September 27, 1901.

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## German Radiotelegraphic Stations in the Pacific

THE first German radiotelegraph station in the Pacific was opened in November, 1909, on Yap (or Uap) Island, in the Carolines, situated about 10 deg. N. and to the north of New Guinea. The station was built by the Telefunken Gesellschaft on behalf of the Deutsche Südsee Phosphat Gesellschaft, which has phosphate mines there, and about 500 kilometers west on Angaur, which belongs to the Palau Archipelago. Yap is connected with the cable system of the Deutsch-Niederländische Telegraphen-Gesellschaft (of Cologne) by three cables to Shanghai, in China, to Guam (in the Marianne Islands, belonging to the United States), and to Menado (on Celebes, Dutch East India). For this reason Yap was selected as a radiotelegraphic center, and further stations have now been erected at Rabaul (seat of the Governor of German New Guinea, who is also Governor of the large Bismarck Archipelago), at Nauru (in the Marshall Archipelago, which extends far to the north of the Equator, while Nauru itself is on the Equator), and at Apia, in Samoa (14 deg. south); a station on the already-mentioned Angaur Island had been built at the same time as that on Yap. The distances worked are considerable. Yap-Rabaul is 2,200 kilometers, Yap-Nauru 3,400 kilometers, Nauru-Samoa 2,700 kilometers, and New Guinea-Samoa 4,000 kilometers. The distance Yap-Tsingtau (in Shantung, also known under the name of Kiaochow; but Kiaochow itself is Chinese, while Tsingtau is German, and possesses a radiotelegraphy station and an observatory, and is joined to the Asiatic railway and telegraph system) is 3,650 kilometers, almost exactly as far as from Clifden, in the west of Ireland, to Glace Bay, in Newfoundland. The station at Apia is to be opened this Spring, the other stations are already working. The stations are equipped with 60 horse-power oil engines, and with umbrella antennæ 120 meters in height, to work with an energy of 25 kilowatts or 30 kilowatts, and with waves ranging from 300 meters up to 2,000 meters; the ordinary wavelength for signaling to ships is 600 meters. Smaller coastal stations for T antennæ and energy of 5 kilowatts are being added. The German Telegraph Department has not proceeded directly in this enterprise. A concession has been granted to the two companies already referred to, the Telefunken-Gesellschaft and Deutsch-Niederländische Telegraphen-Gesellschaft, which, for building and working these stations, have combined with the Deutsch Südsee-Gesellschaft für Drahtlose Telegraphie. The combination was effected in August, 1912, and the service is under the control of an Imperial commissioner. The co-operation of a cable company with a radiotelegraphy company will forestall rivalry between these two telegraph systems. We may supplement this note by a few statements on other radiotelegraphy stations in German colonies, almost all of which are now equipped. In German East Africa there is a coastal station at Dar-es-Salaam, and two stations are at Nuansa and Bukoba, on the Victoria Nyanza. Cameroon has a station at Duala; Togo, one at Toblekohve, near Lome (not yet open); and German Southwest Africa, stations at Swakopmund and Lüderitz Bay. Further stations are contemplated, and an agreement will probably be made with the Netherlands government as to the question of a station at Sumatra, in the East Indies, to serve as intermediate station between East Africa (Dar-es-Salaam) and the Pacific islands (Yap). The distance between East Africa and Sumatra would be 8,000 kilometers, while the farthest distance, so far covered experimentally at night-time, is Nauen-New York, 6,500 kilometers. Nauen and Togo, 5,500 kilometers, have communicated with one another at daytime.—*Engineering.*