KITES

An Historical Survey

CLIVE HART

Revised and Expanded Second Edition

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5 | The Eighteenth Century and Electric Kites

Among children, kites continued to increase in popularity during the eighteenth century. Miss Bayne-Powell writes: 'Kite-flying, though it never became the sport that it is in China and Japan, was very popular in the eighteenth century, indeed we find in many pictures of fields and open spaces, the figure of a boy flying a kite.'[1] In France the sport aroused such interest that the authorities were forced, on October 16, 1736, to forbid for a time the flying of kites in public places, due to riots which had broken out between contending fliers.

It was, however, the use of the kite by physicists and meteorologists that really began the long process of development which continued until the early twentieth century. The earliest application of the European kite for scientific purposes seems to have been the work of Alexander Wilson, in 1749. The claim establishing Wilson's priority was not published until many years later, but there seems to be no reason to doubt the truth of the account. The following description contains the first known mention of 'flying in train', or attaching more than one kite to the same line. Unfortunately, however, it contains no indication of the shape of the kites used, though we may probably assume that they were of the diamond or pear variety, both of which remained popular during the eighteenth century:

> Among the more advanced students, who, in the years 1748 and 1749, attended the lectures on Divinity in the University, was Mr Thomas Melvill. . . . With this young person Mr Wilson then lived in the closest intimacy. Of several philosophical schemes which occurred to them in their social hours, Mr Wilson proposed one, which was to explore the temperature of the atmosphere in the higher regions, by raising a number of paper kites, one above another, upon the

[1] Bayne-Powell, R., *The English Child in the Eighteenth Century*, London, 1939, p. 218.

same line, with thermometers appended to those that were to be most elevated. Though they expected, in general, that kites thus connected might be raised to an unusual height, still they were somewhat uncertain how far the thing might succeed upon trial. But the thought being quite new to them, and the purpose to be gained of some importance, they began to prepare for the experiment in the spring of 1749.

Mr Wilson's home at Camlachie was the scene of all the little bustle which now became necessary; and both Mr Melvill and he, alike dexterous in the use of their hands, found much amusement in going through the preliminary work, till,

Fig. 53. Child's kite in eighteenth-century Germany. Chodowiecki (1726–1801). A four-leg bridle appears to be used

at last, they finished half-a-dozen large paper-kites, from four to seven feet in height, upon the strongest, and, at the same time, upon the slightest construction the materials would admit of. They had also been careful, in giving orders, early, for a very considerable quantity of line, to be spun of such different sizes and strength, as they judged would best answer their purpose; so that one fine day, about the middle of July, when favoured by a gentle steady breeze, they brought out their whole apparatus into an adjoining field, amidst a numerous company, consisting of their friends and others, whom the rumour of this new and ingenious project had drawn from the town.

They began with raising the smallest kite, which, being exactly balanced, soon

mounted steadily to its utmost limit, carrying up a line very slender, but of a strength sufficient to command it. In the mean time, the second kite was made ready. Two assistants supported it between them in a sloping direction, with its breast to the wind, and with its tail laid out evenly upon the ground behind, whilst a third person, holding part of its line tight in his hand, stood at a good distance directly in front. Things being ordered, the extremity of the line belonging to the kite already in the air, was hooked to a loop at the back of the second, which being now let go, mounted very superbly, and in a little time also took up as much line as could be supported with advantage; thereby allowing its companion to soar to an elevation proportionally higher.

Upon launching these kites according to the method which had been projected, and affording them abundance of proper line, the uppermost one ascended to an amazing height, disappearing at times among the white summer clouds, whilst all the rest, in a series, formed with it, in the air below, such a lofty scale, and that, too, affected by such regular and conspiring motion, as at once changed a boyish pastime into a spectacle which greatly interested every beholder. The pressure of the breeze upon so many surfaces communicating with one another, was found too powerful for a single person to withstand, when contending with the undermost strong line, and it became therefore necessary to keep the mastery over the kites by other means.

This species of aërial machinery answering so well, Mr Wilson and Mr Melvill employed it several times during that and the following summer, in pursuing those atmospherical experiments for which the kites had been originally intended. To obtain the information they wanted, they contrived that thermometers, properly secured, and having bushy tassels of paper tied to them, should be let fall at stated periods from some of the higher kites; which was accomplished by the gradual singeing of a match-line.

When engaged in these experiments, though now and then they communicated immediately with the clouds, yet, as this happened always in fine weather, no symptoms whatever of an electrical nature came under their observation. The sublime analysis of the thunder-bolt, and of the electricity of the atmosphere, lay yet entirely undiscovered, and was reserved two years longer for the sagacity of the celebrated Dr Franklin. In a letter from Mr Melvill to Mr Wilson, dated at Geneva, 1st April 1753, we find, among several other particulars, his curiosity highly excited by the fame of the Philadelphian experiment; and a great ardour expressed for prosecuting such researches by the advantage of their combined kites. But, in the December following, this beloved companion of Mr Wilson was removed by death. . . .[1]

[1] Wilson, P., 'Biographical Account of Alexander Wilson', *Transactions of the Royal Society of Edinburgh*, Vol. 10, 1826, pp. 284–7.

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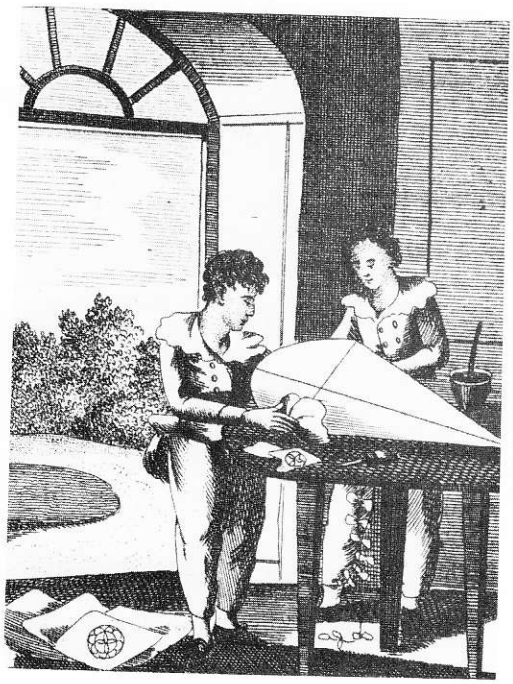
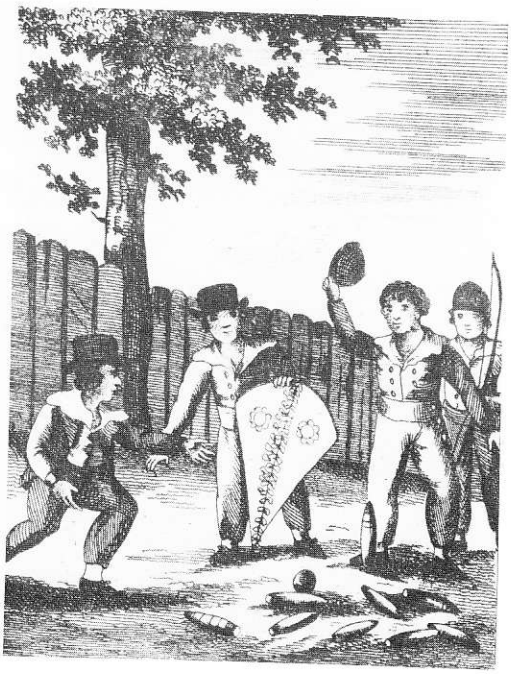
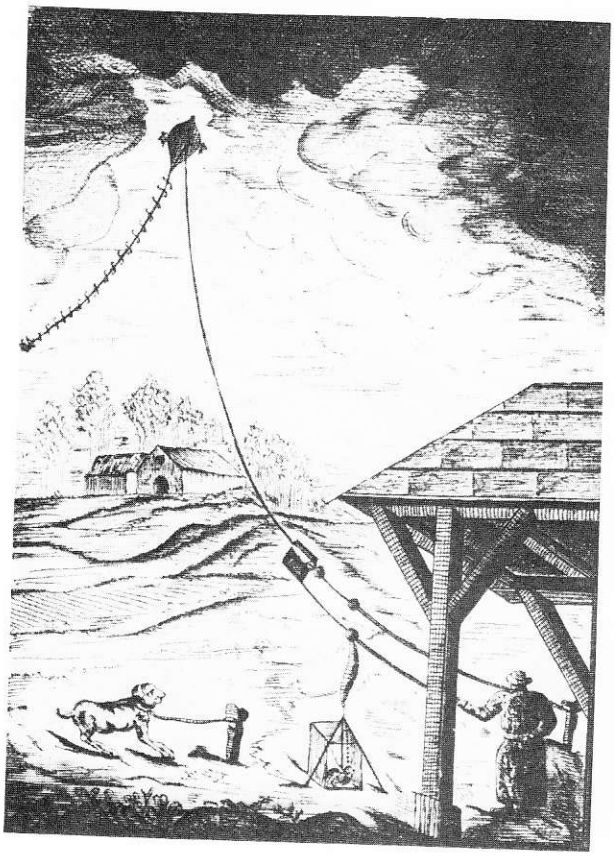
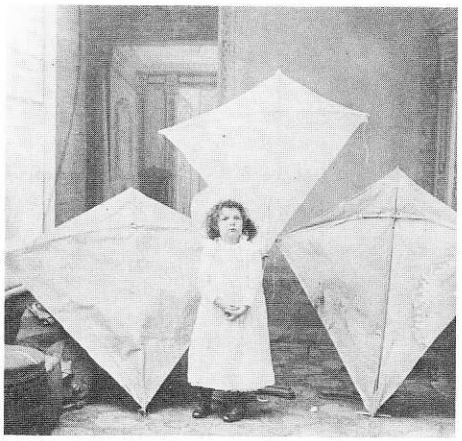




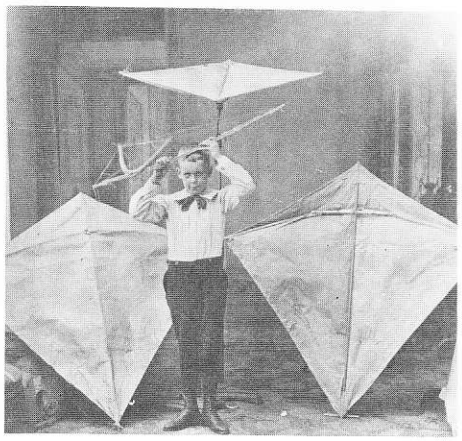
28, 29. Arch-top kite from *Stories of Instruction and Delight*, 1802.



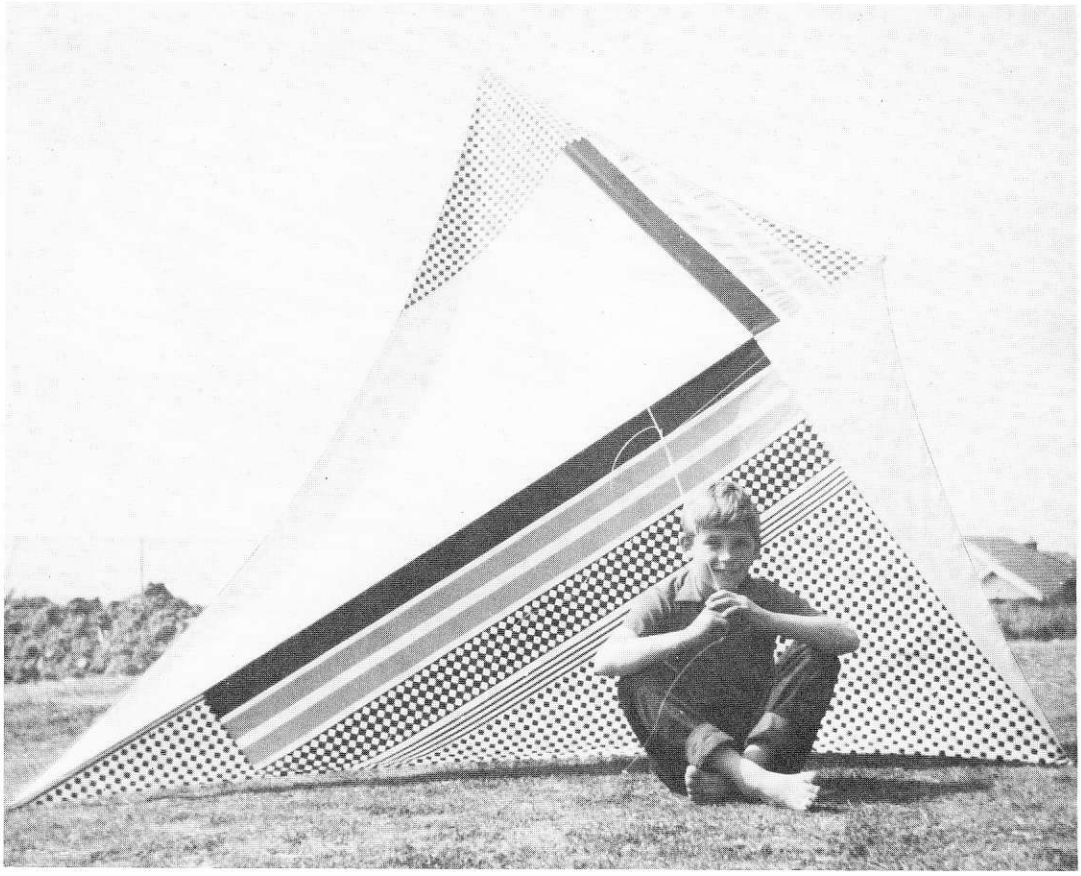
30. De Romas' experiments with a pigeon and a dog.



38. Eddy's daughter, Margaret, with some of her father's kites.



39. Another photograph of Eddy's kites, showing one of the frames.



40. A modern Eddy kite, 9 ft. X 9 ft., held by Philip David Hart.

The Franklin experiment, mentioned above, is no doubt the most famous of all scientific applications of the kite. It took place at some time during June 1752. For this purpose Franklin used a 'common kite' which was apparently very similar to the one depicted in Bate's book (see Fig. 50).

The only contemporary description of the experiment itself is by Priestley, who apparently had the details direct from Franklin. He says, in part:

> . . . he took the opportunity of the first approaching thunder storm to take a walk into a field, in which there was a shed convenient for his purpose. But dreading the ridicule which too commonly attends unsuccessful attempts in science, he communicated his intended experiment to no body but his son, who assisted him in raising the kite.
>
> The kite being raised, a considerable time elapsed before there was any appearance of its being electrified. One very promising cloud had passed over it without any effect; when, at length, just as he was beginning to despair of his contrivance, he observed some loose threads of the hempen string to stand erect, and to avoid one another, just as if they had been suspended on a common conductor. Struck with this promising appearance, he immediately presented his knuckle to the key, and (let the reader judge of the exquisite pleasure he must have felt at that moment) the discovery was complete. He perceived a very evident electric spark. Others succeeded, even before the string was wet, so as to put the matter past all dispute, and when the rain had wet the string, he collected electric fire very copiously. This happened in June 1752, a month after the electricians in France had verified the same theory, but before he heard of any thing they had done.[1]

Shortly after the experiment, Franklin gave instructions as to how it might be repeated:

> Make a small Cross of two light Strips of Cedar, the Arms so long as to reach to the four Corners of a large thin Silk Handkerchief when extended; tie the Corners of the Handkerchief to the Extremities of the Cross, so you have the Body of a Kite; which being properly accommodated with a Tail, Loop and String, will rise in the Air, like those made of Paper; but this being of Silk is fitter to bear the Wet and Wind of a Thunder Gust without tearing. To the Top of the upright Stick of the Cross is to be fixed a very sharp pointed Wire, rising a Foot or more above the Wood. To the End of the Twine, next the Hand, is to be tied a silk Ribbon, and where the Twine and the silk join, a Key may be fastened. This Kite is to be raised when a Thunder Gust appears to be coming on, and the Person

[1] Priestley, J., *History and Present State of Electricity*, London, 1767, pp. 171–2.

> who holds the String must stand within a Door, or Window, or under some Cover, so that the Silk Ribbon may not be wet; and Care must be taken that the Twine does not touch the Frame of the Door or Window. As soon as any of the Thunder Clouds come over the Kite, the pointed Wire will draw the Electric Fire from them, and the Kite, with all the Twine, will be electrified, and the loose Filaments of the Twine will stand out every Way, and be attracted by an approaching Finger. And when the Rain has wet the Kite and Twine, so that it can conduct the Electric Fire freely, you will find it stream out plentifully from the Key on the Approach of your Knuckle. At this Key the Phial may be charg'd; and from Electric Fire thus obtain'd, Spirits may be kindled, and all the other Electric Experiments be perform'd, which are usually done by the Help of a rubbed Glass Globe or Tube; and thereby the *Sameness* of the Electric Matter with that of Lightning compleatly demonstrated.[1]

Franklin's claim to have invented the electric kite did not go undisputed. De Romas, a scientist from Nérac, had apparently thought of the idea before Franklin's experiment took place, but he failed to put it into effect until too late. In great distress at having been forestalled in his invention, de Romas published a book in which he sought to establish that the priority was morally his.

De Romas's kite was of the 'pear' variety which, according to Lecornu,[2] is the oldest shape known in France. He attempted to repeat Franklin's demonstration on May 14, 1753, but was unsuccessful, due to his using a line with too high an electrical resistance. He accordingly wrapped the line with copper wire and tried again, on June 7, 1753, during a storm. This time the experiment was spectacularly successful, producing sparks seven or eight inches long. The line used on that occasion was 780 feet long. Later, using a 1,100 foot line, de Romas claimed to have produced sparks six, ten, and as much as eighteen feet in length.

Some years later de Romas carried out some extraordinary manœuvres with his electric kite, during which he preserved the life of a terrified pigeon, but managed to kill a large dog:

> During a violent storm . . . I raised my kite. Near the lower end of the string, that is, near the place where it was tied to the silk thread, I placed on the ground a tripod made of three brass wires, each eighteen inches long and as thick as a pen,

[1] Franklin, B., *The Papers of Benjamin Franklin*, ed. L. W. Labaree, Vol. 4, New Haven, 1961, pp. 360–9.

[2] Lecornu, J., *Les Cerfs-volants*, Paris, 1902, p. 45.

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[1] de Romas, J.,
1776, pp. 87–9. (M

and meeting in a point at one end. Between the feet of this tripod, and approximately in the middle, I placed a glass vessel eleven inches high and five inches in diameter, and whose mouth was sufficiently wide to allow the introduction of a hand. At the bottom of this vessel I cemented . . . one end of a silk cord. At the other end of this I tied a pigeon by the neck, so that it could not escape from the cell which, in accordance with my plan, must remain open. Finally, at the point of the tripod I attached one end of a metal chain, the other end of which I allowed to pass into the interior of the vessel, being careful, however, that the length of the chain was such that it hung an inch over the head of the bird.

At the sight of these preparations, the people who had gathered to watch my operations, and who were soon frightened by several spontaneous flashes of electricity which they were not expecting, presaged the imminent death of the pigeon.

Fig. 54. Common pear-kites

I directed about twenty flashes of electricity [from the kite] . . . on to the point of the tripod, but the pigeon showed only fear at each flash, and remained safe and sound.

. . . Several feet away from the tripod . . . I drove a stake into the ground . . . To this I tied a dog with a strong silk cord. Having done that . . . I waited until the storm had so abated that the kite line was giving off sparks only three or four inches in length . . . As soon as this happened . . . I directed a single such spark at the head of the dog; and the animal immediately fell dead to the ground.[1]

[1] de Romas, J., *Mémoire, sur les moyens de se garantir de la foudre dans les maisons*, Bordeaux, 1776, pp. 87–9. (My translation.)

Plate 30 illustrates de Romas's pear-kite, showing the balancing tassels at the ends of the wings. The woodcut is from de Romas's book.

Due to the spectacular experiment at Nérac, de Romas gained the reputation of being a kind of sorcerer. This reputation followed him to Bordeaux, where he went in 1759 to demonstrate his lightning-kite to a more august audience, and where he was the victim of a remarkable and unfortunate coincidence. The experiment was to have been carried out in a public garden. While he waited for suitable weather, de Romas left his kite with a café-proprietor, whose premises were situated on a terrace in the gardens. Many of the inhabitants, ignorantly believing the kite itself to be the cause of the atmospheric electricity, became nervous, as they feared a thunderbolt. A storm blew up and lightning did in fact hit the café. The inhabitants, no longer in any doubt, threatened to destroy everything if the kite were not handed over to them. The proprietor was understandably terrified; he complied, and the kite was promptly torn to shreds.

A great many investigators followed Franklin and de Romas in the use of the 'electric kite'. Among these were Fr. Beccaria of Turin, Prince Gallitzin and Dentan at the Hague, and Pilâtre de Rozier, celebrated as the first balloonist. A Dutch physicist, Peter van Musschenbroek, described experiments made during 1756–7, of which the following is one account. (Musschenbroek, like de Romas, used animals as subjects, but they seem to have fared rather better than de Romas's unfortunate dog.)

> On the 20th July, 1757, after a violent storm had broken out about 7 o'clock in the evening, I flew a kite. The steel wire immediately gave off very strong explosions. Sometimes these occurred at the same time as the flashes of lightning, but they ceased when the thunder could be heard. They succeeded one another with the greatest rapidity, producing a noise that could be heard at a great distance. When I brought the wire near the heads of a dog, a buck, and a young bull, these animals were struck so violently that they immediately took flight and were not keen to have the experiment repeated.[1]

Musschenbroek also included in his book a brief mathematical description of the system of forces which cause a kite to fly.[2] He and his celebrated contemporary, Leonhard Euler, were among the first scientists to attempt such mathematical

[1] Musschenbroek, P. van, *Introductio ad philosophiam naturalem*, Leyden, 1762, Vol. I, pp. 295–6. (My translation.)

[2] *Ibid.*, p. 177.

expositions. It was not, however, until the well-known meteorologist C. F. Marvin published a series of articles in the *Monthly Weather Review*[1] at the end of the nineteenth century that a complete treatment of the subject appeared.

One other experimenter with electric kites deserves special mention. This is Tiberius Cavallo, who has left us one of the most comprehensive and detailed accounts. The following passage gives a very clear idea of the techniques involved and the results to be expected:

> The first instrument that I made use of, to observe the Electricity of the atmosphere, was an electrical kite, which I had constructed, not with a view to observe the Electricity of the air, for this, I thought, was very weak and seldom to be observed; but as an instrument, which could be occasionally used in time of a thunder-storm, in order to observe the Electricity of the clouds. The kite however being just finished, together with its string, which contained a brass wire through its whole length, I raised it the 31st of August 1775, at seven of the clock in the afternoon, the weather being a little cloudy, and the wind just sufficient for the purpose. The extremity of the string being insulated, I applied my fingers to it, which, contrary to my expectation, drew very vivid, and pungent sparks: I charged a coated phial at the string several times; but I did not then observe the quality of the Electricity. This successful experiment induced me to raise the kite very often, and to keep it up, for several hours together, thinking that if any periodical Electricity, or any change of its quality took place in the atmosphere, it might very probably be discovered by this instrument . . .
>
> The first electrical kite, that I constructed, was seven feet high, and it was made of paper with a stick or straiter, and a cane bow, like the kites commonly used by school-boys. On the upper part of the straiter I fixed an iron spike, projecting about a foot above the kite, which, I then thought, was absolutely necessary to collect the Electricity, and I covered the paper of the kite with turpentine, in order to defend it from the rain. This kite, perfect as I thought it to be, in its construction, and fit for the experiments, for which it was intended, soon manifested its imperfections, and after being raised a few times, it became quite unfit for farther use; it being so large, and consequently heavy, that it could not be used, except when the wind was strong, and then after much trouble in raising and drawing it in, it often received some damage, which soon obliged me to construct other kites upon a different plan, in order to ascertain which method would answer the best for my purpose. I gradually lessened their size, and varied their form, till I observed upon trial, that a common school-boy's kite, was as good an electrical kite as mine. In

[1] Republished as Marvin, C. F., *The Mechanics and Equilibrium of Kites*, Washington, 1897. This exhaustive monograph is a model of scientific method.

consequence of which I constructed my kites in the most simple manner, and in nothing different from the children's kites, except that I covered them with varnish, or with well boiled linseed oil, in order to defend them from the rain, and I covered the back part of the straiter with tin-foil, which however has not the least power to increase its Electricity. I also furnish the upper extremity of the straiter with a slender wire pointed, which, in time of a thunder-storm, may perhaps draw the Electricity from the clouds, somewhat more effectually; but, in general, I find, . . . that it does not in the least affect the Electricity at the string. The kites, that I generally have used, are about four feet high, and little above two feet wide. This size, I find, is the most convenient, because it renders them easy to be managed, and at the same time they can draw a sufficient quantity of string. As for silk or linen kites, they require a good deal of wind to be raised, and then they are not so cheap nor so easy to be made, as paper kites are. The string sometimes breaks, and the kite is lost, or broken, for which reason, these kites should be made as cheap and as simple as possible.

The string is the most material part of this apparatus; for the Electricity produced is more or less, according as the string is a better, or a worse Conductor. The string, which I made for my large kite, consisted of two threads of common twine twisted together with a brass wire between the strands. This string served very well for two, or three trials, but on examination, I soon found that the wire in it was broken in many places, and it was continually snapping; the metallic continuation therefore being so soon interrupted, the string became soon so bad, that it acted nothing better than common twine without a wire. I attempted to mend it, by joining the broken pieces of wire, and working into the twine, another wire, which proved a very laborious work; but the remedy had very little effect, the wire breaking again after the first trial, which determined me to adopt other methods; and after several experiments, I found that the best string was one, which I made by twisting a copper thread with two very thin threads of twine. . . .

In raising the kite when the weather is very cloudy and rainy, in which time there is fear of meeting with great quantity of Electricity, I generally use to hang upon the string . . . the hook of a chain . . ., the other extremity of which falls upon the ground. Sometimes I use another caution besides, which is to stand upon an insulating stool; in which situation, I think, that if any great quantity of Electricity, suddenly discharged by the clouds, strikes the kite, it cannot much affect my person. As to insulated reels, and such like instruments, that some gentlemen have used for to raise the kite, without danger of receiving any shock; fit for the purpose as they may appear to be in theory, they are yet very inconvenient to be managed. Except the kite be raised in time of a thunder-storm, there is no great danger for the Operator to receive any shock. Although I have raised my electrical kite hundreds of times without any caution whatever, I have very seldom received

> a few exceedingly slight shocks in my arms. In time of a thunder-storm, if the kite has not been raised before, I would not advise a person to raise it while the stormy clouds are just overhead; the danger in such time being very great, even with the precautions above mentioned. . . .[1]

(Later Cavallo also demonstrated that it is the string rather than the kite itself that collects the electricity.)

The kites used by the eighteenth-century investigators were usually cumbersome and inefficient. Tailless kites were still unknown in Europe (except perhaps on the Dutch coast) and the lines, especially those used for conducting electricity, were thick and heavy. It is not surprising that the kites did not fly to very great heights. An elevation of 500 feet was the usual maximum for a single kite, a poor performance which was not substantially bettered until the great period of development of the meteorological kite at the end of the next century.

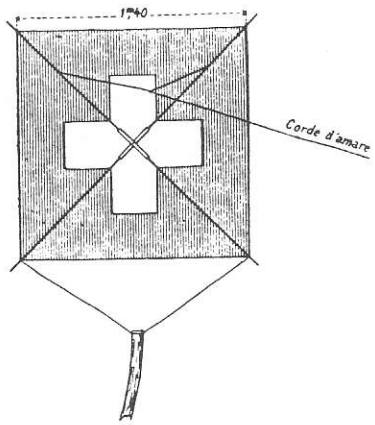

Fig. 55. Swiss signal kite, 1883.

[1] Cavallo, T., *A Complete Treatise on Electricity*, London, 1777, pp. 330–8.

6 | Meteorological Kites

It was not until quite late in the nineteenth century that kites were used regularly for meteorological observations. Soon after the establishment of full-time weather bureaus, kites began to be employed for obtaining detailed records of the upper atmosphere, but for a century after the attempts of Wilson, Franklin, and de Romas, very little interest was taken in their potentialities. This was almost certainly due to the crudity of western kites before the work of Eddy, Hargrave, and their successors. Kites were inefficient, fragile, and awkward, and were encumbered by long tails. Nevertheless, on a number of occasions before the end of the century, investigators tolerated these disadvantages in order to discover what further information kites might be able to provide.

Perhaps the first serious application of the kite in the nineteenth century was in the work of Captain Parry and the Reverend George Fisher at Igloolik, during Parry's second voyage, 1822–23. They wanted to make observations which would determine the law of variation of the temperature of the atmosphere according to height above sea-level in very cold regions. For this purpose they used a paper kite to which was attached a Six's thermometer. In what must have been one of the coldest kite-flyings in history, Fisher and the Captain raised their kite to a measured height of 379 feet. (They believed that the unrecorded height exceeded 400 feet.) The temperature at ground level was —24°, but they stood patiently for fifteen minutes, waiting for the thermometer to readjust. The experiment, although valuable in itself, cannot have exhilarated the men with its results, since no variation of temperature whatever was recorded.[1]

[1] Abbe, C., 'The Kite Used in 1822 by Fisher', *Monthly Weather Review*, Vol. 25, No. 4, April 1897, pp. 163–4.

In the autumn of 1827, Colladon, then a very young man, flew a train of three common French pear-kites near Geneva, using about four hundred yards of line, in an attempt to repeat Franklin's experiment. He was remarkably successful, producing sparks a yard long which flashed around a room in the parental home, causing his aged father some dismay. In later years Colladon wrote an amusing account of his experiment but no scientific information of any value seems to have been drawn from it.[1]

Until this time no one had thought of putting kite-flying on an organized basis. In the 1830s, however, some Americans gathered together for this purpose. They were the members of what was known as the Franklin Kite Club. The following description of the club and its activities is by William J. Rhees, once Chief Clerk of the Smithsonian Institution:

> In 1835–36 several gentlemen formed a society with the name of 'The Franklin Kite Club' for the purpose of making electrical experiments. For a considerable time they met once a week at the City Hospital grounds [in Philadelphia] and flew their kites. These were generally square in shape, made of muslin or silk, stretched over a framework of cane reeds, varying in size from 6 feet upward, some being 20 feet square. For flying the kites, annealed copper wire was used, wound upon a heavy reel 2 or 3 feet in diameter, insulated by being placed on glass supports. When one kite was up sometimes a number of others would be sent up on the same string. The reel being inside the fence the wire from the kite crossed over the road. Upon one occasion as a cartman passed, gazing at the kites he stopped directly under the wire and was told to catch hold of it and see how hard it pulled. In order to reach it he stood up on his cart, putting one foot on the horse's back. When he touched the wire the shock went through him, as also the horse, causing the latter to jump and the man to turn a somersault, much to the amusement of the lookers on. . . .[2]

The Club also practised kite-flying for recreational purposes, using decorative kites imported from China.[3] In good skating weather sleds were drawn, and on one

[1] Colladon, D., 'Expériences sur les cerfs-volants', *La Nature*, Vol. 15, No. 757, July 16, 1887, pp. 97–9.

[2] Abbe, C., 'The Franklin Kite Club', *Monthly Weather Review*, Vol. 24, No. 11, November 1896, p. 416. See also Swaim, J., 'Electro-Meteorological Observations', *The American Journal of Science and Arts*, 1st s., Vol. 32, No. 2, July 1837, pp. 304–7.

[3] Abbe, C., 'Espy and the Franklin Kite Club', *Monthly Weather Review*, Vol. 24, No. 9, September 1896, p. 334.

occasion they revived an old custom by launching a kitten in a basket. (It was subsequently landed safely by parachute.)

Espy, the well-known American meteorologist and author of *The Philosophy of Storms*, was a member of the Club and used kites to investigate the properties of columnar clouds. In one of his comments on this matter he quotes from J. N. Nicollet, who mentions that kites flown by Club-members were made to rise nearly perpendicularly when columnar clouds passed over them, while elsewhere Espy relates some of his own experiences with kites:

> I would recommend that gentlemen residing in mountainous districts, where the clouds sometimes form on the sides of the mountains, should ascertain the perpendicular heights of these clouds at their bases and see whether they are 100 yards high for every degree of Fahrenheit by which the temperature of the air is above the dew-point at the moment of formation . . . Since writing the above a kite was sent up into the base of a cloud and its height ascertained by the sextant and compared with the height calculated from the dew-point, allowing 100 yards for every degree by which the dew-point was below the temperature of the air, and the agreement of the two methods was within the limits of the errors of observation. In this case the base of the cloud was over 1,200 yards high. Moreover, the motions of the kite whenever a forming cloud came nearly over it proved that there was an upmoving column of air under it. I speak of cumulus clouds in the form of sugar loaves with flat bases.
>
> When the kite experiments mentioned before were performed and the kite was allowed to stay up in the air many hundred yards high in the night, by touching with the hand the reel on which the wire was wound which was attached to the kite, the *fingers became luminous*, quite brilliant, though no sensation of shock was produced; but by touching the wire itself a very pungent shock was experienced; and one day in particular when the kite entered the base of a forming cloud the discharge of electricity down the wire, snapping to an iron conductor stuck in the ground, terminating at its upper end within an inch or two of the wire, became fearful . . . indeed the shock on touching the wire became quite sharp when the kite was elevated a few hundred feet, even in a clear sky.[1]

At about the period of Espy's experiments, W. R. Birt was working at Kew Observatory, in England. Assisted by Sir Francis Reynolds, he tried ordinary children's kites to ascertain whether they might be of use in making meteorological observations. As the uncertainty of movement of such kites proved them, however, to be unsatisfactory, he and Reynolds experimented instead with 'an excellent

[1] Espy, J. P., *The Philosophy of Storms*, Boston, 1841, pp. 167, 175.

hexagonal kite of Mr Birt's construction'. This was held fast by means of three cords, one attached 'in the usual manner' (presumably to a three-leg bridle joining the centre and top two corners), and by two others, one fixed to each 'wing'. The three cords were then pegged to the apices of an equilateral triangle laid out on the ground. Tension on the side-cords regulated the kite's attitude and gave it great lifting power (Fig. 56). These experiments took place on August 14, 1847.[1] Birt suggested that kites be used extensively in meteorology, and pointed out the ease with which measuring instruments might be raised and lowered by means of a block and tackle. Nothing, however, seems to have come of the idea,[2] though Birt's

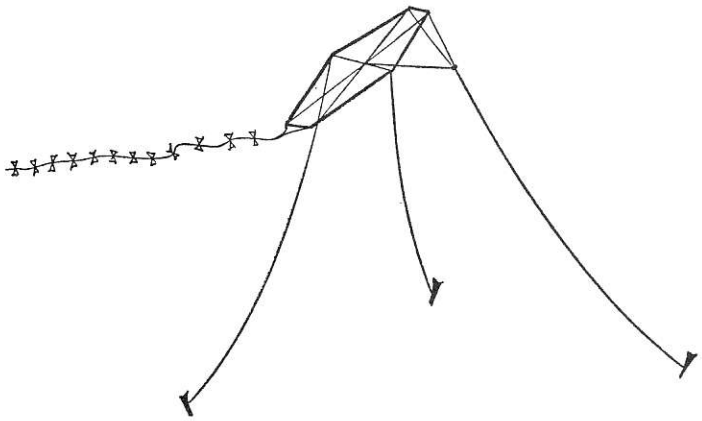

Fig. 56. Birt's kite at Kew, 1847

method of controlling his kite may have come to the notice of Maillot, whose man-lifter (Fig. 63) is remarkably similar.

Birt also suggested that large hexagonal kites, if made of silk and coated with an elastic varnish, could be of use in military as well as civil applications. More than half a century later kites did, in fact, acquire military significance (see Chapter 10).

Other occasional experimenters with meteorological kites during the nineteenth

[1] 'Experiments made at the Kew Observatory on a new Kite-Apparatus for Meteorological Observations, or other purposes', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, Vol. 31, No. 207, September 1847, pp. 191–2.

[2] A suggestion for the meteorological use of kites was made in Russia in 1846 by Professor A. Popov, of Moscow and Kazan. The idea created some interest, but appears never to have been put into effect.

century included Cleveland Abbe in America (1867 and 1876),[1] Fr. van Rysselbergh in Belgium (1880), and a Frenchman, Hervé-Mangon. The last experimented with instrument-carrying kites towards the end of the 1870s and was directly responsible for encouraging an important investigator, Charles du Hauvel, to begin theoretical work on the requirements of a meteorological kite. A British meteorologist, E. D. Archibald, must, however, be credited with initiating the use of the kite as a serious meteorological tool–a use which continued into the 1930s. He began work in November 1883, his principal object being to measure the increase in wind velocity with increasing elevation.[2] Previously the perfecting of the balloon had absorbed most of the attention of scientists working on this subject. Balloons were often unsatisfactory, however, in that, if they were free, the recovery of the instruments was difficult, while if they were captive (that is, retained to the ground by means of a line), lateral winds tended to blow them down in a large arc.

In order to try to overcome these difficulties Archibald made use of kites. Flax string was first employed as the flying line but, acting on the suggestion of Sir William Thompson, Archibald soon substituted steel wire. Of wire line he wrote: 'This I have found a great improvement on string. It is double the strength, one-fourth the weight, one-tenth the section, and one-half the cost.' Wire lines had been used previously, but Archibald's use of steel was to start a long period of development of techniques for flying kites by means of high-tensile steel, or 'piano-wire', as it is usually called.

Archibald's original kites were of the standard diamond type, with tails, and were made of tussore silk and bamboo. Like Alexander Wilson's kites, they were flown in tandem. At various points on the wire Archibald attached four self-recording anemometers, weighing $1\frac{1}{2}$ lb. each. With these comparatively crude tools he managed to reach heights of from 200 to 1,500 feet. Archibald himself continued work for only three years but by the 1890s his pioneering work had been followed up by the efforts of a large number of other individuals and organizations such as the

[1] Abbe writes: 'Perhaps in justice to himself the editor may remark that in July, 1876, having for the first and only time in his life a chance to spend a week on the Jersey coast, he then flew kites at Ocean Beach and Asbury Park in order to determine the depth of the sea breeze, and had the pleasure of seeing the kite which had been borne landward by the sea breeze soon reach the upper return current and be borne seaward by it.' (*Monthly Weather Review*, Vol. 24, No. 6, June 1896, p. 206.) In 1867 he had used kites to study winds under a thundercloud.

[2] Archibald, E. D., 'An Account of Some Preliminary Experiments with Biram's Anemometers Attached to Kite Strings or Wires', *Nature*, Vol. 31, No. 786, November 20, 1884, p. 66.

United States Weather Bureau, the Blue Hill Observatory near Harvard (run privately by A. Lawrence Rotch), the kite station at Trappes in France (run by Teisserenc de Bort), and the meteorological station in Breslau under Dr Weber.

Typical of the sort of work done with kites in the late nineteenth and early twentieth centuries were the researches of the U.S. Weather Bureau and the Blue Hill Observatory. Since their activities are well documented, a summary of them may serve to indicate the kind of thing being done with kites in meteorological stations at this period.

One of the earliest regular investigators was Alexander McAdie. In connexion with his studies at Harvard, he carried out experiments at Blue Hill in 1885. (Later

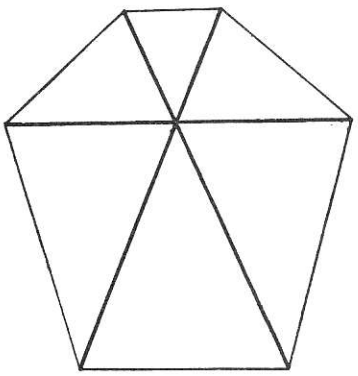

Fig. 57. Barn-door kite, as used by McAdie in 1885

he worked for the U.S. Weather Bureau.) At that time he made use of two large silk-covered kites of the common American hexagonal shape. These are sometimes known as 'barn-door' or 'house' kites (Fig. 57). They were covered in tin-foil to help collect a charge (the foil was later discovered to be unnecessary) and were flown from 1,500 feet of hemp fishing line, around which a thin copper wire was loosely wrapped. Strong charges were experienced, even in fine weather.

> It was not until August 9th [1892] that we succeeded in going through a storm with the kite still flying. About 11 a.m. the kite was sent aloft, and it remained aloft until after 10 p.m. From the observatory one can see to the west fifty or more miles, and a thunderstorm came into view just about sunset. The kite was flying steadily, and whenever a finger was held near the kite wire there was a perfect fusillade of sparks. As the darkness increased, the polished metallic and glass surfaces in the large electrometer reflected the sparks, now strong enough to jump across the air gaps, and the incessant sizzling threatened to burn out the instrument.

> The vividness of the lightning in the west also made it plain that the storm was one of great violence, and as the observatory itself would be jeopardized, one of the four men present proposed to cut the wired string and let the kite go. But even that was easier said than done, for to touch the string was to receive a severe shock. It was necessary, however, to get out of the scrape, and one of the party took the kite string and broke the connection with the electrometer and insulators. While he was in the act of doing this, the others, who by this time were outside the building, saw a flash of lightning to the west of the hill. The observer who was undoing the kite wire did not see this flash. He saw a brilliant flare-up in the electrometer, and at the same instant felt a severe blow across both arms. Notwithstanding, he loosened the wire, and, dropping an end without, it took but a few moments to make it fast on the hillside some distance away from the observatory. There it remained for the rest of the night.[1]

McAdie's kites (which were, of course, of the tailed variety) were relatively unstable and would dive even when flying quite high. It was the invention, almost simultaneously, of the Eddy bow kite and the Hargrave cellular, or box, kite (described below, Chapter 8) that made practicable the regular use of kites for meteorological purposes. Eddy himself had lifted thermometers on an ordinary kite, in about 1890, but soon afterwards, having devised his bow kites and flown several of them successfully in tandem, with minimum thermometers attached, he proposed their adoption for obtaining forecasting information. Up to this time it appears that self-recording instruments had never been raised by means of kites. They were too heavy and cumbersome in the early days, but in the 1890s simple, light, and efficient self-recording instruments were built in France and were soon in use at the Blue Hill Observatory. In August 1894 Eddy brought his kites to the observatory to demonstrate their effectiveness and on August 4 made the earliest automatic record of air-temperature using kites. Five Eddy bows, having a total area of nine square metres, lifted a $2\frac{1}{4}$ lb. instrument to a height of 1,400 feet.

On various occasions during the next year, trains of Eddy kites were used at Blue Hill for raising recording instruments. In 1895–96, however, both Blue Hill and the U.S. Weather Bureau began to use the Hargrave kites which, with some modifications and improvements, continued to be employed in meteorological work for over thirty years. (The typical meteorological kite, carrying about 68 sq. ft. of supporting surface, is shown in Fig. 58.) The kite-stations were equipped with

[1] McAdie, A., 'Franklin's Kite Experiment with Modern Apparatus', *Popular Science Monthly*, Vol. 51, October 1897, pp. 739–47.

power-driven winches, several miles of piano-wire having a breaking-strain of about 300 lb., and clamps for attaching the trains of kites to the main line.

In 1898 the Weather Bureau had seventeen stations taking records in various parts of the country and more such stations were opened subsequently. These operations were continued until the early 1930s, but were greatly curtailed in the later years when sounding balloons were being improved.[1] After the First World War readings taken from aeroplanes superseded the kite-records, and in any case the large number of kites being flown to great heights over the country were becoming a menace to aircraft. Ellendale, the last U.S. Weather Bureau kite-station, was closed in July 1933.[2]

Modified Hargrave kites were employed on most occasions, but the Eddy kites must be given the credit for establishing a high-flying record which stood for a

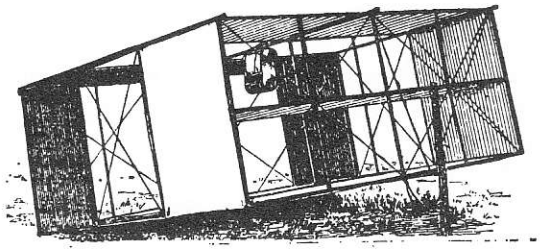

Fig. 58. Meteorological kite with meteorograph attached, *ca.* 1900–1910

number of years: on May 5, 1910, at Mount Weather, Va. (one of the Bureau's stations), a train of ten Eddy bows reached 23,385 ft. This was the highest flight recorded in the U.S., but it falls far short of the altitude of 9,740 metres (31,955 ft.) reached at Lindenberg on August 1, 1919, using a train of eight kites. This remained the world altitude record for half a century.

England lagged behind America and France in the use of kites to explore the upper atmosphere. In 1900 W. H. Dines suggested that kites be used for this purpose. The suggestion was not accepted in official circles, the lack of a suitable site for a kite-flying station being given as the reason for the refusal. In collaboration, however, with another meteorologist, W. N. Shaw, Dines began a series of private kite-experiments in the summer of 1902. For this venture they were able to obtain

[1] Whitnah, D. R., *A History of the United States Weather Bureau*, Urbana, 1961, p. 103.

[2] *Ibid.*, p. 189. In some parts of the world kites continued to be used for another decade or so.

some financial support from governmental and other bodies. The first British kite-station was set up at Crinan, off the west coast of Scotland. In order to be less dependent on the strength of the wind, Dines and Shaw made use of a steam-tug to take readings at sea. (Later a naval vessel was put at their disposal.) In this way they also avoided the hazards involved in sending kite-wires over busy roads. Shortly afterwards Dines also made readings at Oxshott and Pyrton Hill.

Other kite-stations set up at this period included posts in India (1905), Egypt (1907), and one run by Teisserenc de Bort at Hald, in Jutland (1902–3). Furthermore, kite-observations were made during a number of exploring expeditions, such as the Scottish National Antarctic Expedition (1903).

Flying kites for meteorological purposes was not without its dangers. The electric potential built up on the wire was considerable at all times. The following description of its effects, by a Mr John Pyral, is quoted from the *Bradford Observer Budget:*[1]

> In 1842 and 1843 I saw kites sent up and drawn in again, and the electric shocks from them were something terrific. I have seen sparks of fire when the wire was touched with a knife blade, and men and boys severely shaken and some fall to the ground. . . . When Robert Stephenson, the great engineer, was a boy, his father bought him a donkey to ride to school, and while pursuing his journey he used to fly kites with copper wire a mile long; that is 60 years ago. . . . For fun, he used to touch the head of his donkey with the wire, and, of course, the donkey knew about it.

When repeated high flights were undertaken by the Weather Bureau, discharges frequently melted or vaporized the kite wires and sent the kites floating off, unattached, sometimes to distances of more than twenty miles. Shocks were frequent.[2] One Weather Bureau observer reported:

> The charge coming down the kite wire rendered it incandescent and made it appear slightly larger than 1 centimeter in diameter. At the reel a cannon-like report was heard, and melted pieces of wire were scattered in every direction, liberally spraying the men on duty. None of the men was injured, although the one operating the kite reel received a slight shock. Those outside the reel house stated that the building had the appearance of being in flames. Considerable heat

[1] March 13, 1897.

[2] Lecornu quotes a report from *La Flandre de Dunkerque*, September 11, 1894, of a boy who was badly shaken by a bolt that struck his kite when it was flying no more than 100 yards up.

> and a dazzling white glare accompanied the phenomenon. The vaporized wire left a rocket-like trail of yellowish-brown smoke which remained visible for 15 minutes throughout the entire length of the line.[1]

Potentials as high as 50,000 volts have been recorded from kites at 2,000 metres, before a discharge fused the wire. At least one fatality resulted from such discharges: in 1909 Captain Engelstad of the Swedish Navy was killed in Oslo fjord while flying a kite at about 3,000 feet. Children are now warned against flying their kites with a wire line. The warning is obviously wise.

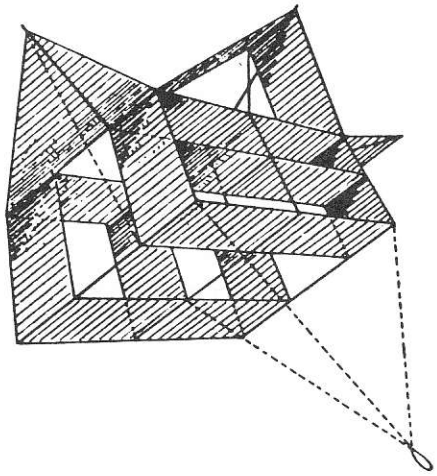

Figure 59: Compound cellular kite with wings, late 19th—early 20th century.

[1] *Monthly Weather Review Supplement No.* 11, Washington, 1918, p. 5.