It is not suggested that Wakefield was solely responsible for these achievements, but all these reforms were part of his plan formulated in the *Letter from Sydney*, and without his work they would have come much later, if at all. Actually they were forced upon the notice of the Government and the public, in season and out of season, by Wakefield and a host of important and unimportant followers, in books, pamphlets, advertisements, speeches, interviews, and by every other form of propaganda suitable for the purpose. In all this labour Wakefield took a principal part, sustained through disappointment and delays by the knowledge that he was fighting for the realisation of his own idea.

In this country as yet his name is commemorated and his services recorded by no monument of brass or stone. There remain his writings, and for us, one hundred years after, it is an act at once of piety and pleasure to read and to praise his first and most remarkable book.

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Lawrence Hargrave.

A Prelude to Biography.

By CECIL W. SALIER.

(Delivered before the Society, November 27, 1928.)

Thanks are due to Mr. H. A. Smith, who first directed attention to the desirability of some record of Hargrave's life. Mr. Smith's interest, sympathy, and help have been manifested generously since this task was taken in hand.

Much work has been done, naturally, at the Mitchell Library, Sydney; while the Public, the Fisher, the Municipal, and the School of Arts Libraries have also been laid under contribution as convenient. The author's thanks are extended to the respective Librarians and their staffs at these institutions; as also to the Curator and Mr. T. C. Roughley, of the Technological Museum, Sydney, and to Mr. W. E. Raymond, of Sydney Observatory. The number of private individuals who have contributed data and clues is too great for detailed recital, but among the

most significant, and without drawing invidious distinctions, may be named Mr. R. T. Baker, late Curator of the Technological Museum; Mrs. F. M. Taylor, of *Building*, Sydney; Mr. R. J. Yeomans; Mrs. Gray, of London (née Hargrave); Captain Geoffrey F. Hughes, Australian Aero Club, New South Wales Section; Mr. Orville Wright, of Dayton, Ohio, U.S.A.; Mr. J. L. Johnson, M.A. (Oxon.), of Kirkby Lonsdale, Westmoreland, England; Mrs. Hudson (née Hargrave); the German Museum, Munich; and lastly, though actually first in time, Rev. Joshua Hargrave, of Blaxland, New South Wales, first cousin to Lawrence.

The task of compiling this "Prelude" has been considerably lightened through the loan, from the Rev. Joshua Hargrave, of a family newspaper-cutting book. Contained in this was an article from an as yet unidentified journal, seemingly a Sydney monthly of about 1890, signed "A.W," and dealing with the life and work in aeronautics up to the year named of Lawrence Hargrave, the particular article being No. XI. of a series treating of "Men of Science." Whoever "A.W." may have been, he was evidently well informed, and the particulars he gives of Hargrave's early life, followed broadly in this essay, have proved uniformly accurate so far as they have been checked by other records or by information derived from other sources.

Among other documents in the possession of the Rev. Joshua Hargrave is a blue print of a genealogical tree of the Hargrave family back to Adam Hargrave, of Yorkshire, who lived at the end of the sixteenth century.

FAMILY AND EARLY LIFE.

From this family tree it appears that the Hargraves, whose surname is given as derived from "Herr-Graf," came to England from the Netherlands during the Continental persecutions against the Protestants in the sixteenth and seventeenth centuries, and that the chief of their family was the head of the Protestant Guild of Clothiers who established the wool manufactories in the West Riding of Yorkshire about the time of the revocation of the Edict of Nantes (1685).

Lawrence Hargrave was born at Greenwich, England, on January 29, 1850, the second son of John

Fletcher Hargrave, who, after practising in London at the Equity Bar and having achieved some distinction as a writer of legal text-books, came to Australia, accompanied by his eldest son Ralph, in 1857, for health reasons. In Australia he prospered, was a member of the Parliament of 1858, became later a Minister of the Crown, relinquished politics for his former profession of the law, was appointed Judge in Equity and Divorce in the Supreme Court of New South Wales, retired in 1881, and died in 1885.

Lawrence received his formal education at Queen Elizabeth's Grammar School at Kirkby Lonsdale, in Westmoreland, England, under the late J. L. Darwent, headmaster from 1860 to 1873, where he showed, we are told, marked aptitude for mathematics. He sailed in the ship *La Hogue*, a vessel of one thousand three hundred and thirty-one tons, long famous as an Australian liner, to join his father in Australia, reaching Sydney in 1866.

For the next six years of his life the details are vague and general. It was intended at one time that Lawrence should follow the traditional family calling of the law, but the boy's tastes lay elsewhere; perhaps the adventure of the voyage out had given him an appetite for roving. We learn that somewhere during this period he accompanied a Mr. Alexander Hamilton Thompson, of Toowoomba, Queensland, in a six months' trip to the Albert River and Sweers and Bentinck Islands, in the south-east corner of the Gulf of Carpentaria, in the barque *Ellesmere*. He also continued his studies under Mr. John Kinloch, but failed to matriculate. This, and preference for a thorough training in engineering to a University course, brought it about that he entered the drafting room of the engineering shops of the Australasian Steam Navigation Company, where he no doubt acquired that technical proficiency which enabled him to construct his later models. At this time the Hargraves lived in a house fronting the then unreclaimed Rushcutters Bay, so that having a water frontage coming to the foot of the garden, it can be easily understood how he began early to experiment with water craft.

LURE OF THE NORTH—TRAVELS TO NEW GUINEA.

For the succeeding six years, 1872-1877, the spirit of adventure possessed him. At this time, as we have ample evidence, the eyes of many people in Australia were turned towards New Guinea, and efforts were made to induce the British Government to take formal possession of that territory as an outpost to, and in the strategic interests of, Australia. The thoughts and ambitions of Lawrence Hargrave turned likewise northwards.

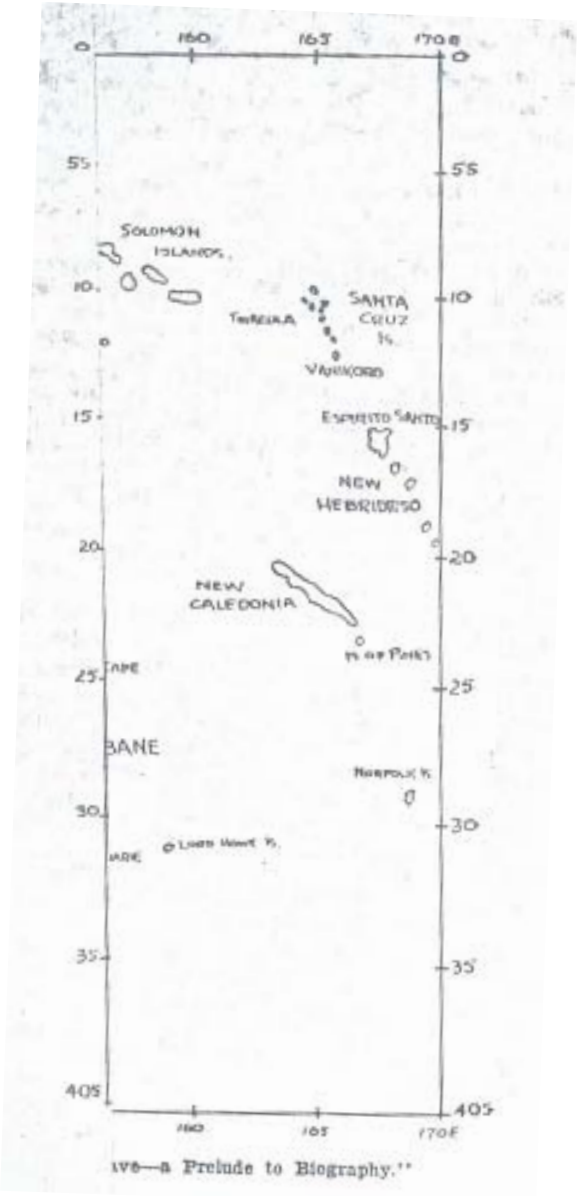
On November 8, 1871, the Rev. Dr. Lang read a paper before the Royal Society of New South Wales on "New Guinea, a highly promising field for settlement and colonization," and one of the results thereof was the formation in Sydney of a "New Guinea Prospecting Association," of which Lawrence, then aged twenty-two, was one of the committee of management. The objects of the Association were to exploit the gold reported to exist in New Guinea, and to trade profitably with the natives; white several of the members expressed their intention of settling permanently in the great northern island. The authorities looked a trifle askance on the venture as a filibustering expedition, and some difficulty and delay were experienced before the settlers could leave Sydney; At length the Association purchased the brig *Maria***,** a twenty year old vessel of one hundred and sixty-seven tons, formerly in the Newcastle coal trade, an unseaworthy craft, and under an inefficient, as events proved, commander. There were seventy-five people in all aboard, sixty-six "settlers" between decks, four sailors forward, and five officers in the cabin. The "settlers" were signed on as sailors in order to escape a clause in the Immigration Act.

The *Maria* left Port Jackson on January 25, 1872. Fine weather was succeeded by bad, the tiller broke, and young Hargrave mortised a capstan bar to replace it; and, after a further spell of favourable winds, fresh storms drifted the vessel on to the Bramble Reef, about thirty miles from Cardwell, on the Queensland coast, where she sank on February 26, Most of those on board escaped in two boats and two rafts, hastily constructed Hargrave being one of the last to be rescued

by the boats from the topmasts of the wreck. One of the boats succeeded in making Cardwell, and the occupants of one raft were hospitably received by the blacks; those on the other raft were murdered. Of the total ship's company of seventy-five, only forty survived the brief, tragic adventure. Thus ended one of the early Australian attempts to open up New Guinea to Australian trade and settlement, conducted by these "spirited and hare-brained young men from Sydney," as Admiral Moresby terms them in the account of the part taken by his ship, H.M.S Basilisk, in rescuing the survivors.

But Lawrence Hargrave was apparently determined to get to New Guinea, and he succeeded. On May 18, 1S75, he sailed as engineer attached to Mr. (afterwards Sir) William Macleay's expedition to the Gulf of Papua in the Chevert. The Chevert was a barque of three hundred and fourteen tons, originally built for a French man-of-war of fourteen guns; and for the purposes of this expedition she was provided with a thirty-five foot steam launch, of which Hargrave was seemingly in charge, and in which members of the party managed to ascend the Katow River for a little distance. The accounts of the Chevert expedition, which lasted six months (May to September, 1875) are naturally concerned chiefly with the scientific results, and an engineer, being a mere means to an end, was not a person of special prominence; but it is probable from his later papers on "Lope de Vega" that Hargrave took extensive notes, and that what he saw in New Guinea exerted considerable influence on his later thought.

He took his discharge from the *Chevert* at Somerset, at the tip of Cape York Peninsula, in September, 1875, and was almost at once enlisted, together with Messrs. Pitterd and Broadbent, also from the *Chevert*, by Mr. Octavius C. Stone, with whom he spent the next few months (October, 1875, to January, 1876) in explorations in the hinterland of Port Moresby. There he made the acquaintance of Rev. W. G. Lawes, of the then recently established London Missionary Society's station at that place. Echoes of this can be found in the "Lope de Vega" papers. The references to Hargrave in Stone's



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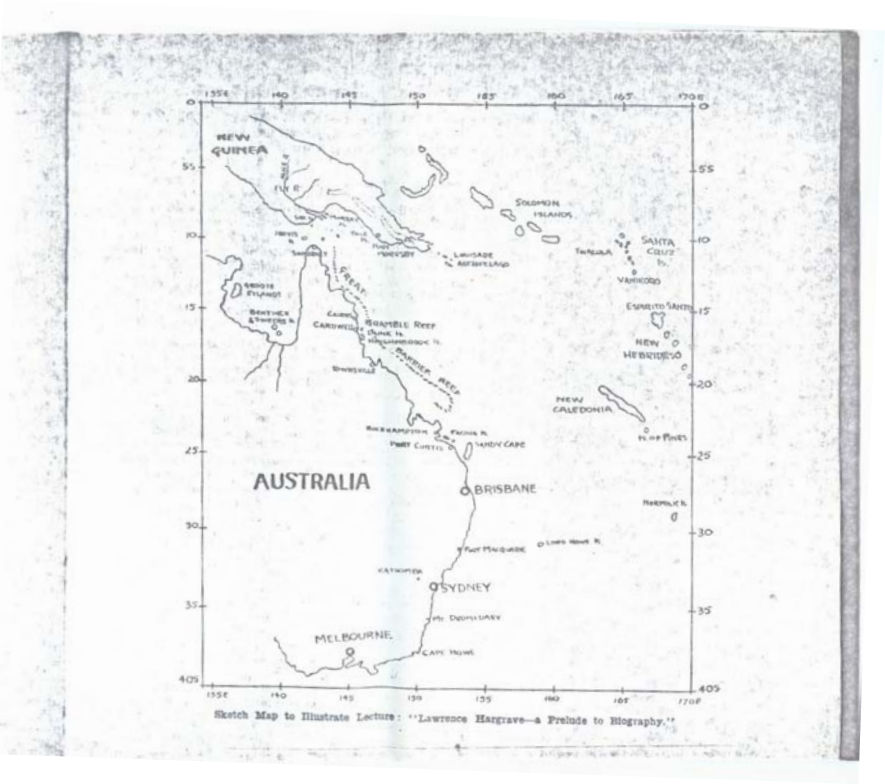
Royal Australian Historical Society.



Sketch Map to Illustrate Lecture: "Lawrence Hargrave—a Prelude to Biography."

A Few Months in New Guinea are few and brief. In one place Stone mentions that, having broken the trigger of his gun, Hargrave made a new one from sheet copper, and refers to him as a sine qua non**,**

Hargrave also very nearly got the small expedition into serious trouble with the natives over a pig, shot to provide an appropriate Christmas dinner, without due preliminary inquiry whether it were wild or the private property of the Papuans. The strains of a violin soothed the savage breast, and all ended satisfactorily. During this trip the explorers met Luigi Maria D' Albertis. The result of this meeting was that when D' Albertis organised an expedition to explore the Fly River in the steam launch ***Neva,*** Hargrave enlisted as engineer at the nominal salary of one shilling per month.

The perilous nature of the expedition to those engaged in it may be understood when it is known that the steam launch *Neva* was an open boat of about twelve tons, and was deeply laden with stores and fuel. On leaving Somerset her complement was ten men—three whites, one Chinese, and six coloured.

This expedition left Sydney by mail steamer on April 20, 1876, and by launch from Somerset on May 18. New Guinea was reached on May 21, and finally left behind on the return voyage on November 21. During the interval, and through difficulties connected with fever, fuel, currents, shoals, and trees fallen across rivers, the launch ascended the Fly River for over four hundred miles, but turned back on Hargrave logging, at D'Albertis' request, the impossibility of proceeding further. The north-west branch of the Fly, the Alice Hargrave River, was then ascended, but similar difficulties were encountered, and Hargrave, again at the request of the leader, once more logged the impossibility of steaming up the rapids. Accordingly the expedition returned to the coast, and on September 9 Hargrave left New Guinea for Somerset. He was again in these northern parts in 1877, probably the latter part thereof, when he visited Torres Straits to report on pearling stations for the firm, now defunct, of Parbury Lamb and Company. Thus for about six years (1872-1877), and those the highly impressionable ones of early man-

hood, Hargrave was predominantly interested in New Guinea, and closely associated with men whose names are indissolubly linked with the extension of geographic knowledge in that quarter; and he participated in expeditions which did much to open up that island to the knowledge and commerce of Europeans.

From the nature of the contents of the "Lope de Vega" papers, which will be dealt with at a later stage of this essay, it is in effect certain that Hargrave kept a diary of his adventures; it is abundantly clear that he observed widely and acutely, and the experiences of those formative years undoubtedly provided matter for thought and speculation for the rest of his life.

SETTLING DOWN IN LIFE

It would seem almost suddenly after this roving life he settled down and "went nowhere." This change occurred in 1877-1878.

In June, 1877, he was proposed for membership of the Royal Society of New South Wales, and was elected in due course. In April, 1878, he joined the Empress of India Lodge of Freemasons, and remained a member until his death. In February, 1912, he lectured on "The Use of Certain Implements in Ancient Masonry and Astronomy." In 1878 he was appointed Extra Assistant Astronomical Observer, under the late H. C. Russell, at Sydney Observatory; and on September 7, 1878, he was married to Margaret Preston Johnson. Of this marriage, six children were born—five girls (one of whom died in infancy) and one boy, Geoffrey.

OBSERVATORY.

His connection with the Observatory lasted about live years only. He retired in 1883, a man of moderate independent means, and thenceforth devoted himself exclusively to the task of scientific research and the extension of man's knowledge of, and mastery over, the powers of Nature.

His principal work at the Observatory was assisting the Government Astronomer in re-measuring Herschel’s

double stars during the years 1879 to 1883. Seven hundred and forty-six of Herschel's doubles were remeasured, and four hundred and eighty new doubles were discovered.

On November 8, 1881, Hargrave, in company with Mr. F. M. Bladen, was stationed at Katoomba, where he observed and reported on the transit of Mercury. In 1882 he was at Mount Dromedary, on the south coast of New South Wales, to observe the transit of Venus, but "unfavourable weather over the whole of the colony frustrated the well laid plans for the observations at each of the stations selected for the purpose," as we learn from the Anniversary Address of Mr. Rolleston, delivered to the Royal Society in May, 1883.

ROYAL SOCIETY OF NEW SOUTH WALES.

Of the Royal Society he was likewise a member till death. He became a Life Member, but except for one year on the Council he does not appear to have taken any prominent part, except in the matter of papers, of which twenty-three in all have been printed in the Society's *Journal and Proceedings.* His one year on the Council is probably attributable to the influence of Professor Threlfall, who was closely associated with Hargrave at that particular time, and who, in his Presidential Anniversary Address delivered on May 1, 1895, paid Hargrave, a then living member, the rare compliment of reference, remarking that he could "not let this opportunity pass without expressing my strong conviction of the importance of the work which Mr. Hargrave has done towards solving the problem of artificial flight." In addition to reading papers, Hargrave frequently exhibited his models at social functions held by the Society.

After his death, his connection with the Royal Society was thus referred to by the President, Mr. R. Greig Smith, in that portion of his Anniversary Address delivered on May 3, 1916, which was devoted to obituary notices:—

Mr. Hargrave was of a quiet and retiring disposition, and preferred to discuss the various subjects in which he was interested, and in which he had a deep knowledge, to a small

circle of friends rather than to a large audience. His familiar face will be sadly missed by those members of our Society who rarely saw his favourite seat vacant at our meetings.

AERONAUTICS.

After the exceeding activity of his wanderyears, Hargrave thus settled down, but the essential vitality of the man demanded an outlet which was found not along physical, but along intellectual lines, and manifested itself in the directions of scientific research and speculative imagination. That research was levelled at the achievement of human flight—a project deemed quite chimerical by the majority of the ordinary run of folk at that time. But Hargrave was confident of success, and his speculative vision, piercing beyond the puny models constructed by his own hands, saw clearly in the future the—

"Heavens fill with commerce, argosies of magic sails, Pilots of the purple twilight, dropping down with costly bales,"

Of which Tennyson spoke, though he ventured to differ from the poet with regard to the—

"Heavens fill with shouting, and there rain'd a ghastly dew From the nations' airy navies, grappling in the central blue."

It is not, perhaps, making an invidious accusation to affirm that most people are lacking in this capacity for long-sighted imaginative vision, particularly when coupled, as in Hargrave's case, with unconquerable optimism. He told with quiet, humorous appreciation how, after he had read a paper at one of the Royal Society meetings, he had met an "honest man," whose honesty, seemingly, consisted in solemnly but frankly warning him of the folly of his ways, whose end would undoubtedly be Callan Park.

In the possession by Hargrave in high degree of this quality of imaginative vision, and its deficiency in the majority of people, can we not see the explanation of certain developments in Hargrave's character and the ground of his life experiences?

Seeing clearly and optimistically the final attainment of the goal towards which his work tended, he was

nevertheless in constant contact with people most of whom considered his research a folly, its denomination as "work" a joke, and his visions of future scientific achievement the dreams of, at best a crank, at worst a "mad kite-flier."

This seems to have been the case, to some extent at least, within even the ranks of the Royal Society. On the other hand, it must be remembered that the Royal Society was a miscellaneous collection of individuals, all admittedly interested in science, but the nature and extent of whose interest necessarily varied with the character and capacity of the particular individual. On behalf of the Royal Society it should also be borne in mind that, in the sixteen years from 1884 to 1899, the Society's *Journal* contained eighteen papers by Lawrence Hargrave, presumptive evidence that there were some members, and influential members at that, who were genuinely interested in the topics upon which he spoke. But the broad statement holds, and, as Hargrave himself remarked in a letter to Octave Chanute:—

> The people of Sydney who can speak of my work without a smile are very scarce; it is doubtless the same with American workers. I know that success is dead sure to come, and therefore do not waste time and words in trying to convince unbelievers.

Hence, though he communicated the results of his thoughts and experiments fully and immediately to the Royal Society, he did so, in part at least, as a means of securing publication, and thus of bringing a knowledge of his results to fellow-workers outside as well as within Australia.

He remarks in the opening of the paper on "The One-wheeled Car" (1907) that:—

> It is the special privilege of members of this Society to have a journal as a sort of bank in which they can safely deposit, ideas of a more or less bizarre nature which, when first presented, appear ridiculous, but when printed and circulated have a way of being first looked into and examined critically by the most remote people, and their merits recognised and acted upon.

The reference to the "remote people" becomes intelligible when we learn that he corresponded with aeronautical

workers in Europe and America, and that correspondence now in the possession of the Royal Aeronautical Society, London, “is important evidence in the case for Hargrave's status among the pioneers of aviation. It supports the inference that his work was probably better known amongst the other scattered members of that little world of flight than might be supposed from the degree to which he figured as a public personality."

Hargrave resigned from his astronomical post in 1883, and, with a private income sufficient for his needs, thenceforth devoted himself solely to the prosecution of his scientific researches, particularly those connected with the problem of human flight. In the course of this he built many models and other apparatus, usually of small size and simple construction, and he several times remarked on the difficulty of securing in Sydney the necessary materials, and on the consequent cost of his work. Mr. Crossland Taylor, one of his English correspondents and a man keenly interested in aeronautics, demonstrated his friendship for the Australian, whom he had never seen, by the execution of frequent commissions for the purchase of stores. In regard to the matter of cost, a memoir written by Mr. Berriman at the request of the Council of the Royal Aeronautical Society, as a preface to a collection of Hargrave’s aeronautical papers in that Society's Library, includes the interesting note that "In twenty-eight years, from 1887 to his death in 1915, Hargrave spent, according to a carefully kept record in his journal, exactly £418/19/1 on experimental material."

Although, as will be shown later, HargraveJs mental activities embraced a much wider field, he is best known for his work in aeronautics. The following cannot pretend to be a full account of his work even in this one field, and for the inadequate summary given in the succeeding paragraphs the writer gratefully acknowledges his indebtedness to Mr. T. C. Roughley, whose two articles, entitled "Lawrence Hargrave—Australia's Pioneer in Aviation," which appeared in the (New South Wales) *Technical Gazette* in 1923-4, are the most complete account to date of the great inventor's life work.

Lawrence Hargrave

Hargrave's first contribution was the oft-referred-to paper on "The Trochoided Plane," read before the Royal Society of New South Wales on August 6, 1884. The opening paragraph is worthy of quotation in full. He says:—

> I have been told that the subject of this paper is one that would interest the members of this Society, and therefore I have strung together my thoughts, experiments, and deductions that refer in any way to the trochoided plane, pointing out where I see Nature working with it, and how it can be used by man for the transmission of force; and I trust that if other members have heard of or made similar observations they will bring them forward, so that my mistakes may be corrected by comparison with the ideas of others, and also that the truth may be elicited about a matter that does not seem to get its fair share of investigation.

The nature and contents of the paper make it clear that it represents the condensed results of extensive observation, considerable experiment, and much acute thought, spread over a fair period of time; but, perhaps because its contents are, as he says, "strung together," it seems deficient in order, and to the non-mathematical and non-mechanical mind is more striking in the illustrations, examples, and experiments quoted than for its capacity to carry logical conviction.

Mr. T. C. Roughley describes this paper as a "theoretical and highly technical discussion of the movements of animals such as worms, slugs, jelly-fish and fishes, and the motion of ocean waves"; and a more recent writer in the Sydney ***Sun*** of June 24, 1928, concluded that Hargrave had come to the conclusion that "everything in Nature, even the things with legs to a degree, appeared to progress by the creation of a wave moving and applying pressure to a plane surface. Furthermore, he deduced that all such waves had an almost identical shape —that of the normal wave of the sea."

Hargrave himself delivered the opinion that there was evidence to show that Nature almost universally used the trochoided plane for the transmission of force, and that the use of the plane by man opened up a wide field for engineers.

The trochoided plane is defined in the opening of the paper as "a flat surface, the centre of which moves at a

uniform speed in a circle, the plane being kept normal to the surface of a trochoidal wave, having a period equal to the time occupied by the centre of the plane in completing one revolution"; and the trochoidal wave here mentioned is in turn defined as "the projection of a right helix on to a plane parallel to its axis, and is resolvable into an infinite number of trochoided planes."

"The simplest troehoided plane," he further remarks, "may be constituted by attaching a flat surface to the ordinary crank and connecting-rod motion of the reciprocating engine." This device was illustrated by the first diagram appended to the paper, and the general movement of the trochoided plane was, explained as "reducible to the simple principle of the plane at right angles to the connecting-rod, moving in a circle and guided by a straight line."

Though the serried array of definitions is difficult to follow, it is quite clear that Hargrave believed himself to have discovered, and was enunciating, generalised theory of natural motion, and of the method used by Nature to transmit force, a theory whose comprehension of and use by man would open up a new and valuable field for exploitation in the realm of mechanics. From certain statements made to the present writer, it seems probable that Hargrave developed a metaphysical extension of this general mechanical theory.

Several models were exhibited at this meeting of the Royal Society, being "the result of about a dozen efforts in the direction of artificial flight," for to Hargrave "the trochoidal action of fins, muscles, and legs seemed so plain that I could not help being led to theorise on the action of wings in flight. I say theorise simply because I have not a flying machine to show you, but the chain of evidence seems so complete that I have no doubt it will soon be accomplished without the aid of the screw or gasbag."

Thus the flapping wings which were the means of' propulsion of most of Hargrave's aeroplane models were the application of the trochoidal theory to the solution of the problem of heavier-than-air flight, and the evidence

seemed to the experimenter so cogent, valid, and complete that he was led to anticipate the early conquest of the air by man.

In his second paper, read on June 3, 1885, entitled "Notes on Flying Machines," he stated: "Experimenting with nearly fifty models has resulted in these that I hope to show you supporting themselves and moving horizontally in such a way that, if the motion is not that used by birds, it is at all events very like it." A model exhibited later, on December 2, 1885, weighing 1.47 lbs., driven by rubber bands in tension, flew one hundred and twenty feet at a speed of 14.6 miles per hour;

Thenceforward till 1893-4 Hargrave continued to construct models of flying machines, successively embodying the results of experience with their predecessors and improved from observations on previous flights. All these models were of simple but ingenious construction, demonstrating the resourcefulness of their creator, who, far from the long-established seats of learning, was forced, for the most part, to blaze his own track in the domain of aeronautics, and rely on the method of trial and error; since in the early days, at least, the amount of news that could dribble to him relating to aeronautical research in other parts of the world was, as he Stated some years later, very slight.

It was trial and patient experiment that convinced him of the superiority of planes set at a dihedral angle to the flat ones which he first employed, and it was trial that persuaded him of the equality, if not superiority, of the flapping wing over the screw propeller as a means, of propulsion; though, according to modern technical opinion, the form of Hargrave's early screw propeller was an inefficient one.

The clock-work which he first used as motive power was succeeded, on the suggestion of II. C. Russell, by elastic bands in tension, and these by compressed air; while experiments were made with steam and internal combustion engines. The latter was not a success, but with steam he constructed an engine which developed energy on a scale equivalent to about one horse-power.

to ten pounds weight of engine, for its time, as Chanute pointed out, a considerable achievement. In the course of these experiments with engines, Hargrave independently invented an engine of the type now commonly known as "rotary." Something concerning this will be said later. '

With regard to Hargrave's experiments and achievements with engines, Mr. Berriman, in the memoir previously quoted, remarks: "Fundamentally, his case was the same as those of Langley, Maxim, and others—the want of a suitable engine, and the feeling that the obligation to design one rested with the aeronautical pioneer." As we know to-day, that want was supplied by the internal combustion engine developed in response to demands other than those of aviation, and the utilisation of petrol and other oils as the source of power.

Mr. Berriman further states that "Hargrave's work on engines probably had little influence on that of others," and that "viewed in the light of to-day, and its model scale-work, his early compressed air engines were as good as anything he made subsequently."

But with such motors driving flat-surfaced monoplanes, Hargrave, by patient and persistent experiment, achieved such success that Octave Chanute, writing of him in 1894 in his ***Progress in Flying Machines,*** and giving a lengthy and detailed account of his work to that date, enthusiastically claimed that "if there be one man more than another who deserves to succeed in flying through the air, that man is Laurence Hargrave, of Sydney, New South Wales."

At that time there was, perhaps, no higher living authority, no one better acquainted with the past history and existing condition of the science and art of aeronautics, than Chanute.

From 1884, then, to about 1893, Hargrave's time and energy were devoted principally to the building and experimental testing of aeroplane models, with a single flat supporting surface, usually of paper, propelled chiefly by flapping wings actuated by motors employing various sources of power. Most of these had successful flights, the best being that registered by a flapping-wing single-cylinder compressed-air-driven model which, on April 8,
1890, flew a distance of three hundred and sixty-eight feet.

Details of the construction and performances of the successive models would be wearisome, except to the expert, and would occupy too much space to be reproduced here; but the inquirer will find the matter in Hargrave's own papers, and in the works of Chanute and Roughley, to which reference has been made.

From the very first Hargrave was confident of success, and as early as 1889 he affirmed that "an expressed demand for rapid locomotion is all that is necessary to bring into existence as diverse a variety of flying machines as we see in Nature."

It was stated above that Hargrave, in this domain, was forced "to blaze his own track." So far as he was able by correspondence, he kept in touch with contemporary work in aeronautics, and appreciated the sympathy and help of his correspondents abroad, but he was impatient at the delay in attaining a goal which to his inward and sanguine vision appeared so close and certain. Writing to the English journal, *Aeronautics*, in 1909, he remarks:—

> I note with pleasure all English aeronautical news that dribbles to me. It is typical of English character throughout. Ridicule and intolerance of independent thought, slowness to grasp the import of a new idea, and opposition if any vested interest is assailed. Curiosity if things are done in a far country. Tardy appreciation of danger when a neighbour threatens. A rapid and thorough seizure of the situation. And then supremacy.

Curiously prophetic words when we remember the late war! All the aeroplanes with which he experimented up to about 1893 had flat surfaces, arranged either horizontally or at a slight dihedral angle, and they flew horizontally. But there was no arrangement for steering; they were not constructed either to swerve to right or left, or to rise or descend. But about the year mentioned, Hargrave's attention was directed to the problem of "lift," or what was called "aspiration," whereby birds or artificial objects were raised from the ground without the application of power and by the force of the motion of the air alone.

"In 1892," says Roughley, "Hargrave had performed a few isolated experiments with curved surfaces, the behaviour of which opened up to his imagination far-reaching possibilities." The direct frontal attack on the problem of flight was, therefore, abandoned in favour of research into the dynamic principles underlying the movements of concave-convex surfaces in a wind, in order to discover how they might be adapted to enable man to rise from the ground in a machine heavier than the surrounding atmosphere.

In 1893, he began experiments with kites which he called "cellular." "The novelty," as, he pointed out, "consisted in the combination of two well known facts. First that the necessary surface for supporting heavy weights may be composed of parallel strips superposed with an interval between them. Second, that two planes separated by an interval in the direction of motion are more stable than when conjoined." In his experiments with these kites built with such superposed parallel strips, he discovered that one with horizontal surfaces curved with the convex side upwards pulled twice as hard as one with flat surfaces. He therefore concluded that a flying machine with curved surfaces would be better than one with a flat body-plane. His early monoplanes, it will be remembered, were all of the latter type; and he saw that it was "certain that the numerous accidents that have happened to the india-rubber and compressed air-driven machines have been solely due to imperfections in the flat or V shaped body-planes." So impressed was Hargrave with the performances of the cellular kites that he predicted that "in all probability it (i.e., the curved plane) will prove to be the permanent type of supporting surface of flying machines."

In a famous experiment conducted at Stanwell Park in 1894, in which, however, for structural reasons, the kites had flat surfaces, a system of four box-kites lifted Hargrave sixteen feet from the ground in a breeze of twenty-one miles per hour. Except for a few—and soon abandoned—attempts at gliding, this was the only occasion on which Hargrave was actually in the air. He

had desisted from gliding, on the ground that "an accident might readily occur without making any real progress with flying machines."

It is frequently claimed for Hargrave that he "invented" the box-kite. That, however, is not strictly correct, and he himself disclaimed "invention." He did, indeed, experiment largely with box or cellular kites in this research into the problem of lifting surfaces, and his researches achieved such a measure of success and received sufficient publicity that the simple and efficient types which he designed, but, as usual, did not patent, were seized on and adapted to practical ends of which he, at the time, did not probably think. They led, on the one hand, to the military observation kite, and on the other, and in combination with suitable recording instruments, to the Marvin-Hargrave apparatus used for meteorological observations by the Weather Bureau of the United States of America.

A considerable amount of time was devoted to this investigation of the theory of the "lift" possessed by curved surfaces, which, though independently discovered by Hargrave, had been demonstrated by Phillips in England in 1884.

It is interesting, as illustrative of the manner in which Hargrave's mind reverted to its fundamental ideas, whatever may have been the particular problem on which he happened at the time to be engaged, to refer to the paper entitled "Sailing Birds are Dependent on Wave Power," read on September 6, 1899. In this he pointed out that sailing birds circle, glide, and swoop around without flapping their wings, and pass most of their time over the face or rising side of waves. By so doing they abstract power from the moving water as the progress of the wave raised the air above it at a velocity proportional to its speed and slope. Hargrave inferred that a moderate swell was amply sufficient to support a plane and keep it moving at about thirty-five miles per hour in a calm.

At the conclusion of the paper on "The Possibility of Soaring in Horizontal Wind," read on September 1, 1897, wherein he had detailed his experiments with flat

and curved surfaces and the respective "lift" obtained with each, he asserted: "A very few trials will convince the most sceptical that if we are not soaring in moderate breezes before the end of the century, it will not be from ignorance of the way to do it." And he proceeds: "It is obvious that soaring sails for marine propulsion have a vast future before them, and it is probable that craft so rigged will make better weather with a gale in their teeth than our best screw steamers." The idea sketched in the last sentence has never, apparently, been followed, up and developed.

In 1898 (June 1 and November 2), Hargrave read two further papers detailing fresh investigations into the lift possessed by curved surfaces. Of these, now called- "soaring machines," he exhibited both a monoplane and a biplane form, which consisted of one (or two) curved surfaces, provided with a tail and balanced by a weight suspended below. The side pieces which existed in the former box-kites have now been dispensed with. These constructions were found to be very stable, and soared in winds of twelve to fourteen miles per hour, A similarity of form may be noticed between the Hargrave biplane "soaring machine" and the biplanes of the early aviators, except that in the former the rudder was behind and in the latter in front of the planes.

"Up to the time of his kite experiments," says Mr. Berriman. "Hargrave had paid little attention either to cambered surfaces, to high aspect ratios, or to the biplane arrangement, all of which had been tried by other pioneers." In another passage lie states that:—

> The real field of Hargrove's probably direct influence on early aeroplane design begins with his work on cellular kites. His first paper on the subject was read in 1893 . . . and Plate VI. (in the 1895 paper) might have been copied from the Voisin biplane of the type used by Farman and Delagrange in 1907. This class of aeroplane was popularly known at that time, and for several years later, as the “box-kite.”
>
> Santos Dumont, who made the first officially recorded flight in 1906, used a machine embodying the same principle, but he flew it tail first, so to speak. For the brief space between this historical achievement and the Wrights' arrival in Europe in 1908, the box-kite aeroplane was supreme, and it is only proper that Hargrave’s name should be remembered in connection with it.

Lawrence Hargrave

With the 1899 paper on "Sailing Birds are Dependent on Wave Power," Hargrave's series of contributions to the *Proceedings* of the Royal Society of New South Wales on aeronautical topics came in effect to an end. From 1884 to 1899 inclusive he had read, in all, eighteen papers. From the year last mentioned to the paper on "Rigid Stable Aeroplanes" (1909) there is an interval of ten years, during which, however, he read six other papers on such subjects as "The One-wheeled Car," of which something will be said presently. It is clear from other sources that his interest in aviation remained undiminished. In 1899 he visited England, read a paper and exhibited models at a meeting of the Aeronautical Society of Great Britain on May 26. Percy S. Pilcher, the glider, was in the chair, and Sir Hiram Maxim took part in the subsequent discussion. At the end of 1903 he had an attack of typhoid fever, and it was during his convalescence from this that he wrote to congratulate Wilbur Wright on the historic flight of December 17, 1903, the first successful flight in a man-carrying, power-driven aeroplane. This epoch-making event was the final term in a course of development, in which the important experimental work of the great gliders like Lilienthal and Pilcher, in combination with the scientific research of such pioneers as Langley, Maxim, Hargrave, and others achieved practical success and actually began man's conquest of the air. But with the attainment of that success the control of future progress passed largely from the hands of the theoretical and scientific investigator into those of the engineer, the aeroplane designer, and the practical exponent of the new art of flying.

In the very nature of the case, this meant that the succeeding development of aerial navigation should take place in the older centres of civilisation, Europe and the United States of America, with their superior technical equipment, larger aggregates of population, and greater accumulation of wealth. Though Hargrave maintained his interest in aeronautics, experimented still on the problem of automatic stability and remained faithful to his first love, the trochoided plane, in still preferring flapping wings for propulsion, he could scarcely have felt

otherwise than that his life work in this sphere was in the main done, and that the control of events had passed permanently from the hands of himself and his colleagues who had done the pioneering work. Like Othello, he found his occupation gone.

The bulk of his later models went to Germany in 1910, which might perhaps be taken as an implicit acceptance of this fact, and as recognition that the value of these was now not so much direct and practical as stimulative and historical.

In the Abstract of Proceedings of the Royal Society for the meeting of December 2, 1908, we read that: —

> Mr. Lawrence Hargrave exhibited a series of lantern slides (seventy-four in number) illustrating the "Evolution of the Flying Machine."

The title is not strictly accurate, as we to-day would understand it. The wonderful development of flight since 1903, which is coupled with such famous names as the Wright brothers, Santos Dumont, Farman, is not recorded among those seventy-four slides. These actually illustrate in detail the full course of Hargrave's own experiments, engines and models from the " trochoided plane" to an "eighty foot three-celled kite" and a "four-winged balanced motor, one cylinder, no fly wheel, one tiller for universal steering on three-celled aeroplane flying machine"— a course of research whose object was for its prosecutor "knowledge, knowledge of our neighbours and surroundings to dispel the dark clouds of prejudice and oppression."

This exhibition was, in effect, Margrave's aeronautical swan-song.

BY-PATHS OF RESEARCH.

Hargrave's contributions to the science of aeronautics have for the time being absorbed our attention; indeed that side of his life-work is the out most widely known to the general public. But it is antecedently improbable that it could have monopolised all his time, thought, and energy. In the very nature of the case, the various problems with which lie found himself con-

fronted while pursuing this main investigation would themselves demand examination and inquiry along different but related lines.

In "The Trochoided Plane" he asserted that:—

> If a pair of equal floats be made with a total displacement exceeding that of a man, it will be found that crank, guides, and connecting-rod (these are portions of the mechanism of the plane defined by Hargrave at the opening of his paper) can be dispensed with, and the floats can be trochoided by- the feet. The steering is effected by bearing a little heavier on the float to which it is wished to turn; the increased skin resistance will do the rest. The total absence of mechanism will commend this form of exercise, and I hope to see it become a feature in our regattas.

Along these lines Hargrave constructed a pair of what have been described as "water skis," with which he actually walked on the waters of Sydney Harbour; but others who essayed the feat could not make a success of it, so that the pious hope concerning such water races in future regattas has remained a dream only,

Hargrave experimented with a hydroplane, which, however, did not reach practical results owing to the lack of adequate power and suitable engine. Like all the early workers in aeronautics, he experimented and speculated in numerous other directions in the domain of mechanics. Like them, he devoted much time and thought and the labour of his hands to the problem of the construction of a light and efficient motor suitable for use in flying machines, trying in the course of his experiments several sources of power, and constructing engines of diverse types, all in the search for the engineer's ideal—"a horse-power in a watch-case." Historically, the solution of that problem came eventually, not from the school of workers in aeronautics, but from that field of land motor traction which to-day bulks so largely in, and is so radically modifying, our social life. He experimented with an internal combustion engine without achieving any particular success, and he constructed, in 1889, a small motor of the type now popularly known as "rotary."

In "Flying Machine Memoranda," read on August 7, 1889, he wrote:—

The idea was conceived that a three-cylinder screw engine could be made by turning the boss of the propeller into an engine, thus allowing the cylinders to revolve on the crank-shaft, the shaft and crank-pin being stationary and the thrust coming direct on the valve face. Of course, the idea was put into execution with all speed.

The idea may have been independently conceived elsewhere, and the principle has been embodied in several engines, of which the French-patented "Gnome" is probably the best known. Parenthetically it may be mentioned that the "Rotary" engine has certain disadvantages, and most of the various makes of aeroplanes with which we are all more or less familiar to-day are driven by engines of types different from the rotary. In any case, Hargrave did not patent the idea and so secure the rights to the fruits of the invention, nor did he apparently push the conception to the limit of making a full-scale engine of a practically successful character; indeed, it needed, probably, the exploitation of petrol as a source of power to bring that about.

But when that development had taken place and practical success had been achieved, he was quick to realise certain further possibilities of development, and to combine the now successful rotary engine with the gyroscopic principle, which is best known in connection with the mono-rail system of another Australian engineer and inventor, Louis Brennan. The outcome of this was the brief paper "On the One-wheeled Car," read before the Royal Society on September 4, 1907. He says:—

After many millions of boys had spun and whipped tops, it was discovered that when the top is spun in fixed bearings in a surrounding cage, the top and cage will remain in any position apparently defying gravity. This is the gyroscope . . . and now I want you to see that there is a great advantage in spinning the top with one wheel only, and that by so doing any country not precipitous can be negotiated by a motor car so fitted, the car being always on an even keel.

In the diagrams with which this paper was illustrated, and which, it is to be inferred, were taken from an actual model of working size, we have the revolving cylinder, or rotary engine, housed in a flat case whose diameter is parallel to the ground. The revolution of the heavy cylinders of the engine acts gyroscopically, so

securing, as he says, that the vehicle is always on an even keel. But part of the energy of the motor is, by suitable bearings, transferred to the axle of a single wheel whose diameter is vertical, or nearly so, to the ground, and thus the machine is propelled. Along the base of the engine-casing in the diagrams run two lengthy bearing rods, "each sufficient to accommodate two bike saddles." The inventor asserted of this vehicle that:—

> If the car is on a perfect track, little push is required, leaving a large balance to speed up the gyro, and carry a large weight. If the car is on a steep and stony hillside, plenty of push is wanted, and some of the live load must walk, to leave enough gyro to sleep the remainder.

But the one-wheeled car, like the soaring sails and other mechanical devices of Lawrence Hargrave, remains a vision still.

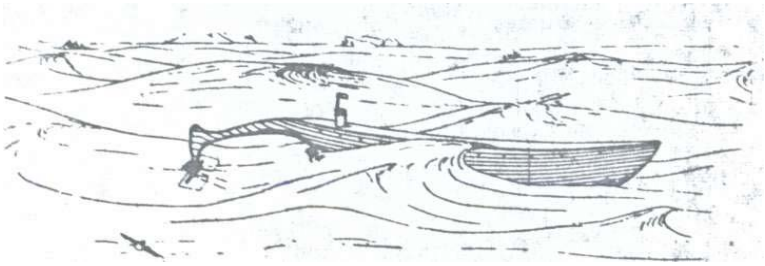
Another device of his, and one to which he gave much thought, though evidence of this appears at greater length in his letters and journals than in published papers, enables us to realise vividly what an attentive reader of his papers comes to regard as Hargrave's outstanding mental characteristic, imaginative vision. That device is the "Wave-propelled Vessel."

In "The Trochoided Plane," which we see occupies a fundamental place as the exposition of the writer's basic ideas, he had stated that:—

> The power may be abstracted from the swell of the ocean by means of the trochoided plane, thus: Take a flat float and rigidly connect a plane at some distance below parallel to the float, and it will be found that the plane and the float alternately pull each other in the direction of propagation of the waves, the result being that the apparatus progresses through the water faster than a float without the plane attached. If the plane is fixed vertically or at right angles with the float, the resultant is in a direction contrary to that in which the waves are moving.

He reverted to this idea later when, as he says in the opening sentences of the paper "On a Wave- propelled Vessel," read on September 2, 1891: "During a forced delay in the flying machine work, time has been found to make a model that anyone can see has a future "before it." As the final term in a series of experiments, a model weighing twelve and a half pounds advanced

at a rate of three-quarters of a mile per hour against the wind. Not a very great success, one would think, from the practical point of view, and hardly sufficient to warrant the optimistic utterance above quoted. But the significance of the whole thing may be gauged if we look at the matter from another viewpoint, that of Hargrave himself, and take advantage of the light thrown on his mental processes by the diagrams which illustrated the paper with which we are now dealing. These diagrams give the detailed construction of a model which was about twenty-seven inches only in length. But, in



Hargrave's wave-propelled vessel, 1891.
(From *Journal*, Royal Society, N.S.W., Vol. 25.)

addition, the author added an imaginative picture, presumably drawn by himself, showing a vessel of the proportions of an ocean liner propelled by a device, of course, on a proportionately enlarged scale, similar in general lines and identical in principle with that described in the paper on "The Trochoided Plane." This picture appears to the present writer to be specially noteworthy. The vigour of the drawing is evident at a glance, which would seem to augur no inconsiderable amount of artistic capacity on the part of the draftsman, but it is of further interest because of what may be called its psychologic implications. Remember that, although the general idea had been in Hargrave's mind for at least seven years, it had been embodied in actual models of quite small dimensions. It seems abundantly evident that once the idea of such a means of marine propulsion had been conceived, it gave its creator little rest till its practicability had been demonstrated by the construction

and trial of a model that did really work. It has been written of Hargrave that "it was typical of him that, having evolved a theory, there was 110 rest until he saw its effects in actual practice."

From that apparently meagre basis his imaginative vision leapt, in this instance, at once to the conception of a vessel constructed on the lines of the model, but of the proportions of an ocean-going vessel, and capable of carrying passengers and cargo to an amount and with a speed comparable with the liners built and engined according to more orthodox principles. But this immediate leap of mental vision to the imaginative realisation of the full ideal possibilities of the root idea looms more largely as the predominant quality in Hargrave's mental processes the more one studies the course of his thought and experiments. It becomes perhaps specially noticeable when we consider the various diversions from his main research line, aeronautics, possibly because we there lack such numerous connecting links in the chain of thought as are furnished us in his many papers on the problems of flying. It can be seen there clearly enough, too, for even when he was experimenting with small models of flying machines made of pine and paper, propelled by stretched elastic or compressed air and weighing a few pounds only, he looked forward with serene optimism to the day upon whose eve we ourselves are, when man-carrying, power-driven aeroplanes would very materially reduce the time of transit for passengers and mails, and, with the aid of photography, leave few places, or none, on the earth's surface unknown to and unmapped by man.

In the paper on "Flying Machine Work," read on August 3, 1892, his concluding paragraph runs thus:—

> A word of protest may not be out of place here against the repeated connection of the flying machine with dynamite missiles. It is natural for the military man to view it as a possible means of destroying the enemy from a secure position, but we are not all intent on the wholesale destruction of human life; and there is no doubt in the writer's mind that the flying machine will tend to bring peace and goodwill at all, that it will throw light on the few unexplored corners of the earth, and that it will herald the downfall of all restrictions to the free intercourse of nations.

Remembering recent history, and the part played by aircraft in the Great War, we can see how utterly Hargrave's optimism in this regard has been falsified by the event; and when, in due course, we come to his last days, the words above quoted will appear in an aspect of tragic irony.

Another instance of the working of this trait can be seen in the paper on "Port Sydney," read before the Royal Society of New South Wales on September 5, 1906. With the rapid growth of Sydney as a seaport, the project therein outlined is worthy of note by residents of this city to-day, although Hargrave's contribution towards the solution of an increasingly grave traffic problem has, seemingly, been quite lost sight of. The paper, which is a brief one, opens in the characteristically Hargravean direct, concise, and completely assured manner, thus:—

Without preamble, I place before you the following statement as being axiomatic, and the plans and sections annexed as sufficient for any patriotic New South Walesman to thoroughly grasp the situation and see that the railway and eastern quay of Port Sydney are wanted by the city, now (i.e., 1906), and the rest of the work at an early date, by the State .and the Continent.

(1) The wharfage accommodation of Sydney is inadequate to the immediate future requirements of the State.

(2) That lengthening and dredging existing wharves and berths in sites tortuous of approach and already crowded by ferries will only increase the congestion.

(3) That an area of at least one hundred and forty-seven acres with soundings of five fathoms and under, clear of the fair way, is now available at the Sow and Pigs shoal for the construction of Port Sydney, without the payment of a penny for resumption or compensation.

(4) That eight thousand yards of quay can be placed thereon, as shown in the plan.

(5) That there is ample room to turn for vessels of one thousand feet in length, drawing forty feet of water.

(6) That the sectional area for scour being unaltered, no complications with the holders of riparian rights can ensue.

(7) That with our present knowledge of subways from the Thames tunnel to date, the one shown on the plan presents no difficulties.

(8) That there is no obstruction to the fairway while the work is in progress.

(9) That the whole of the work is well within the scope of local contractors.

(10) That the Panama Canal must make Sydney one of the most important seaports in the Pacific if we make it easily accessible to existing shipping.

The plans of Sydney Harbour which accompany the paper show the location at the Sow and Pigs of four parallel two-sided wharves, each one thousand yards long, extending south-west to north-east, connected at the north-eastern end by a sort of magnified "assembly platform," and on the easternmost of the wharves there is a rail-head which is connected by a railway line, partly above the ground and partly in tunnels under portions of the city or the harbour, of about six miles with Sydney Central Station. In addition to the two plans of Port Sydney and of Port Jackson, with the location of Port Sydney therein, the paper was illustrated by a diagram showing the water levels about the Sow and Pigs shoal, and two others giving sections of the proposed railway.

Though Hargrave "purposely omitted detail of construction because any staff of engineers will review known methods and evolve better ones," he had his own "views on the best course of procedure," and it is abundantly clear to the present writer that at the time he wrote the paper under discussion and prepared the plans and diagrams, Hargrave had before his mind's eye a photographically clear picture of a completed Port Sydney rising in beauty from the waters of our harbour, and providing a safe and efficient anchorage for a world's argosies trading to the future Queen City of the South pacific—Sydney.

LOPE DE VEGA

Hargrave's interest in Port Jackson was not restricted to its present condition and its future development. He endeavoured to pierce into its past, and believed himself to have solved the historico-geographical mystery of the disappearance of the Spanish Captain, Lope de Vega, off Tinacula in 1595; and to have adduced proof of the presence of de Vega and his crew in our harbour nearly two hundred years before the advent of the First Fleet under Governor Phillip.

The gradual development of his thought on this topic and the progress of his general theory with regard to the matter was broadly similar to that which took place in connection with aeronautics; so that, biographically, the history of that development is of an interest at least equal to that of the theory itself as the latter finally shaped itself in his mind. Therefore no excuse is necessary for its consideration here. The ground was first publicly broken in a paper on "Lope de Vega." read before the Royal Society of New South Wales on June 2, 1909, opening:—

> The subject matter of this paper has been floating in my mind for many years, and I now submit it to you because a photograph has appeared in the public Press which would lead others to similar conclusions. The few facts communicated to you, with the assistance of others that may be forthcoming, may help to raise the veil that enshrouds the fate of Lope de Vega and his wife, Mariana de Castro.

In view of the later development of the theory, it is noteworthy that the major part of this first paper, all —that is, except the postscript— deals with New Guinea and Torres Straits matter, in the course of which he quotes from memoranda made in July, 1876, and December, 1877. It is thus evident that Hargrave had preserved the notes made during his New Guinea travels, that he not infrequently referred to them, and that his experiences during his wanderyears not only made a powerful impression at the time, but supplied him with food for thought and speculation for, as he himself says, "many years."

The thought provoked by the "photograph in the public Press" that others were, or might be, working along similar lines to his own, determined him to make public his ideas and his evidence, in the hope that the cooperation of other workers might lead the more quickly and surely to the formation of a full and correct judgment on the matter under review. The same principle actuated him in his flying machine work, and the remark of Mr. E. A. Berriman in the latter connection may aptly be quoted in this:—

> To Hargrave the free interchange of knowledge among pioneers was a governing ideal to which he adhered through life,

and this is a big point to be remembered in his favour by any who may be inclined to think that sometimes, from the purely scientific point of view, he published precipitately.

To return to the first paper 011 "Lope de Vega," we find that the first thirteen pages deal exclusively with matters heard or observed in, or relating to, New Guinea and Torres Straits. The story of a Spanish wreck off Murray Island, from which was retrieved a mass of coral-incrusted copper ingots, was combined with notes on native fishing weirs, tortoiseshell masks and figures, on the native houses, a native trestle bridge, and a "curious object" seen at Stephens Island. From all these Hargrave deduced a foreign influence and ethnic strain in the people of the Straits, and the point of the wreck decided him that that influence was a Spanish one.

The writer (M. Nicholas) of an "Appreciation" of Hargrave remarks that:—

> Few keener students of ancient geography than Hargrave ever lived. I think he had in his possession copies of the charts made by every navigator of note from the time that the mariners of Spain first -voyaged across unknown seas in search of now continents to conquer. . . . He had the peculiar faculty of being - able to recreate each navigator in person, and while he recounted his version of the trials and tribulations of each of those old time seadogs, he would roll back the centuries and make each subject tell his own particular narrative. . . . He seemed to be able to live with the ancient voyageurs, to accurately interpret their aspirations and intentions, and to appreciate their ambitions, fulfilled or unfulfilled.

With this knowledge, enlightened by such imaginative vision, Hargrave came to the conclusion that the Spanish ship which had brought the foreign influence to the Torres Straits region was the *Santa Isabel*, under Lope de Vega, which had "separated" from Mendana's expedition off Santa Cruz in 1595. And that imaginative vision led him, as Nicholas remarks, to re-create and to attempt to picture in dramatic language some actual incidents in the disastrous voyage. In later presentations of the theory, these dramatic pictures do not appear. In a "postscript" of about two and a half pages, Hargrave deals with certain rock carvings on Woollahra Point within a few yards of his own door, which, on specified grounds, he decided were the work neither of

our aboriginals nor of Englishmen, convicts or free settlers, but of the Spanish-American crew of de Vegans vessel. From internal evidence it may be safely inferred that this postscript was an after thought; that after he had worked out the major portion of the paper, the possible connection therewith of the carvings had flashed across his mind, and he had thereupon jotted down some of the main ideas that such a connection evoked.

This first paper was sent to Professor A. C. Haddon, who briefly and somewhat curtly traversed Hargrave's main ethnological positions, concluding:—

> I hope these remarks will assist in straightening out Mr. Hargrave's theorisings. I leave Australian ethnologists to deal with his interpretation of Australian rock markings.

Hargrave's rejoinder is somewhat weak, and, indeed, principally contains a re-statement of his main points in brief; but his reference to himself as an "ordinary engineer" would be disengenuous were it not, as the present writer is inclined to believe, a semi-ironic and self-depreciatory phrase covering a real inward hurt at what he felt was the cavalier treatment accorded by a scientific "big gun" to a new but valid contribution to knowledge. The inclusion by Hargrave of matter referring to the Woollahra rock carvings seemingly induced Mr. Charles Hedley to introduce to Hargrave's notice the "Memoirs of the Geological Survey of New South Wales, Ethnological Series No. 1, 1899." In this monograph by W. D. Campbell are figured and described a great number of rock carvings, extending from the north of Brisbane Water to Botany Bay and from the coast across Kuringai Chase to Berowra Creek. Hargrave had, apparently, not previously known of this publication, but he at once noticed the Statement that the rock carvings had been executed by a "point tool," and also the numerous human figures similar to those which he himself had noticed at Woollahra Point.

Accordingly, he prefaces his second paper, read on December 1, 1909, with the statement that the former one had " brought to light so many points and incidents that circumstantially supply missing links in the voyage

of the *Santa Isabel*, that no excuse is needed for again touching on the fate of Lope de Vega."

Pages 412 to 422 of that year's *Journal* of the Royal Society of New South Wales then deal at length with the evidence from rock carvings and the supposed Spanish wreck, etc., at Port Curtis, on the Queensland coast; and the concluding pages, 422 to 425, revert to the wreck off Murray Island and the Torres Straits matter treated of in the previous paper.

The reception given to the Lope de Vega theory by the acknowledged historical authorities was not favourable; but Hargrave, undaunted by their adverse criticism, privately circulated a pamphlet of eighteen pages, dated December, 1910, in which further items of evidence are added to the previous collections and additional illustrations given.

Finally, in 1912, he set himself to the task of putting forward a complete, inclusive, and up-to-date statement of the whole case, with full and elaborate photographic and other illustrations of the various points of the theory. Typescripts of this final draft are in the possession of the Mitchell Library and of the Municipal Library, both of Sydney. They begin with the statement that:—

> Three pamphlets have already been circulated dealing in a very imperfect manner with this subject. They contain so many inaccuracies that friends have since pointed out, and such a mass of additional matter has come under notice, that the time seems propitious to re-arrange, correct, delete, and illustrate as clearly as may be things that happened in the Commonwealth of Australia during the reign of our Queen Bess.

The typescript, carefully planned and drafted, consists of about eighty foolscap pages of type and some sixty illustrations, the whole being elaborately and fully indexed. In the case of both copies there are numerous additions and emendations in handscript, and at the end of each is a series of dates, the first being in type, the others in handscript. Evidently Hargrave kept the type- script under periodical review, and as he re-read and corrected his matter he scored out the last standing date and substituted the date of revision. One curious fact may be noted in passing: the series of dates in the two copies mentioned above do not correspond. It would

seem that the two typescripts were independently corrected. But the facts as they stand point unmistakably to the frequent re-reading by Hargrave of the matter he had prepared, and form convincing evidence of his thorough belief in his theory and his conviction that the chain of evidence which he had adduced was sufficiently strong to establish the truth of the theory, and that it sustained without material damage the test of strict periodical scrutiny. The final section of the typescript (in the Municipal Library copy) may be quoted as concisely setting forth what that theory was as it finally shaped itself in his mind, and that section which existed in the original draft of 1912 remained unchanged (with one small addition, noted below) through all the successive revisions. Thus then Hargrave concludes:—

The points that stand out in this narrative are at least as plentiful as the accepted histories of La Perouse and Sir John Franklin. They are the discovery of Bora Bora by Mendana. The safe passage of Lope de Vega from Santa Cruz to Port Jackson. The presence on the *Santa y Zabel* of Central American stone workers who were familiar with Aztec picture writing. The record on the stone of much travelling, with the bearings and distances of the journeys in the search for gold, together with the everyday incidents and adventures of the travellers The game that supplied the larder. The national dress and ships of the commanders. The conventional modesty that impels present day travellers to clothe naked savages when depicting, them is shown to have existed when Sydney rocks were carved, and the fashion in clothing to have taken root and survived in Torres Straits to this day. The national symbol of conquest carved where the Spanish arms were victorious. A flag and the arms of a warship carved on the rock close to a natural wharf, with ancient ringbolts and a flagstaff socket with the victor's symbol close by. A rock-cut chess-board with a double square that has never been played on by an Englishman. The arrival of another vessel at Port Jackson after the remnant of Mendana's fleet had reported how they had lost at least one-third of their numerical strength near the active volcano of Tinacula. The existence of a grid, on the shore of Sydney Harbour, suitable for hauling up a carack of about sixty tons. The northward journey of the two vessels in company. The wreck of one of them at Port Curtis. The building of fish-traps by foreigners. The wreck and salvage of the *Santa y Zabel* at Jervis Island. The curious copper ingots and gun thrown overboard to lighten and float her off. (The Spanish place-names at Port Jackson and on the track of Kos and Abob,—Addition in handscript mentioned above.) These are the things that the writer wishes his

fellow colonists to quickly know, so that if they are in possession of knowledge or relies, they may be induced to think that possibly they will aid in making the reality of this sea and land travelling still plainer.

And these are the things that, in Hargrave's opinion, perforated “the veil that hides the voyage and fate of Lope de Vega and Mariana de Castro, as illustrating the earliest events in Australian history.”

The well-Known rock carving at Meriverie, near Ben Buckler, recently enclosed by the Waverley Council as a measure of preservation, illustrates in brief this theory of Hargrave's. This inscription is thus explained by him. The two old-fashioned ships are, of course, the *Santa y Zabel* and her consort, the *Santa Barbara*, indicated by the "B A" and "Z A" at the beginning of the lines. The "W" is the native name of the country, the island which then extended from South Head to Ben Buckler, Spanish having no W. The oval enclosing the cross is the Spanish symbol of victory, and the ideograph below show's that the ***whole*** island was conquered. "L" is Lope de Vega, and "N," "i," and "H" were witnesses to the record, cutting their signatures with sword point or dagger. Thus the whole inscription reads:—

"We in the *Santa Barbara* and *Santa Isabel* conquered, W……from point to point by the Sign of the cross."*

His imaginative vision led him also to reconstruct the two Spanish ships from the outlines of the hulls, which alone are sketched on the rock. The restorations are given in the pamphlet of 1910, which shows the *Santa Barbara* as steered by a long oar or sweep, and both vessels us hearing on their chief square sail the cross in the oval, which he termed the "symbol of victory." He likewise restored or interpreted the carving of the

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*Mr. Hugh Wright, Mitchell Librarian, points out that Campbell’s original drawing of this inscription, made in September, 1893, does not include the letters “N,” “i,” and “H,” the “W” is represented by “N,” and the oval does not surround a cross. [thus proving that Hargrave’s theory applying to Meriverie was conceived later than 1893, and that his imaginative explanation of the markings was erroneous.-Editor.]

human figure which he had noted at Woollahra Point. As is well known, these carvings represent the human figure, as a rule, in outline only, the procedure having been that the object to be carved was laid on the rock, the outline sketched, holes cut at intervals along this outline, and the spaces between these holes then fully carved out. The figure at Woollahra Point, which was about five feet high, represented a human figure with arms outstretched, with three dots and a line in the circle of the head, curious protuberances on each side of the neck, large heavy feet, and angular projections at the knees. To the enlightened eye of Hargrave this crude carving, which others had attributed to our aboriginals or to convicts, was revealed as the outline picture of the wife of Lope de Vega, Mariana de Castro, in male dress, which was assumed for convenience and safety. The dots are two eyes and a rich gem set in a hair band, the protuberances the outline of the ruff of the period, the heavy feet are sabots (the little gap at one toe was even asserted to be deliberately carved and meant to convey the information that she was a strenuous walker), and the angular projections are the bottom corners of the wide male knickerbockers.

Vividly as Hargrave undoubtedly visualised, and dramatically as he depicted these voyagings of Lope de Vega, and convinced though he himself was of the truth of his theory in the whole and in many of the details, his views, in the words of the *Australian Encyclopaedia,* "failed to secure approval from more expert historians"

As mentioned above, Professor A. C. Haddon controverted his deductions from personal observation in New Guinea. Captain J. H. Watson asserted the mythical character of the details relating to the Spanish wreck on Facing Island and the early settlement at Port Curtis in a paper read in 1909; and Mr. C. H. Bertie, in an article contributed to the Sydney *Sun* of September 24, 1912, has adduced cogent reasons for holding that the ringbolts at Woollahra Point are of a date much more recent than that claimed for them by Hargrave. Mr. Bertie also deals with the rock carvings, and, quoting the authority of Mr. R. H. Mathew, maintained that these

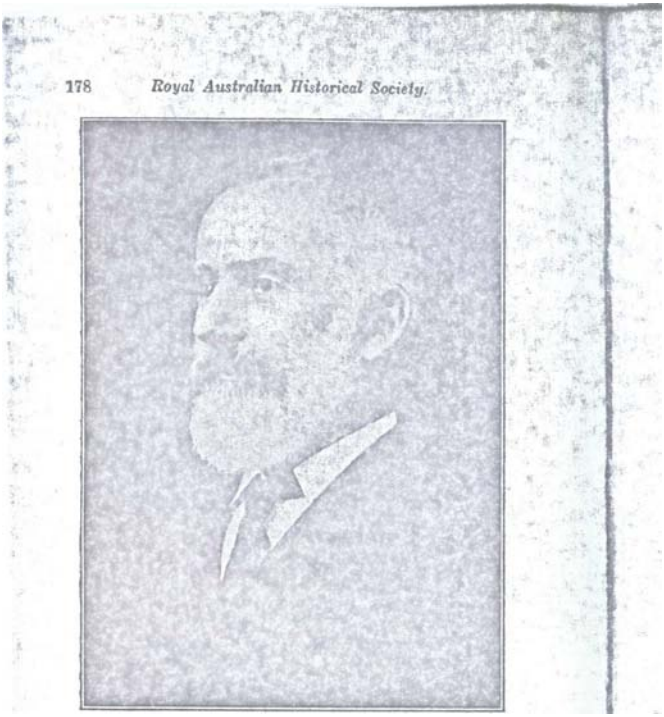
are "characteristically aboriginal," and that there is an "absence of any carvings which can be regarded as indisputably and characteristically Spanish."

But in spite of the weight of authority against him, Hargrave made at least *one* convert. Mr. M. Nicholas, whose statement about Hargrave's interest in the old navigators was quoted above, in the "Appreciation" of Hargrave which was published in the now defunct *Sea, Land and Air* of February, 1920, affirmed that his subject, "after much investigation, was able to prove conclusively, from certain marks on low-lying rocks, that at least one high-pooped vessel of Spain dropped anchor in Sydney Harbour many, many years before Captain Cook saw the light of day—a theory which, though unrecorded in documentary form in the history of the world, is, nevertheless, now regarded as accurate."

But such converts as Nicholas were probably few, and confined in the main to that limited personal circle in which Hargrave, a naturally reticent, and, by habit, unexpansive man, felt he was addressing a sympathetic audience; and the popularly received view is that Hargrave had accepted and adopted, without sufficiently critical examination, any point which seemed to support his speculative theory.

THE LAST YEARS.

About 1912, then, we find that Hargrave's fundamental theory of natural motions, advanced in the paper on "The Trochoided Plane," had been entirely overlooked, his numerous locomotory devices had borne no practical fruit, his contributions to the science of aeronautics had been built on and carried to a practical success by men on the other side of the world, *his* share in laying the foundations being, naturally, largely forgotten through his refusal to patent his ideas, and his attempt to elucidate the early history of Australia and of geographical discovery thrust aside as vain and credulous. Assuredly not a particularly comfortable situation for a man in the sixties. To a man of the optimistic, imaginative, and speculative type of Hargrave, there remains always the consolation of the "inner vision," but



Lawrence Hargrave, 1911.

there is reason to believe that during these years of his life his hopes tended to centre round a concrete object— his son, Geoffrey Lewis Hargrave. Geoffrey was born in 1892, one boy among four girls. After making a brief excursion, according to family precedent, into the fields of the law, the boy adopted engineering as a profession.

One of the sisters, Mrs. Gray, tells us that he was "an extremely promising young engineer, who had been of great assistance to his

father when working at some of his later models, and would doubtless have continued work in aviation had he lived." He studied at the Sydney Technical College, and the Technological Museum has on exhibition a rotary aeroplane engine made by him.

The accounts given indicate that during these latter years father and son worked together in their workshop at Woollahra Point as chums and fellow craftsmen; and we can easily imagine the feelings of the father in having with him at the work bench one on whom he could rely for understanding and sympathy—an engineer like himself and his own son. Perhaps he dreamed that, coached by himself, Geoffrey would carry on the work he had initiated, achieve the success which had eluded him, and receive the public recognition which he himself had, somehow, missed. If he did entertain such thoughts and ambitions, they, like his former ones, were doomed to disappointment. On the outbreak of war in August, 1914, the boy enlisted, was sent to Gallipoli in reinforcements for the famous "Fighting Thirteenth" Battalion, and there, on or about May 24, 1915, was killed. The news of his son's death was for the father almost a *coup de grace.* Mention of the boy's name was forbidden in the stricken household, and report has it that at this time Hargrave destroyed many papers and memoranda, as if they had been hoarded for Geoffrey's future use, and with his death the reason for their preservation had ceased to be.

Force of habit, no doubt, kept Hargrave more or less to his usual routine. He attended the meeting of the Royal Society in June, 1915, for instance; but when illness came there was little power or will to resist, and after an illness of about three weeks, Lawrence Hargrave died on July 6, 1915, at Lister Private Hospital, Darling-hurst, Sydney, the causes of death being certified as appendicitis and peritonitis. He was buried in Waverley Cemetery on July 7, the funeral service being conducted by his cousin, the Rev. Joshua Hargrave, in the presence of a small body of personal friends. Mrs. Hargrave and the daughters went to England, where the former died

and the latter still reside. Obituary notices appeared in the Press and in the *Proceedings* of the Royal Society of New South Wales, but the state of war then existing necessarily involved that the passing of a retired and retiring man, although a great one, should be completely overshadowed by the World War and soon forgotten by the people at large.

MEMORIALS

Not but that his memory was cherished by a faithful band of personal friends and associates, while the increasing company of those interested in aviation and the history of its development could not fail to learn something, at least at second hand, Concerning Hargrave's contribution to man's mastery of the air.

Indeed each successive event in the progress of practical flying, particularly such as connected Australia with the new art, like the successful flights from Europe and the United States, was the occasion in the Press of references to Hargrave's work, its lack of appreciation in Australia, and the successful development of his ideas abroad.

The famous Ross Smith flight in 1919, the first journey through the air from England to Australia, produced in Sydney a crop of such Press matter, much of which had for its immediate theme the desirability of commemorating Hargrave's work and erecting in his honour a memorial more fitting than the undistinguished headstone which marks his last resting place in Waverley Cemetery.

The idea of such a public and permanent memorial had, no doubt, previously occurred to many, but it was not till the coming of the Smiths at the end of 1919 that a definite proposal was actually launched

The late Colonel Oswald Watt then inaugurated a "Lawrence Hargrave Memorial Fund," whose object was "to secure world-wide publicity for the, proposal to erect a suitable monument which will at once perpetuate the memory of the deceased scientist who discovered the principles of flight, and that of the first Australian air-

man (i.e., Ross Smith), to fly across the planet from England to Australia in an aeroplane constructed on the principles of Hargrave's invention."

The then Premier of New South Wales, Mr. W. A. Holman, when asked, was ready to dedicate a site for the monument either in the Botanic Gardens or in the Domain; an appeal was made to the public for the required funds; a bank account was opened, and Colonel Watt, President, and Mr. E. J. Hart, Secretary, of the Australian Aero Club, New South Wales section, were the first trustees of the fund.

The project was publicly launched on January 7, 1920, by Major-General J. Gordon Legge, C.B., C.M.G., Chief of General Staff, in the course of a lecture in Sydney under the auspices of the Aero Club. It was anticipated that in the enthusiasm evoked by Ross Smith's success, the amount required for the proposed monument would soon be collected. In plain fact, the actual subscriptions amounted to between £300 and £350 only. Through the operation of interest, the fund stands to-day (1928) at a little under £500, the present trustees being Captain Geoffrey F. Hughes, President, and Major T. M. Scott, M.C., of the Aero Club.

Deeming it inadvisable to attempt to "boost" the fund at a time like the present, when many more popularly-appealing calls are being made on the purses of the public, the trustees are investing the money in hand in the assured hope that in due time the fund will have so grown that its purpose may be achieved. That "consummation devoutly to be wished" is, however, unlikely for some years to come, since a monument on a fitting scale is roughly estimated to cost about £2,000.

In 1922 a proposal was made to the trustees by the Royal Society of New South Wales that "a most fitting form of memorial would be an edition of his (Hargrave's) collected aeronautical papers." It was estimated that such a memorial volume, to be editedand published by the Royal Society at the cost of the fund, would consist of about one hundred and thirty pages of text, seventy plates, and twenty text figures: that an edition of one thousand copies, which would be distributed among the libraries and scientific institutions all

over the world, would cost approximately £365. The trustees, though appreciating the appropriate nature of' the form of memorial proposed by the Royal Society, have been unable to accept the suggested amendment, feeling themselves bound by the exact terms of the original scheme. The appeal to the public was for the erection of a monument, and it further Contained the suggestion "that the figure of the late inventor surmount the pillar, one side of the plinth to bear a carved replica of his original Hargrave box-kite, and the other a model of the Vickers-Rolls-Royce Vimy biplane which carried Sir Ross Smith and his party from England to Australia."

Such being the proposal to which the public were asked to, and did subscribe, the trustees hold themselves incompetent to change the form of memorial without the consent of all the contributors. But this it is impossible to obtain, since some of these are dead, and of others the present addresses are unknown.*

HARGRAVE EXHIBITS—SYDNEY AND MUNICH.

But if Sydney, where he did most of his research work, does not yet possess a statue of Hargrave, it does contain a memorial to him—a large glass show-case on the second floor of the Technological Museum, Ultimo. This case contains about two dozen photographs of Hargravean devices and models, and nine early flying machine models. These were presented to the Museum by Hargrave himself about 1891. In the paper on "Nos. 13 and 14 Compressed Air Flying Machines," read on July 1, 1891, he remarked that "nine of the successful models described in the Royal Society's *Proceedings*, representing five distinct types of flying machines, have been given to the Technological Museum with the object of rendering them at all times accessible to the public free of charge"; while shortly before his death he donated a box-kite with reverse curves, which hangs from the ceiling near the show-case.

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*The address of the “Lawrence Hargrave Memorial Fund” is C/o Australian Aero Club, New South Wales Section, Barrack House, 16 Barrack Stress Sydney, New South Wales.

Lawrence Hargrave

The Annual Report of the Museum for 1919, made by the then Curator, Mr. Richard T. Baker, refers to the exhibit in the following terms:—

The arrival of Sir Ross Smith and his brother, Sir Keith Smith, at Darwin, Australia, on December 12, after accomplishing the voyage from England in a Viekers-Vimy aeroplane in twenty- eight days, recalls the fact that there are housed in this Museum many of the original models of that great Australian pioneer in aeronautics, Lawrence Hargrave, whose lifelong work in dynamic flight helped considerably to make such a performance possible. In the largest case in the building are nine monoplane models, ranging from his earliest wing-flapping, rubber-band propelled machines to those with revolving screw, and driven by compressed air. Each of these models accomplished flights in a horizontal course, which ranged up to three hundred feet in length, and his engines are a marvel of simplicity and lightness. An original photograph of his earliest revolving-cylinder engine, invented by him in 1889, is also on view. This engine is the direct forerunner of several of the present day rotary engines, of which the French "Gnome" is a well-known example. A Hargrave box-kite is also to be seen, and it is generally conceded that the box-kite, as perfected by him, was the most stable thing that had flown up till that time, and eventually proved to be the prototype of the early French planes, the Santos-Dumont, Voisin, and Farman.

It will have been noted that the models housed now in Sydney are comparatively few, and all, with the exception of the box-kite, early; while it is a matter of common knowledge that many others of later construction were given to Germany, and are now housed in the German Museum at Munich. Exactly how they came to be so donated is a story of which the present writer feels that he lacks many, and those the most important, chapters. Certain facts are known, but the series is far from complete; and till further facts, supported by evidence and definitely dated, are brought forward, it seems advisable to rest in the situation as it stands.

The following is a translation of the text of a memorial tablet set up in honour of Hargrave in the collection of aerodynamical material in the German Museum at Munich :—

Lawrence Hargrave, in Sydney, made, in the years 1884-1909, pioneering researches into the problem of flight. In his experiments ho made use of small models built by himself of both ornithopters and soaring machines driven by steam, petrol, com-

pressed air, etc. He also made, independently of Lilienthal, attempts at gliding with aerofoils. His greatest suecess is in theintroduction of box-kites for meteorological purposes. He undertook ascents with great man-lifting kites. He early recognised as the result of his experiments and calculations the possibility of motor flight.

Mr. Roughley, at the conclusion of his papers before referred to, and in dealing with this matter of the donation of models to Munich, has set down the opinion that "Hargrave's decision was reached as a result of the fact that he looked upon the development of aviation from the viewpoint of civilisation rather than from a national one. He desired his work to benefit mankind, and countries and border lines had no place in his vision. He was persuaded that in Germany his models would be readily available to students and engineers all over Europe, while in Australia their influence would scarcely be felt. Hargrave succumbed to the argument, and his models were lost to Australia for all time." However that may be, and pending the production of further evidence, the present writer is disinclined to hazard an opinion, there is little doubt that Mr. Roughley has, in a general way, correctly diagnosed the Hargravean outlook; and so we return, after this brief discussion of his works, to the man himself.

CONCLUSION.

Some of the prominent traits in Hargrave's character have been indicated in the foregoing epitome of his career and achievements, and stress has been laid on what has increasingly appeared to the writer to have been his outstanding mental characteristic, that of imaginative vision. The vital energy of the man, after finding temporary expression in the activity of his wanderyears, after his marriage and retirement sought and found another outlet along the lines of mechanical construction and speculation. Hence the patient, lifelong, and minutely careful series of experiments which give him the right to be classed among the great contributors to the solution of the problem of human flight. That research was sustained by the inward assurance of ultimate success, and by the selfless motive that successful flight was the thing

to be striven for entirely apart from the question as *to* who should be the particular individual by whom that ultimate success would be achieved. In addition to the constant note of optimism, his papers are marked by a conciseness which frequently seems obscurity; actually what he described was present to his own mind with a vividness and clarity of detail which might almost be termed photographic. His generosity of spirit and devotion to the ideal of scientific progress, independent of the personalities of the workers, is plain in nearly every paper he wrote, and in the liberality with which he sent copies of his own papers to workers in the same field in England and the United States of America, from whom he asked only a return in kind to the end that progress- might thereby be quickened and success the sooner attained. The same object inspired, as we have seen, the donation of models to our Technological Museum, and also the similar donations of a model to the Field Columbian Exhibition, Chicago (now in the Smithsonian Institution, Washington), and of a series of twenty-five photographs to the Engineering Association of New South Wales. His belief that human flight would tend to the breaking down of barriers between nations and to the increase of peace and goodwill between peoples has been exemplified by quotation, and illustrates the temper of the man and the spirit which inspired his life-work.

As characteristic of this attitude, there may be quoted the report of a speech made by him in 1909. At a meeting held at the Hotel Australia, Sydney, on April 28, 1909, to inaugurate the "Aerial League of Australia." Hargrave was elected to the chair, and in replying to the vote of thanks moved to him at the conclusion of the meeting, he expressed his dissent from the second of the printed Objects of the League, ***viz.,*** "To secure best recognition for Australian efforts."

"It would be idle," he said, "for him to say that he was blind to the personality contained therein. If by some peculiarity of eyesight he had been able twenty- five years ago to see one of the possibilities of to-day, and by steady thought and busy hands had put rude matters into forms that others now understood—well,

why use that horrid union word, 'recognition'? If his old work gave them a lead in any direction, they should receive it as freely as it was given, improve upon it, and then pass on their new knowledge as freely as the germs were given to them."

Habitually a reticent man, and usually speaking only when directly addressed, he was nevertheless ever free, courteous and helpful, with a wide range of knowledge always at the disposal of the sincere inquirer.

Character, in the words of Emerson, "speaks over our heads," and the character of Lawrence Hargrave, expressed in his writings and embodied in concrete form in his constructions, gives him unimpeachable right to be ranked among the most notable personalities of Australian history.

THE FOLLOWING SLIDES WERE EXHIBITED TO ILLUSTRATE THE LECTURE:—

Queen Elizabeth Grammar School, Kirkby Lonsdale, 1928.
Scene: Kirkby Lonsdale, 1928.
Ship *La Hogue.*
Map.
Hargrave at about 40.
Trochoidal Movement, 1884.
Fish Movement, 1884.
Early Planes, 1885, 1889.
Later Plane, 74 ounces, 1890.
Early Kites (cellular), 1893.
Box-kite and Diagram of Movement, 1894
"Hillcrest."
View of Stanwell Park, 1916.
Lifting Experiment (with Farman Plane), 1894.
Group at Stanwell Park, about 1897.
Biplane Soaring Machine, 1898.
Rotary Engine, 1889.
One-wheeled Car, 1907.
Wave Propelled Vessel, 1891.
Port Sydney, 1906.
Lope de Vega Typescript, 1912-14, end showing revision dates.

Santa Y sabel at Woollahra Point.
Woollahra Point Carving (Mariana de Castro).
Woollahra Point, from aeroplane, 1928.
Grid at Carrara.
Meriverie Inscription.
Geoffrey Hargrave, about 1915.
Grave of Lawrence Hargrave, Waverley Cemetery, 1928.
Exhibit, Technological Museum. Sydney, 1919.
Flying Machine Hall, Munich, 1922 (?).
Munich: Motors, 1928.
Munich: Steam Motor, etc.
Munich: Box Kites, etc.
Munich: Quadraplane.
Hargrave, aged 61 years, 1911.

LIST OF PAPERS BY LAWRENCE HARGRAVE THAT WERE PRINTED IN THE *JOURNAL* OF THE ROYAL SOCIETY OF NEW SOUTH WALES:—

1884—August: Notes on the Trochoided Plane.
1885—June: Notes on Flying Machines.
December: On a Form of Flying Machine.
1887—June: Recent Work on Flying Machines.
December: Autographic Instruments used in the Development of Flying Machines.
1889—August: Flying Machine Memoranda.
1890— June: On a Compressed-air Flying Machine.
December: On the 74 Oz. Compressed-air Flying Machine.
1891—July: Nos. 13 and 14 Compressed-air Flying Machines.
September: On a Wave-propelled Vessel.
1892—August: Flying Machine Work and the l-6th-HP. Steam Motor.
1893—June: Flying .Machine Motors and Cellular Kites.
1895— June: Aeronautical Work.
1896—August: On the Cellular Kite.
1897—August: The Possibility of Soaring in Horizontal Wind.
1898—June: Aeronautics.
November: Soaring Machines.

1899—September: Sailing Birds are Dependent on Wave-power.
1906—September: Port Sydney.
1907—September: The One-wheeled Car.
1908—December: (Evolution of the Flying Machine— 74 slides).
1909—June: Lope de Vega (I.).
December: Lope de Vega (II.).
December: Rigid Stable Aeroplanes

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ERRATUM

In the *Journal*. Vol. 15, Part I. p. 46, seventh line from the bottom, please strike out "G. H. Gordon, brother of."