The government has now determined on the construction of a small harbor at Skagen, and of two isolated moles, respectively at Hanstholm and Vorupør.

The author concludes that in view of the precarious nature of tidal harbor work, and the instances in which success has been only partial, a departure from established practice is called for. Harbors of refuge have a limited range of utility, unless in land-locked positions.

LESSONS OF THE BALTIMORE FIRE.*

By F. W. FITZPATRICK.

TEN years ago there swept over a portion of Minnesota a combination of forest fire and cyclone that resulted in the wiping out of several thriving villages and an appalling loss of life, paralleled only by that of the Iroquois Theatre holocaust. That was the "Hinkley fire." I was in the relief party that went to the villages' succor, and never shall I forget that scene of utter desolation that unfolded itself before us that night. The heat had been so intense, and the gale so fierce a one, that the effect on the buildings and trees and all about was as if Hades itself had been let loose. Here and there were a few lonesome chimneys left standing; all else was totally consumed. The ground was charred and hardened into an almost pavement-like surface, and comparatively clean, and there was not a vestige of a tree trunk or charred building timber to be found; absolute and complete combustion, annihilation. My first impression of the Baltimore fire brought back that other scene to me. Fire had made almost as clean a sweep in that city, leaving here and there but the tall fireproof "skyscrapers" that, at a distance—where I first saw the ruins—reminded me much of the sentinel-like chimneys at Hinkley.

Of course, I have the utmost sympathy for the business men there who have suffered such terrible losses, and in what follows I have no intention of being heartless, but will discuss the case as does a doctor in a clinic discuss the "subject" upon whom he is operating, in a few words, and without dramatic or sentimental embellishments.

Never before have our theories of fireproof construction received so severe a test; and that those skyscrapers are still standing, and that their structural members that were properly protected are intact, is all the vindication the most enthusiastic of us supporters of tile fireproofing theories could hope for.

Something like 150 acres of territory is gutted.

I was able to note the intensity of the heat as indicated by its action on the metals and brick and stone; and while the wind evidently played some peculiar pranks and made strange twistings, the terrible drafts created by the fire itself performed some wonderfully acrobatic feats, so to speak, in twisting lines vertically as well as horizontally. In places it would seem as if the blast had passed over three and four-storied buildings to attack the six and seven-storied ones most fiercely, while leaving the former to burn more slowly, and sometimes from the top down. Three or four buildings escaped in this manner from absolute destruction; one, the Safe Deposit Company building, a two-story well-built affair, went scot free. The brickwork and the iron shutters showed really but very little of the effects of the terrific heat that must have been all about it. Some actions of that fire baffle scientific explanation. In the very case of this Deposit Company building, I can understand how the fire could have swept over it so quickly; and there being nothing about its exterior that would readily ignite, that it should escape; but some distance away stands the old United States Stores building, across the street from the new Custom House. On every side of this building its neighbors have been completely gutted, while it stands to all appearances absolutely intact. The glass in the windows is not broken, and the window frames are but blistered, while the shutters inside the closed windows are charred and scorched. Could the heat simply have been intense enough to scorch this woodwork inside, through the glass, but, unaccompanied by flames, and being influenced by counter currents of air, it left the exterior unmarred? The building suffered some in the upper story by reason of the breaking of the skylights, and fire getting in that way. Then here and there in the streets stands a wooden telephone or telegraph pole comparatively untouched, and near it an iron one twisted into all sorts of shapes.

The combustion in the buildings was complete and most searching. Usually after a fire there will be charred bits of floor joists still sticking to the walls, and masses of closely packed goods or papers on the ground, their very density preventing their combustion. But not so here. In most of the buildings burned, particularly along the lines of the most intense fire, there is not a vestige of anything but brick and iron left. One would think that the draft had drawn whatever little residue there might have been up, and scattered it about in cinders and dust. Charred papers were found miles off, and whole sheets of tin were carried blocks away. Indeed, the suction or draft created was so great that many skylights and iron roofs appeared to have been at first lifted before collapsing. Some of the skylight glass appears to have been broken outward, too, and before fire could have had effect upon it from within. In some buildings the glass from the windows is mainly within them, and in others it is on the outside and well away from them, again showing that the suction of air along those streets, toward the vortex of the fire, must have been something tremendous. Then in some

buildings there is very little glass to be found; it seems to have disappeared; while about others I found stalactite formations of fused glass, which indicated the terrific heat there must have been generated.

At one building, on the sidewalk there had been a bulletin board with a sheet of the latest news pasted upon it. This was but a trifle scorched around the edges. Nothing was left of the building but a few little stubs of the walls, but this bulletin board was at the corner of intersecting streets. A cross draft of cold air may have protected it, or may there not have been created an almost absolute vacuum at certain points—this for instance?

On another building, where iron and glass and stone were either twisted or fused out of all recognizable shape, a small glass sign stands undamaged with the gilded letters as bright as new!

At the fiercest of the fire were centered most of the important commercial houses. The fire fed on the factories and manufacturing plants below that point, and there gaining tremendous headway and intensity, swept this commercial district virtually out of existence. "Slow-burning," "mill-constructed," and all kinds of buildings, good and bad, went by the board. The fire seemingly tackled them from the top first, in a quick, blast-like stroke, and then what might be called a secondary fire worked horizontally along, and burned from the ground up to the point apparently first attacked by the fiercer flames. As the photographs will show, a few stalagmites, as it were, of walls and piers alone mark the site of these buildings—and only the "skyscrapers" stand in anything like structural entity, splendid monuments to our progress in the science of building.

The Continental Trust building, a fifteen-story structure, one of Baltimore's latest and best buildings, was attacked a little more than half way up its height. You can easily follow the work of the fire in these tall buildings. The most intense blast struck it about the tenth floor. I found typewriters and other metallic materials in that story absolutely fused into a molten mass, which means at least 2,800 deg. From that point up the flames were evidently less intense. Similar blasts to the first apparently struck this building subsequently, and on the other side from that first attack, but they were undoubtedly of slightly less intensity. Then the fire ate away from the second story upward more slowly, and then downward. Of course, window frames and glass, and the doors, and the finish, even the floor strips in the concrete, and all the contents of this and the other fireproof buildings, were destroyed. Some of the newspapers in their excitement stated that these buildings burnt as quickly and as completely as the wooden ones, and people, the unthinking ones, generally decry against the "so-called fireproof construction," as they call it, because they have discovered by this fire that they were wrong in their ideas that a fireproof building guaranteed immunity to even highly inflammable materials used in its decoration or stored within it. To say that the structures actually burned is, of course, foolish and manifestly incorrect, even to the most ignorant, because they are still standing, and many of them in an easily repairable condition. Take this Continental Trust, for instance; all the structural steel was incased in tile, and not a bit of it is warped or out of level. The exposed metal portions are twisted into all kinds of fantastic shapes, but the structure itself, the frame, is intact. The structural conditions of all these skyscraping buildings that were built at all within the general scheme of our theories of fireproofing stood the awful test remarkably well. The Equitable building, which is, I imagine, an old building, and one in which, though tile was used, its application was not made along scientific lines, makes a worse showing than any of the others. The soffits of its beams were exposed, the tile arches were segmental, the haunches were not concreted, evidently to save money, and on top of the beams was a heavy two-inch plank floor covered with a finished dressed flooring. But a portion of the webs of the beams being protected, the heat has twisted and curved these beams all out of shape, and necessarily distorted the columns, so that the building will undoubtedly have to be entirely rebuilt. The structures of the Calvert building, the Herald, the Union Trust, the Maryland Trust, are in fair shape to be repaired as far as the structures go, for the steelwork was fully protected by the tile fireproofing.

These skyscrapers were built to contend with ordinary conditions; for instance, if the fire had originated in any of them, it could not have gotten beyond control, and no one ever anticipated that they would be subject to any such test from without. Even if such a possibility had been thought of, I venture to state that no one in Baltimore would have been willing to pay the increased cost that would have been entailed had these buildings been erected to withstand any such terrific heat and flame. And there are few places in the country where skyscrapers could be subjected to any such test. Those in New York are surrounded by a better class of buildings than generally obtained in Baltimore. So are those in Chicago. The Washington Post very aptly puts it that a "fireproof building is one that is fireproof itself and is surrounded by fireproof buildings." That, I grant, would be an ideal condition, one that I have long prayed for and preached for, but yet that definition of a fireproof structure is not essentially correct. Such another conflagration is possible in a city like Boston, or San Francisco, or New Orleans, where you find great office buildings

rising from among shanties and the most inflammable of structures, and vast areas of these all about.

In repairing these buildings in Baltimore and in building new ones of their class in this burnt district, no greater precautions need be taken, as far as structure is concerned, than we find in the best of the old ones, say the Continental Trust, for instance, because a better general class of buildings than the old wooden ones will be insisted upon by the authorities, presumably, and in that case no such conflagration could again be possible in that district.

The general condition of the tile is good. Some are of course cracked, but in the floors there is no indication of the disintegration of the materials. In some places the bottom web of the floor arches has been knocked off. It is hard to say what caused this expansion—water, perhaps; but one case that worried me a good deal was the absence of bottom webs on the floor arches in the vestibule of the Continental building. I was considerably relieved when told by one of the officers of the building that the marble men in erecting their work had knocked off all these webs for the purpose of facilitating the fastening of the marble! The superintendent who allowed anything of that kind to happen deserves at least castigation, but I was pleased, nevertheless, to find that this was no fire effect.

I have preached hard and earnestly and long against granite being used, or stone for that matter, anywhere fire can get at it. The granite and stone in all the buildings, skyscrapers as well as the others, is utterly destroyed. Possibly it may be recut in places, but the shaling and splintering generally puts it beyond redemption. The brickwork stood remarkably well, and is simply another proof of our old theory that any material to successfully withstand fire must have gone through as severe heat in its manufacture as it will ever be exposed to afterward.

The decorative terra cotta here and there has been broken off, but on the whole it came out of the fray with flying colors. The less glazing there is to terra cotta, however, the better. The terra cotta people should make their facework heavier and thicken their internal angles, so as to overcome the natural weakness of the material at its angular connections with the face and they should encourage the use of porous non-glazed surfaces.

Some people say that this fire proves that an *absolutely* fireproof building is virtually an impossibility, or one that under such stress would afford protection to its contents. It is only the unthinking who would make any such statement. The people who built the structures we have under discussion, the Baltimore skyscrapers, used fireproof methods only about their structural parts. In the finish and all else in these buildings there was absolutely no difference between them and the firetraps that stood all about them, and which have now disappeared from the face of the earth. In so far as that fireproofing went it has been most eminently successful, and this terrible fire demonstrates its value more forcefully and potently than anything that has happened in the past twenty years.

Think of the test the steelwork was subjected to! Imagine dropping a lot of closely bound and connected metal, one very susceptible to variations in temperature, into a furnace where different parts of that metal would be subject at the same time to heats of 98 deg., 3,000 deg., and 400 deg., and remember that that metal was incased in sometimes not over two inches of tile, and that its parts were not warped, disjoined, or otherwise damaged by that terrific heat-test. At some one time those tall buildings underwent about those variations of temperature. Realizing this, and having those buildings standing before us in splendid proof of their stability, how can any one making claim to the possession of even ordinary intelligence state that "fireproofing" is not fireproof?

The great fire of Chicago in 1871 had for effect that, the country over, frame buildings were barred within certain limits. This great fire of Baltimore is another step in the popular education, and will result in people doing more thorough fireproofing in their structures, and using less damageable materials in their exterior and interior decorations. But this education is slow—awfully, pitifully slow—and enormously costly. It will take another such terrible experience to thoroughly impress the people with the fact that we so-called cranks on construction *are* right, and not making unreasonable demands in the line of improved methods of building. We realize and appreciate the possibility of such things happening, but people call us "croakers" until the things we foretold would happen do happen; then they come to us and tell us how clever we are, and ask our advice as to how *they* should build; and then they go off and erect the flimsiest of things the too complaisant laws will allow; because, forsooth, our way costs more money than they care to expend. Judging from my mail these days, both architects and laymen have experienced a change of heart, and are anxiously and insistently desirous of advice how to build *well*, rather than cheaply. But the desire will only last a few weeks, or months, perhaps. City law; *compelling* people to build well are our only absolute safeguard—good laws and laws well enforced by competent and zealous officers are the solution of the building problem.

Some time ago, in these same columns and in the daily press, I made a statement that may be worth repeating to-day. In the light of what has happened within the week, the quotation may not be without point: "By years of persistent digging at the same subject we cranks on fireproofing have succeeded in

*From Fireproof.

getting people to build a large number of buildings whose structures are absolutely impervious to fire. [Baltimore must have proved that beyond a shadow of a doubt and to the most skeptically inclined.] . . . It has been hard work, and we have received many rebuffs, but it is now time to increase the scope of our efforts a little, and try and get people acquainted with the ways of preventing fires within those fireproof structures and the destruction of any of their parts or ornamentation. . . . Perhaps after a few more years of persistent work we may get them to close up elevator and stair shafts in fireproof partitions and doors. . . . We may induce them to use fireproof materials in the finish of their rooms, some form of cement or tile floors instead of wood, metal furnishings instead of wood again. . . . There is but one method of building a fireproof structure that is compatible with safety and our necessities, one that will neither burn nor be materially affected by any fire within or without. . . . A structure whose frame is of steel, thoroughly protected with cement and incased entirely in hollow fireproof tile, whose floors are also of hollow fireproof tile arches, partitions of brick or hollow tile, and whose outer walls are of brick or terra cotta—not stone or granite, because both of these are actually dangerous in a fire. . . . But the work of education must be by easy stages, and we must give these things to the people in small doses; to attempt to get any one to build anywhere near perfectly at one fell swoop would be an overdose, and you know what overdoses usually lead to." With all the lessons of the Baltimore fire now before me, I cannot think of anything I would care to add to the above, written months ago, and preached for years back.

The perfectly fireproof building above alluded to, fireproof in the sense that the average man interprets the term (in that no damage can be done to the building by fire, and that all he may put within that building is absolutely safe from external attack) is possible. I could build a structure, a skyscraper, upon which even an inferno like that at Baltimore would not inflict more than a few hundred dollars' worth of actual damage. But who in these times of careful calculation of dividends and returns upon investments would pay for such a building? I would build its exterior all of brick or hollow tile, and with molded brick trimmings, and some little terra cotta ornamentation, more carefully made and burned than the usual commercial terra cotta; not a particle of marble, stone, or granite would be outside of that building. I would make the frame of steel, just as we do to-day and no heavier, and I would carefully incase all that steel in tile, a trifle heavier and thicker than is the average on the market to-day; the floors would be of hollow tile arches, covered with cement, or tile, or marble—no wood; all the window and skylight frames would be of metal covered with a heavy asbestos covering; all the windows and skylights I would doubly glaze with wired glass; all the casings and finish would be of cement, and the doors of metal, and each story cut off from the other absolutely, no open elevator or stair wells. Such a building, with the ordinary precautions, suggested by the average intelligence, closed windows and some water and other fire-fighting appliances within, would have withstood that fire in Baltimore unscathed, and would have protected all that might have been within it from damage in spite of the nearly 3,000 deg. of heat developed at some points during that fire!

But the exigencies of the time seem not to permit so perfect a structure. Even fireproofing tile has been reduced in thickness to its minimum ability to withstand ordinary fire; the trade demands it; people will not pay for more tonnage. Everything that goes into a building has to be pared down and shaved, particularly in the structure, so that there may be profit in renting the building. If there is anything upon which money is spent at all lavishly, it must be fine carvings on the outside, and rare marbles, and polished woods inside, things that catch the eye and give an apparent value to property. Natural enough, but lamentable just the same, and in Baltimore's case, at least, exceedingly expensive ultimately.

Architects are too prone to take certain standards of make of any material and use it everywhere regardless of varying conditions. Now, as I said before, in the upbuilding of this district of Baltimore, or in building in sections in other cities that are pretty well filled with good buildings, mostly fireproof structures, nothing more is needed than was used in Baltimore's skyscrapers we now have under consideration. But in crowded districts of comparatively flimsy structures, in just such a place as were those very buildings in Baltimore, and in other old cities where like conditions exist, or in New Orleans, or San Francisco, or Boston, or in some parts of New York, or in any other extra-hazardous positions, in Heaven's name why not take extraordinary precautions, and use a heavier and thicker tile in floors and in incasing the steel; wired glass on the exposed fronts, and at least metal frames at such exposed windows; why should not every precaution be taken that experience teaches us is necessary, or that even tends to minimize the damage that could be done by just such another conflagration?

A careful examination, such as I have made of that entire district, was immensely interesting and certainly helpful in developing any Sherlock Holmes propensities one might have. So many seemingly inexplicable things happened, what might be termed freaks of fire, and yet, if one knew all the circumstances, and put ones and twos enough together, most of those

freaks could be readily explained. The escape of certain small buildings from almost any damage, the abrupt cutting of fire at some one point where no insuperable barrier presented itself, the skipping of flames over large areas seemingly drawn to some particular point of attack, high up in the air and not along the prevailing direction of the wind, while another fire was more slowly eating into the very foundations of that same building; the peculiar forms of some of the ruins, setting at naught the very first principles of statics—all of these strange things were, as I say, fascinatingly interesting, and will be food for thought and study and experiment and much theorizing on the part of those scientifically inclined, and will ultimately, of course, prove of considerable benefit to the world. I saw in one place three brick arches resting on columns of granite that had been completely eaten away, yet the arches stood absolutely intact and carrying a considerable weight above them and without a particle of support under the two central skewbacks; these arches apparently reflecting into one structural supporting arc sustaining the pendative load at the two intermediate points by mere adhesion.

A considerable portion of the Custom House now under construction will have to be torn down. In one place there is a granite cornice temporarily covered with planks; the planking is not even scorched, while the granite underneath it is shaled off, cracked, and badly scaled. Most of the damage was by heat unaccompanied by flames. Some of the ironwork inside not yet protected with fireproofing will also have to be taken down. The handsome marble court house, recently completed, was somewhat damaged externally. It was just outside of the zone of fire, but received a hot enough blast to damage its stonework to the tune of \$75,000 or so.

In Baltimore, as everywhere else, there was and is some lamentable negligence in the way of superintendence, which simply goes to prove, as I have always contended, the folly of using any material whose safety in construction depends absolutely and solely upon perfect superintendence. For instance, in the Continental building the brickwork is of course carried from story to story. I noted great patches on the side walls some thirty or more feet in length by the full height of a story, where the entire facing course of brick had been detached and had fallen off, showing that in all that extent of wall there was not a particle of bond, either of metal or of brick, between that course and the backing. Such work as that and the allowing of marble workers, and steam fitters, and other craftsmen to ruthlessly break through flooring and cut everything to pieces, in order to install their work with greater ease, is certainly shameful, and shows culpable and criminal negligence on the part of the superintendent who allows it.

In the fireproof buildings, most of the partitions were in most excellent shape, but I noticed in one that whole sections of partition were on the floor, in connected condition, and not in the shape they would have been had they fallen there. It seemed a case of their being thrown down by some terrific force. The fire could have had no such effect unless the draft was even greater than the maximum of my calculation—the rate of 180 miles an hour was undoubtedly reached—and it certainly was not the work of the firemen. Insistent investigation showed me that they had tried to cut off the fire near that point with dynamite, and it was these series of explosions so near that had thrown down section after section of those partitions in such peculiar shape and manner.

A considerable part of the front wall of the Union Trust building will have to be taken down. The steel frame in that outer wall was not carefully enough protected, so that the heat has warped it, and as a result that front wall is distorted into all sorts of shapes. It is in a dangerous condition. The interior framing is, I believe, in perfect condition.

It is to be regretted that there were no important or tall concrete constructions in that zone of fire. Had there been, we certainly would have had a good basis of the comparative value of that mode of construction. There was but one concrete building that I could find. There may have been others that were destroyed, but the one I examined was about 30 by 75 feet, four stories high, built on the Hennebique system, and it seemed fairly intact, except in one or two of its concrete beams. The condition of the iron front shows that there was a quick attack of flame, and it is evident that there was comparatively little combustible material within the building, because even the gas pipes are in fairly good shape. That the floors stood up while the wooden floors in the adjacent buildings were destroyed proves that the system is certainly better than wood—if the building can be completed without collapsing; but that this was a test of what it would do in a tall construction or in a more exposed place is stretching the point to its utmost elasticity. That the heat and flame in that one section, as in some other low points, were comparatively quickly over and not of the most intense, is shown by the condition of the metal in this building, and by the fact that directly across the street, in one of the fireproof skyscrapers, the Maryland Trust building, for the same height up, four or five stories, the decorative plastering on the ceilings is not even charred, and some of the light fixtures are hanging intact. The fire seems to have swept by at frightful velocity, quickly devouring all woodwork and anything combustible, but leaving even the concrete and plastering in pretty good shape. The plastering and everything else in the Maryland building above the fifth floor show that the heat was

vastly more intense above the line of that concrete building. I should imagine that the heat at that one point was not over 600 deg.; at the seventh and eighth floors in some of these skyscraper buildings, it must have reached nearly 3,000 deg., because I found in one place a safe that was not only warped all out of shape, but one of its angles, that nearest the window, was fused, molten down, and had trickled much as candle grease does over a candlestick. Again, at the twelfth and topmost stories I noted that some brass had but begun to fuse alongside of some cast iron that was badly warped, but had not nearly reached the fusing point. The heat there was certainly not over 2,000 deg., while in other places on the top of three and four-storied buildings I found lead that showed no signs of fusing, all of which would indicate that the heat was most intense at the point where the first blast of flame struck those tall buildings. The resulting variation of temperature in the height of these skyscrapers was enough, one would think, to distort the steel whatever it might be incased in or protected with.

The owners of these skyscrapers may feel somewhat aggrieved that their buildings, being called "fireproof," did not meet the popular interpretation of that term, and safeguard not only the structural parts, but all the goods and inflammable materials within and about the buildings. And they may, and with justice, feel abused in that their architects advised the use of granite or stone exterior walls, when they ought to have known that a much lesser fire even would play havoc with those materials; but after viewing the absolute destruction of everything else in their vicinity, upon more mature reflection, and realizing the terrific and unexpected test their buildings passed through, something that neither they nor their architects ever dreamed of or deemed possible, and that we have been laughed at every time we suggested, they must appreciate that amid all that desolation they alone have any cause for thankfulness, for their buildings may be repaired and refitted ready for tenants long before their neighbors can possibly hope to complete new and much smaller buildings.

Much is to be learned from that fire in the way of improving methods to fight fire, bettering water systems, and all that sort of thing; but as far as the actual science of building is concerned, that fire may do a general good in that it will open the eyes of the people to the advantages of building as we suggest, using the materials we advise and taking the precautions against fire that we have urged for years; but, I frankly confess, it neither revealed, demonstrated, nor proved anything engineers and fireproof specialists did not know before and have so persistently advocated heretofore. With the results of that fire clearly laid out before me, I would not change in the slightest particular any steel framing I have on hand, nor would I change the standard patterns for fireproofing floors, partitions, column coverings, etc., except to slightly increase their thicknesses for extraordinarily hazardous risks—as all sane men would do anyway—nor could I advise anything better in interior finish, in the glazing of windows, and the hundred other minutiae and detail of building, than I have advised and used prior to that fire. The trouble is not with the engineers, the teachers, but with the refractory pupils, upon whom even such a lesson is liable to make small impression. In so far as the theories we have preached and practised have been applied in the structures that have so successfully passed through the test of the Baltimore fire, are we fully vindicated in our beliefs, and have we just cause for jubilation; for we may now demonstrate the soundness of our contention, when questioned by the skeptical or doubting ones, by merely pointing to the steel, tile-incased structures that resisted and were the victors in the mighty battle that was waged against them at Baltimore February 7, 1904.

THE WRIGHT EXPERIMENTS IN FLYING.

IN October last we resumed the trials on the Kill Devil practice ground with the machine which we had used during the previous year, and succeeded in making flights in which the operator remained in the air over a minute, at one time being suspended 1 minute, 11.80 seconds. While carrying on the experiments, our power machine was under construction. In dimensions it measures a little over 40 feet from tip to tip of the wings, of which there are a pair. Its length fore and aft, to use a nautical phrase, is about 20 feet, and the weight, including that of the operator, as well as the engine and other machinery, is slightly over 700 pounds. We designed the machine to be driven by a pair of aerial screw propellers placed just behind the main wings. One of the propellers was set to revolve vertically and intended to give a forward motion, while the other underneath the machine and revolving horizontally, was to assist in sustaining it in the air.

We decided to use a gasoline motor for power, and constructed one of the four-cycle type, which, revolving at a speed of 1,200 revolutions a minute, would develop 16 brake horse power. It was provided with cylinders of 4-inch diameter and having a 4-inch stroke and intended to consume between 9 and 10 pounds of gasoline an hour. The weight of the engine, including the wheel, is 152 pounds.

We had calculated that this amount of mechanical power would be sufficient to maintain the machine in the air, as well as to propel it, the calculations being the result of gliding experiments, which showed that