the seventh heaven, and she was kind enough to do so.

When Colonel Blasengame reached home that night, he found his wife sitting up for him—and still mending and patching.

"Why, honey!" he cried, "why don't you put up that everlastin' work and go to bed?"

"I've been doing it so long, it doesn't seem like work," she exclaimed, with a faint smile. "I thought you'd be tired, and I fixed you a pot of coffee. Mrs. Winchell couldn't come."

As the Colonel drank his coffee, he related the incidents of the night. His wife listened, asking a question now and then: how was the Yankee girl dressed, and did she seem to be afraid?

"Well," said the little woman at last, "you must watch that Flewellen. You've had one fuss with him."

"That's the reason I'll never have another," remarked the Colonel, dryly.

Then they went to bed, and by that time there was not a light to be seen in Halcyondale except the one that shone from the windows at Chippendale's where Harvey Haskell, speaking in no loud voice, was telling all the troubles he had had on account of the wrinkled and crooked course of true love.

THE PROBLEMS OF A PACIFIC CABLE

By Herbert Laws Webb

A CABLE across the Pacific Ocean has been planned by different people at different times during the past thirty years. At present there are no less than five different plans for trans-Pacific cables before the public of two hemispheres. Probably the oldest definite scheme was broached by Mr. Sandford Fleming, the chief engineer of the Canadian Pacific Railway. In the early seventies Mr. Fleming stated that the Canadian transcontinental railway and telegraph would be incomplete without an extension across the Pacific Ocean to connect with the telegraph systems of the countries on the far side of the Pacific. The Pacific cable has also received considerable attention in the United States, and, owing to recent events, may at the present time almost be considered a burning question. Up to a few years ago American Pacific cable schemes were confined to a cable between the Californian coast and the Hawaiian Islands, and several enterprising gentlemen have at various times obtained exclusive concessions for landing a cable at Honolulu. One of these concessionaires was the late Cyrus W. Field, of Atlantic cable fame. At the present time, however, it is recognized, and indeed for some years past it has been recognized by those familiar with the management of cable systems, that an American Pacific cable could not stop at Honolulu, but would necessarily have to connect with either Australia, Japan, or China in order to secure direct communication between the American continent and the vast system of telegraphs of the Far East.

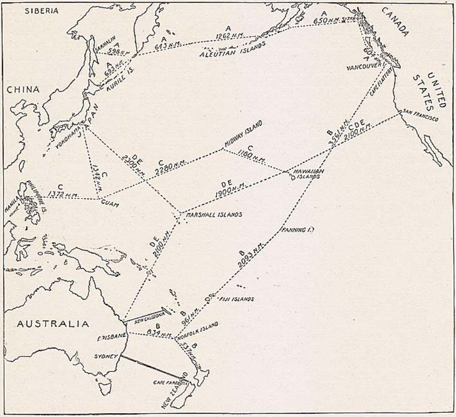
The oldest of Pacific cable schemes is generally known as the "all-British" cable, which would start from Vancouver and connect with both Australia and New Zealand. This is the most ambitious cable-laying plan that has been formed since the days of the first Atlantic cable. The first section of the British Pacific cable would join Vancouver with Fanning Island, and would require a length of cable of about 3,560 nautical miles, which is about 1,000 miles longer than the longest of the older Atlantic cables. Within recent years, however, it may be noted that a French Atlantic cable has been laid from Brest to Cape Cod, which measures a total length of 3,185 nautical miles, thus closely approaching the length of the Vancouver-Fanning cable. From Fanning Island the cable would run to Fiji, and thence to Norfolk Island, from which point one section would run to Australia and another to New Zealand.

A second government cable in the Pacific is proposed by the United States Government. According to the original bill this was intended to connect the Californian coast with Honolulu only. During this session a government plan for laying a cable clear across the Pacific, to give direct communication with the Philippines, will be urged. The Secretary of the Navy has prepared a draft of a bill providing for Pacific cables to be constructed under the supervision of the Navy Department. The Chief of the Bureau of Equipment estimates the cost of laying and equipping the proposed cables at $10,000,000. Senator Lodge has introduced a bill authorizing the Postmaster-General to contract with an American cable company for telegraph communication with Honolulu, Guam, Manila, China and Japan. The annual payment to the company is not to exceed $400,000 for twenty years. Government messages are to be transmitted free for twenty years and at half rates thereafter. The cable must be in operation by January 1, 1903. Two other bills relating to the construction of Pacific cables, either by the United States Government or with its aid, have been introduced this session.

Two other American plans have been put forward by two companies, one of which proposed a cable running from San Francisco to Honolulu, and thence, via the Marshall Islands, to Japan and Australia; and the other proposed a somewhat similar plan, and a few years ago claimed to have an exclusive concession from the Hawaiian Government for landing-rights in the Hawaiian Islands. Any claim to such an exclusive concession has now disappeared. Each of these companies has approached Congress at various times for government aid in laying the proposed cables; but although it has sometimes appeared as if Congress would grant the required aid to one or other of the two, such a measure always eventually has been lost.

The fifth plan for a trans-Pacific cable was expounded by Mr. Harrington Emerson in a recent issue of the *Engineering Magazine*. Mr. Emerson proposes what might be called an Arctic cable, running from Cape Flattery to Sitka, from there by way of the Aleutian Islands to an island in the Kurile group, whence a short cable to the Siberian coast and another to Japan would give connection with the existing Russian and Japanese lines. Mr. Emerson argues for this northern route with a good deal of plausibility, pointing out that the total length of cable required is only about 5,000 miles, as compared with between 7,000 and 8,000 miles for either of the southern routes; also that the cables following the line of the Alaskan coast and the Aleutian and Kurile islands could be laid in short sections, of which the longest need not exceed 528 miles. This would naturally give cables of a high speed and low cost, compared with the long sections required between either Vancouver and Fanning Island or San Francisco and Honolulu. This northern route was first suggested by Mr. Fleming in the early seventies, in connection with his plan before described. It was at that time considered that physical difficulties existed in the southern part of the Pacific Ocean, which would prove insuperable obstacles to the laying of a cable on a direct route between Canada and Australasia. As regards communication between North America and Australia, the northern route across the Pacific advocated by Mr. Emerson would be a very round-about one and would involve almost as many transmissions and as high rates as the present route via Europe and India, and practically the same objection holds as regards communication between America and the Philippines. There is the further objection to this route that the cables would traverse a part of the ocean much exposed to fogs and heavy storms and suffering from a prolonged winter, which would render repairs often a matter of great difficulty, while probably of frequent necessity. What is a fatal objection to the Arctic route, in the minds of those most interested in an American Pacific cable, is that it leaves the Hawaiian Islands out of the question altogether.

In the past thirty-five years some eighteen cables have been laid across the Atlantic Ocean, and at the present time another is building to afford direct connection between Germany and the United States, which, touching at the Azores, will



Proposed Pacific Cables.

A—Northern Route from Cape Flattery, via the Alaskan Coast, Aleutian Islands and Kurile Islands, to Siberia and Japan; 5,040 nautical miles.
B—All-British cable from Vancouver, via Fanning, Fiji, and Norfolk Island to Australia and New Zealand; 7,986 nautical miles.
C—United States Government cable, from San Francisco, via Hawaii and Guam, to the Philippines and Japan; 8,254 nautical miles.
D—Pacific Cable Company of New York, from San Francisco via Hawaii and the Marshall Islands to Australia and Japan. (Landing points between Hawaii and the Far East not definitely chosen.) About 8,400 nautical miles.
E—Pacific Cable Company of New Jersey. Similar route to that proposed by the Pacific Cable Company of New York.

have a total length of over 5,000 miles. In view of the constant activity in Atlantic cables which has resulted in a new cable about every two years since the first successful cable of 1866, it stands to reason that the difficulties offered by the Pacific Ocean must be very great for the nineteenth century to reach its close without a definite scheme for spanning the Pacific by telegraph having been adopted. The difficulties may be summed up in a few words: First, the great cost of a complete system of cables; second, the extreme depth of water known to exist in certain parts of the Pacific and feared in others; third, the long distances between landing-points; and fourth, the lack of intermediate points having an active trade. The estimated cost of the British Pacific cable, for a single cable connecting Vancouver with Australia and New Zealand, is placed at about $7,000,000, including two repairing-ships and a sum of $175,000 for maintenance of the cables for six months. The president of one of the cable companies of New York estimates the total capital cost of a cable to Japan, Australia, and the Philippines via Hawaii at $12,000,000, and the cost of maintenance, including two repairing-ships, and of operating expenses, at $300,000 a year. It is not considered that a single cable will be sufficient to insure permanent communication, and any scheme for a Pacific cable must provide eventually for duplicate cables throughout the entire route, so that the total capital cost of a thoroughly reliable and efficient Pacific cable system may be put down at approximately $26,000,000, which would include two repairing-ships, a reasonable quantity of spare cable, and the equipment of operating stations at the various landing-points.

Sums such as these are well calculated to intimidate private capital from embarking in a venture subject to the risks that submarine cables are known to suffer from, and where the returns in the shape of a large volume of paying traffic cannot be considered a certain quantity. One of the companies, however, has offered to the United States Government to lay such a system of cables and to transmit, free of charge, all the official telegrams of that Government for twenty years, provided the United States will assist the company with a subsidy of $275,000 a year. After twenty years Government messages will be transmitted at half rates, it being stipulated that the commercial rate from the United States to Japan, Manila, and Australia shall not exceed one dollar per word, which is about one-half the existing rates. It will be seen that this proposal does not contemplate a subsidy in the strict sense of the word, as the company would give the Government a very fair return for its money by transmitting all official telegrams free for twenty years, and at half rates thereafter. It is quite conceivable, in view of the events of the past eighteen months, that the Government might have rather the best of the bargain. How much the United States Government has spent in the past two years in cablegrams to the Far East is not public knowledge, and how much it would have spent in the past four or five years for cablegrams to Honolulu if a cable had existed can only be guessed at. But some idea may be had of the freedom with which the Government spends money on telegrams when international difficulties exist, from the statement of the president of the Central and South American Telegraph Company before a Senate committee some years ago to the effect that his company had received from the United States Government, during the dispute with Chili, upward of $50,000 in a single month for telegrams to Valparaiso. Numerous instances of costly government telegrams to different parts of the world are on record, and it is impossible to estimate how much a government may spend in telegraphing in grave emergencies, and equally impossible to estimate how much may be saved by these costly government messages. It may be safely stated that a trans-Pacific cable, had it been in existence during the past two years, would have had very extensive patronage from Washington.

The great cost of the Pacific cable system, whichever route is adopted, would probably for some years to come deter private capital from attempting the establishment of a cable unaided, and this large capital cost is the chief argument in favor of a government cable, as a government can raise money at very much lower interest than a private company. The difference between two and a half or three per cent. and five or six per cent. is all-important when the capital on which that interest has to be paid runs well up into the millions. Apart from this feature of the enterprise, a government scheme has little to recommend it. A Pacific cable system would necessarily be run as a competitive enterprise, for much of its traffic would be between Europe and the Far East, and would have to be fought for with the existing systems that connect Great Britain with China, Japan, and Australia. It is pretty generally recognized, I believe, that competitive enterprises are better managed by commercial companies than by government departments.

Turning to the physical features of the cable itself, it is clear that the doubts as to the practicability of a Pacific cable, freely expressed in various quarters a few years ago, no longer exist. This is evident from the fact that firm offers have been made both to the Canadian Government and to the United States Government to lay a complete system of cables across the Pacific for certain specified sums. These offers have been made by some of the oldest and most experienced cable manufacturers, with a full knowledge of what is required and of all the conditions of the Pacific Ocean that have so far been discovered. The great depths known to exist in the Pacific Ocean are not on any of the routes along which it has been proposed to lay cables. The greatest depth of which accurate soundings have so far been made are in the neighborhood of the Kermadec Islands, a few hundred miles to the northeast of New Zealand. In this part of the Pacific soundings of over 5,000 fathoms, or about six miles, have been made. None of the proposed routes, however, goes near these tremendous depressions in the ocean bed. Complete surveys have not been made of the southern Pacific to the westward of the Hawaiian Islands and the Fiji Islands, and although no very great depths are known to exist on any of the proposed routes, a detailed survey would no doubt reveal many inequalities of just as serious a nature. The route between California and Hawaii has been pretty thoroughly surveyed by United States Government vessels, and a thoroughly practicable route for a cable has been established by the aid of these soundings. The greatest depth discovered was about 3,100 fathoms, at about the point where the route for the American cable from California to Hawaii crosses that of the British cable from Vancouver to Fanning. The average depth of the route after deep water has once been struck ranges from 2,400 fathoms to 3,100, a large part of the distance being in water closely bordering on 3,000 fathoms in depth. This great depth, of which some idea may be got by imagining Fifth Avenue from Washington Square to Seventy-ninth Street set on end, is not exceeded on any existing cable route, though closely approached on many. The Atlantic cables are laid in a depth of from 2,400 fathoms up to about 2,700 fathoms, and such depths as 2,700 to 2,800 fathoms are found in many other parts of the ocean, so that no startling novelty is presented by what is known so far of the Pacific route. Cables have frequently been repaired in depths of considerably over 2,000 fathoms, and numerous instances are on record of repairs effected in depths of 2,700 fathoms, or about three miles. The difference between 2,700 fathoms and 3,100 fathoms is more than counterbalanced by the improvements that have been made in the manufacture of submarine cables and in the art of repairing them. What is a greater obstacle than the depth of the Pacific Ocean is the long distance between landing-points. This applies specially to the British project, which on its longest section calls for a cable of 3,560 miles in one section. In order to get a fair working speed over a section of this length a very heavy cable has to be constructed. No such difficulty exists in connection with the American scheme, as the section from San Francisco to Honolulu will be but a little over 2,000 miles long, which is not much more than most of the Atlantic cables, and less than some of them.

The principal conditions to be considered in connection with a submarine-cable project are the selection of a route which will afford a bed for the cable where it will be free from undue risk of interruption, and the design of a cable which will give the maximum security against interruption, the maximum strength to enable it to be lifted for repairs, and the maximum speed of signalling. The selection of the route, which is necessarily brought within narrow limits by the points between which the cable is to be laid, is determined nowadays by an extremely careful preliminary survey of the ground. Deep-sea soundings are usually taken a good many miles apart. Even in government surveys, made when a plan such as the laying of a Pacific cable is under consideration, the distance between soundings is often ten or fifteen miles. Intervals as long as this are quite sufficient to allow of a submarine mountain being passed over without any suspicion of its existence. Submarine-cable contractors in making a detailed survey preliminary to the actual laying of a cable usually sound over a zigzag course, following the general direction of the proposed route, and making the soundings at very frequent intervals. Such a sounding expedition was described in an article on a cable expedition in SCRIBNER'S MAGAZINE for October, 1890. On this survey, made between Spain and the Canary Islands, two ships spent about three weeks in sounding over a course of some 780 miles, and a very large number of soundings, revealing previously unknown inequalities, were made. At one point a submarine mountain, rising from a depth of 2,400 fathoms to within about 250 feet of the surface of the ocean, was discovered. If soundings had been made in a straight line ten or fifteen miles apart, this mountain and other banks of lesser magnitude might easily have been passed over. In fact, one bank, of a much less steep slope than the mountain just referred to, *was* passed over by the sounding expedition and was discovered by a sounding-ship a few miles ahead of the cable-ship during the actual laying of the cable. The discovery was fortunately made in sufficient time to permit the cable-ship to avoid laying the cable taut over the bank. How important it is to have the most detailed and accurate survey that can possibly be made before starting to lay a long deep-sea cable can readily be understood from the following facts.

A cable-ship paying out deep-sea cable at the rate of from six to eight knots an hour, the usual rate of paying out in deep water, in a depth of say 2,500 fathoms, has about twenty miles of cable suspended between the stern of the ship and the bottom of the ocean. The cable, in a manner, slides down an inclined plane until it finally reaches the bottom about twenty miles behind the point over which the ship is actually steaming. If, for example, we could imagine New York City submerged with a depth of about three miles of sea water over it, and a cable-ship laying a cable from north to south, when the ship was over the City Hall the cable would begin to reach the bottom somewhere in the neighborhood of Yonkers. If now we imagine Murray Hill, instead of being the gentle eminence that it is, were a mountain rising to a height of nearly 15,000 feet, the cable would be suspended from its peak in a long loop, and by the time the ship got southward to a point below the Narrows such a length of cable would be hanging between the peak of the submarine mountain and the stern of the ship that the breaking strain of the cable would be exceeded and the cable would part from its own weight. This sort of accident has actually happened on several cable expeditions, and can only be avoided by a careful and accurate preliminary survey of the ground over which a new cable is to be laid. It is well-known that in laying a long cable, or indeed a cable of any length of over a few miles, a certain percentage of "slack" has to be allowed for, that is, that the amount of cable actually laid exceeds the air-line distance between the two points connected, by about ten per cent. This slack is usually supposed to permit the cable to adjust itself to the contour of the ocean-bed, but in reality it is impossible to lay a cable without slack, and in any case practically no amount of slack would prevent ultimate disaster if a cable were laid over a precipitous elevation rising 10,000 or 15,000 feet from the bottom of the ocean. Even if the ocean were absolutely level, however, it would not be possible to lay a cable without slack, for the reason that the resistance of the water to the passage of the cable through it causes, as above described, a long length of cable to be suspended between the stern of the ship and the bottom of the ocean when the ship is going at normal speed over deep water. The cable, then, has a motion akin to a sliding down the inclined plane of water which partially supports it, and this results in a certain amount of cable being paid out in excess of that required to cover the distance in a straight line. Just what shape the cable takes when it finally slides onto the bottom of the ocean it is impossible to say, as no one has ever been down to investigate, but one thing is certain, and that is that for the cable to have a fair chance it must lie on the bottom, and not be suspended at any point from a submerged mountain or precipice. A large number of breakages of deep-sea cables have been due to "suspension."

The enemies to submarine cables are many. Apart from the dangers arising from laying cables over unequal ground, which would cause them to be suspended and sooner or later to chafe through, there are occasionally mysterious deposits of chemical matter, even in deep water, which attack the armor wires of the cable, destroying their strength and rendering it impossible to lift the cable for repairs. In the earlier Atlantic cables the galvanized iron armor wires which give the cable mechanical strength to enable it to be properly laid and subsequently, if necessary, lifted for repairs, were surrounded by hemp to preserve the wires from the action of the sea-water. It was found that the hemp itself was soon destroyed, permitting the iron to be attacked in its turn, and many miles of valuable Atlantic cable have had to be abandoned because the cable could not be lifted for repairs. An improvement over the hemp covering was the substitution of a double covering of tape, soaked in a preservative compound of pitch, with which the entire cable was enveloped, and a recent refinement on this method is to tape and compound each individual sheathing wire, now of steel instead of iron, before the sheathing is applied to the cable. This method of protecting the sheathing wires insures the modern cable under normal conditions a very much longer life than many of its predecessors have had. In the neighborhood of the points where cables are landed many untoward conditions have to be guarded against, the chief of which are chemical deposits, rocks, tides, and anchors of vessels. In order to give the cable protection against all these enemies the shore-end, usually extending for several miles from the actual landing-place into comparatively deep water, is provided with a much heavier protection than the rest of the cable. Usually the shore-end is made up of the regular deep-sea type of cable enclosed in a second covering of very heavy armor wires. The shore-end often weighs over twenty tons to the nautical mile. From the point where the shore-end leaves off the cable tapers down by means of lengths of a less heavy type, known as "intermediate," to the deep-sea cable, weighing about two tons per nautical mile, which is usually laid when the depth of water reaches about three hundred fathoms. Among the most active and insidious of the enemies of submarine cables are the numerous families of submarine borers, of which the best known is the *teredo navalis*. Some of these borers have a special liking for the gutta-percha insulating envelope of the cable, through which they drill until the copper conductor is exposed to the sea, resulting in the complete breakdown of the cable. Submarine borers are usually not found in depths of over a few hundred fathoms, but all shallow-water cables and those parts of all deep-sea cables which lie in shallow water are now protected against the attacks of the *teredo* and all his family by the envelopment of the gutta-percha core with a continuous brass tape, which forms an impregnable armor against the boring implements of these submarine mosquitoes.

One of the essential features of a submarine cable is the speed of signalling. In operating long cables very delicate instruments are required, and the currents arriving at the receiving end are very feeble in comparison with those employed in land-line signalling. The longer the cable, naturally, the feebler the impulses arriving at the receiving end. A short cable, a cable of under 1,000 miles being generally considered a short cable, gives a speed of signalling amply sufficient for all purposes with a conductor weighing about 100 pounds to the mile, surrounded by an insulating envelope of gutta-percha weighing about an equal amount. When we come to a cable of about twice this length it is found necessary, in order to get a practically unlimited speed, that is, a speed as high as the most expert operator can read at, to employ a core of 650 pounds of copper to the mile, insulated with 400 pounds of gutta-percha to the mile. These are the proportions of copper and gutta-percha in the 1894 Anglo-American Atlantic cable, which is considered the record Atlantic cable for speed of working, and has been worked, by automatic transmission, at the rate of some 45 words a minute. The type of cable proposed for the Vancouver-Fanning section of the British Pacific cable, as designed by Lord Kelvin, is to have a core of 552 pounds of copper and 368 pounds of gutta-percha to the mile, and is calculated to give a speed of 12 words per minute over a length of 3,560 miles. It is not considered safe to adopt a very much heavier core than this, for the reason that the weight of the complete cable with a core that should weigh more than about half a ton to the nautical mile would be so great that picking it up for repairs from a depth of 3,000 fathoms would be an extremely difficult and hazardous operation.

The speed of a cable is usually reckoned in reputed words of five letters each. Consequently the calculated speed of 12 words per minute for the Vancouver-Fanning cable means an average of 60 letters per minute. A cable having this theoretical speed would carry about seven commercial eight-letter words per minute, or 420 words per hour; reckoning a cable day at about twenty hours, this gives a capacity of about 8,400 words per day, and allowing 300 working days to the year, of 2,520,000 words in a year. In the case of a trans-Pacific cable a working day of twenty hours is not an excessive estimate. The largest year's traffic between Europe and America and Australia, of which there is any available record, occurred in the year 1895, when a total of 1,860,423 words were transmitted, so that a cable having a capacity of over 2,000,000 words per year is really sufficient to cope with all the traffic it is likely to get in the first year or two. The figures given above are based more especially on the British Pacific cable where the through speed is limited by the speed of the long Vancouver-Fanning section. An American cable, of which the longest section would be not more than two-thirds the length of the Vancouver-Fanning cable, would have a very much higher speed and could easily accommodate double the total traffic given as the capacity of the British Pacific cable.

The total time which would be required to establish a complete line of cable across the Pacific Ocean is generally put at about three years, but it need not take quite so long as this. The average rate at which cable is manufactured in the principal large factories in England is about twenty nautical miles per day. The total amount of cable that would be required for a single line across the Pacific is about 8,000 miles, so that the making of the cable would occupy a factory continuously for about sixteen months. On some occasions cable-making has been carried on at a considerably higher rate than twenty miles per day. A record piece of cable-making was 1,027 miles made in twenty-seven working days, or at the average rate of thirty-eight miles per day. On this occasion the maximum length made in any one day was fifty-two miles. So it is evident that if necessary the cable could really be made at a higher rate than twenty miles per day, and in any case there is little doubt that the whole work could be finished in less than two years. The detailed survey would naturally be made during the manufacture of the cable, and the laying would be done in sections as portions of the cable were finished. One important reason for the work taking a long time is the great distance of the scene of operations from the point where deep-sea cables are made. Cable-ships have not the speed of trans-Atlantic liners, and the cable would have to be carried a voyage of about three months from the point of manufacture before any work could be begun at all.

With so many different schemes in the air, some of them being actively pushed and ready to take definite shape at any moment, it seems probable that the Pacific cable will be soon laid. A cable laid by an American commercial company seems to have the best chances of success as a sound undertaking. The lack of intermediate points having a large population and volume of trade is not as serious an objection as is generally made out. A cable to a new point, to a large extent, creates its own traffic. The establishment of telegraphic communication results in new ways of doing business and opens up new avenues of profitable endeavor. The electric current, like that set alive by royalty or by the President at the opening of an exhibition, sets in motion a variety of machinery that before lay dormant. The trade of the Pacific is looking up, and hosts of enterprising Americans are busily engaged in looking up that trade. A trans-Pacific cable is not an absolute necessity, because communication, certain, if expensive and relatively slow, between America and the Far East is already had over the existing system, but that such a cable would soon find a profitable traffic is not to be questioned by those who are at all familiar with the rising volume of trade between the Far East and America. And be it remembered that to-day every commercial transaction between two points separated by the sea, like this article, begins and ends with a cable.