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H.B.

WHAT IS HAPPENING IN CHINA

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WHAT IS HAPPENING IN CHINA

RIOTS in Shanghai and Hankow, and the police of the international settlements shooting down the rioters! Huge processions of maddened students parading Peking with inflammatory anti-foreign posters. Mobs wrecking consulates in Kiukiang. Strikes and boycotts paralysing foreign trade. Revival of the old Boxer war-cry to "kill the foreigners." Conferences of sober-minded Chinese educators seriously passing resolutions which threaten the success and possibly the very existence of mission schools and colleges. What does it all mean? Is it simply due to "half-baked students" and labour agitators, as we are told? Is it all the result of Bolshevik propaganda? Or does it represent the mutterings of a new clash of colour, the presage of a coming struggle between the Pan-Asiatic races and the Western world?

Whatever it means, it is plainly a serious business, and if we want to understand it aright we must get down beneath the surface and try to find the real causes underlying all this unrest. It is no use to content ourselves with affixing convenient labels to these disturbances—"anti-foreign," "anti-Chris-

tian," "Red," and the like—as though that was sufficient to explain what is taking place. The causes lie far deeper than that, and we shall need to bring all our sympathy and imagination to bear upon the situation, and to try, honestly and fairly, to understand and appreciate the Chinese point of view. It may not be a very easy process. We may disclose a good deal that is hurtful to our national pride and prestige. We may find much that appears utterly unreasonable and unjustified. But we shall come in contact with hidden forces of vast potentiality for the future good or ill of China, and for the peace of the whole world. We shall discover a strong undercurrent of vigorous life flowing through the channels of this ancient nation. We shall find ourselves in a company which includes large numbers of thoughtful, intelligent men and women, consumed with a real passion for the welfare of their country, and ready to devote every effort to her advancement. And if we can but appreciate their view-point, and can co-operate with them in their splendid adventure, our study will not have been in vain.

RECENT POLITICAL HISTORY

Let us attempt, then, in the first place, to follow some of the leading events in China's political history during the past twenty-five years. It is not a very cheerful story. It appears, on the face of it, to be strewn with the wreckage of immature

hopes and precipitate attempts at reform. But again, let us remind ourselves that there is far more than appears on the surface.

(a) *The Boxer Outbreak.*—However we may regard the Boxer uprising of 1900, it is probably true to say that it represented China's last great effort to maintain her historic attitude of political isolation. For fully a century the West had been knocking, with increasing persistence, upon her doors, and concession after concession had been reluctantly granted—usually as a result of military defeat—from which merchant and missionary alike profited. But in 1900 one supreme attempt was made to rid the country of these insistent foreigners. With the failure of that effort China set herself to adjust her national life as best she could to the demands of an international world, in spite of the burden of an indemnity amounting in all to wellnigh a hundred million pounds. Her educational system, with its centuries-old tradition of classical scholarship, was changed overnight to a modern system of State schools and colleges, in which a large place was accorded to the acquisition of Western history and political economy, modern science, and the English language. Hundreds of students left her shores to study in the best Universities of Japan and the West. The rapid growth of the Japanese Empire and the startling results of the Russo-Japanese War led to an attempt to remodel the Chinese army and navy on Western lines. Meanwhile communications, both by rail and road, were developed, foreign trade increased

by leaps and bounds,[1] the postal and telegraphic services expanded to hitherto undreamed-of dimensions, the public press became a new power in the land, and modern ideas of every character began to occupy the minds of the educated classes.

(b) *The Republic and After.*—It was not long before striking results followed from the assimilation of these new ideas, and in 1911 the Old World was electrified by the news that China had swept aside her age-long system of government and had inaugurated a Republic. There were many wise heads who were profoundly troubled by the suddenness of this change, and gravely doubted whether it was not dangerously premature. Probably they were right, for subsequent events have proved that until China has produced a far larger body of public-spirited statesmen and a more intelligent and articulate electorate, the Republican ship of State will need to plough its course through very troubled waters. But it is a significant fact that so strong has been the growth of public opinion that every attempt to put back the clock, and to revert to a monarchical system, has met with immediate failure. Whatever its difficulties, present or future, it looks as though the Republic has come to stay.

Under such circumstances it has been inevitable that the past few years, since the Republic came into being, should have witnessed a constant

[1] The annual foreign trade of China has now reached an annual total value of approximately three hundred million pounds.

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struggle between a small body of liberal-minded, intelligent, constitutional leaders and a large, dominant force of autocratic militarists, with all the advantage, for the time being, in the hands of the latter. The result has been little short of political chaos and national bankruptcy. President has succeeded President, and Cabinet Cabinet, with breathless rapidity. Factions of every description have contended with one another for the plums of office. The prestige and authority of the Central Government has been increasingly undermined, partly by the protests of the constitutionalists against high-handed and corrupt practices, partly by the jealousy and intrigue of those who wished to climb into power. Provincial tuchuns have recruited and maintained their own armies of defence in a manner characteristic of mediæval barons, utilising for their support the funds that should have been applied to civil purposes, or gone to the help of the weaker provinces. Widespread poverty, lawlessness, and banditry, and a recrudescence of opium-growing under military protection, have resulted.

(c) *Growth of Anti-foreign feeling.* — Meanwhile the small but resolute band of patriotic constitutionalists have endeavoured in various ways to arouse their fellow-countrymen and to secure a strong public opinion for the overthrow of military autocracy and the evolution of an orderly system of parliamentary government. It has been a slow, uphill fight, and unfortunately the attention of those who have led it has again and again been

diverted from their task by a deep-rooted suspicion and fear of the intentions of the foreign Powers. A succession of unfortunate incidents has deepened their mistrust. Among them may be mentioned the complete subjugation of their neighbour Korea, without a word of effectual protest from the Western world; the presentation by Japan of the deeply-resented Twenty-one Demands; the cynical disregard of China's position as one of the Allies at Versailles, and the handing over of part of her territory to Japan (an act which has never been forgotten, in spite of the subsequent agreement at Washington); the large share taken by certain of the foreign Powers and their nationals in the smuggling of arms and morphia into China; the talk of foreign intervention for the forcible "pacification" of the country, and of "paramount positions" of commercial interest; the long delay on the part of France in ratifying the promises of the Washington Conference with respect to the revision of China's tariff; the restrictions placed upon Chinese ratepayers in the International Settlements, and so on.

Such actions as these, coming at a time when patriotic Chinese are engaged in an implacable fight against the forces of reaction within the country, and are irritated beyond endurance by the patronising, and ofttimes dictatorial and bullying tone assumed by the foreign press, have made them hyper-sensitive on all national issues, and profoundly suspicious of the motives actuating the foreign Powers. Anti-foreign sentiment has

thus been fostered, and a national "inferiority complex" produced.

Other factors have helped to intensify this feeling. The growing race-consciousness, so typical of all Oriental nations to-day, has found a ready soil in China as in India, and is expressing itself in an increasing demand for the abolition of the special concessions extorted from China at the time of her political and military impotence. These concessions not only include liberty for foreign commerce and missionary propaganda, but also limit China's power to impose any tariff on foreign goods beyond a bare five per cent., and confer the rights of extra-territoriality on all foreign residents in the country. This question of extra-territoriality, which, in the present unsettled condition of the country, may appear to the majority of foreigners to be almost outside the realm of discussion, has become a burning one in China since the War. This is partly because the victory of the Allies enabled China to abrogate this right in the case of Germany and Austria, but still more because Soviet Russia has voluntarily surrendered the privilege on the part of her citizens. This renunciation, accompanied, as it has been, by a wholesale communistic propaganda in China, and by attacks on the "imperialistic" and "capitalistic" designs of other Powers, has added fuel to the fire of suspicion directed against those who refuse to accord China a full and equal place in the family of nations. Numbers of thoughtful Chinese are to-day looking to Russia's method of economic communism as the

only hope of successfully resisting the aggression of the Western Powers, and thus lend a willing ear to Soviet suggestion.

THE EDUCATIONAL ADVANCE

But it is now time to leave the political situation for the moment, and to attempt to follow what has been taking place in the educational sphere, where also changes profound and far-reaching have occurred.

(a) *The Renaissance.*—Prior to the year 1905 the Chinese Government took no appreciable share in the maintenance of educational institutions, which were left to private enterprise. The Chinese schools of that day still pursued their time-honoured course of classical study, and it was the missionary agencies of North America and Europe (particularly those of the United States) which bore the responsibility of introducing modern education to the Chinese people. Mission schools and colleges gradually occupied the main strategic centres and attracted the best students in the country, thus filling a place of unlimited potentiality among the eager minds of that generation. At the same time an increasing number of intelligent youths found their way to the educational centres of the Western world and of Japan, returning to their fatherland to sow seeds of a vast intellectual revolution.

The change of educational system which took place in 1905 was followed by the opening up of

Government schools in all parts of the land, and before many years had elapsed a veritable renaissance was seen to be occurring. The old concept of a Central Kingdom of China, surrounded on all sides by barbaric or semi-barbaric nations, gave place to a new appreciation of China's position in the modern world. The backward outlook, which interpreted all events in the light of ancient history and philosophy, was succeeded by a keen passion for everything scientific and new. The unquestioning worship of authority, so characteristic of a former age, was followed by an attitude of sheer iconoclasm in which moral sanctions and social customs were alike attacked. Nothing escaped the onslaught. The classical style of literary writing—most sacrosanct of China's heritage—was made the object of attack by a brilliant band of young intellectuals of the Peking Government University, and a new form of colloquial Chinese became popularised in publications and newspapers throughout the length and breadth of the country. At the same time every form of radical and revolutionary theory, from Soviet communism to birth control, found ready access to the daily increasing volume of student publications and magazines.

Nor was it merely in destructive criticism and in the rapid assimilation of revolutionary ideals that the New Culture Movement (as it became known) expressed itself. A vast amount of solid constructive work was soon put on foot. Associations for the reform of education, scientific and

philosophical societies, and national organisations for the spread of popular education rapidly came into existence, whilst the growth of the public press became quite phenomenal.

Meanwhile an increasing number of well-trained and highly intelligent men and women came to the front to take the lead in these various educational enterprises. Many of these were graduates of mission colleges and Universities to which they owe both loyalty and gratitude. Others again were recruited from the ranks of those who had taken high place in the Universities of the West and of Japan. But all alike were filled with an ardent zeal to raise the educational system of China to a level worthy of her history and civilisation. In spite of the heartbreaking conditions produced by political strife and financial penury, they have kept steadily forward at their task, and their achievements have been beyond praise. Neither political faction nor provincial jealousy has broken their ranks, and it may be confidently asserted that these educationists represent the most solid and united group that is to be found in any sphere of life in China to-day.

These educational leaders are for the most part attached to Government or private schools, many of which, in spite of their weakness of discipline, now maintain standards fully equal to (or even superior to) those of the institutions under mission control. Only last year a graduate of one of the leading Teacher Training Colleges in England proceeded to China with the intention of applying

some of the more modern educational methods—the Dalton method, Intelligence Tests, Projects, and the like—to Chinese conditions. He found on his arrival that he had long been anticipated, and that there was an abundant literature on the subject ready to hand in Chinese, all of it the product of modern-trained Chinese educationists.

(b) *The Anti-Christian Movement.*—But at this point the natural question will be asked as to why intelligent men and women of this character should have taken so prominent a part in the Anti-Christian Movement, of which we have been hearing so much of late. Seeing that many of them owe their own education to missionary organisations, why should they now seek to restrict the freedom of such institutions?

To answer that question fairly let us attempt to place ourselves in the position of one of these leaders, and even though we find his attitude unjustified, let us try to appreciate it sympathetically. What are the facts with which he is confronted in his earnest desire to see his country overcome the serious obstacles under which she is at present labouring?

He finds, in the first place, that the sense of nationality is still very weak in China, and that much provincialism exists everywhere; that the great mass of the people are wholly illiterate; that the tuchuns and politicians, speaking generally, "care for none of these things"; that the educationists are, in his opinion, the sole hope of any widespread patriotic movement for the welfare

of the country. He finds, moreover, that there exist what appears to him to be dual systems of education taking root, the one wholly Chinese and under the control of the Chinese authorities, the other foreign-controlled, foreign-financed, and to a large extent foreign-staffed, not needing to conform to Government standards or requirements, but protected by "treaty rights" in the prosecution of its aims. He finds also that the avowed purpose of this far-flung system of mission schools and colleges is that of religious propaganda, whereas possibly he himself is a non-Christian. Or it may be that he is one of those educators (of whom there are many in China) who conscientiously believe that religion and education should be kept apart, and that any religious work which may be carried on in schools, whether in the nature of Biblical instruction or attendance at religious worship, should be on a wholly voluntary basis. We may deplore his attitude, and wish with all our hearts that he shared our conviction that the teaching of true religion was a fundamental part of that presentation of truth and building up of character, which form the sole purpose of real education; but we can see his point of view, and can at least understand why it is that he is demanding that all schools and colleges—whether missionary or otherwise — should be subject to Government requirements, both as regards the standards they maintain, the qualifications of the teachers they employ, and the subjects which they teach.

It must also be admitted that much of the recent

opposition to foreign-controlled schools in China arises from a deep-seated suspicion of the true motives underlying this interest in education on the part of foreign nations. Here also various incidents —many of them perfectly legitimate and well-intentioned—have strengthened this attitude of suspicion. The fact that in certain schools national flags other than those of China have been placed in prominent positions, and students taught to salute them on occasions and to observe the national holidays of the countries they represent, raised serious doubts as to the denationalising effect of such a system of education. The reported offer of the German Government, prior to the War, to subsidise schools in China for the spread of German "Kultur"; the generous action of the British Chambers of Commerce in raising a large sum for the strengthening of British schools; the suspicion that Japanese schools in Manchuria were being utilised for the purpose of "peaceful penetration," were all alike capable of serious misunderstanding from the point of view of a high-spirited nationalist.

But perhaps the most serious matter of all has been the widespread fear that the returned Boxer Indemnity Funds would be used for the strengthening and endowing of foreign institutions rather than for the advancement of Chinese schools and colleges. Much of the correspondence which has appeared in the English press, openly advocating the use of this money for commercial purposes beneficial to British trade (which correspondence finds a ready access to Chinese newspapers), has

deepened the mistrust which Chinese educators are feeling. Moreover, the fact that Chinese representatives are in a very small minority upon the Committee which is to advise the British Government as to the best method of utilising the released funds "for purposes *mutually beneficial to Great Britain and China*" has given rise to a prevalent idea that Britain is far more concerned about her own interests that those of China. In this particular matter British policy is contrasted to its disadvantage with that of America and Russia, both of which countries have entrusted the administering of their portions of the released Indemnity Funds to boards possessing a majority of Chinese representatives.

If suspicions and apprehensions, such as those above indicated, are entertained by the thoughtful educational leaders of the country, it is little wonder if they are shared, in an exaggerated form, by the main mass of the student body, who possess neither the experience nor the poise of their teachers. These young men and women are accorded a liberty, and possess an influence over the uneducated classes, which it is difficult for those who have never resided in China to realise. They are for the most part high-spirited and patriotic, impetuous and often immature in judgment, eagerly responsive to every new idea, and falling an easy prey to propagandists of every type. On the other hand, they include within their ranks thousands of men and women of splendid ability and noble purpose, inspired by

true devotion to their country's cause, and possessed of a strong determination to build out of the present wreckage a fairer China than has yet been. Let us not over-emphasise their undisciplined actions, but try to accord to them a measure of sympathy and patience which refuses to be quenched by the excesses of the extremists or the wildness of their utterances, and which sees in this surging life of young China a passion that may one day be transmuted into glorious service for the redemption of the nation.

SOCIAL AND ECONOMIC CHANGE

There is yet another factor in the situation in China which demands brief notice before we conclude this Survey, and that is the change in social and industrial conditions which is gradually sweeping over the country. Modern industrialism, with all its menace to human life and relations, has already reached China, and factories and mills employing modern machinery are now numbered by the hundred. Many of these are financed by foreign capital, but a far greater number are now being run with Chinese money and staff. Iron-works, cotton-mills, paper-mills, flour-mills, silk filatures, not to mention scores of other industrial enterprises, are drawing hundreds and thousands of workpeople to the large towns and cities, bringing in their train all that array of social problems with which students of industrial history in our own country are only too familiar.

The home industry or small workshop, unhygienic as it was, had its personal relationship between employer and employed. It is now giving place to enormous industrial machines, both in the Treaty Ports and in Inland China, in the vast majority of which human life and comfort receive but scant attention. Women and little children are employed from twelve to fifteen hours a day in dusty, insanitary, over-crowded rooms and shops, in many cases taking equally long shifts by night, and all for a mere pittance. Many of the foreign-owned mills of Shanghai, which have produced substantial dividends for their shareholders during the past ten years, are still employing child labour for long hours per day or night, and the very mild measures of reform[1] which have been recommended by a special Industrial Commission after two years' negotiations have so far failed to secure ratification by the apathetic ratepayers of the International Shanghai Settlement. Such facts as these afford ready ammunition for the communistic propagandist or anti-foreign agitator, as he inveighs against the exploitation of human life by so-called "callous capitalists." These foreign-owned mills form but a small percentage of the total, and conditions within them, as competent observers have pointed

[1] These recommendations include the abolition of child-labour under ten years of age (rising to twelve in four years' time), the limiting of hours of children under fourteen to twelve (these twelve hours to include one hour of rest), and the prohibition of child labour in dangerous places. It is suggested that the prohibition of night work for children be considered in four years' time.

out, are far superior to those to be found in most Chinese industrial enterprises; but it is impossible to gloss over the fact that they are employing labour under conditions that would not be tolerated for a moment in this country.

The working classes of China will not always remain inert under the oppressive conditions to which modern industrialism is subjecting them. They are learning, as in Japan, to organise themselves into labour unions for the protection of their rights, and the strike and boycott are already becoming familiar and powerful weapons in China's new industrial life.

Other social changes are also taking place in the country, the most striking of which is the emancipation of womanhood. Many of the colleges and Universities in China are now co-educational, and intelligent women are gradually taking their place in almost every walk of life. If the University with which I am personally connected can be taken as a fair sample, it can confidently be claimed that these girl students are assuming their new position with a poise, a dignity, and a self-possession which speak volumes for their strength of character and for the possibilities which they represent for the future welfare of the country.

It is, however, impossible to have social changes of so sweeping a character without grave dangers, and China is no exception. New-found liberty easily degenerates into licence, and the spread of low-class cinemas and dance-halls, the rapid increase of lotteries and other forms of public gambling,

and the opening of licensed quarters for prostitution in many of the larger cities, are among the new perils which China has received from her contact with other nations. It is little wonder that one often hears the question raised by thoughtful Chinese as to whether China has not gained more harm than good from her contact with a so-called Western Christendom.

WHAT CAN WE DO?

An honest attempt has been made in the foregoing pages to present the Chinese point of view, and to show something of the causes which have brought about the present unhappy situation. That situation, in so far as it affects foreign nations, may be summed up in a word as a *fear of exploitation*—first political, then economic, more recently educational. And now the crucial question confronts us as to what we can do to help allay this fear, and to assist the liberal forces of the country in their hard struggle for constitutional government and peaceful progress. It is plain that China's salvation must come from her own sons and daughters. Already, within the virile membership of the Chinese Church there are men and women of marked ability occupying positions of importance in politics, in education, industry, and in official life. How can we aid them in their task, and extend to them the hand of sympathy, of confidence, and of brotherhood?

1. In the first place we need to remember that

China is an independent nation, possessing her own sovereign rights, and that not only are "spheres of influence" to be regarded as things of the past, as Lord Balfour emphasised explicitly in his statement at Washington on 28th December 1921, but that talk of foreign control, or of interference with China's right to work out her salvation in her own way, will merely provoke violent opposition. It is by conference and not by compulsion that China will eventually be stabilised, and it is for us as a nation to show sympathy with her in her task, to remain steady and patient under provocation, to assist in any way possible in the re-establishment of her finance, and to place the welfare of the Chinese people before all partisan interests, whether political, commercial, or educational. The doctrine of force, which many urge as the only method applicable to Eastern conditions, produces at the best but temporary benefits, and alienates those liberal elements with whom we should strive to co-operate. Furthermore it plays into the hands of the military autocrats of China, and inevitably postpones the day when their power will be taken from them, and orderly government set up.

2. In the second place, let us frankly face the fact that although China has gained certain real advantages from the treaties of half a century ago, she does not possess the liberty of a fully autonomous nation so long as she is subject to the conditions which they impose on her. She has no power of jurisdiction over the increasing number

of foreigners who invade her territories, nor can she improve her impoverished exchequer by raising her tariff on imported goods.[1] Whatever the difficulties and possible risks may be, justice and generosity alike demand that early attention be given to a consideration of the steps by which the removal of both these handicaps to national progress may be expedited.[2] At bottom the question is a psychological one. Until China feels herself, like Japan, treated on a basis of absolute equality, rational discussion is always in danger of being submerged in a tumult of feeling provoked by what is regarded as a stigma of inferiority. The Chinese merchant, in his dealings with the foreign trader, has always appreciated just treatment, and has shown himself ready to make immediate response. The Chinese people have never been lacking in gratitude to those foreign residents who have proved to have their interests at heart. A just and generous treatment of the aspirations of the nation will prove

[1] As an example of the injustice of the present system, it may be mentioned that Chinese tobacco imported into Japan is subject to a tariff of 350 per cent; Chinese manufactured silk imported into America, 35 to 60 per cent; Chinese tea imported into Britain, 25 per cent; whilst foreign goods imported into China cannot be taxed beyond a bare 5 per cent.

[2] As a result of the Washington Conference an International Commission is to be set up to inquire into the present practice of extra-territorial jurisdiction, with a view of finding a basis on which the Powers might relinquish their privileges. The disturbed state of the country has been mainly responsible for the delay in setting up this body. The Tariff Conference, hitherto held up by the action of France, is expected to meet shortly, and will, it is hoped, enlarge its scope so as to include other matters vital to China's welfare.

in the long run, as in South Africa, to be both the wisest and the most Christian policy.

3. In the third place, let us see to it that in our conduct of missionary activities in China we make it quite plain that our great concern is not to impose something alien, whether it be ecclesiastical organisation or educational method, still less is it to protect ourselves behind our so-called " treaty rights," but to offer to China the free gift of Christian service. Christ alone can satisfy the heart of China and guide to a true solution of her serious problems, and it must be our earnest endeavour to express His spirit in every relation of life. As the late President Burton of Chicago recently remarked :—

" We must not lose sight of the fact that our fundamental purpose is to make the largest possible contribution to China's welfare; and we must be ready to make any adjustments of policy or practice which may at any time be necessary in order to enable us to achieve this end." . . . " For the religion of Christ does not consist solely in the acceptance of any religious belief, or the adoption of any religious principle, but in the application of the Christian spirit to the whole of life."

Anything which savours of denationalization, or of unwillingness to submit to Chinese requirements (in so far as they do not involve freedom of conscience) must be rigorously excluded from our educational work, and an attempt made to articulate all our activities into the life of the nation.

4. Finally, let us make it our determined policy

to lend encouragement to every enterprise which has for its object the self-development of the Chinese people and the success of Chinese national organisations, and let us employ every effort to hasten the day when the control of all Christian activities—whether educational or medical or ecclesiastical—shall be in the hands of chosen Chinese leaders. It is characteristic of the missionary movement, as has often been remarked, that it only succeeds when it puts itself out of business; but timidity, conservatism and an exaggerated sense of our trusteeship too often hinder our progress towards this goal. Let us take our courage in our hands and go forward in a supreme act of faith in the controlling power of the Divine Spirit. It will demand patience and humility and the grace that is content to watch the mistakes of others with genuine sympathy and confidence. But our experience of God, and the remembrance of all He has accomplished through devoted members of the Chinese Church, should serve to calm all fears and allay every apprehension. It is not for nothing that China has been preserved through forty long centuries of history and remains to-day the most populous nation on earth. God has assuredly a unique place for her to fill in the world. Let us then strengthen the hands of those who are striving to " build Jerusalem " out of these chaotic conditions in China.

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EDUCATIONAL PROGRESS UNDER THE CHINESE REPUBLIC

"There has been a revolution in China, and though that revolution has been far more fertile in altering the names of institutions and things than in changing the things themselves, it has been a great revolution. And it is part of a more gradual but far more potent revolution. That greater, slower movement has released, and is daily releasing, forces of quite incalculable potency."

"The great hope of improvement lies, of course, in the spread of education on modern lines. But this, to be thorough and sound, must be gradual. Education is undoubtedly making rapid strides, and is bound to advance in the future."

Thus wrote Mr. W. J. Clennell in July 1924, in the course of an illuminating and somewhat pessimistic account of modern conditions in Fukien*, and the events of the past year have given an added significance to his words. Revolutionary forces of incalculable potency have undoubtedly been released, the ultimate effect of which nobody can foretell. At the same time every intelligent and sympathetic observer of Chinese affairs is agreed that the great hope of the country lies in the spread of education on modern lines. What, then, it may well be asked, is the present position of education in China, and how far is Mr. Clennell justified in claiming that it is making rapid strides in the country, in spite of political confusion, civil war and national insolvency?

I.

From time immemorial the Chinese people have venerated scholarship, and it is necessary to dig down

* "Papers respecting Labour Conditions in China" 1925. pp. 52, 66.

very far into China's historic past to discover the source of this regard. As Mr. Alfred Sze said in London a few years ago,—

"China's philosophers were writing on religion and ethics at the same period as Plato and Aristotle in Athens; her historians were recording the story of her past before Caesar described his conquest of Gaul and invasion of Britain; her poets wrote melodious poetry, which is read with pleasure today, when Alfred reigned in England and William the Conqueror invaded it; and her scholars were writing, through a thousand years, commentaries on her classics which have moulded the thought of the Chinese during more than twenty centuries."

This veneration for learning invested the scholar with peculiar authority and influence, and procured for him the paramount place in Chinese society. It freed him from various vexatious conditions to which the non-scholarly class were subjected; it opened up to him a path of official appointment leading to the highest posts in the land; and it gave to him and his *confreres* a power of moulding public opinion which has persisted to this present day.

At the same time it must be remembered that up to very recent years the education obtainable in China was almost entirely literary and classical in character, and was wholly dependent upon private enterprise. Dotted all over the country were the various academies (*shu-yuan*) where famous teachers gathered together groups of eager students for courses of instruction which were always more tutorial than institutional. For several hours a day, and for many months in the year, they would browse together in the rich fields of China's classical lore, memorising the text, discussing the commentaries, and learning to take part in those severe but

delightful contests of literary skill which verse-making and scroll-matching afforded. Natural science, western history and geography and foreign languages found little or no place in such an educational course, for to the Chinese scholar, secure in his belief in China's cultural supremacy, there was no object in wasting precious time in the pursuit of such subordinate subjects. The history, the philosophy and the literature of ancient China provided inexhaustible mines of intellectual wealth demanding the study of a life-time. Little wonder that in the early days of contact with the western world the Chinese *intelligentsia* came to regard all foreigners as utter barbarians. For generations they had been taught that the hall-mark of culture was the ability to converse in literary allusion and innuendo. To call a spade a spade was the obvious resort of the unlettered boor; to the literary mind it was but necessary to allude to the implement of Wang-han-ming, or some such legendary figure.

Thus education, whilst truly democratic, insofar as it was open to the humblest peasant in the land, became more and more confined to the leisured classes; on the one hand, to men waiting to obtain official rank, on the other hand, to those who by birth or natural inclination had come to appreciate the literary heritage of the race. The Government, as such, did nothing to promote education beyond holding the examinations which admitted to official rank. It was left to individual Chinese scholars, and to groups of public-spirited men, to keep alight the torch of scholarship in the land.

Such, then, was the position of education in China right up to the end of the nineteenth century, the only exception—and it is a significant one—being the schools and colleges which had been opened in various parts of the country under missionary auspices, and which were already exerting a marked influence in certain circles. We have but to contrast that position with the educational situation as it exists in China today, and to realise that there are now approximately 200,000 government and private schools of all grades, teaching some seven million scholars, staffed to a large extent by teachers trained along essentially modern lines, and offering modern courses of instruction, to appreciate the truth of the assertion that a profound revolution has indeed taken place, and that education has made extraordinary strides.

II.

The influences which have brought about so rapid and drastic a change in China's age-long educational system have been diverse, but three may be singled out as of primary importance.

First in order of time, if not of potency, has been the permeating influence of the modern schools and colleges which grew up in China in connection with the missionary movement, particularly during the latter part of last century. It is these institutions which may claim to have introduced modern education to China, and it is remarkable to notice how many of China's outstanding educators today owe their early traning to this source.

Secondly, there has been the growing influence of the men and women who have completed their education abroad. Ever since Yung Wing broke through the traditional isolation of his native land, and succeeded, after fifteen years of patient effort, in obtaining facilities for other Chinese students to follow his early example, there has been a widening current of student emigration to western lands and Japan.

Thirdly, there has been the profound effect produced on Chinese minds by the meteor-like advance of her neighbour Japan,—a success obviously attributable to her assimilation of western education and science.

These factors, together with others of lesser importance, gradually convinced the Chinese of the urgent necessity of organising a completely new system of education throughout the country. Apart, however, from the "hundred-days' reforms" of the luckless Emperor Kuang-Hsu in the year 1898, all of which were speedily submerged in the tide of reaction which followed, no change of any kind was made until after the failure of the tragic Boxer uprising. With the signing of the Peace Protocol in 1901 and the restoration of the chastened and disillusioned Court, changes came thick and fast. In 1902 a decree went forth abolishing the old "*shu-yuan*" throughout the country, and calling for the establishment of a college or university in every province, a middle school in every prefecture, a higher primary school in every county, and lower primary schools throughout the rural districts. The following year a modernised curriculum was framed for the elementary schools, and a special commission appointed to draw up a complete educational system for the country.

On September 5th, 1905, the historic official examinations were abolished, and two years later a decree of equal significance and importance placed female education, for the first time, on an official footing.

In spite of these epoch-making decrees progress for the first few years was necessarily slow. Buildings were easily obtained, largely by the use of temples; funds were procured from national or provincial exchequers; pupils were to be found everywhere: but the supply of teachers was hopelessly inadequate. Graduates of former mission colleges, and old-time Chinese pedagogues, were hastily pressed into the service, whilst steps were immediately taken for the establishment of modern Teacher-Training Colleges all over the country.

Meanwhile a temporary halt was occasioned by the outbreak of the Revolution and the overthrow of the Manchu Government. No sooner had the new Republic been established, however, than it set to work with renewed vigour, to tackle the educational problem, and one of the first acts of the Republican Government was the reorganisation of the school system. A scheme was drawn up by the Ministry of Education in 1912 and adopted throughout the country, dividing the course of national education into the following stages:-

Lower Primary School stage	— 4 years.
Higher do.	— 3 years.
Middle Schools or Normal Schools	— 4 years.
Universities or Professional Colleges	— 4, 5, or 6 years.

During the ten years that followed, education went forward by leaps and bounds. This can be seen at a glance by the the following statistics:—

	1910-11 (Year before Republic)	1922-23.
Schools	57,267.	178,972
Students	1,626,529.	6,819,486.

Note. These figures for 1922-23 include 7,382 schools and 214,264 students under missionary auspices.

It is often stated, by those who criticise China's educational progress without full knowledge of the facts that this phenomenal advance has been top-heavy, and that far too much attention has been given to higher education. That this is not the case can be seen by the following analysis of the last available figures (those for 1922-23):-

Elementary school students	6,601,802
Secondary school students	182,804
College and University students	34,880
	6,819,486

Nor was it merely along quantitative lines that these twelve years produced so rich a harvest. Each year saw a large addition to the ranks of China's educational leaders, drawn from the best educational institutions of Japan, American and Europe, together with an increasing number of men and women who had graduated from modern universities in China itself. The influence of these keen minds soon made itself felt.

Associations for the reform of education sprang up all over the country, resulting in the formation, in 1922, of one of the most influential and representative organisations at present existing in China, the National Association for the Advancement of Education. At the same time the Provincial Educational Associations were strengthened by the presence of these same recruits; invitations were extended to noted western educators, particularly to Professor Paul Monroe, Head of the Teachers Training College of Columbia University, and to his associates, to visit China for the purpose of educational surveys; and as a result of the advice proffered by these experts the national educational system once again came under review. This culminated in the adoption, in 1922, of the so-called 6-6-4 system, consisting of six years of Primary Education (the first four of which it is hoped to make compulsory, as soon as conditions allow), six years of Secondary Education (three years of Junior Middle School work, followed by three years of Senior Middle School education, Normal training or Vocational instruction), and four or more years of Higher Education, to be spent either in a University, a Teachers' College or a Professional School.

This system is now in vogue in the greater part of China, for it is a remarkable fact, and one from which great encouragement can be derived, that in spite of the tragic divisions which at present split up the country into numberless political and military camps, education remains the chief unifying force in China. Delegates from every province attend the great educational conferences which are held annually, and the decisions arrived at in the course of the very up-to-date discussions which take place there quickly affect the educational policy of every province.

III.

Whilst these far-reaching changes were taking place in what may be called the technique of education, developments no less significant and profound were occurring in the realm of thought. China's "golden age" of original and constructive thinking had been followed by many centuries of mere scholasticism, during which rigid lines and stereotyped opinions were laid down which circumscribed the Chinese mental outlook. Throughout this period, as Dr. Hu Shih has recently reminded us*, the scientific method of critical investigation had never been entirely absent, but apart from the production of novels there was but little of a creative nature. The chief cause of this literary sterility was due to the fact that the literary medium—Wenli—was in reality nothing more than a dead language, as far removed from the current thought of the day as Latin was from the Italian of Dante's time. It was the realisation of this fact, coupled with the conviction that "no dead language can produce a living literature", which gave birth to the great literary revolution which has been raging in China for the past ten years, and which owes its inception to the work of Hu Shih and Chen Tu-shiu.

* See article on "The Chinese Renaissance" by Dr. Hu Shih in "Bulletin on Chinese Education". 1923.

Commencing with a series of articles in "La Jeunesse" (a paper issued in connection with the Peking National University), Hu Shih and his associates inaugurated a campaign for the use of a modernized form of colloquial Mandarin—"Pei Hua", as it has come to be termed—for literary purposes. A storm of protest broke upon their heads from the ranks of the old Chinese scholars, but, quite undismayed, they pursued their crusade, and within two years it became obvious that they were the heralds of a veritable renaissance. Throughout the country associations for the propagation of "Pei Hua" began to appear; newspapers, journals and reviews, issued in "Pei Hua" or some modification of it, appeared by the hundred; novels, poems and essays, written in vigorous colloquial, and replete with modern phrases and concepts, began to crowd the pages of these magazines; a new and virile language had come to the birth.

Associated with this literary revolution, and to a large extent the product of it, there came a profound change of mental outlook amongst educated classes. The passivity of past generations gave place to a state of mind that was frankly iconoclastic and rebellious, impatient of imposed authority, critical of formerly accepted dogmas, responsive to every from of radical theory, and pragmatic in its philosophical concept. This changed outlook naturally reacted upon the educational programme, with results well summarized by the late Dr. K. S. Liu, Dean of the College of Arts & Science of the South-Eastern University, in an admirable monograph published two years ago. In this he described the tendencies of modern education in China to consist of the following:—

a. Social emphasis,—education being regarded primarily from the point of social efficiency, with a view to the development of a stronger sense of nationality.

b. The sense of freedom,—by which is indicated not merely an escape from the former classical bondage, but also liberty for educational experiment, such as is offered by Project Methods, the Dalton Plan, etc etc.

c. Vocational preparation,—with a view to the fitting of the student to become a better and more efficient citizen in whatever walk of life he elect to follow.

d. Scientific improvement,—including not merely the teaching of all forms of Natural Science by approved methods, but also the encouragement of the scientific habit of mind (criticism, exact observation, experimentation) throughout the educational course.

e. Character building,—with a view to emphasizing the moral factor in education, the place of physical training and athletics, the responsibility for social service, and the like.

IV.

It now remains to enquire how far the ideals expressed in the previous section have been actually attained in practice, and to attempt to sum up the more important achievements in educational progress since the establishment of the Republic.

It must be admitted at the outset that throughout a large portion of the country—particularly those provinces which are far removed from the more progressive centres of thought—but little real change has yet occurred. The framework of the new educational system has for the most part been set up, but the materials for erecting the edifice are still wanting. On the other hand it must never be forgotten that it is only a few brief years since these changes were inaugurated; that those years have been marked by widespread disorder and confusion; and that the rapacious maws of the militarists have again and again engulfed the civil funds intended for educational purposes. Under such circumstances the marvel is not that so much remains to be accomplished, but rather that so large a measure of achievement has already been reached. The statistics given on an earlier page afford some indication of the reality of that achievement. The nature of it will now be briefly considered under three main heads.

1. *Teacher-Training.* It was a very sure educational instinct which led the Republican Goverment, in the early days of its inception, to place its first stress upon the establishment of Normal Schools. The provision of well-trained teachers is of course essential to any educational scheme, and China has been peculiarly fortunate in the men who have undertaken this work for her. Commencing in 1903, with the first Men's Normal Schools, followed four years later by the first Normal Schools for Girls, the number and quality of these institutions have steadily increased until now there are 275 in all in the country, of which 67 are

for Girls. The students attending them have similarly increased, now totalling 31,553 men and 6,724 women, in addition to many others who are taking educational courses in Universities.

From the first, a relatively high standard has been set, and at the present time a student desiring to qualify as an elementary school teacher is required to take three years of Junior Middle School training followed by three years of special normal instruction, including practice teaching. For a teachership in a secondary school a four years course in a University or Teachers College is required, the curriculum of which includes not only an extensive knowledge of Chinese and of the ordinary "content" subjects, but also special courses in Child Psychology, a foreign language (usually English), Educational Measurements, Theory of Education, School Administration, Teaching Methods, etc. An enormous quantity of modern literature on educational problems and methods has been produced within recent years by the College of Education of the South-Eastern University, where extensive experiments in Intelligence Tests and other modern methods have been conducted,

An excellent opportunity was afforded to me, about two years ago, of testing the results of this training, During the course of an extensive educational tour in the interior I visited a large number of Chinese cities, and wherever I went I made a practice of paying a surprise visit to the Government Schools, and of sitting down in one or other of the classes. I thus had a unique opportunity of hearing subjects such as Mathematics, Chemistry and English being taught by some of

the graduates of these newer Normal Schools, and I was deeply impressed by the character of their work and the up-to-date methods which they were employing. Later in the same year the China Medical Board of the Rockefeller Foundation established a Post - Graduate Science Summer School in Peking, at the conclusion of which the instructors (amongst whom was a member of my own staff) bore strong testimony to the excellent work that had been done, and to the keenness and ability of these school teachers.

The enthusiasm of some of these modern teachers is in marked contrast to the comparative apathy displayed by most sections of Chinese society. This enthusiasm is seen not only in the zest with which they continually formulate new plans for educational advance, but also in the devotion with which they stick to their profession in face of the most disheartening financial conditions. Of the many Government teachers with whom I am personally acquainted, I hardly know of a single man who is not many months in arrear in salary, but it is the rarest thing to find a teacher willing to thow up his work and seek other forms of employment.

Female Education. Until the year 1897 the only schools or colleges for girls in China were those conducted by missionaries. In that year the first Girls School financed and staffed by the Chinese was opened in Shanghai. It was not however until the memorable decree of March 8th 1907 that the educational emancipation of women really took place, when the first Girls Normal Schools were authorized and provision was made

for the opening of elementary schools for girls. Since that date progress has been extraordinarily rapid, as the following figures will show:—

	1906	1912	1922
Girls in government or private schools . .	306	141,130	418,170

All forms of education are now open to girls and women. Thus, in addition to the 67 Normal Schools already referred to, there are 25 general secondary schools, 158 Vocational Schools (for teaching sericulture, handicrafts, etc,) and one government college of University rank. From these figures it would appear as if but meagre accommodation was so far provided for the higher education of China's women. Whilst admittedly quite inadequate,—as indeed is every type of female education at present—it must be remembered that since the year 1920, when the Peking National University and the Nanking Teachers College first opened their doors to women, practically all the higher educational institutions have become co-educational. This opportunity, together with the excellent facilities afforded by the various Christian Colleges and Universities, makes ample provision at present for those qualified and willing to pursue a college education. Their number is however rapidly increasing, and it is quite certain that the present meagre total of girl students in all stages of education in China will be enormously expanded in the near future.

3. *Popular Education.* One of the most encouraging signs in China today is the interest that is taken by the educated classes, and particularly by the student body, in the combatting of illiteracy and the spread of

popular education. This was a prominent feature in the first educational programme of the Republic, with the result that Lecture Halls were opened in all the chief towns (totalling 2,139 in all by the year 1917), Public Libraries and Reading Rooms were established in many centres, and a number of schemes were set on foot for the purpose of giving partial education to those unable to attend an ordinary school. Amongst these may be instanced the Open-Air Schools, the "Language-made-easy" Schools (of which there were nearly 5,000 by the year 1915), Half-Day Schools and Night Schools. In most of these efforts the work of instruction has been carried on by the voluntary services of students. A large number of colleges and secondary schools in China now maintain Free Night Schools for the poor children of the district, the teaching being done voluntarily by the students, who in many cases also make themselves responsible for the expenditure involved. The Daily Vacation Bible School Movement (which provides elementary education for poor children, together with some simple Bible Instruction, during six weeks of the summer vacation) also recruits a large number of voluntary workers, more than 500 such schools being conducted in one province (Shantung) last summer.

During the last two or three years a new method of attacking the illiteracy problem has been carried on with considerable success by Mr. James Yen and Mr. Daniel Fu of the Chinese Y. M. C. A., who first employed it amongst the Chinese labourers serving in France. This scheme consists in the gathering out from the Chinese language of one thousand of the most commonly used

words, and the organising of classes for the purpose of teaching illiterates to recognise each of these thousand characters. Classes are held every night of the week for four months, at the end of which time it is claimed that the most ignorant peasant ought to be able to read the simple books which have now been prepared in this limited vocabulary. Great enthusiasm has been aroused by this scheme, and over two million of these text-books have been issued.

By methods such as these, together with the rapid spread of the public press, the growing use of lectures and cinemas, open-air demonstrations and the like, knowledge is being disseminated in China at a far more rapid rate than has ever before been known, with the result that a national public opinion can now be created and mobilised. It is true that political conditions are at present seriously hampering educational advance, and that indiscipline is rife in many schools, but it is nevertheless in the spread of solid education,—modern and scientific, and, above all, based on a stable moral and religious foundation—that the hope of China's future lies, and nobody can survey the history of her progress during the past ten years without finding good cause for satisfaction and hopefulness.

HAROLD BALME,
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NOTE.

To readers of Prof. G. R. Twiss's recently published report on "Science and Education in China" the foregoing paper may appear to savour of plagiarism. It should be stated that this paper was written and published before the writer had the opportunity of seeing Prof. Twiss's valuable book.

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Chinese Revolution and Christian Union

A PRACTICAL EXPERIMENT IN CHRISTIAN FELLOWSHIP

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CHINESE REVOLUTION AND CHRISTIAN UNION

A PRACTICAL EXPERIMENT IN CHRISTIAN FELLOWSHIP.

By Harold Balme, F.R.C.S.

To attempt to follow events in China is like trying to watch naval manœuvres through a fog. Fantastic figures appear and disappear, distorted in shape and bewildering in appearance, and we soon lose all sense of direction or perspective. Fortunately it is quite unnecessary to try to keep track of the various military leaders who come and go so rapidly, or even of the many governments which spring up overnight. These are but the superficial eddies on the turbulent stream. The basic fact that we must grasp, if we want to understand a little of what is happening under the surface, is that China is going through an amazing process of revolution, and that this is affecting every sphere of life and thought throughout the country.

After all, this is not to be wondered at. Throughout the whole of last century—but especially during the latter half—a series of explosive ideas was sown broadcast in the land, as the result of contact with Western civilisation. Nationalism, democracy, industrialism, liberty of thought, the value of human personality, the rights of the "under-dog," the equality of the sexes: these were some of the high explosives which were dropped, from time to time, amongst the placid and conservative Chinese, and it is not to be surprised at if the result is Revolution. And this has invaded every class of the community, everywhere producing conflict between Liberal and reactionary forces.

You see it in the political world, in the struggle between those groups who are striving to overthrow autocracy and establish democratic government, and the corrupt politicians and rapacious militarists who are fighting for their own hand. You see it in the educational world, in the heroic efforts to establish modern schools and colleges and popularise modern knowledge in the face of a dead weight of conservative inertia, political propagandism and wild rationalistic theory. You see it in the industrial world, in the appalling problem of the sweated women and children in factories and mills. You see it in the social sphere, where the emancipation of China's splendid womanhood and girlhood is facing all the perils of new-found liberty. You see it in international relations, in the struggle of China's true patriots to obtain an independent and equal place for their country in the family of nations. You see it in the religious world, in the challenge which Young

China is presenting to every form of religious thought and activity.

It is Revolution which is taking place in China, and no one can foretell what the end will be. Will the forces of liberty and goodwill win out? Or will the reactionary elements of selfish militarism and callous exploitation, of race-hatred and class-hatred, prove victorious? On the issue of that question the peace of the whole world may well hang.

In face of such a situation, fraught with danger but charged with immeasurable potentialities for good, a priceless opportunity is offered to all who believe in the ultimate victory of those spiritual and eternal principles which Jesus Christ has given to men. In that great brotherhood, of which He is the firstborn, lies the one solution to all these menacing problems. And if we can but spread that brotherhood throughout China, and help to raise up a body of men and women who are prepared fearlessly to apply Christ's way of life in every sphere where revolution is taking place, we need have no anxiety about the future.

To accomplish this task, three things are essential. We must unite all our forces for the attack. We must co-operate to the full with the virile body of Christian leaders who now form the backbone of the Christian Church in China. And we must concentrate our main efforts on the building up of a Christian community which will permeate every department of life and thought in China with Christian truth, Christian ideals of service, and Christian sacrifice.

During the past twenty years a series of unique experiments has been taking place in this direction in different parts of China, and it is an account of one of these experiments with which we are concerned in this article.

At the beginning of the present century, a strange combination of circumstances, arising out of the terrible Boxer massacres, brought together a group of Christian missionaries of various denominations in North China. The stations which they had established with such care and patience had all been destroyed. Their little flocks of Chinese Christians had been scattered, many of them perishing in the persecution. The foundations of the whole missionary enterprise had been shaken. It was evident that a new day was dawning in China, a day which would inevitably bring revolutionary change throughout the country. How were they to meet it? Above all, how were they to produce, out of the wreckage around them, a new body of Christian leaders, trained and equipped to meet the demands of the new era, and devoted to the cause of Christ?

As they talked and prayed and meditated together, the conviction deepened in the group that what was needed was a great Christian college or university, where the children of

Christian families, and any other students willing to attend the classes, might receive a full training in Arts or Science, in Medicine or Theology, under the guidance and daily influence of highly qualified Christian teachers—thus equipping them to become leaders of the new Christian community that must assuredly arise.

It was a noble conception; but how was it to be accomplished? How could any missionary society attempt such a gigantic task? Think of the number of expert teachers who would be required; of the buildings and equipment; of the cost of upkeep. Plainly it was beyond the powers of the strongest of them. But what no one group could accomplish, single-handed, might perchance become possible if only they dared to unite their forces in the attempt.

If only they dared!

Gradually conviction begat courage, and courage swiftly turned to action. First the English Baptists and American Northern Presbyterians joined hands in the common endeavour. Then followed the Anglicans (S.P.G.) and the Canadian Presbyterians. Then, in quick succession, came Congregationalists and Lutherans, Southern Presbyterians from the United States and Methodists from both England and America, until now there are something like fifteen different missionary organisations of Great Britain, Canada and the United States sharing in the enterprise.

With the advent of these new forces new adventures became possible. Instead of the humble start in 1904, with three modest colleges situated in as many Shantung cities, a splendid site of over 100 acres was gradually acquired in the provincial capital of Tsinan, and here, in 1917, the Shantung Christian University (as it had come to be called in English, or the "Cheeloo" University in Chinese) was assembled. Since that time building has been added to building, through the munificence of Christian people in all three countries, until to-day the University consists of a large School of Arts and Science, with its modern laboratories and classrooms; a School of Theology; a School of Medicine, with attached University Hospital and Nurses' Training School; a beautiful Church; a Library, a commodious Administrative Building; an Institute and Museum for Extension Lectures; and comfortable dormitory accommodation for nearly 500 men and women students. At the same time the staff has been similarly expanded, and now comprises over a hundred Christian men and women, approximately half of whom are Chinese, a quarter British (English and Canadian), and a quarter American.

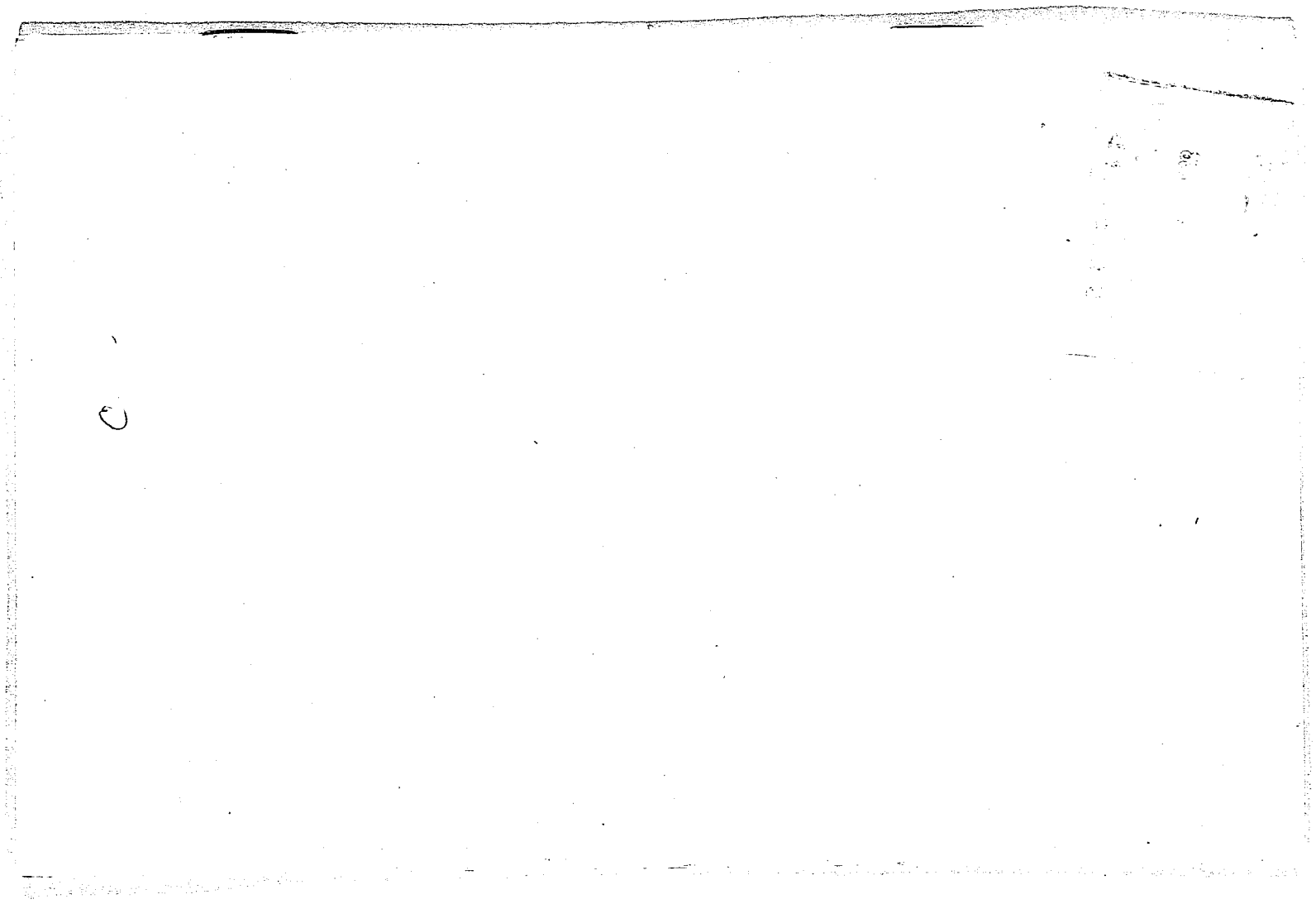
But how has the experiment succeeded? Has it been possible for men and women of different nationality or race and of different Church affiliation to work together in harmony and happiness without the compromise of their principles or the

loss of more than they have gained? Nobody who has had the privilege of being connected with the University would hesitate long for a reply. It has been one of the richest of spiritual experiences, each individual member of the staff, whilst holding firmly to his own convictions and giving them free expression, finding his spiritual life profoundly affected and enriched by the contribution and personality of the other members of the group. Perhaps the highest point of this experience of fellowship has been realised in the Annual Staff Retreats, held at the beginning of each academic year, when Chinese and British, Canadians and Americans, representing all branches of Christ's Church, live and sleep and pray and worship together in a little cluster of cottages on the hills above Tsinan, and learn something deeper of their essential unity in Christ. A striking proof of the power of this sense of unity to overleap national barriers was seen last spring and summer, when, in the enforced absence of their foreign colleagues, the Chinese members of staff successfully carried on the whole work of the University.

And what of the results? God only knows what they may be. Nearly 1200 men and women have already passed through the University, and are to-day scattered all over China. Some are in business, some (a very few) in Government posts, many are teaching in important schools and colleges, some are acting as physicians and nurses, whilst a large band are working as evangelists, ministers of the Church and teachers of religion. Of those whose records are known, over seventy per cent. are in the direct service of the Church in one capacity or another. And it is our belief and prayer that these men and women, who come of their own free will to study in the University,—where, without "compulsory chapels" or "compulsory religious instruction," the non-Christian students come under the constant influence of their Christian classmates and of the Christian staff in a hundred different ways—many more will go out to make a vital Christian contribution to the solution of China's ills.

As to finance, the support of the University is derived partly from the contribution of the co-operating Missionary Societies, partly from Chinese gifts and fees, and partly from funds directly contributed by Christian friends in Great Britain and America.

The work of the University calls for sympathy and prayer and succour, if it is to be adequately maintained and made successful. It has many trials to face, in these days of anti-Christian movements and anti-foreign misunderstandings; but with courage and faith all things are possible. And what better hope of a peaceful and prosperous China could we have than the raising up of a body of Christian leaders ready and able to plunge into the morass and guide their beloved country into paths of truth and light and liberty?



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A GRAPHIC METHOD FOR CALCULATING SOLAR ECLIPSES

BY

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PREFACE

At present there are three methods in use for the calculation of solar eclipses. First, the graphic method in which, by using a sector, the approximate times of each circumstance may be obtained. This method is simple and easy to comprehend, but lacks in exactness. Second, the altitude-parallactic method, in which by combining altitude and parallax with longitude and latitude of both sun and moon, we may compute the eclipse by trigonometry. This method is by no means simple and requires the frequent computation of both latitude and longitude. Third, the Bessellian method which is in general use, but is too abstruse for the ordinary student, and is very laborious.

Since it is possible in computing lunar eclipses, to secure quite accurate results by the use of trigonometric methods, it is a matter of regret that the same method has not been adapted to the calculation of solar eclipses. The endeavor to make such an adaptation has resulted in the plan submitted herewith, for which I bespeak your kind consideration. In this method, we use the graphic method as a basis, and then apply the trigonometric method to the results so obtained, the main idea of the plan being as follows:

At the instants of first and last contacts, the distance in arc between the centers of the sun and moon must equal the sum of their semi-diameters, therefore if we take the Earth's axis and the radius of the circle of latitude of the place for which the calculation is made as ordinate and abscissa, and find the corresponding co-ordinates for the sun and moon, we may obtain the distance in arc between the centers of the two bodies. If at a certain given time, the distance so obtained is equal to the sum of the semidiameters of the sun and moon, that time is the exact time of first (or last) contact. If not equal, we may then take another instant, a very little before or after the first time selected, and repeating the process, soon arrive at the desired result. To find the time of the middle of the eclipse, we take the approximate time, as found by the graphic method, and then find the distance at that time between the centers of the bodies. Then repeating the process for the instants immediately before and after the approximate time, we soon obtain the time of the least distance between the centers, which of course is the time of the middle of the eclipse.

The advantages of this method are obvious; first, the graphic method is simple and easy to understand, and the application of trigonometry to it is quickly made; second, the times secured, if the method is used correctly, will only be a few seconds out; and thirdly, this method reduces the calculation of solar and lunar eclipses to one method, which not only secures the scientific desideratum of unity, but greatly economizes the time of the student.

H. E. Wang

Shantung Christian University
Tsinan, Shantung, China
February 13th, 1928

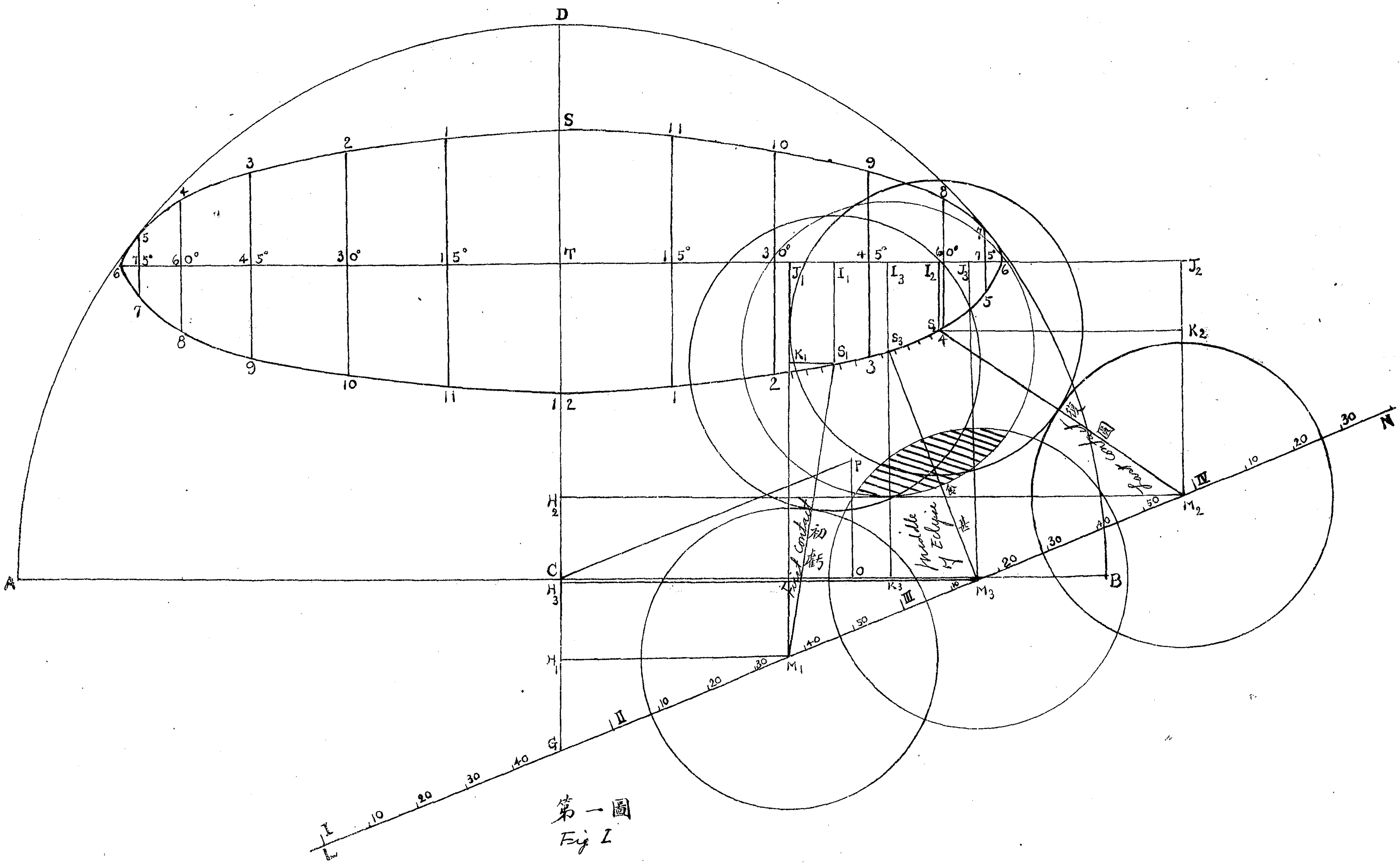
Note by translator

At Prof. Wang's request, seeing he does not understand English, I have translated the Chinese original into English, and would say that while there may be a few numerical errors in the Chinese copy, in the translation, or in the reprinting, yet there are none which will vitiate the method, which is the chief consideration.

Prof. Wang was formerly a student of mine in the Tengchow College and showed exceptional ability in Mathematical Astronomy, and in the thirty years since that time has become the leading Chinese authority on the subject.

W. M. Hayes

North China Theological Seminary
Tenghsien, Shantung, China
April 19th, 1928



D
S
T
A
C
B
G
N
P
First Contact 初虧
Middle of Eclipse 甚
Last Contact 復圓

第一圖
Fig I

THE GRAPHIC METHOD
for
Computing Circumstances of a Solar Eclipse

To calculate the circumstances of a solar eclipse, it is necessary to know the appearance of the earth as viewed from the sun and the exact situation of the place of observation—in the present case, that of Tsinan.

Viewed from the sun, the earth, owing to its very great distance, would appear as a minute circle, and the points of incidence and emergence on its surface made by a line passing through the centers of both bodies (the Geo-helio-centric line) would appear as one and the same point. Each arc of latitude and longitude would also appear as a short, straight line, indistinguishable from its sine. We will then, in drawing a diagram of the Earth's hemisphere, take the above point of incidence as a center, and using the difference between the horizontal parallaxes of the sun and moon as radius, draw a semi-circle which will represent the Earth's northern hemisphere as viewed from the moon.

The sun's equatorial horizontal parallax does not differ with that of the latitude of the place of observation, but that of the moon must, in this case, be reduced to the latitude of Tsinan. From the latter subtract the E. H. P. of the sun, and using the remainder as radius, draw the desired diagram.

Let us now take, for an example, the partial solar eclipse of May 9th, 1929, and proceed to compute the times of first and last contact as well as that of the middle of the eclipse.
The local data for Tsinan are,

Long. E.	$7^h\ 48^m\ 33^s$
Lat. N.	$36°\ 45'\ 24''$
Geocentric Lat. N.	$36°\ 34'\ 17''\cdot8$

Earth's Radius $p = 0.998800$. $\log p = 9\cdot9994795$.

From the Nautical Almanac we find the elements of the eclipse to be as follows:

Greenwich Mean Time conjunction Sun and Moon in R. A. May 9th,			$5^h\ 58^m\ 0^s\cdot2$
R. A. of Sun and Moon			$3^h\ 2^m\ 36^s\cdot7$
Hourly Motion of Sun in R. A.			$9^s\cdot73$
" " " Moon " "			$144^s\cdot02$
Sun's Declination	N.	$17°$	$14'\ 1''\cdot9$
Hourly Motion in Declination	N.		$40''\cdot4$
Moon's Declination	N.	$16°$	$55'\ 16''\cdot8$
Hourly Motion in Declination			$13'\ 31''\cdot2$
Sun's Equatorial Horizontal Parallax			$8''\cdot7$
Moon's " " "			$60'\ 24''\cdot7$
Sun's Semi-diameter			$15'\ 50''\cdot3$
Moon's " "			$16'\ 26''\cdot9$

The Moon's E. H. P. $60'\ 24''\cdot7$ reduced to that of Tsinan is $3624''\cdot7 \times 0\cdot998800 = 3620''\cdot35$. Subtract $8''\cdot7$ equals $3611'\cdot65 = AC$ (diagram I). With C as center and A C as radius draw the

semi-circle ABD representing the Earth's northern hemisphere as seen from the Moon. On CD, the Earth's axis, take C—12 = AC × sin (36° 34′ 17″·8 − 17° 14′ 1″·9) = 1195″·94, 12 being the position of Tsinan at noon. Again take CS = AC sin (36° 34′ 17″·8 + 17° 14′ 1″·9) = 2914″·55. Seeing that the latitude of the point of emergence is S 17° 14′ 1″·9, and the points of emergence and incidence appearing as one, therefore CS = AC × sin 53° 48′ 19″·7, S being the position of Tsinan at midnight. Bisecting S—12 at T, TS = 859″·31. Through T draw 6T6 at right angles to CD, then TC = AC × cos 36° 34′ 17″·8 = 2900″·55, being the radius of Tsinan's circle of latitude, and the two points 6,6 will be the position of Tsinan at 6 a. m. and 6 p. m. respectively. To the right and left of T6 take

$$T15° = T \times \sin 15° = 750″·72$$
$$T30° = T \times \sin 30° = 1420\ ·58$$
$$T45° = T6 \times \sin 45° = 2051\ ·01$$
$$T60° = T6 \times \sin 60° = 2511\ ·95$$
$$T75° = T \times \sin 75° = 2801\ ·72$$

Through 15°, 30°, 45°, 60°, and 75° draw lines at right angles to T6 and take

$$15° - 1 = TS \times \sin 75° = 830″·02$$
$$30° - 2 = TS \times \sin 60° = 744\ ·18$$
$$45° - 3 = TS \times \sin 45° = 607\ ·62$$
$$60° - 4 = TS \times \sin 30° = 429\ ·65$$
$$75° - 5 = TS \times \sin 15° = 222\ ·40$$

The points 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, so obtained will represent the position of Tsinan at these respective hours. Connecting these points by a continuous curved line, we obtain an ellipse representing Tsinan's circle of latitude as viewed obliquely from the Sun.

Again on CB take CO = (144^s·02 − 9^s·73) 15 × cos 16° 55′ 16″·8 = 1927″·13. (We multiply by the cosine of the Moon's declination because it has been reduced to the arc of a great circle.) Draw OP = 13′ 31″·2 − 40″·2 = 12′ 50″·8 = 770″·8. Now join CP and CP will represent the moon's hourly motion away from the sun, or regarding the sun as stationary, the path traversed in an hour by the moon. Prolong DC downwards and take CG = 16° 55′ 16″·8 − 17° 14′ 1″·9 = −18′ 45″·1 = −1125″·1. G being the position of the moon at the instant of conjunction, then LGN parallel with CP represents the moon's apparent path. In the right angled triangle COP we have

$$\tan OCP = \frac{OP}{OC}$$
$$\log OP = 2·886942$$
$$\log OC = \underline{3·2849118}$$
$$\log \tan OCP = 9·6020302$$
$$OCP = 21° 48′ 0″·2$$
$$\sin OCP = \frac{OP}{CP}$$
$$CP = \frac{OP}{\sin OCP}$$

$$\log OP = 2·886942$$
$$\log \sin OCP = \underline{9·5698051}$$
$$\log CP = 3·3171369$$
$$CP = 2075″·57$$

CP being the moon's hourly motion. Since the time of conjunction is G at 5^h 58^m 0^s·2 Greenwich mean time and the equation of time is −3^m 39^s·59

therefore the apparent time of conjunction is 6^h 1^m 39^s·79. Adding

Tsinan Long. E. 7^h 48^m 33^s makes 13^h 50^m 12^s·79 on 1^h 50^m 12^s·79 p.m.

60^m − 50^m 12^s·79 = 9^m 47^s·21 = 9^m·79

60^m : 9^m·79 :: 20 75″·57 : G—2, $G-2 = \frac{9·79 \times 2075·57}{60} = 338″·63$. On GN take G—2 = 338″·63, the position of the moon at 2. p. m.

Next by means of the hourly motion CP, lay off 3, 4, 5, representing the position of the moon at these hours. As the moon moves along its path, eclipsing a portion of the sun's disc, which also apparently moves along its circle of latitude (its center facing the observer), we can reduce the position of each body to minutes by dividing each hour of their respective paths into ten minute sections and then again subdivide by proportion. Now lay a right angled triangle on the diagram with its base parallel to the moon's path, and move it backward or forward until the other side cuts the same time points on the apparent orbits of both bodies, Draw a line connecting these points, and it will represent the nearest approach in arc of the centers of the two bodies, and the time indicated will be that of the Middle of the Eclipse. Following the scale of the diagram, open the legs of the dividers until the distance between the points is equal to the sum of the radii of the sun and moon, then with one point following the moon's path, the other following the circle of latitude (the sun's apparent path) find, before the central eclipse, the same point of time on both; this will be the time of first contact. Repeating the process on the other side of the point of central eclipse, will give the time of last contact, According to this method, we obtain the following results in Tsinan apparent time:

Time of First Contact	2^h	37^m	p.m.
Time of Central Ecipse	3^h	16^m	p.m.
Time of Last Contact	3^h	57^m	p.m.

The above results are only approximate and are the best that can be obtained from the diagram by following the usual method. While the method is lucid, yet it has this serious defect, so I would submit the new method given below to your consideration.

Prof. Wang's new method begins here.

A, To calculate the Time of First Contact.

Let TG and T6 be the axis of ordinates and abscissas, then by means of their coordinates we may at any time obtain the distance in arc between the centers of the two bodies. If this is exactly equal to the sum of their radii, that time will be the time of first contact; otherwise we must seek it as below. Take 2^h 37^m as the time of first contact and suppose the centers of the sun and moon to be at S_1 and M_1 respectively. The total time from G to M_1 will be

$$9^m·79 + 37^m = 46^m·79$$

$$60^m : 46^m·79 :: 2075″·57 : M_1G$$

$$M_1G = \frac{46·79 \times 2075·57}{60} = 1618″·6$$

At right angles to TG draw $M_1 H_1$ and the moon's coordinates, $M_1 J_1$ and T J_1; also the sun's coordiantes, $S_1 I_1$ and T I_1. We then proceed to find their values in arc as follows:

(1) For the Moon.
In the right angled triangle $M_1 H_1 G$, let M_1 represent the angle H_1M_1G, then

(2) For the Sun.
2^h 37^m reduced to arc equals 39° 15′ then we have

$M_1 = 21°48' \ 0''.2$

then $H_1G = M_1G \times \sin M_1$

$\log M_1G = 3.2091405$

$\log \sin M_1 = 9.5698051$

$\log H_1G = 2.7789456$

$H_1G = 601''.1$

$M_1J_1 = TG - H_1G = 3180''.35 - 601''.1$

$= 2579''.25$

$M_1H_1 = M_1G \times \cos M_1$

$\log M_1G = 3.2091405$

$\log \cos M_1 = 9.9677748$

$\log M_1H_1 = 3.1769153$

$T\ J_1 = M_1H_1 = 1052''.85$

$TI_1 = T6 \times \sin 39° \ 15'$

$\log T6 = 3.4624813$

$\log \sin 39° \ 15' = 9.801201$

$\log TI_1 = 3.2636823$

$TI_1 = 1835''.19$

$90° - 39° \ 15' = 50° 45'$

$S_1I_1 = Ts \times \sin 50° \ 45'$

$\log Ts = 2.9341453$

$\log \sin 50° 45' = 9.888961$

$\log S_1I_1 = 2.8231063$

$S_1I_1 = 665''.44$

Next we proceed to find the distance between the centers of the two bodies. In the right angled triangle $M_1S_1K_1$ we have

$M_1J_1 = 2579''.25$

$S_1I_1 = 665\ .44$

$M_1K_1 = 1913''.81$

$T\ I_1 = 1835''.19$

$TJ_1 = 1502\ .85$

$S_1K_1 = 332''.34$

$\tan S_1M_1K_1 = \frac{S_1K_1}{M_1K_1}$

$\log S_1K_1 = 2.5215825$

$\log M_1K_1 = 3.2818988$

$\log \tan S_1M_1K_1 = 9.2396837$

$S_1M_1K_1 = 9° \ 51' \ 4''.7$

$S_1K_1 = M_1S_1 \times \sin S_1M_1K_1$

$M_1S_1 = \frac{S_1K_1}{\sin S_1M_1K_1}$

$\log S_1K_1 = 2.5215825$

$\log \sin S_1M_1K_1 = 9.2332308$

$\log M_1S_1 = 3.2883517$

$M_1S_1 = 1942''.46$

The sum of the radii of the two bodies is $1937''.2$ but at this instant the distance between their centers is $1942''.46$ which is in excess by $5''.26$, therefore $2^h\ 37^m$ is not the exact time of first contact.

Let us now try $2^h\ 38^m$ for the time of first contact. By this time both M_1 and S_1 have slightly altered their positions, but the diagram is unchanged. Now from G to the point $2^h\ 38^m$ the total interval is

$9^m.79 + 38^m = 47^m.79$

$60^m : 47^m.79 :: 2075''.57 : M_1G$

$M_1G = \frac{47.79 + 2075.57}{60} = 1653''.17$

As before in the right angled triangle M_1H_1G we have

$H_1G = M_1G \times \sin M_1$

$\log M_1G = 3.2183173$

$\log \sin M_1 = 9.5698051$

$\log H_1G = 2.7881224$

$H_1G = 613''.93$

$M_1J_1 = TG - H_1G = 3180''.35 -$

$613''.93 = 2566''.42$

$H_1M_1 = M_1G \times \cos M_1$

$\log M_1G = 3.2183173$

$\log \cos M_1 = 9.9677748$

$\log H_1M_1 = 3.1860921$

$T\ J_1 = H_1M_1 = 1534''.94$

As to the sun, $2^h\ 38^m$ equals

$39° \ 30'$. Then as

$T\ I_1 = T6 \times \sin 39° \ 30'$

$\log T6 = 3.4624813$

$\log \sin 39° \ 30' = 9.803511$

$\log T\ I_1 = 3.2659923$

$T\ I_1 = 1844''.98$

$90° - 39° \ 30' = 50° \ 30'$

$S_1I_1 = TS \times \sin 50° \ 30'$

$\log T\ S = 2.9341453$

$\log \sin 50° \ 30' = 9.887406$

$\log S_1I_1 = 2.8215513$

$S_1I_1 = 663''.06$

To obtain the distance between the centers, in the right angled triangle $S_1\ M_1\ K_1$ we have

$M_1J_1 = 2566''.42$

$S_1I_1 = 663\ .06$

$M_1K_1 = 1903''.36$

$T\ I_1 = 1844''.98$

$T_1J_1 = 1534\ .94$

$S_1K_1 = 310''.04$

$\tan S_1M_1K_1 = \frac{S_1K_1}{M_1K_1}$

$\log S_1K_1 = 2.9113626$

$\log M_1K_1 = 3.2795207$

$\log \tan S_1M_1K_1 = 9.2118419$

$S_1M_1K_1 = 9° \ 15' \ 2''$

$S_1K_1 = M_1S_1 \times \sin S_1M_1K_1$

$M_1S_1 = \frac{S_1K_1}{\sin S_1M_1K_1}$

$\log S_1K_1 = 2.4913626$

$\log \sin S_1M_1K_1 = 9.206156$

$\log M_1S_1 = 2.2852066$

$M_1S_1 = 1928''.46$

This sum is less than the sum of the radii by $8''.74$ showing that the eclipse has already begun. It also shows that the exact time of contact must lie between $2^h\ 37^m$ and $2^h\ 38^m$, and as $5''.26$ is less than $8''.74$ it must lie nearer the former time.

Let us then suppose that $2^h\ 37^m\ 20^s$ is the exact time and make another trial. In the moon's moving from G to the point $2^h\ 37^m\ 20^s$, the time required is

$9^m.79 + 37^m.3333 = 47^m.1233$

$60^m : 47^m.1233 :: 2075''.57 : M_1G$

$M_1G = \frac{47.1233 \times 2075.57}{60} = 1630''.13$

Using the right angled triangle M_1G_1H to obtain the moon's coordinates, we have

$H_1G = M_1G \times \sin M_1$

$\log M_1G = 3.212223$

$\log \sin M_1 = 9.5698051$

$\log H_1G = 2.7820281$

$H_1G = 605''.38$

$M_1J_1 = TG - H_1G = 3180''.35 - 605''.38$

$= 2574''.97$

$$M_1H_1 = M_1G \times \cos M_1$$

$$\log M_1G = 3\cdot212223$$

$$\log \cos M_1 = \underline{9\cdot9677748}$$
$$\log M_1H_1 = 3\cdot1799978$$

$$TJ_1 = M_1H_1 = 1513^{s}\cdot59$$

Reducing $2^h\ 37^m\ 20^s$ to arc, $39^\circ\ 20'$ and computing the sun's coordinates, we have

$$TI_1 = T6 \times \sin 39^\circ 20'$$

$$\log T6 = 3\cdot4624813$$

$$\log \sin 39^\circ 20' = \underline{9\cdot801973}$$
$$\log TI_1 = 3\cdot2644543$$

$$TI_1 = 1838^{s}\cdot46$$

$$90^\circ - 39^\circ 20' = 50^\circ 40'$$

$$S_1I_1 = TS \times \sin 50^\circ\ 40'$$

$$\log TS = 2\cdot9341453$$

$$\log \sin 50^\circ\ 40' = \underline{9\cdot888444}$$
$$\log S_1I_1 = 2\cdot8225893$$

$$S_1I_1 = 664^{s}\cdot64$$

To find the distance between the centers of the bodies, we have

$$M_1J_1 = 2574^{s}\cdot97$$

$$S_1I_1 = \underline{664\cdot64}$$
$$M_1K_1 = 1910^{s}\cdot33$$

$$TI_1 = 1838^{s}\cdot46$$

$$M_1H_1 = \underline{1513\cdot59}$$
$$S_1K_1 = 324^{s}\cdot87$$

$$\tan S_1M_1K_1 = \frac{S_1K_1}{M_1K_1}$$

$$\log S_1K_1 = 2\cdot511844$$

$$\log M_1K_1 = \underline{3\cdot2811128}$$
$$\log \tan S_1M_1K_1 = 9\cdot2307312$$

$$S_1M_1K_1 = 9^\circ\ 39'\ 15''$$

$$S_1K_1 = M_1S_1 \times \sin S_1M_1K_1$$

$$M_1S_1 = \frac{S_1K_1}{\sin S_1M_1K_1}$$

$$\log S_1K_1 = 2\cdot511844$$

$$\log \sin S_1M_1K_1 = \underline{9\cdot224536}$$
$$\log M_1S_1 = 2\cdot287308$$

$$M_1S_1 = 1937^{s}\cdot8$$

Which exceeds the sum of the radii by $0^{s}\cdot6$, an amount too small to be considered, therefore $2^h\ 37^m\ 20^s$ may be regarded as the time of first contact.

B. To Calculate the Time of Last Contact.

Let us assume that $3^h\ 57^m$ is the exact time, and regard the centers of the sun and moon at S_2 and M_2 respectively. At right angles to T G draw $M_2\ H_2$ and the moon's coordinates $M_2\ T_2$ and $T\ J_2$ also those of the sun, $S_2\ I_2$ and $T\ I_2$ The time required for the moon to pass from G to M_2 will be

$$9^m\cdot79 + 117^m = 126^m\cdot79$$

$$60^m : 126^m\cdot79 :: 2075^{s}\cdot57 : M_2G$$

$$M_2G = \frac{126\cdot79 \times 2075\cdot57}{60} = 4386^{s}\cdot03$$

To obtain the value of the moon's coordinates in arc, in the right angled triangle M_2H_2G, let M_2 represent the angle H_2M_2G. Since M_2 equals $21^\circ\ 48'\ 0^{s}\cdot2$ we have

$$H_2G = M_2G \times \sin M_2$$

$$\log M_2G = 3\cdot6420715$$

$$\log \sin M_2 = \underline{9\cdot5698051}$$
$$\log H_2G = 3\cdot2118766$$

$$H_2G = 1628^{s}\cdot83$$

$$M_2J_2 = TG - H_2G = 3180^{s}\cdot35 - 1628^{s}\cdot83$$

$$= 1551^{s}\cdot52$$

$$M_2H_2 = M_2G \times \cos M_2$$

$$\log M_2G = 3\cdot6420715$$

$$\log \cos M_2 = \underline{9\cdot9677748}$$
$$\log M_2H_2 = 3\cdot6098463$$

$$T\ J_2 = M_2H_2 = 4072^{s}\cdot36$$

Next calculate the Sun's coordinates as follows, $3^h\ 57^m$ reduced to arc equals $59^\circ\ 15'$. Then we have

$$T\ I_2 = T6 \times \sin 59^\circ\ 15'$$

$$\log T6 = 3\cdot4624813$$

$$\log \sin 59^\circ\ 15' = \underline{9\cdot934199}$$
$$\log T\ I_2 = 3\cdot3966803$$

$$T\ I_2 = 2492^{s}\cdot76$$

$$90^\circ - 59^\circ\ 15' = 30^\circ\ 45'$$

$$S_2I_2 = TS \times \sin 30^\circ\ 45'$$

$$\log T\ S = 2\cdot9341453$$

$$\log \sin 30^\circ\ 45' = \underline{9\cdot708670}$$
$$\log S_2I_2 = 2\cdot6428153$$

$$S_2I_2 = 439^{s}\cdot35$$

We shall now find the distance at this instant between the centers of the sun and moon. In the right angled triangle $M_2S_2K_2$ we have

$$M_2J_2 = 1551^{s}\cdot52$$

$$S_2I_2 = \underline{439\cdot35}$$
$$M\ K_2 = 1112^{s}\cdot17$$

$$T\ J_2 = 4072^{s}\cdot36$$

$$T\ I_2 = \underline{2492\cdot76}$$
$$S_2K_2 = 1579^{s}\cdot6$$

$$\tan M_2S_2K_2 = \frac{M_2K_2}{S_2K_2}$$

$$\log M_2K_2 = 3\cdot0461693$$

$$\log S_2K_2 = \underline{3\cdot198548}$$
$$\log \tan M_2S_2K_2 = 9\cdot8476213$$

$$M_2S_2K_2 = 35^\circ\ 8'\ 54''\cdot7$$

$$M_2K_2 = M_2S_2 \times \sin M_2S_2K_2$$

$$M_2S_2 = \frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2 = 3\cdot0461693$$

$$\log \sin M_2S_2K_2 = \underline{9\cdot7601953}$$
$$\log M_2S_2 = 3\cdot2859740$$

$$M_2S_2 = 1931^{s}\cdot85$$

which is less than the sum of the radii by $5^{s}\cdot35$, which shows that $3^h\ 57^m$ is not the time of last contact. Let us then try $3^h\ 58^m$ as the correct time. By this time, both S_2 and M_2 have shifted forward, but the diagram being unchanged we continue to follow it. The time required for the moon to pass from G to the point $3^h\ 58^m$ is

$$9^m\cdot79 + 118^m = 127^m\cdot79$$

$$60^m : 127^m\cdot79 :: 2075^{s}\cdot57 : M_2G$$

$$M_2G = \frac{127\cdot79 \times 2075\cdot57}{60} = 4420^{s}\cdot62$$

By means of the right angled triangle M_2H_2G we find the value of the moon's coordinates as follows.

$$H_2G = M_2G \times \sin M_2$$

$$\log M_2G = 3\cdot 645483$$

$$\log \sin M_2 = \underline{9\cdot 5698051}$$
$$\log H_2G = 3\cdot 2152881$$

$$H_2G = 1641'' \cdot 68$$

$$M_2J_2 = TG - H_2G = 3180'' \cdot 35 - 1641'' \cdot 68$$
$$= 1538'' \cdot 67$$

$$M_2H_2 = M_2G \times \cos M_2$$

$$\log M_2G = 3\cdot 645483$$

$$\log \cos M_2 = \underline{9\cdot 9677748}$$
$$\log M_2H_2 = 3\cdot 6132578$$

$$TJ_2 = M_2H_2 = 4104'' \cdot 48$$

To find the sun's coordinates, we first reduce 3^h 58^m to arc 59° $30'$, then we have

$$T I_2 = T6 \times \sin 59^\circ 30'$$

$$\log T6 = 3\cdot 4624813$$

$$\log \sin 59^\circ 30' = \underline{9\cdot 935320}$$
$$\log T I_2 = 3\cdot 3978013$$

$$T I_2 = 2499'' \cdot 2$$

$$90^\circ - 59^\circ 30' = 30^\circ 30'$$

$$S_2I_2 = TS \times \sin 30^\circ 30'$$

$$\log T S = 2\cdot 9341453$$

$$\log \sin 30^\circ 30' = \underline{9\cdot 705469}$$
$$\log S_2I_2 = 2\cdot 6396143$$

$$S_2I_2 = 436'' \cdot 13$$

Using the right angled triangle $S_2M_2K_2$ to find the distance in arc between the centers of the two bodies, we have

$$M_2J_2 = 1538'' \cdot 67$$

$$S_2I_2 = \underline{436'' \cdot 13}$$
$$M_2K_2 = 1102'' \cdot 54$$

$$T J_2 = 4104'' \cdot 48$$

$$T I_2 = \underline{2499 \cdot 20}$$
$$S_2K_2 = 1605'' \cdot 28$$

$$\tan M_2S_2K_2 = \frac{M_2K_2}{S_2K_2}$$

$$\log M_2K_2 = 3\cdot 0423923$$

$$\log S_2K_2 = \underline{3\cdot 2055514}$$
$$\log \tan M_2S_2K_2 = 9\cdot 8368409$$

$$M_2S_2K_2 = 34^\circ\ 28'\ 54'' \cdot 8$$

$$M_2K_2 = M_2S_2 \times \sin M_2S_2K_2$$

$$M_2S_2 = \frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2 = 3\cdot 0423923$$

$$\log \sin M_2S_2K_2 = \underline{9\cdot 7529285}$$
$$\log M_2S_2 = 3\cdot 2894638$$

$$M_2S_2 = 1947'' \cdot 4$$

Which is greater than the sum of the radii by $10'' \cdot 2$, therefore 3^h 58^m is not the time of last contact. Comparing results, we see though that the true time of last contact must lie between 3^h 57^m and 3^h 58^m but nearer the former than the latter.

Let us then suppose that 3^h 57^m 20^s is the correct time, and make a new calculation. The time required for the moon to pass from G to the point 3^h 57^m 20^s is in all

$$9^m \cdot 79 + 117^m \cdot 3333 = 127^m \cdot 1233$$

$$60^m : 127^m \cdot 1233 :: 2075'' \cdot 57 : M_2G$$

$$M_2G = \frac{127\cdot 1233 \times 2075\cdot 57}{60} = 4397'' \cdot 56$$

Calculating the moon's coordinates by means of the right angled triangle M_2H_2G we have

$$H_2G = M_2G \times \sin M_2$$

$$\log M_2G = 3\cdot 6432119$$

$$\log \sin M_2 = \underline{9\cdot 5698051}$$
$$\log H_2G = 3\cdot 2130170$$

$$H_2G = 1633'' \cdot 11$$

$$M_2J_2 = TG - H_2G = 3180'' \cdot 35 - 1633'' \cdot 11$$
$$= 1547'' \cdot 24$$

$$M_2H_2 = M_2G \times \cos M_2$$

$$\log M_2G = 3\cdot 6432119$$

$$\log \cos M_2 = \underline{9\cdot 9677748}$$
$$\log M_2H_2 = 3\cdot 6109867$$

$$T J_2 = M_2H_2 = 4083'' \cdot 07.$$

Reducing 3^h 57^m 20^s to arc 59° $20'$ and calculating the sun's coordinates we have

$$T I_2 = T6 \times \sin 59^\circ 20'$$

$$\log T6 = 3\cdot 4624813$$

$$\log \sin 59^\circ 20' = \underline{9\cdot 934574}$$
$$\log T I_2 = 3\cdot 3970553$$

$$T I_2 = 2494'' \cdot 91$$

$$90^\circ - 59^\circ 20' = 30^\circ 40'$$

$$S_2I_2 = T S \times \sin 30^\circ 40'$$

$$\log T S = 2\cdot 9341453$$

$$\log \sin 30^\circ 40' = \underline{9\cdot 707606}$$
$$\log S_2I_2 = 9\cdot 6417513$$

$$S_2I_2 = 438'' \cdot 28$$

By means of the right angled triangle $S_2M_2K_2$ we next find the distance between the centers as below.

$$M_2J_2 = 1547'' \cdot 24$$

$$S_2I_2 = \underline{438'' \cdot 28}$$
$$M_2K_2 = 1108 \cdot 96$$

$$T J_2 = 4083'' \cdot 07$$

$$T I_2 = \underline{2494 \cdot 91}$$
$$S_2K_2 = 1588 \cdot 16$$

$$\tan M_2S_2K_2 = \frac{M_2K_2}{S_2K_2}$$

$$\log M_2K_2 = 3\cdot 0449156$$

$$\log S_2K_2 = \underline{3\cdot 2008934}$$
$$\log \tan M_2S_2K_2 = 9\cdot 8440222$$

$$M_2S_2K_2 = 34^\circ\ 55'\ 31'' \cdot 3$$

$$M_2K_2 = M_2S_2 \times \sin M_2S_2K_2$$

$$M_2S_2 = \frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2 = 3\cdot 0449156$$

$$\log \sin M_2S_2K_2 = \underline{9\cdot 7577780}$$
$$\log M_2S_2 = 3\cdot 2871376$$

$$M_2S_2 = 1937'' \cdot 03$$

which is only $0''.17$ less than the the sum of the radii, so that 3^h 37^m 20^s may be regarded as the time at which the eclipse ends.

C. To Find the Time of the Middle of the Eclipse.

Let us take 3^h 16^m as the time sought and regard S_3 and M_3 as the respective positions of the two centers at this time, At right angles to T G draw M_3 H_3 and the sun's and moon's coordinates S_3 I_3, T I_3 and M_3 J_3, T J_3 The time which the moon requires to pass from G to M_3 is

$$9^m \cdot 79 + 76^m = 85^m \cdot 79$$

$$60^m : 85^m \cdot 79 :: 2075'' \cdot 57 : M_3G$$

$$M_2G = \frac{85\cdot 79 \times 2075\cdot 57}{60} = 2967'' \cdot 72$$

To obtain the value in arc of the moon's coor-

dinates, let M_3 represent the angle H_3M_3G in the right angled triangle M_3H_3G then we have

$$H_3G = M_3G \times \sin M_3$$

$$\log M_3G = 3\cdot4724239$$

$$\log \sin M_3 = \underline{9\cdot5698051}$$
$$\log H_3G = 3\cdot0422290$$

$$H_3G = 1102'' \cdot 12$$

$$M_3J_3 = TG - H_3G = 3180'' \cdot 35 - 1102'' \cdot 12$$
$$= 2078'' \cdot 23$$

$$M_3H_3 = M_3G \times \cos M_3$$

$$\log M_3G = 3\cdot4724239$$

$$\log \cos M_3 = \underline{9\cdot9677748}$$
$$\log M_3H_3 = 3\cdot4401987$$

$$T J_3 = M_3H_3 = 2755'' \cdot 48$$

To find the value in arc of the Sun's coordinates, we reduce $3^h\ 16^m$ to arc 49° then

$$T I_3 = T6 \times \sin 49^\circ$$

$$\log T6 = 3\cdot4624813$$

$$\log \sin 49^\circ = \underline{9\cdot877780}$$
$$\log T I_3 = 3\cdot3402613$$

$$T I_3 = 2189'' \cdot 08$$

$$90^\circ - 49^\circ = 41^\circ$$

$$S_3I_3 = T S \times \sin 41^\circ$$

$$\log T S = 2\cdot9341453$$

$$\log \sin 41^\circ = \underline{9\cdot816941}$$
$$\log S_3I_3 = 2\cdot7510863$$

$$S_3I_3 = 563'' \cdot 75$$

Now using the right angled triangle $M_3S_3K_3$ we may calculate the distance in arc between the centers of the two bodies

$$T J_3 = 2755'' \cdot 48$$

$$T I_3 = \underline{2189\ \cdot 08}$$
$$M_3K_3 = \ 566'' \cdot 40$$

$$M_3J_3 = 2078'' \cdot 23$$

$$S_3I_3 = \underline{563\ \cdot 75}$$
$$S_3K_3 = 1514'' \cdot 48$$

$$\tan M_3S_3K_3 = \frac{M_3K_3}{S_3K_3}$$

$$\log M_3K_3 = 2\cdot753123$$

$$\log S_3K_3 = \underline{3\cdot180262}$$
$$\log \tan M_3S_3K_3 = 9\cdot572861$$

$$M_3S_3K_3 = 20^\circ\ 30'\ 19'' \cdot 16$$

$$M_3K_3 = M_3S_3 \times \sin M_3S_3K_3$$

$$M_3S_3 = \frac{M_3S_3}{\sin M_3S_3K_3}$$

$$\log M_3K_3 = 2\cdot753123$$

$$\log \sin M_3S_3K_3 = \underline{9\cdot5444339}$$
$$\log M_3S_3 = 3\cdot2086891$$

$$M_3S_3 = 1616'' \cdot 92$$

which is the distance sought at $3^h\ 16^m$ p. m.

Now let us assume $3^h\ 17^m$ as the exact time and calculate the distance between centers at this instant. The time required for the moon to pass from G to the point $3^h\ 17^m$ is

$$9^m \cdot 79 + 77^m = 86^m \cdot 79$$

$$60^m : 86^m \cdot 79 :: 2075'' \cdot 57 : M_3G$$

$$M_3G = \frac{86\cdot79 \times 2075\cdot57}{60} = 3002'' \cdot 31$$

Using the right angled triangle M_3H_3G to calculate the moon's coordinates we have

$$H_3G = M_3G \times \sin M_3$$

$$\log M_3G = 3\cdot477456$$

$$\log \sin M_3 = \underline{9\cdot5698051}$$
$$\log H_3G = 3\cdot0472611$$

$$H_3G = 1114'' \cdot 97$$

$$M_3J_3 = TG - H_3G = 3180'' \cdot 35 - 1114'' \cdot 97$$
$$= 2065'' \cdot 38$$

$$M_3H_3 = M_3G \times \cos M_3$$

$$\log M_3G = 3\cdot477456$$

$$\log \cos M_3 = \underline{9\cdot9677748}$$
$$\log M_3H_3 = 3\cdot4452308$$

$$M_3H_3 = 2787'' \cdot 6$$

Reducing $3^h\ 17^m$ to arc $49^\circ\ 15'$ and calculating those of the sun, we have

$$T I_3 = T6 \times \sin 49^\circ\ 15'$$

$$\log T6 = 3\cdot4624813$$

$$\log \sin 49^\circ\ 15' = \underline{9\cdot879420}$$
$$\log T I_3 = 3\cdot3419013$$

$$T I_3 = 2197'' \cdot 36$$

$$90^\circ - 49^\circ\ 15' = 40^\circ\ 45'$$

$$S_3I_3 = TS \times \sin 40^\circ\ 45'$$

$$\log TS = 2\cdot9341453$$

$$\log \sin 40^\circ\ 45' = \underline{9\cdot8147530}$$
$$\log S_3I_3 = 2\cdot7488983$$

$$S_3I_3 = 560'' \cdot 92$$

Using the right angled triangle $M_3S_3K_3$ to again obtain the distance between the centers, we have

$$T J_3 = 2787'' \cdot 6$$

$$T I_3 = \underline{2197\cdot36}$$
$$M_3K_3 = \ 590\cdot24$$

$$M_3J_3 = 2065'' \cdot 38$$

$$S_3I_3 = \ 560\ \cdot 92$$
$$S_3K_3 = 1504'' \cdot 46$$

$$\tan M_3S_3K_3 = \frac{M_3K_3}{S_3K_3}$$

$$\log M_3K_3 = 2\cdot771029$$

$$\log S_3K_3 = \underline{3\cdot1773794}$$
$$\log \tan M_3S_3K_3 = 9\cdot5936496$$

$$M_3S_3K_3 = 21^\circ\ 25'\ 17'' \cdot 4$$

$$M_3K_3 = M_3S_3 \times \sin M_3S_3K_3$$

$$M_3S_3 = \frac{M_3K_3}{\sin M_3S_3K_3}$$

$$\log M_3K_3 = 2\cdot771029$$

$$\log \sin M_3S_3K_3 = \underline{9\cdot562561}$$
$$\log M_3S_3 = 3\cdot210468$$

$$M_3S_3 = 1616'' \cdot 1$$

which is the distance between the centers at $3^h\ 17^m$.

Now let us assume $3^h\ 18^m$ as time for the midde of the eclipse, and again obtain the distance between the centers. The time required for the moon to pass from G to the point $3^h\ 18^m$ is

$$9^m \cdot 79 + 78^m = 87^m \cdot 79$$

$$60^m : 87^m \cdot 79 :: 2075'' \cdot 57 : M_3G$$

$$M_3G = \frac{87\cdot79 \times 2075\cdot57}{60} = 3036'' \cdot 91$$

Using the right angled triangle M_3H_3G to find the moon's coordinates, we have

$$H_3G = M_3G \times \sin M_3$$

$$\log M_3G = 3\cdot482431$$

$$\log \sin M_3 = \underline{9\cdot5689051}$$
$$\log H_3G = 3\cdot0522361$$

$$H_3G = 1127'' \cdot 81$$

$$M_3J_3 = TG - H_3G = 3180^{=}\cdot35 - 1127^{=}\cdot81$$
$$= 2052^{=}\cdot54$$

$$M_3H_3 = M_3G \times \cos\ M_3$$
$$\log\ M_3G = 3\cdot482431$$
$$\log\cos\ M_3 = \underline{9\cdot9677748}$$
$$\log\ M_3H_3 = 3\cdot4502058$$
$$T\ J_3 = M_3H_3 = 2819^{=}\cdot72$$

Reducing $3^h\ 18^m$ to arc $49^\circ\ 30'$ and, finding the value of the sun's coordinates, we have

$$T\ I_3 = T6 \times \sin\ 49^\circ\ 30'$$
$$\log\ T6 = 3\cdot4624813$$
$$\log\sin\ 49^\circ\ 30' = \underline{9\cdot881046}$$
$$\log\ T\ I_3 = 3\cdot3435273$$
$$T\ I_3 = 2205^{=}\cdot6$$

$$90^\circ - 49^\circ\ 30' = 40^\circ\ 30'$$
$$S_3I_3 = TS \times \sin\ 40^\circ\ 30'$$
$$\log\ TS = 3\cdot9341453$$
$$\log\sin\ 40^\circ\ 30' = \underline{9\cdot812544}$$
$$\log\ S_3I_3 = 2\cdot7466893$$
$$S_3I_3 = 558^{=}\cdot07$$

From these coordinates we again compute the distance between the centers, In the right angled triangle $M_3S_3K_3$, we have

$$T\ J_3 = 2819^{=}\cdot72$$
$$T\ I_3 = \underline{2205\ \cdot6}$$
$$M_3K_3 = 614^{=}\cdot12$$

$$M_3J_3 = 2052^{=}\cdot54$$
$$S_3I_3 = \underline{558\ \cdot07}$$
$$S_3K_3 = 1494^{=}\cdot47$$

$$\tan\ M_3S_3K_3 = \frac{M_3K_3}{S_3K_3}$$
$$\log\ M_3K_3 = 2\cdot788239$$
$$\log\ S_3K_3 = \underline{3\cdot1744878}$$
$$\log\tan\ M_3S_3K_3 = 9\cdot6137512$$
$$M_3S_3K_3 = 22^\circ\ 20'\ 18^{=}\cdot4$$

$$M_3K_3 = M_3S_3 \times \sin\ M_3S_3K_3$$
$$M_3S_3 = \frac{M_3K_3}{\sin\ M_3S_3K_3}$$
$$\log\ M_3K_3 = 2\cdot788239$$
$$\log\sin\ M_3S_3K_3 = \underline{9\cdot579871}$$
$$\log\ M_3S_3 = 3\cdot208368$$
$$M_3S_3 = 1615^{=}\cdot72 \text{ which}$$

is the distance between the centers at $3^h\ 18^m$.

Finally we shall assume $3^h\ 19^m$ as the time of the middle of the eclipse and again calculate the distance between the centers. In passing from G to $3^h\ 19^m$ the moon requires

$$9^m\cdot79 + 79^m = 88^m\cdot79$$
$$60^m : 88^m\cdot79 :: 2075^{=}\cdot57 : M_3G$$
$$M_3G = \frac{88\cdot79 \times 2075\cdot57}{60} = 3071^{=}\cdot50$$

Using the right angled triangle M_3H_3G to obtain the moon's coordinates in arc we have

$$H_3G = M_3G \times \sin\ M_3$$
$$\log\ M_3G = 3\cdot487351$$
$$\log\sin\ M_3 = \underline{9\cdot5698051}$$
$$\log\ H_3G = 3\cdot0571561$$
$$H_3G = 1140^{=}\cdot66$$

$$M_3J_3 = TG - H_3G = 3180^{=}\cdot35 - 1140^{=}\cdot66$$
$$= 2039^{=}\cdot69$$

$$M_3H_3 = M_3G \times \cos\ M_3$$
$$\log\ M_3G = 3\cdot487351$$
$$\log\cos\ M_3 = \underline{9\cdot9677748}$$
$$\log\ M_3H_3 = 3\cdot4551258$$
$$T\ J_3 = M_3H_3 = 2851^{=}\cdot84$$

Reducing $3^h\ 19^m$ to arc it equals $49^\circ\ 45'$. Then to obtain the sun's coordinates

$$T\ I_3 = T6 \times \sin\ 49^\circ\ 45'$$
$$\log\ T6 = 3\cdot4624813$$
$$\log\sin\ 49^\circ\ 45' = \underline{9\cdot882657}$$
$$\log\ T\ I_3 = 3\cdot3451383$$
$$T\ I_3 = 2213^{=}\cdot80$$

$$90^\circ - 49^\circ\ 45' = 40^\circ\ 15'$$
$$S_3I_3 = TS \times \sin\ 40^\circ\ 15'$$
$$\log\ T\ S = 2\cdot9341453$$
$$\log\sin\ 40^\circ\ 15' = \underline{9\cdot810316}$$
$$\log\ S_3I_3 = 2\cdot7444613$$
$$S_3I_3 = 555^{=}\cdot22$$

Having the above values, we may use them in the right angled triangle $M_3S_3K_3$ to obtain the distance between the centers as follows:

$$T\ J_3 = 2851^{=}\cdot84$$
$$T.\ I_3 = \underline{2213\ \cdot80}$$
$$M_3K_3 = 638\ \cdot04$$

$$M_3J_3 = 2039^{=}\cdot69$$
$$S_3I_3 = \underline{555\ \cdot22}$$
$$S_3K_3 = 1484\ \cdot47$$

$$\tan\ M_3S_3K_3 = \frac{M_3K_3}{S_3K_3}$$
$$\log\ M_3K_3 = 2\cdot804848$$
$$\log\ S_3K_3 = \underline{3\cdot171572}$$
$$\log\tan\ M_3S_3K_3 = 9\cdot633276$$
$$M_3S_3K_3 = 23^\circ\ 15'\ 30^{=}\cdot5$$
$$M_3K_3 = M_3S_3 \times \sin\ M_3S_3K_3$$
$$M_3S_3 = \frac{M_3K_3}{\sin\ M_3S_3K_3}$$
$$\log\ M_3K_3 = 2\cdot804848$$
$$\log\sin\ M_3S_3K_3 = \underline{9\cdot596464}$$
$$\log\ M_3S_3 = 3\cdot208384$$
$$M_3S_3 = 1615^{=}\cdot80 \text{ which}$$

is the distance between the centers at $3^h\ 19^m$. We have now found the distances between centers at the times given to be

$3^h\ 16^m$	$1616^{=}\cdot92$
3 17	1616 ·10
3 18	1615 ·72
3 19	1615 ·80

Comparing results we see that the least distance is at $3^h\ 18^m$, so this time may be taken as that of the Middle of the Eclipse.

Magnitude of the Eclipse.

The magnitude of the eclipse is found by subtracting the least distance between the centers from the sum of the radii of the two bodies, and dividing the remainder by the sun's diameter. In this case the magnitude equals

$$\frac{1937\cdot2 - 1615\cdot72}{1900\cdot6} = 0\cdot1691$$

or approximately 0·17

To Find the Position of the Eclipse.

The position of the eclipse on the sun's limb is

reckoned from the north point of the sun's disc. From the diagram we can see that

$$I_1S_1M_1 = 180° - 9° 39' 15''$$

$$= 170° 20' 45''$$

that is, the point of first contact is on the west limb of the sun, 170° 20′ 45″ from the north point of its disc. From the diagram we can see that

$$I_2S_2M_2 = 90° + 34° 55' 31''.3$$

$$= 124° 55' 31''.3$$

that is, the point of last contact is on the east limb of the sun, 124° 55′ 31″.3 from the north point of its disc.

To obtain its position reckoned from the highest altitude of the sun's limb, we must find the angle made by the sun's hour circle and the vertical circle and subtract the same from the angle made by the sun's R.A. and semi-diameter (see Fig. 2) The sun's hour angle at the time of first contact is $2^h\ 37^m\ 20^s$ or 39° 20′ Then we have

$$ZP = 90° - 36° 45' 24'' = 53° 14' 36''$$

$$ZPS = 39° 20'$$

$$PS = 90° - 17° 14' = 72° 46'$$

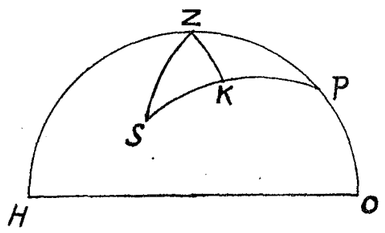


Fig. 2

From Z to PO draw the vertical arc ZK. Then in the right angled spherical triangle ZPK according to Napier's formula we have

$$\cos P = \tan PK \times \cot ZP$$

$$\tan PK = \cos P \times \tan ZP$$

$$\log \cos P = 9{\cdot}888444$$

$$\log \tan ZP = \underline{10{\cdot}126701}$$
$$\log \tan PK = 10{\cdot}015145$$

$$PK = 45° 59' 50''$$

$$SK = 72° 46' - 45° 59' 50'' = 26° 46' 4''$$

$$\sin PK = \tan ZK \times \cot P$$

$$\tan ZK = \sin PK \times \tan P$$

$$\log \sin PK = 9{\cdot}856914$$

$$\log \tan P = \underline{9{\cdot}913529}$$
$$\log \tan ZK = 9{\cdot}770443$$

$$ZK = 30° 31' 1''$$

$$\sin SK = \tan ZK \times \cot S$$

$$\cot S = \frac{\sin SK}{\tan ZK}$$

$$\log \sin SK = 9{\cdot}653575$$

$$\log \tan ZK = \underline{9{\cdot}770443}$$
$$\log \cot S = 9{\cdot}883132$$

$$P = S = 52° 30' 4''$$

$$Q = 189° 39' 15''$$

$$P = \underline{52° 30' 4''}$$
$$V = Q - P = 137° 9' 11''$$

which is the angle of position reckoned from the highest point of the sun's disc. The eclipse then begins on the lower left hand side of the sun's disc. In a similar manner we find

$$Q = 124° 55' 31''$$

$$P = \underline{57° 24' 37''}$$
$$V = Q - P = 67° 30' 54''$$

which means that the eclipse ends on the upper left hand limb of the sun.

The appearance of the eclipse is represented in Fig. 3 below

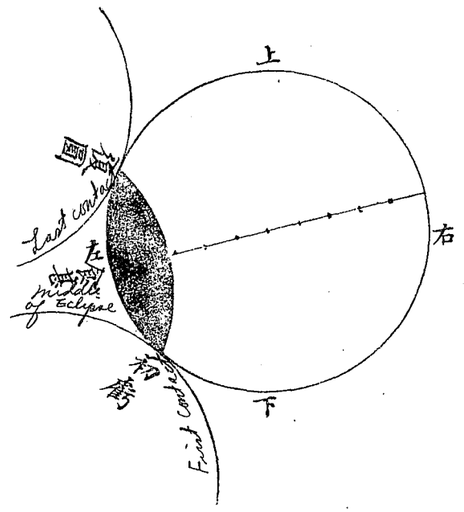


Fig. 3

As we view an eclipse of the sun, we do so from within the celestial sphere, while diagram 1 represents it as viewed from the exterior, so the directions east and west are reversed. To represent an eclipse of the sun as viewed from the earth (see Fig. 3) draw a circle whose radius may be taken as equal to that of the sun. From the highest point on the upper limb measure an arc of 137° 9′ toward the east and we have the point of first contact. Measuring from the same point an arc of 67° 31′ will give the point of last contact.

According to the same scale, using the moon's radius as radius draw an arc which cuts the first and last points of contact, as shown in the figure, then the portion of the sun's disc included in that arc will indicate to the eye the section which is eclipsed. Dividing the sun's diameter into equal sections, the magnitude of the eclipse is also apparent.

To sum up the circumstances of the eclipse of May 9th, 1929, as viewed from Tsinan, apparent time, we have

First Contact . . .	2^h	37^m	20^s	p. m.
Middle of Eclipse .	3	18	0	p. m.
Last Contact . . .	3	57	20	p. m.

Applying the equation of time, the above numbers become

First Contact . . .	2^h	33^m	40^s	p. m.
Middle of Eclipse .	3	14	20	p. m.
Last Contact . . .	3	53	40	p. m.
Magnitude of Eclipse	0.1691,			
Point of First Contact	137° 9′ Angle from vertex			
Point of Last Contact	67° 31′ Angle from vertex			

繪圖月掩星算法

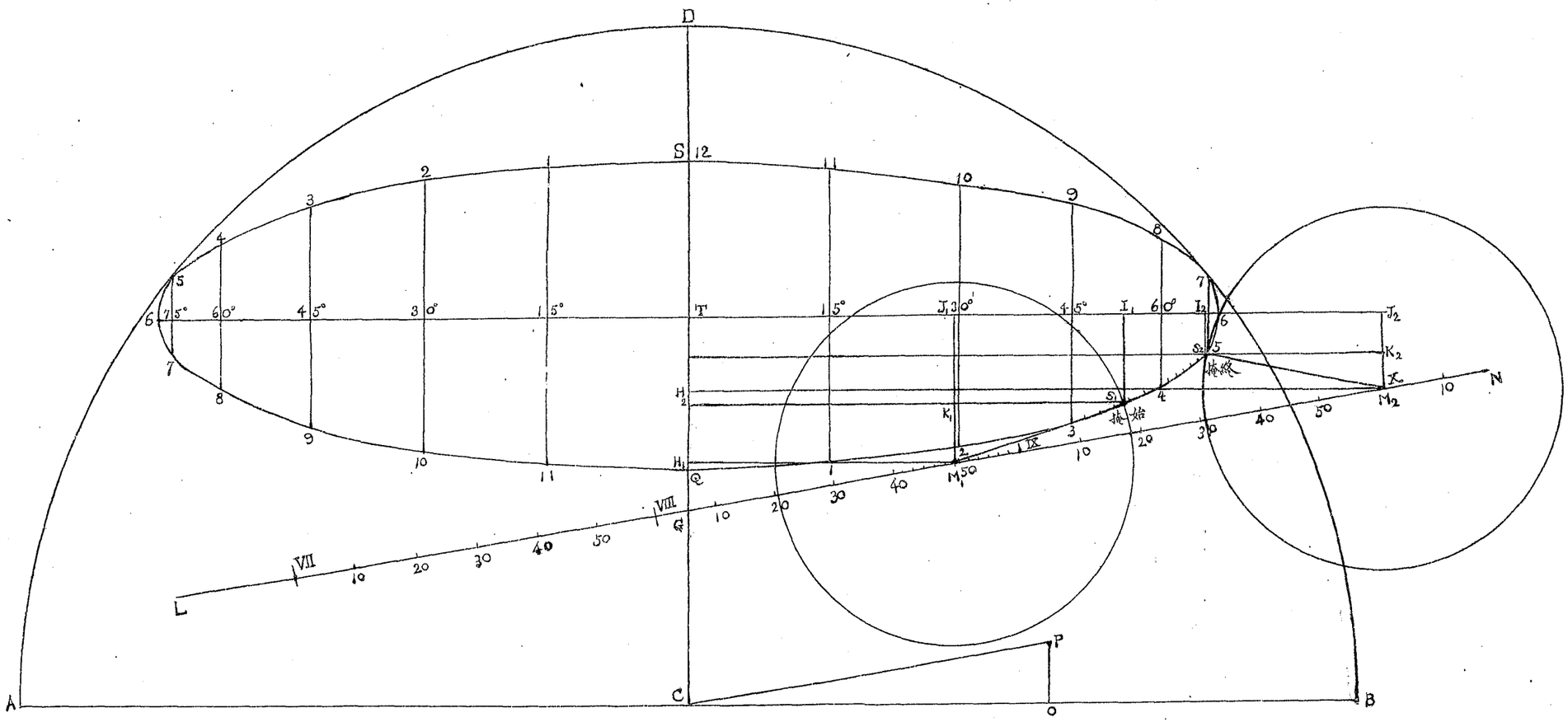
濟南齊魯大學

王錫恩著

緒　言

月掩星與月掩太陽、事實相同、故推算月掩星、與日食同法、其理說亦根據於日食、惟太陽過午線、爲視時十二小時、而星過午線之時、則爲春分點過午線之時、與星之赤經度相加、因而諸星過午線之視時、各有不同、午線後一、二、三、四諸小時、與星過午線之時分相加、始得當時之時分、午線前則相減、此當牢記者也、一九二四年三月十二日、月掩金牛甲星、余曾以白賽爾(Bessel)法、推得掩始掩終之時分、今以此法推之、所得時分略同、然此法尤爲精密、本篇求掩終時分、其第三與第四兩次、相差二秒、亦足顯出、讀者觀之、自知此法之精密也、

中華民國十七年六月一日、王錫恩謹識、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第一圖

繪圖月掩星算法

推算月掩星、與算日食同法、惟日過午線時、爲視時 12 小時、而星過午線時、爲春分點過午線之時，與星之赤經度相加、故星過午線之視時、各有不同、所用繪圖之半經、若爲行星、則以星月二地平視差之較爲半徑、若爲恆星、因恆無地平視差、則以月地平視差爲半徑、試演一題、以明繪圖之法、及推算之程序、

1924 年 3 月 12 日、月掩金牛星 [a tauri (Alde)]、求濟南之時分與方位、

查 1924 年、英國航海通書、以遞較法、推得月掩金牛甲星之用數表、開列於下、

星月赤經度相合、在格林維基平時、3 月 12 日、下午 $0^h\ 27^m\ 6^s$

星月赤經度	$4^h\ 31^m\ 33^s\cdot 32$
月赤經每小時之速率	$121\cdot 79$
星赤緯度	$+\ 16^\circ\ 21'\ 27''$
月赤緯度	$+\ 16\ \ 36\ \ 53\cdot 36$
每小時之速率	$+\ \ \ 4\ \ 45\cdot 51$
月地平視差	$\ \ \ \ 54\ \ 12\cdot 86$
月視半徑	$\ \ \ \ 14'\ \ 46\cdot 30$

月地平視差 $54'\ 12''\cdot 86 = 3252''\cdot 86$ 係赤道地平視差、變爲濟南地平視差、爲 $3252''\cdot 86 \times 0\cdot 998800 = 3248''\cdot 96 = AC$ 以 C 爲心、以 AC 爲半徑、作 ADB 半圓周、爲自月視地北半球之式、如第一圖所示、又作 CD 垂線爲地軸、於 CD 線上、截取 $CQ = AC \times \sin(36^\circ 34' 17''\cdot 8 - 16^\circ 21' 27'') = 1122''\cdot 61$ Q 卽星過午線之點、又截 $CS = AC \times \sin(36^\circ 34' 17'\cdot 8 + 16^\circ 21' 27'') = 2592''\cdot 32$ S 卽星過子線之點、平分 QS 於 T、$TS = 734''\cdot 86$ 過 T 點作 6T6 線、正交 CD、截 $T6 = AC \times \cos 36^\circ 34'$

$17'' \cdot 8 = 2609'' \cdot 47$ 卽濟南緯度圈之半徑、又於 T6 線左右、截

$T15° = T6 \times \sin 15° = 675'' \cdot 33$

$T30° = T6 \times \sin 30° = 1304 \cdot 64$

$T45° = T6 \times \sin 45° = 1845 \cdot 04$

$T60° = T6 \times \sin 60° = 2259 \cdot 71$

$T75° = T6 \times \sin 75° = 2520 \cdot 37$

於 15°、30°、45°、60°、75°、各點作正交線、於正交線上下、截

$15° - 1 = TS \times \sin 75° = 709'' \cdot 82$

$30° - 2 = TS \times \sin 60° = 636 \cdot 40$

$45° - 3 = TS \times \sin 45° = 519 \cdot 62$

$60° - 4 = TS \times \sin 30° = 367 \cdot 43$

$75° - 5 = TS \times \sin 15° = 190 \cdot 19$

所得 1、2、3、4、5、6、7、8、9、10、11、12、各點、卽濟南各小時所到之點、將各點聯之、成一橢圓、卽自星視濟南緯度圈之式、因自星斜視、故成橢圓、此橢圓切 ADB 半圓周之點、卽星出入之點、又於 CB 線上、截 $CO = 121^s \cdot 79 \times 15 \times \text{Cos } 16°36'53'' \cdot 36 = 1750'' \cdot 57$ 於 O 點作垂線、截 $OP = 4'45'' \cdot 51 = 285'' \cdot 51$ 聯 CP 二點、CP 卽月每小時所行之路、又截 $CG = 16°36'53'' \cdot 36 - 16°21'27'' = 15'26'' \cdot 36 = 926'' \cdot 36$ G 卽星月赤經度相合時、月所在之點、過 G 點作 LN 線、與 CP 線平行、爲月視行之道、準 COP 直角三角形、則有

$$\tan OCP = \frac{OP}{CO}$$

$$\log OP = 2 \cdot 455621$$

$$\log CO = 3 \cdot 243181$$

$$\log \tan OCP = 9 \cdot 212440$$

$$OCP = 9°15'47'' \cdot 24$$

$$\sin OCP = \frac{OP}{CO}$$

$$CP = \frac{OP}{\sin OCP}$$

$$\log OP = 2 \cdot 455621$$

$$\log \sin OCP = 9 \cdot 206739$$

$$\log CP = 2 \cdot 248882$$

$$CP = 1773'' \cdot 71$$

CP 爲月每小時所行之路、月在 G 點爲格林維基平時下午 $0^h27^m6^s$、當日時差爲 $+9^m54^s \cdot 82$、自平時減時差得視時、故星月、赤經度相合之時、爲視時 $0^h17^m11^s \cdot 18$、以濟南東經 $7^h48^m33^s$ 改之、爲下午 $8^h5^m44^s \cdot 18$ $5^m44^s \cdot 18 = 5^m \cdot 7363$ $60^m : 5^m \cdot 7363 :: 1773'' \cdot 71 : 8-G$、$8-G = \frac{5 \cdot 7363 \times 1773 \cdot 71}{60} = 168'' \cdot 28$、於 GN 線上、截 $8-G = 168'' \cdot 28$ 得 8 小時月在 8 點、又以 CP 爲度、截 7、9、10、諸點、爲月諸小時所至之處、星過午線之時、等於春分點過午線之時、與星之赤經度相加、查航海通書、知 3 月 12 日、春分過格林維基午線、在下午 $0^h40^m28^s \cdot 28$、濟南東經 $7^h48^m33^s$、應加 $1^m16^s \cdot 76$、得春分點過濟南午線、在下午 $0^h41^m45^s \cdot 04$、金牛甲星視赤經度爲 $4^h31^m33^s \cdot 32$ 變平時、爲 $4^h30^m48^s \cdot 83$、與春分點過午線之時相加、得下午 $5^h12^m33^s \cdot 87$、爲星過午線之時、以 Q 代之、$Q = 5^h12^m33^s \cdot 87$、將月道每小時之距、平分六份、每份爲 10^m、緯度圈每小時之距、亦平分六份、每份亦爲 10^m、以圓規開口、等於星月二半徑之和、因恆星無半徑、卽等於月半徑、一尖循月道、一循緯度圈、在月道與緯圈、最近處之前、尋得時分相同之點、(緯度圈之時、在 Q 點之後、與 Q 點之時分相加、在 Q 點之前、與 Q 點之時分相減) 卽星月前相切之時、謂之掩始、在最近處之後、尋得時分相同之點、卽星月後相切之時、謂之掩終、茲據此法、求得此次月掩金牛甲星、各限時分、開列於下、

掩始 下午 $Q + 3^h37^m = 8^h49^m33^s \cdot 87$
掩終 下午 $Q + 4^h48^m = 10^h0^m33^s \cdot 87$
} 濟南視時、

以上所得掩始、掩終、各限時分、乃係略數、不能密合、欲得眞時、須另求之、

求掩始眞時

設 TG、T6 爲縱橫軸、求星月之縱橫坐標、借求星月兩心距、若某時之星月兩心距、適等於月半徑、則某時卽掩始眞時、否則另算、

取 $Q+3^h37^m=5^h12^m33^s\cdot87+3^h37^m=8^h49^m33^s\cdot87$、爲掩始時分、設此時月心在 M_1、星心在 S_1、自 G 點至 M_1、共有

$8^h49^m33^s\cdot87-8^h5^m44^s\cdot18=43^m49^s\cdot69=43^m\cdot8282$

$60^m:43^m\cdot8282::1773''\cdot71:M_1G$

$$M_1G=\frac{43\cdot8282\times1773\cdot71}{60}=1295''\cdot70$$

自 M_1 至 TG 線作垂線 M_1H_1、及月之縱橫坐標、M_1J_1、TJ_1、星之縱橫坐標、S_1I_1、TI_1、

求月之縱橫坐標、準 M_1H_1G 直角三角形、H_1M_1G 角、以 M_1 代之、$M_1=9°15'47''\cdot24$ 則有

$$H_1G=M_1G\times\sin M_1$$

$$\log M_1G=3\cdot1125045$$

$$\log\sin M_1=9\cdot206739$$
$$\log H_1G=2\cdot3192435$$

$$H_1G=208''\cdot57$$

$$C\ Q=1122''\cdot61$$

$$C\ G=926\cdot36$$
$$Q\ G=196\cdot25$$

$$T\ Q=734\cdot86$$
$$T\ G=931\cdot11$$

$$T\ G=931''\cdot11$$

$$H_1G=208\cdot57$$
$$M_1J_1=TH_1=722\cdot54$$

$$M_1H_1=M_1G\times\cos M_1$$

$$\log M_1G=3\cdot1125045$$

$$\log\cos M_1=9\cdot994300$$
$$\log M_1H_1=3\cdot1068045$$

$$TJ_1=M_1H_1=1278''\cdot8$$

求星之縱橫坐標、3^h37^m 變度爲 $54°15'$

$$TI_1=T6\times\sin54°15'$$

$$\log T6=3\cdot4165218$$

$$\log\sin54°15'=9\cdot909328$$
$$\log TI_1=3\cdot3258498$$

$$TI_1=2117''\cdot63$$

$$90°-54°15'=35°45'$$

$$S_1I_1=TS\times\sin35°45'$$

$$\log TS=2\cdot866202$$

$$\log\sin35°45'=9\cdot766598$$
$$\log S_1I_1=2\cdot632800$$

$$S_1I_1=429''\cdot34$$

求星月兩心距、準 $M_1S_1K_1$ 直角三角形、則有

$$M_1J_1=722''\cdot54$$

$$S_1I_1=429\cdot34$$
$$M_1K_1=293\cdot20$$

$$TI_1=2117''\cdot63$$

$$TJ_1=1278\cdot80$$
$$S_1K_1=838\cdot83$$

$$\tan M_1S_1K_1=\frac{M_1K_1}{S_1K_1}$$

$$\log M_1K_1=2\cdot467164$$

$$\log S_1K_1=2\cdot923674$$
$$\log\tan M_1S_1K_1=9\cdot543490$$

$$M_1S_1K_1=19°15'58''\cdot6$$

$$M_1K_1=M_1S_1\times\sin M_1S_1K_1$$

$$M_1S_1=\frac{M_1K_1}{\sin M_1S_1K_1}$$

$$\log M_1K_1=2\cdot467164$$

$$\log\sin M_1S_1K_1=9\cdot5184596$$
$$\log M_1S_1=2\cdot9487044$$

$$M_1S_1=888''\cdot6$$

月半徑爲 $886''\cdot3$、今所得星月兩心距、$888''\cdot6$、較月半徑、尙多 $2''\cdot3$、故知 $8^h49^m33^s\cdot87$、不爲掩始眞時、

次取 $Q+3^h38^m=5^h12^m33^s\cdot87+3^h38^m=8^h50^m33^s\cdot87$ 爲掩始時分、此時月心 M_1、星心 S_1、應向前稍移、因與前圖相類、仍以前圖諸線代表之、自 G 點至 M_1、共有

$8^h50^m33^s\cdot87-8^h5^m44^s\cdot18=44^m49^s\cdot69=44^m\cdot8282$

$60^m:44^m\cdot8282::1773''\cdot71:M_1G$

$$M_1G=\frac{44\cdot8282\times1773\cdot71}{60}=1325''\cdot14$$

求月之縱橫坐標、準 M_1H_1G 直角三角形、則有

$$H_1G=M_1G\times\sin M_1$$

$$\log M_1G=3\cdot122262$$

$$\log\sin M_1=9\cdot206739$$
$$\log H_1G=2\cdot329001$$

$$H_1G=213''\cdot31$$

$$TG=931''\cdot11$$

$$H_1G=213\cdot31$$
$$M_1J_1=TH_1=717\cdot80$$

$$M_1H_1=M_1G\times\cos M_1$$

$$\log M_1G=3\cdot122262$$

$$\log\cos M_1=9\cdot994300$$
$$\log M_1H_1=3\cdot116562$$

$$TJ_1=M_1H_1=1307''\cdot86$$

求星之縱橫坐標、3^h38^m 變度爲 $54°30'$

$$TI_1=T6\times\sin54°30'$$

$$\log T6=3\cdot4165218$$

$$\log\sin54°30'=9\cdot910686$$
$$\log TI_1=3\cdot3272078$$

$$TI_1=2124''\cdot26$$

$$90°-54°30'=35°30'$$

$$S_1I_1=TS\times\sin 35°30'$$

$$\log TS=2\cdot866202$$

$$\log\sin 35°30'=9\cdot763954$$
$$\log S_1I_1=2\cdot630156$$

$$S_1I_1=426''\cdot73$$

求星月兩心距、準 $M_1S_1K_1$ 直角三角形、則有

$$M_1J_1=717''\cdot80$$

$$S_1I_1=426\cdot73$$
$$M_1K_1=291\cdot07$$

$$TI_1=2124''\cdot26$$

$$TJ_1=1307\cdot86$$
$$S_1K_1=816\cdot40$$

$$\tan M_1S_1K_1=\frac{M_1K_1}{S_1K_1}$$

$$\log M_1K_1=2\cdot4639975$$

$$\log S_1K_1=2\cdot911903$$
$$\log\tan M_1S_1K_1=9\cdot5520945$$

$$M_1S_1K_1=10°37'21''\cdot4$$

$$M_1K_1=M_1S_1\times\sin M_1S_1K_1$$

$$M_1S_1=\frac{M_1K_1}{\sin M_1S_1K_1}$$

$$\log M_1K_1=2\cdot4639975$$

$$\log\sin M_1S_1K_1=9\cdot5261114$$
$$\log M_1S_1=2\cdot9378861$$

$$M_1S_1=866''\cdot73$$

月半徑爲 $886''\cdot3$、今所得星月兩心距、爲 $866''\cdot73$、較月半徑、又少 $19''\cdot57$、故知 $8^h50^m33^s\cdot87$、亦非掩始時分、

觀上二次所得星月兩心距、較月半徑 $8^h49^m33^s\cdot87$ 時、多 $2''\cdot3$、$8^h50^m33^s\cdot87$ 時、少 $19''\cdot57$、故知掩始分、距 $8^h49^m33^s\cdot87$ 時爲近、卽取 $Q+3^h37^m10^m=5^h12^m33^s\cdot87+3^h37^m10^s=8^h49^m43^s\cdot87$ 爲掩始時分、再試眞否、自 G 點至 M_1、共有

$$8^h49^m43^s\cdot87-8^h5^m44^s\cdot18=43^m59^s\cdot69$$
$$=43^m\cdot9948$$

$$60^m:43^m\cdot9948::1773''\cdot71:M_1G$$

$$M_1G=\frac{43\cdot9948\times1773\cdot71}{60}=1300''\cdot48$$

求月之縱標坐標、準 M_1H_1G 直角三角形、則有

$$H_1G=M_1G\times\sin M_1$$

$$\log M_1G=3\cdot1141014$$

$$\log\sin M_1=9\cdot206739$$
$$\log H_1G=2\cdot3208404$$

$$H_1G=209''\cdot33$$

$$TG=931''\cdot11$$

$$H_1G=209\cdot33$$
$$M_1J_1=TH_1=721\cdot78$$

$$M_1H_1=M_1G\times\cos M_1$$

$$\log M_1G=3\cdot1141014$$

$$\ln g\cos M_1=9\cdot994300$$
$$\log M_1H_1=3\cdot1084014$$

$$TJ_1=M_1H_1=1283''\cdot51$$

求星之縱橫坐標、$3^h37^m10^s$ 變度爲 $54°17'30''$

$$TI_1=T6\times\sin 54°17'30''$$

$$\log T6=3\cdot4165218$$

$$\log\sin 54°17'30''=9\cdot909555$$
$$\log TI_1=3\cdot3260768$$

$$TI_1=2118''\cdot73$$

$$90°-54°17'30''=35°42'30''$$

$$S_1I_1=TS\times\sin 35°42'30''$$

$$\log TS=2\cdot866202$$

$$\log\sin 35°42'30''=9\cdot766159$$
$$\log S_1I_1=2\cdot632361$$

$$S_1I_1=428''\cdot91$$

求星月兩心距、準 $M_1S_1K_1$ 直角三角形、則有

$$M_1J_1=721''\cdot78$$

$$S_1I_1=428\cdot91$$
$$M_1K_1=292\cdot87$$

$$TI_1=2118''\cdot73$$

$$TJ_1=1283\cdot51$$
$$S_1K_1=835\cdot22$$

$$\tan M_1S_1K_1=\frac{M_1K_1}{S_1K_1}$$

$$\log M_1K_1=2\cdot4666755$$

$$\log S_1K_1=2\cdot921800$$
$$\log\tan M_1S_1K_1=9\cdot5448755$$

$$M_1S_1K_1=19°19'23''\cdot8$$

$$M_1K_1=M_1S_1\times\sin M_1S_1K_1$$

$$M_1S_1=\frac{M_1K_1}{\sin M_1S_1K_1}$$

$$\log M_1K_1=2\cdot4666755$$

$$\log\sin M_1S_1K_1=9\cdot5196938$$
$$\log M_1S_1=2\cdot9469817$$

$$M_1S_1=885''\cdot08$$

月半徑爲 $886''\cdot3$、今所得星月兩心距、爲 $885''\cdot08$、較月半徑、仍少 $1''\cdot22$、故知 $8^h49^m43^s\cdot87$、亦非掩始眞時、

又取 $Q+3^h37^m5^s=5^h12^m33^s\cdot87+3^h37^m5^s=8^h49^m38^s\cdot87$、爲掩始時分、自 G 點至 M_1、共有

$$8^h49^m38^s\cdot87-8^h5^m44^s\cdot18=43^m54^s\cdot69=43^m\cdot9115$$

$$60^m:43^m\cdot9115::1773''\cdot71:M_1G$$

$$M_1G=\frac{43\cdot9115\times1773\cdot75}{60}=1298''\cdot11$$

求月之縱橫坐標、準 M_1H_1G 直角三角形、則有

$$H_1G = M_1G \times \sin M_1$$

$$\log M_1G = 3\cdot113275$$

$$\log \sin M_1 = 9\cdot206739$$
$$\log H_1G = 2\cdot320014$$

$$H_1G = 208'' \cdot 93$$

$$T\ G = 931'' \cdot 11$$

$$H_1G = 208\ \cdot 93$$
$$M_1J_1 = T\ H_1 = 722\ \cdot 18$$

$$M_1H_1 = M_1G \times \cos M_1$$

$$\log M_1G = 3\cdot113275$$

$$\log \sin M_1 = 9\cdot994300$$
$$\log M_1H_1 = 3\cdot107575$$

$$TJ_1 = M_1H_1 = 1281'' \cdot 08$$

求星之縱橫坐標、$3^h37^m5^s$ 變度爲 $54°16'15''$

$$TI_1 = T6 \times \sin\ 54°16'15''$$

$$\log\ T6 = 3\cdot4165218$$

$$\log \sin 54°16'15'' = 9\cdot909427$$
$$\log\ TI_1 = 3\cdot3259488$$

$$TI_1 = 2118'' \cdot 11$$

$$90° - 54°16'15'' = 35°43'45''$$

$$S_1I_1 = TS \times \sin 35°43'45''$$

$$\log\ TS = 2\cdot866202$$

$$\log \sin 35°43'45'' = 9\cdot766379$$
$$\log\ S_1I_1 = 2\cdot632581$$

$$S_1I_1 = 429'' \cdot 12$$

求星月兩心距、準 $M_1S_1K_1$ 直角三角形、則有

$$M_1J_1 = 722'' \cdot 18$$

$$S_1I_1 = 429\ \cdot 12$$
$$M_1K_1 = 293\ \cdot 06$$

$$TI_1 = 2118'' \cdot 11$$

$$TJ_1 = 1281\ \cdot 08$$
$$S_1K_1 = \ 837\ \cdot 03$$

$$\tan M_1S_1K_1 = \frac{M_1K_1}{S_1K_1}$$

$$\log\ M_1K_1 = 2\cdot466957$$

$$\log\ S_1K_1 = 2\cdot922741$$
$$\log \tan M_1S_1K_1 = 9\cdot544216$$

$$M_1S_1K_1 = 19°17'46'' \cdot 1$$

$$M_1K_1 = M_1S_1 \times \sin M_1S_1K_1$$

$$M_1S_1 = \frac{M_1K_1}{\sin M_1S_1K_1}$$

$$\log\ M_1K_1 = 2\cdot466957$$

$$\log \sin M_1S_1K_1 = 9\cdot5191066$$
$$\log\ M_1S_1 = 2\cdot9478504$$

$$M_1S_1 = 886'' \cdot 85$$

月半徑 $886'' \cdot 3$、今所得星月兩心距、爲 $886'' \cdot 85$、較月半徑、只多 $0'' \cdot 55$、相差甚微、故 $8^h49^m38^s \cdot 87$、爲掩始直時、

求掩終眞時

取 $\&+4^h48^m = 5^h12^m33^s \cdot 87 + 4^h48 = 10^h0^m33^s \cdot 87$ 爲掩終時分、此時月心在 M_2、星心在 S_2、自 M_2 至 TG 線、作垂線 M_2H_2、及月之縱橫坐標、M_2J_2、TJ_2、星之縱橫坐標、S_2I_2、TI_2、自 G 點至 M_2、共有

$$10^h0^m33^s \cdot 87 - 8^h5^m44^s \cdot 18 = 1^h54^m49^s \cdot 69 = 114^m \cdot 8282$$

$$60^m : 114^m \cdot 8282 :: 1773'' \cdot 71 : M_2G$$

$$M_2G = \frac{114 \cdot 8282 \times 1773 \cdot 71}{60} = 3394'' \cdot 47$$

求月之縱橫坐標、準 M_2H_2G 直角三角形、H_2M_2G 角、以 M_2 代之、$M_2 = 9°15'47'' \cdot 24$、則有

$$H_2G = M_2G \times \sin\ M_2$$

$$\log\ M_2G = 3\cdot530772$$

$$\log \sin\ M_2 = 9\cdot206739$$
$$\log\ H_2G = 2\cdot737511$$

$$H_2G = 546'' \cdot 4$$

$$TG = 931'' \cdot 11$$

$$H_2G = 546\ \cdot 4$$
$$M_2J_2 = TH_2 = 384\ \cdot 71$$

$$M_2H_2 = M_2G \times \cos\ M_2$$

$$\log\ M_2G = 3\cdot530772$$

$$\log \cos\ M_2 = 9\cdot994300$$
$$\log\ M_2H_2 = 3\cdot525072$$

$$TJ_2 = M_2H_2 = 3350'' \cdot 21$$

求星之縱橫坐標、4^h48^m 變度爲 $72°$

$$TI_2 = T6 \times \sin\ 72°$$

$$\log\ T6 = 3\cdot4165318$$

$$\log \sin\ 72° = 9\cdot978206$$
$$\log\ TI_2 = 3\cdot3947278$$

$$TI_2 = 2481'' \cdot 58$$

$$90° - 72 = 18°$$

$$S_2I_2 = TS \times \sin 18°$$

$$\log\ TS = 2\cdot866202$$

$$\log \sin\ 72° = 9\cdot489982$$
$$\log\ S_2I_2 = 2\cdot356184$$

$$S_2I_2 = 227'' \cdot 08$$

求星月兩心距、準 $M_2S_2K_2$ 直角三角形、則有

$$M_2J_2 = 384'' \cdot 71$$

$$S_2I_2 = 227\ \cdot 08$$
$$M_2K_2 = 157\ \cdot 63$$

$$TJ_2 = 3350'' \cdot 21$$

$$TI_2 = 2481\ \cdot 58$$
$$S_2K_2 = \ 868\ \cdot 63$$

$$\tan M_2S_2K_2 = \frac{M_2K_2}{S_2K_2}$$

$$\log\ M_2K_2 = 2\cdot197639$$

$$\log\ S_2K_2 = 2\cdot938835$$
$$\log \tan\ M_2S_2K_2 = 9\cdot258804$$

$$M_2S_2K_2 = 10°17'8''$$

$$M_2K_2 = M_2S_2 \times \sin M_2S_2K_2$$

$$M_2S_2 = \frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2 = 2\cdot197639$$

$$\log \sin M_2S_2K_2 = \underline{9\cdot251768}$$
$$\log M_2S_2 = 2\cdot945871$$

$$M_2S_2 = 882''\cdot82$$

月半徑爲 $886''\cdot3$、今所得星月兩心距、爲 $882''\cdot82$、較月半徑、尙少 $3''\cdot48$、故知 $10^h0^m33^s\cdot87$、不爲掩終時分、次取 $Q+4^h49^m = 5^h12^m33^s\cdot87+4^h49^m = 10^h1^m33^s\cdot87$、爲掩終時分、此時月心 M_2、星心 S_2、應向前稍移、因與前圖相類、仍以前圖諸線代表之、自 G 點至 M_2、共有

$$10^h1^m33^s\cdot87 - 8^h5^m44^s\cdot18 = 1^h55^m49^s\cdot69 = 115^m\cdot8282$$

$$60^m : 115^m\cdot8282 :: 1773''\cdot71 : M_2G$$

$$M_2G = \frac{115\cdot8282 \times 1773\cdot71}{60} = 3424''\cdot03$$

求月之縱橫坐標、準 M_2H_2G 直角三角形、則有

$$H_2G = M_2G \times \sin M_2$$

$$\log M_2G = 3\cdot5345378$$

$$\log \sin M_2 = \underline{9\cdot206739}$$
$$\log M_2G = 2\cdot7412768$$

$$M_2G = 551''\cdot18$$

$$TG = 931''\cdot11$$

$$H_2G = \underline{551\cdot18}$$
$$M_2J_2 = TH_2 = 379\cdot93$$

$$M_2H_2 = M_2G \times \cos M_2$$

$$\log M_2G = 3\cdot5345378$$

$$\log \cos M_2 = \underline{9\cdot994300}$$
$$\log M_2H_2 = 3\cdot5288378$$

$$TJ_2 = M_2H_2 = 3379''\cdot39$$

求星之縱橫坐標、4^h49^m 變度爲 $72°15'$

$$TI_2 = T6 \times \sin 72°15'$$

$$\log T6 = 3\cdot4165218$$

$$\log \sin 72°15' = \underline{9\cdot978817}$$
$$\log TI_2 = 3\cdot3953388$$

$$TI_2 = 2485''\cdot07$$

$$90° - 72°15' = 17°45'$$

$$S_2I_2 = TS \times \sin 17°45'$$

$$\log TS = 2\cdot866202$$

$$\log \sin 17°45' = \underline{9\cdot484107}$$
$$\log S_2I_2 = 2\cdot350309$$

$$S_2I_2 = 224''\cdot03$$

求星月兩心距、準 $M_2S_2K_2$ 直角三角形、則有

$$M_2J_2 = 379''\cdot39$$

$$S_2I_2 = \underline{224\cdot03}$$
$$M_2K_2 = 155\cdot90$$

$$TJ_2 = 3379''\cdot39$$

$$TI_2 = \underline{2485\cdot07}$$
$$S_2K_2 = 894\cdot32$$

$$\tan M_2S_2K_2 = \frac{M_2K_2}{S_2K_2}$$

$$\log M_2K_2 = 2\cdot192846$$

$$\log S_2K_2 = \underline{2\cdot951493}$$
$$\log \tan M_2S_2K_2 = 9\cdot241353$$

$$M_2S_2K_2 = 9°53'18''\cdot6$$

$$M_2K_2 = M_2S_2 \times \sin M_2S_2K_2$$

$$M_2K_2 = \frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2 = 2\cdot192846$$

$$\log \sin M_2S_2K_2 = \underline{9\cdot2347535}$$
$$\log M_2S_2 = 2\cdot9580925$$

$$M_2S_2 = 908''\cdot0$$

月半徑爲 $886''\cdot3$、今所得星月兩心距、爲 $908''\cdot0$、較月半徑又多 $21''\cdot7$、是 $10^h1^m33^s\cdot87$、亦非掩終眞時、

觀上二次所得星月兩心距、較月半徑、$10^h0^m33^s\cdot87$ 時少 $3''\cdot48$、$10^h1^m33^s\cdot87$ 時、多 $21''\cdot7$、故知掩終眞時、距 $10^h0^m33^s\cdot87$、時爲近、卽取 $Q+4^h48^m10^s = 5^h12^m33^s\cdot87+4^h48^m10 = {}^s10^h0^m43^s\cdot87$ 爲掩終時分、再試眞否、自 G 至 M_2、共有

$$10^h0^m43^s\cdot87 - 8^h5^m44^s\cdot18 = 1^h54^m59^s\cdot69 = 114^m\cdot9948$$

$$60^m : 114^m\cdot9948 :: 1773''\cdot71 : M_2G$$

$$M_2G = \frac{114\cdot9948 \times 1773\cdot71}{60} = 3399''\cdot49$$

求月之縱橫坐標、準 M_2H_2G 直角三角形、則有

$$M_2G = M_2G \times \sin M_2$$

$$\log \sin M_2G = 3\cdot5314135$$

$$\log \sin M_2 = \underline{9\cdot206739}$$
$$\log H_2G = 2\cdot7381525$$

$$H_2G = 547''\cdot21$$

$$TG = 931''\cdot11$$

$$H_2G = \underline{547\cdot21}$$
$$M_2J_2 = TH_2 = 383\cdot90$$

$$M_2H_2 = M_2G \times \cos M_2$$

$$\log M_2G = 3\cdot5314135$$

$$\log \cos M_2 = \underline{9\cdot994300}$$
$$\log M_2H_2 = 3\cdot5257135$$

$$TJ_2 = M_2H_2 = 3355''\cdot16$$

求星之縱橫坐標、$4^h48^m10^s$ 變度爲 $72°2'30''$

$$TI_2 = T6 \times \sin 72°2'30''$$

$$\log T6 = 3\cdot4165218$$

$$\log \sin 72°2'30'' = \underline{9\cdot978309}$$
$$\log TI_2 = 3\cdot3948308$$

$$TI_2 = 2482''\cdot18$$

$$90° - 72°2'30'' = 17°57'\cdot30''$$

$$S_2I_2 = TS \times \sin 17°57'30''$$

$$\log TS = 2\cdot866202$$

$$\log \sin 17°57'30'' = \underline{9\cdot489009}$$
$$\log S_2I_2 = 2\cdot355211$$

$$S_2I_2 = 226''\cdot57$$

求星月兩心距、準 $M_2S_2K_2$ 直角三角形、則有

$$M_2J_2=383''\cdot90$$

$$S_2I_2=226\cdot57$$
$$M_2K_2=157\cdot33$$

$$TJ_2=3355''\cdot17$$

$$TJ_2=2482\cdot18$$
$$TI_2=872\cdot99$$

$$\tan M_2S_2K_2=\frac{M_2K_2}{S_2K_2}$$

$$\log M_2K_2=2\cdot196812$$

$$\log S_2K_2=2\cdot941009$$
$$\log\tan M_2S_2K_2=9\cdot255803$$

$$M_2S_2K_2=10°12'58''\cdot5$$

$$M_2K_2=M_2S_2\times\sin M_2S_2K_2$$

$$M_2S_2=\frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2=2\cdot196812$$

$$\log\sin M_2S_2K_2=9\cdot2488627$$
$$\log M_2S_2=2\cdot9479493$$

$$M_2S_2=887''\cdot5$$

月半徑爲 $886''3$、今所得星月兩心距、爲 $887''\cdot5$、較月半徑仍多 $1''2$、是 $10^h0^m43^s\cdot87$、亦非掩終眞時、

又取 $Q+4^h48^m8^s=5^h12^m33^s\cdot87+4^h48^m8^s=10^h0^m41^s\cdot87$ 爲掩終時分、自 G 點至 M_2、共有

$$10^h0^m41^s\cdot87-8^h5^m44^s\cdot18=1^h54^m57^s\cdot69=114^m\cdot9615$$

$$60^m:114^m\cdot9615::1773''\cdot71:M_2G$$

$$M_2G_2=\frac{114\cdot9615\times1773\cdot71}{60}=3398''\cdot43$$

求月之縱橫坐標、準 M_2H_2G 直角三角形、則有

$$H_2G=M_2G\times\sin M_2$$

$$\log M_2G=3\cdot5312778$$

$$\log\sin M_2=9\cdot206739$$
$$\log H_2G=2\cdot7380168$$

$$H_2G=547''\cdot04$$

$$TG=931''\cdot11$$

$$H_2G=547\cdot04$$
$$M_2H_2=TH_2=384\cdot07$$

$$M_2H_2=M_2G\times\cos M_2$$

$$\log M_2G=3\cdot5312778$$

$$\log\cos M_2=9\cdot994300$$
$$\log M_2H_2=3\cdot5255778$$

$$TJ_2=M_2H_2=3354''\cdot11$$

求星之縱橫坐標、$4^h48^m8^s$ 變度爲 $72°2'$

$$TI_2=T6\times\sin 72°2'$$

$$\log T6=3\cdot4165218$$

$$\log\sin 72°2'=9\cdot978288$$
$$\log TI_2=3\cdot3948098$$

$$TI_2=2482''\cdot04$$

$$90°-72°2'=17°58'$$

$$S_2I_2=TS\times\sin 17°58'$$

$$\log TS=2\cdot866202$$

$$\log\sin 17°58'=9\cdot489204$$
$$\log S_2I_2=2\cdot355406$$

$$S_2I_2=226''\cdot68$$

求星月兩心距、準 $M_2S_2K_2$ 直角三角形、則有

$$M_2J_2=384''\cdot07$$

$$S_2I_2=226\cdot68$$
$$M_2K_2=157\cdot39$$

$$TJ_2=3354''\cdot11$$

$$TI_2=2482\cdot07$$
$$S_2K_2=872\cdot04$$

$$\tan M_2S_2K_2=\frac{M_2K_2}{S_2K_2}$$

$$\log M_2K_2=2\cdot196977$$

$$\log S_2K_2=2\cdot940551$$
$$\log\tan M_2S_2K_2=9\cdot256426$$

$$M_2S_2K_2=10°13'50''$$

$$M_2K_2=M_2S_2\times\sin M_2S_2K_2$$

$$M_2S_2=\frac{M_2K_2}{\sin M_2S_2K_2}$$

$$\log M_2K_2=2\cdot196977$$

$$\log\sin M_2S_2K_2=9\cdot249466$$
$$\log M_2S_2=2\cdot947511$$

$$M_2S_2=886''\cdot16$$

月半徑爲 $886''\cdot3$、今所得星月兩心距爲 $886''\cdot16$、較月半徑、只少 $0''\cdot14$、相差甚微、故 $10^h0^m41^s\cdot87$、爲掩終眞時、

求方位

自月輪正北點起算之方位、由圖可知、

$$S_1M_1K_1=90°-19°17'46''\cdot1=70°42'13''9$$

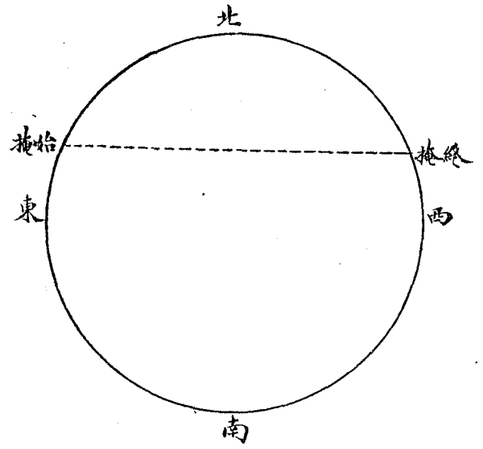
即掩始切點、在月面正北偏東 $70°42'13''\cdot9$

$$S_2M_2K_2=90°-10°13'50''=79°46'10''$$

即掩終切點、在月面正北偏西 $79°46'10''$

天空月掩星視象

人視天空月掩星、係渾圓內觀之象、第一圖之式、係渾圓外觀之象、故二者東西相反、欲繪天空月掩星圖、如第二圖所示、即以月半徑作圓、自正北點、向東取 $70°42'$、爲掩始切點、向西取 $79°46'$、爲掩終切點、二切點之聯線、即星在月後視行之道也、



第二圖

1924 年 3 月 12 日、月掩金牛甲星、濟南所見、爲

掩始　下午 $8^h49^m38^s\cdot87$
掩終　下午 10 0 41 ·87　} 濟南視時

以當日時差 $+9^m54^s\cdot82$、改之、爲

掩始　下午 $8^h59^m33^s\cdot69$
掩終　下午 10 10 36 ·69　} 濟南平時