fessor W. P. Gerrish and Professor E. S. King, and the work at Arequipa, for the southern sky, was at different times in charge of Professor W. H. Pickering, Professor S. I. Bailey, Mr. R. H. Frost, Dr. DeLisle Stewart, and Mr. Leon Campbell. The total cost of the catalogue, distributed unevenly throughout the years since the accumulation of the necessary spectrum plates was begun, may be uncertainly estimated at a quarter of a million dollars—largely paid from funds provided by Mrs. Henry Draper. Special gifts to aid in the observations and in the printing of the catalogue have been made by Mr. G. R. Agassiz, Professor E. C. Pickering, Mr. and Mrs. C. W. Elmer, and Mrs. James R. Jewett. An edition of six hundred copies has been issued. The printing was done by the Harvard University Press.

Discussions of the assembled data have been published during the past two or three years in Harvard Circulars 226, 229, 239, 240, 243, 245, and 248; Harvard Bulletins 787, 792, 796; Proceedings of the American Academy of Arts and Sciences **59**, No. 9, 1924; Scientific Monthly **18**, 449, 1924; and elsewhere. Lists of errata are given immediately after the preface in Harvard Annals **98** and **99**. A description of the Harvard classification of spectra is given in each volume. A note on the accuracy of the published positions appears in Harvard Annals **98**, 14, and a special note on the magnitudes in **96**, 14.

To supplement the Henry Draper Catalogue, particularly for the faint stars in the Milky Way, an extension of the work is now in progress. Special plates for magnitudes and spectra have been procured in several regions. The extension will be printed in small parts as soon as completed. The first installment may appear within a year.

THE NEW CALENDAR OF THE EASTERN CHURCHES.

By MIRIAM NANCY SHIELDS.

In number 5279 of the *Astronomische Nachrichten,* issued on March 18, 1924, is an article by M. Milankovitch of Belgrade, dated October, 1923. Its title is "The End of the Julian Calendar and the New Calendar of the Eastern Churches." M. Milankovitch, as indicated below, was a delegate to the congress which decided upon this new calendar; it is a slight improvement over the Gregorian calendar.

Thinking that this matter is of general interest I have translated this article, endeavoring to give a faithful reproduction of the author's statements.

In May, 1923, there met in Constantinople under the presidency of the ecumenical patriarch, Meletius IV, a congress of the orthodox oriental churches (of which the Russian, the Greek, the Serbian and the Roumanian are most important) which decided on a reform of the

Julian calendar or rather the replacement of it by a new calendar. This decision has already been carried out by the Russian church; the others may soon follow, so that the Julian calendar, now almost 2000 years old, will go out of use.

I had the honor to take part in this congress as delegate of the government of the Serbs, Croatians and Slovenes and as a representative of astronomical science. Therefore I may be permitted to report on the important decisions of this congress in regard to the question of the calendar, and to explain them briefly.

As is known, heretofore all the oriental Christian churches held fast to the Julian calendar, which is thirteen days behind the Gregorian. This condition proved to be inconvenient, particularly in the newly organized South-Slav and Roumanian kingdoms, with their mixed Greek-Orthodox and Roman Catholic populations, whereby the otherwise numerous holidays were celebrated twice. A reform of the Julian calendar was, therefore, an urgent necessity, especially since its inadequateness had been shown by science long ago. A complete adoption of the Gregorian calendar was, however, not advisable either from a religious or scientific standpoint because the astronomical data concerning the length of the tropical year which lay at the base of the Gregorian reform are now replaced by others. So it was advised to remove the difference of thirteen days mentioned before, but by the distribution of leap years to make allowance for the progress of astronomy. But in order not to go too far and make a new divergence between the dates of the two Christian calendars in future time, a leap-year rule proposed by me was accepted, which differs from the Gregorian but nevertheless agrees with it until the year 2800.

The principle of this leap-year rule is very simple. In the Julian calendar every fourth year was a leap-year, which gave an average length to the calendar year of 365 days 6 hours, which is more than 11 minutes greater than the length of the tropical year. On this account the Gregorian calendar counts as leap-years only those century years whose first two figures are exactly divisible by four. Of the following century years only the years 2000, 2400, 2800, etc., will be leap-years. In this way during the space of 800 years six days are left out—contrary to the Julian calendar—and thus an average length of the calendar-year is obtained which differs by twenty-six seconds from the length of the tropical year. The new leap-year rule of the orthodox churches, on the contrary, is laid down as follows. Of the century-years only those shall remain leap-years whose first two figures when divided by nine give a remainder of two or six. Hence of the following century-years only the years 2000, 2400, 2900, etc., will be leap-years. First, one can see from this that a deviation from the Gregorian calendar will first occur after 877 years; second, that by this leap-year rule during the space of 900 years seven days are removed from the Julian calendar. This gives an average length for the calen-

dar year of 365 days, 5 hours, 48 minutes and 48 seconds, which differs by only 2 seconds from the present length of the tropical year.

The establishment of the date of Easter brought some difficulty to the Congress. As is well known, the date of Easter depends on the phases of the moon, since Easter must fall on that Sunday which follows the first full moon after the vernal equinox. This rule, which has been accepted by all Christian churches, is so clear and unequivocal that (it would seem) no difference would be possible in regard to the date of Easter if one determined the phases of the moon accurately and not by the old rules of reckoning which give inaccurate results. For this reason the Congress of Constantinople decided—on the proposal of its president—that the phases of the moon necessary for the establishment of Easter shall be ascertained by accurate astronomical computations in which the date of the Jerusalem meridian governs.

On account of this arrangement the Easter-dates of the two Christian calendars will disagree six times during the next fifty years, in 1924, 1927, 1943, 1954, 1962 and 1967. The dates of Easter in the eastern churches for these years are as follows: March 23, 1924, April 24, 1927, March 28, 1943, April 25, 1954, March 25, 1962, and April 2, 1967, while in the Gregorian calendar the dates are as follows: April 20, 1924, April 17, 1927, April 25, 1943, April 18, 1954, April 22, 1962, and March 26, 1967. The reason for this divergence is the following: in the years 1924, 1943 and 1962 the true full moon comes several hours after the vernal equinox, while the Gregorian epact-reckoning places it before the equinox. In the years 1927, 1954 and 1967, the true full moon falls on a Sunday while the epact-reckoning places it on Saturday.

Moreover it is to be hoped that these differences will soon be adjusted, since the Congress of Constantinople has decided to take steps to bring about a complete agreement of the Christian calendars, which may very easily be brought to pass by good will on both sides.

After these introductory remarks the following statement of the decisions of the Congress of Constantinople on the question of the calendar will be entirely intelligible.

1. Thirteen days are taken from the Julian calendar, which represent its difference in time caused by counting in solar years since the first ecumenical council in Nicaea. Accordingly October 1, 1923 will be counted as October 14, 1923.

2. The holidays which fall on the days taken away will either all be celebrated together on October 14, 1923, or when the bishop of the diocese orders.

3. All the months of the year will keep the same number of days in the future as they have had in the past. As before, the month of February will have 29 days in leap-years.

4. As previously, there will be two kinds of years, common years

with 365 days, and leap years with 366 days. Those years will be leap-years which can be divided without remainder by 4, as has been the case heretofore. Only the century-years form an exception for which the rule of the following paragraph applies.

5. The century-years (those which end with two zeros) will be leap-years only if their century-numbers when divided by 9 give a remainder of 2 or 6. All the other century-years will be common years. Accordingly, of the following century-years only those printed in heavy type will be leap-years.

2000	2100	2200	2300	**2400**	2500	2600	2700	2800
2900	3000	3100	3200	**3300**	3400	3500	3600	3700

By this arrangement the average length of the civil year is 365 days, 5 hours, 48 minutes and 48 seconds, in close agreement with the length of the solar year.

6. The fixed holidays retain the dates which they have had up to this time.

7. The movable holidays depend on the date of Easter. In agreement with the canonical decisions which remain unchanged Easter will be celebrated on the Sunday which follows the first full moon after the vernal equinox.

8. The Easter full moon will be determined by astronomical calculations; allowance is thus made for expected improvement in our knowledge. The date of Easter will always be determined by the time of the Holy City, Jerusalem.

9. The ecumenical patriarch will request the observatories or chairs of celestial mechanics in Athens, Belgrade, Bucharest and Pulkowa (Petrograd) to compute long-time Easter tables, and will give them to all the orthodox churches.

10. This reform of the Julian calendar can in no way be a hindrance to a later alteration which might be made by all Christian churches.

Addendum to 5.

The new calendar is more accurate than the Gregorian, the average length of whose year differs by 24 or 25 seconds from the length of the tropical year. The difference between the length of the average civil year of the new calendar and the Gregorian is so small that a difference of date will first occur after 877 years. Of the following years the heavy typed ones are the leap-years of the Gregorian calendar.

2000 2100 2200 2300 **2400** 2500 2600 2700 **2800**

A divergence first takes place in the year 2800.

Addendum to 8.

Because the day is reckoned from midnight to midnight the civil

date of the first opposition of the moon after the vernal equinox will be determined by reckoning the time according to the meridian of the Church of the Holy Sepulchre. The first Sunday after this date is Easter. If this date itself falls on Sunday, Easter will be celebrated the following Sunday.

University of Denver, May, 1924.

THE SHADOW BANDS OF TOTAL ECLIPSES.

By CHARLES S. HASTINGS.

The shadow bands frequently seen for a few seconds immediately before the second and after the third contact in total eclipses of the sun are an impressive feature which adds immensely to the awe inspiring spectacle. This is due not only to the eager attention of the observer, the rarity of the phenomenon which occurs only at such moments, but also to the lack of an obvious cause. Still, the explanation does not seem difficult although apparently overlooked.

A short description of the phenomenon will prove helpful to the reader who has not had the good fortune to observe a total eclipse of the sun.

During the brief intervals mentioned the ground, and every other surface exposed to the sun, appears to be covered with bands of alternate light and shade which generally move with considerable speed, sometimes in one direction at right angles to themselves, sometimes in the opposite. The separation of the bands varies greatly; in exceptional cases, as in that which I observed in the eclipse of 1900 at Norfolk, Va., on the roof of the hotel, they were very close together and seemed to oscillate slowly instead of sweeping by at a considerable speed. At that occurrence the air was very quiescent.

The explanation which I offer is as follows:

Suppose one could take an instantaneous photograph of a plane surface illuminated solely by a single star; it is evident that, owing to the imperfect homogeniety of the air, the photograph would show a mottled distribution of light and shade. Moreover, it is obvious that the irregularities of distribution would be due to the lower levels of the air, just as the reticulated illumination of a wall from sunlight reflected from a rippled surface of water occurs only when the distance from reflecting surface to screen is inconsiderable. A similar illustration might be borrowed from the character of the illumination of a wall by an arc light shining through a window of ordinary glass—the irregular mottling vanishes when the wall is remote from the window.

Now suppose that the source of light, instead of being a point-source as in case of the star, becomes a linear source of even moderate