Proposal to encode Ancient Chinese Mathematical Symbols

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1. Introduction of the new block - Ancient Chinese Mathematical Symbols. Because Chinese mathematics emerged independently, when writing mathematical books, Chinese people created many special symbols. Especially in Ming and Qing Dynasty, a lot of western mathematics books were translated verbally and introduced into China by western missionaries. In order to adapt to the vertical writing of Chinese books, the Chinese native scholars modified the western mathematical symbols slightly and then a set of new symbols were made and used into books and papers. These changes are mainly reflected in the following aspects:

- **Mathematical Symbols**. Most of them were just rotated but some of them were reformed.
- Name of unknowns. The Latin letters and the Greek letters will be translated into the names of Chinese era, twenty-eight lunar mansions or the sixty-four hexagrams.
- Equations. The simple equations would be written vertically, and the complex equations would be written horizontally, sometimes the column could be so long to contain the equations and sometimes an equation could cross several columns.

If there are mathematical symbols which had been reformed and used in China before China drew up standards, we will put them into this new block. Considering that there are also many unexplored books, we set the new block from U+1EF00 to U+1EF3F.

1.2. Introduction of specific blocks.

(1) **Combining Diacritical Marks**. Like "point A'", "point A''" in western symbol system, when expressing some similar and different geometric points, ancient Chinese mathematician would use some left-falling strokes (撇). One to three left-falling strokes were found in *Qiuyishu Tongjie* (求一術通解).

(2) **Combining Diacritical Marks for Symbols**. The UCS contains a number of combining diacritical marks for symbols. For example, can be represented as "乂 丨 文文 〇 〇 〇 ゝ", where ゝ(U+20E5) is used for indicating a negative number. There are also some marks in *Xuesuan Bitan* (學算筆談), *Siyuan Yujian* (四元玉鑑) and *Zhusuan* (珠算). In the books, ⌀ is used for deleting or updating the number during the mathematical operation, and ◎ is used for marking the redundant characters in the process of copying and printing, and ◻ is used as "!" in math, which means factorial. For example, both 五⌋ and 5! represent 5 × 4 × 3 × 2 × 1.
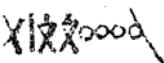
(3) **Enclosed Ideograms**. The UCS contains a number of enclosed ideograms in BMP and SMP. In ancient Chinese math books, the ideograms enclosed by circles are also found in *Pingsanjiao Bianjiao Huqiushu* (平三角邊角互求術), *Weiji Suyuan* (微積溯源), *Qiuyishu Tongjie* (求一術通解), *Duishu Xiangjie* (對數詳解), *Daishushu* (代數術) and *Zhusuan* (珠算). And the ideograms enclosed by squares are also found in *Yuanlü Kaozhen Tujie* (圓率攷眞圖解), *Daishu Beizhi* (代數備旨), *Subu Yancao* (粟布演草), *Duishu Xiangjie* (對數詳解) and *Siyuan Yujian Xicao* (四元玉鑑細草). In general, most of the characters are used for marking the formula so as to quote and discuss them in later words.

(4) **Ancient Chinese Mathematical Symbols**. A brief introduction is given here.
   a) ⊥,⊤ and ╪,⊥ means "plus" (+),⊤means "minus" (-), and ╪ means " plus or munus" (±). They were adopted in

Daiweiji Shiji (代微積拾級). For saving the space, the ⌊ and ⌉ usually closed to the characters narrowly. For example "a + b" would be represented as "甲⌊乙". So the usage of them obviously differ from UP TACK (⊥), DOWN TACK (⊤) and PERPENDICULAR SIGN (⊥) and COUNTING RODS (⊥, ⊤).

b) ⨆ and ⋔. ⨆ is the variant of ⌊, and ⋔ is the variant of ⌉. They were adopted in *Xingxue Beizhi* (形學備旨) and *Daishu Beizhi* (代數備旨). And the usage of ⨆ differ from NONFORKING (⋔).

c) ⫪. ⫪ means "find positive difference". For example, 5 ⫪ 3 = 3 ⫪ 5 = 2.

d) ⦃ and ⦄. They are the variants of "{" and "}".

e) ⸱⸱⸱⸱. ⸱⸱⸱⸱ means "et cetera" (……). The explanatory notes of *Duishu Xiangjie* (對數詳解) enumerated this symbol particularly, for it hasn't been used before.

f) ⼺ and ⽊. ⼺ is deformed from the radical of 微, which means "differential" (d). ⽊ is deformed from the radical of 積, which means "integral" (∫). And the usage of them as operators is different from them as radicals, so they should be separated.

2. Character Data.

2.1. Character position and name.

Combining Diacritical Marks Extended (U+1AB0 - U+1AFF)

◌́	1AC0	COMBINING CHINESE PRIME
◌̋	1AC1	COMBINING CHINESE DOUBLE PRIME
◌̕	1AC2	COMBINING CHINESE TRIPLE PRIME

Combining Diacritical Marks for Symbols (U+20D0 - U+20FF)

◌̸	20F1	COMBINING LONG SOLIDUS OVERLAY
◌⃝	20F2	COMBINING ENCLOSING OCTAGON
◌	20F3	COMBINING CHINESE FACTORIAL SYMBOL

Ancient Chinese Mathematical Symbols (U+1EF00 - U+1EF3F)

⊥	1EF00	CHINESE PLUS SIGN
⊤	1EF01	CHINESE MINUS SIGN
⊧	1EF02	CHINESE PLUS-OR-MINUS SIGN
⨆	1EF03	CHINESE VARIANT PLUS SIGN
⋔	1EF04	CHINESE VARIANT MINUS SIGN
⫪	1EF05	CHINESE POSITIVE DIFFERENCE SIGN
⦃	1EF06	CHINESE LEFT CURLY BRACKET

彐	1EF07	CHINESE RIGHT CURLY BRACKET
灬	1EF08	CHINESE ELLIPSIS
彳	1EF09	CHINESE DIFFERENTIAL SIGN
禾	1EF0A	CHINESE INTEGRAL SIGN

十	U+5341,U+034F,U+4E00,U+034F,U+25EF
二十	U+5341,U+034F,U+4E8C,U+034F,U+25EF
三十	U+5341,U+034F,U+4E09,U+034F,U+25EF
四十	U+5341,U+034F,U+56DB,U+034F,U+25EF
五十	U+5341,U+034F,U+4E94,U+034F,U+25EF
六十	U+5341,U+034F,U+516D,U+034F,U+25EF
七十	U+5341,U+034F,U+4E03,U+034F,U+25EF
八十	U+5341,U+034F,U+516B,U+034F,U+25EF
九十	U+5341,U+034F,U+4E5D,U+034F,U+25EF
甲	U+7532,U+034F,U+25EF
乙	U+4E59,U+034F,U+25EF
丙	U+4E19,U+034F,U+25EF
丁	U+4E01,U+034F,U+25EF
戊	U+620A,U+034F,U+25EF
己	U+5DF1,U+034F,U+25EF
庚	U+5E9A,U+034F,U+25EF
辛	U+8F9B,U+034F,U+25EF
呷	U+5477,U+034F,U+25EF
𠮙	U+20B99,U+034F,U+25EF

㖂	U+20C33,U+034F,U+25EF
叮	U+53EE,U+034F,U+25EF
㖕	U+3595,U+034F,U+25EF
子	U+5B50,U+034F,U+25EF
丑	U+4E11,U+034F,U+25EF
寅	U+5BC5,U+034F,U+25EF
卯	U+536F,U+034F,U+25EF
辰	U+8FB0,U+034F,U+25EF
巳	U+5DF3,U+034F,U+25EF
午	U+5348,U+034F,U+25EF
未	U+672A,U+034F,U+25EF
申	U+7533,U+034F,U+25EF
酉	U+9149,U+034F,U+25EF
亥	U+4EA5,U+034F,U+25EF
角	U+89D2,U+034F,U+25EF
亢	U+4EA2,U+034F,U+25EF
氐	U+6C10,U+034F,U+25EF
房	U+623F,U+034F,U+25EF
申	U+4E8C,U+034F,U+7533,U+034F,U+25EF
酉	U+4E8C,U+034F,U+9149,U+034F,U+25EF
亥	U+4E8C,U+034F,U+4EA5,U+034F,U+25EF
天	U+4E8C,U+034F,U+5929,U+034F,U+25EF
甲	U+7532,U+034F,U+4E8C,U+034F,U+25EF

乙	U+4E59,U+034F,U+4E8C,U+034F,U+25EF
丙	U+4E19,U+034F,U+4E8C,U+034F,U+25EF
丁	U+4E01,U+034F,U+4E8C,U+034F,U+25EF
戊	U+620A,U+034F,U+4E8C,U+034F,U+25EF
己	U+5DF1,U+034F,U+4E8C,U+034F,U+25EF
庚	U+5E9A,U+034F,U+4E8C,U+034F,U+25EF
辛	U+8F9B,U+034F,U+4E8C,U+034F,U+25EF
子	U+5B50,U+034F,U+4E8C,U+034F,U+25EF
丑	U+4E11,U+034F,U+4E8C,U+034F,U+25EF
寅	U+5BC5,U+034F,U+4E8C,U+034F,U+25EF
卯	U+536F,U+034F,U+4E8C,U+034F,U+25EF
壹	U+58F9,U+034F,U+25EF
貳	U+8CB3,U+034F,U+25EF
叄	U+53C1,U+034F,U+25EF
千	U+5343,U+034F,U+25EF
天	U+5929,U+034F,U+25EF
地	U+5730,U+034F,U+25EF
人	U+4EBA,U+034F,U+25EF
術	U+8853,U+034F,U+25EF
又	U+53C8,U+034F,U+25EF
〇	U+3007,U+034F,U+2B1C
四	U+56DB,U+034F,U+2B1C
五	U+4E94,U+034F,U+2B1C

六	U+516D,U+034F,U+2B1C
七	U+4E03,U+034F,U+2B1C
八	U+516B,U+034F,U+2B1C
九	U+4E5D,U+034F,U+2B1C
十	U+5341,U+034F,U+2B1C
十二	U+5341,U+4E8C,U+034F,U+2B1C
十四	U+5341,U+56DB,U+034F,U+2B1C
十六	U+5341,U+516D,U+034F,U+2B1C
十七	U+5341,U+4E03,U+034F,U+2B1C
乾	U+4E7E,U+034F,U+2B1C
否	U+5426,U+034F,U+2B1C
問	U+554F,U+034F,U+2B1C
履	U+5C65,U+034F,U+2B1C
屯	U+5C6F,U+034F,U+2B1C
師	U+5E2B,U+034F,U+2B1C
步	U+6B65,U+034F,U+2B1C
比	U+6BD4,U+034F,U+2B1C
泰	U+6CF0,U+034F,U+2B1C
訟	U+8A1F,U+034F,U+2B1C
蒙	U+4749,U+034F,U+2B1C
隨	U+96A8,U+034F,U+2B1C
需	U+9700,U+034F,U+2B1C

It is important to point out that this kind of enclosed ideographic has fixed form and certain system, so they cannot be added or reduced casually.

The reason why ㊢ is different from it in the evidence figures is that, there were mistakes in books in the process of transcribing. Because the serial characters were marked in the Twelve Earthly Branches order and "巳" in the Ten Heavenly Stems cannot be in the serial for no reason, the correct character should be "己".

2.2. Character properties.

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1AC0;COMBINING CHINESE PRIME;Mn;230;NSM;;;;;N;;;;;
1AC1;COMBINING CHINESE DOUBLE PRIME;Mn;230;NSM;;;;;N;;;;;
1AC2;COMBINING CHIENSE TRIPLE PRIME;Mn;230;NSM;;;;;N;;;;;
20F1;COMBINING LONG SOLIDUS OVERLAY;Mn;1;NSM;;;;;N;;;;;
20F2;COMBINING ENCLOSING OCTAGON;Me;0;NSM;;;;;N;;;;;
20F3;COMBINING CHINESE FACTORIAL SYMBOL;Mn;230;NSM;;;;;N;;;;;
1EF00;CHINESE PLUS SIGN;Sm;0;L;;;;;N;;;;;
1EF01;CHINESE MINUS SIGN;Sm;0;L;;;;;N;;;;;
1EF02;CHINESE PLUS-OR-MINUS SIGN;Sm;0;L;;;;;N;;;;;
1EF03;CHINESE VARIANT PLUS SIGN;Sm;0;L;;;;;N;;;;;
1EF04;CHINESE VARIANT MINUS SIGN;Sm;0;L;;;;;N;;;;;
1EF05;CHINESE POSITIVE DIFFERENCE SIGN;Sm;0;L;;;;;N;;;;;
1EF06;CHINESE LEFT CURLY BRACKET;Sm;0;L;;;;;N;;;;;
1EF07;CHINESE RIGHT CURLY BRACKET;Sm;0;L;;;;;N;;;;;
1EF08;CHINESE ELLIPSIS;Sm;0;L;;;;;N;;;;;
1EF09;CHINESE DIFFERENTIAL SIGN;Sm;0;L;;;;;N;;;;;
1EF0A;CHINESE INTEGRAL SIGN;Sm;0;L;;;;;N;;;;;
```

3. References.

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    [第一百十四款，補劉彝程、沈善蒸、崔朝慶算式]

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(第一卷) 丁取忠, 左潛, 曾紀鴻, 吳嘉善, 李善蘭, (第二卷) 鄒伯奇, 丁取忠, 左潛, (補卷) 丁取忠. 粟布演草 (二卷) 補 (一卷). 白芙堂叢書本.

方中通. 珠算 (一卷). 隨衍室本.

徐建寅, (英) John Fryer. 運規約指 (三卷). 江南製造局本.

華蘅芳. 學算筆談 (十二卷). 原刻本.

…… (There are also 75 books collected in the series but not put to use for examples)

4. Acknowledgement.

symbols are modified from Symbola and Sursong.

5. Figures.
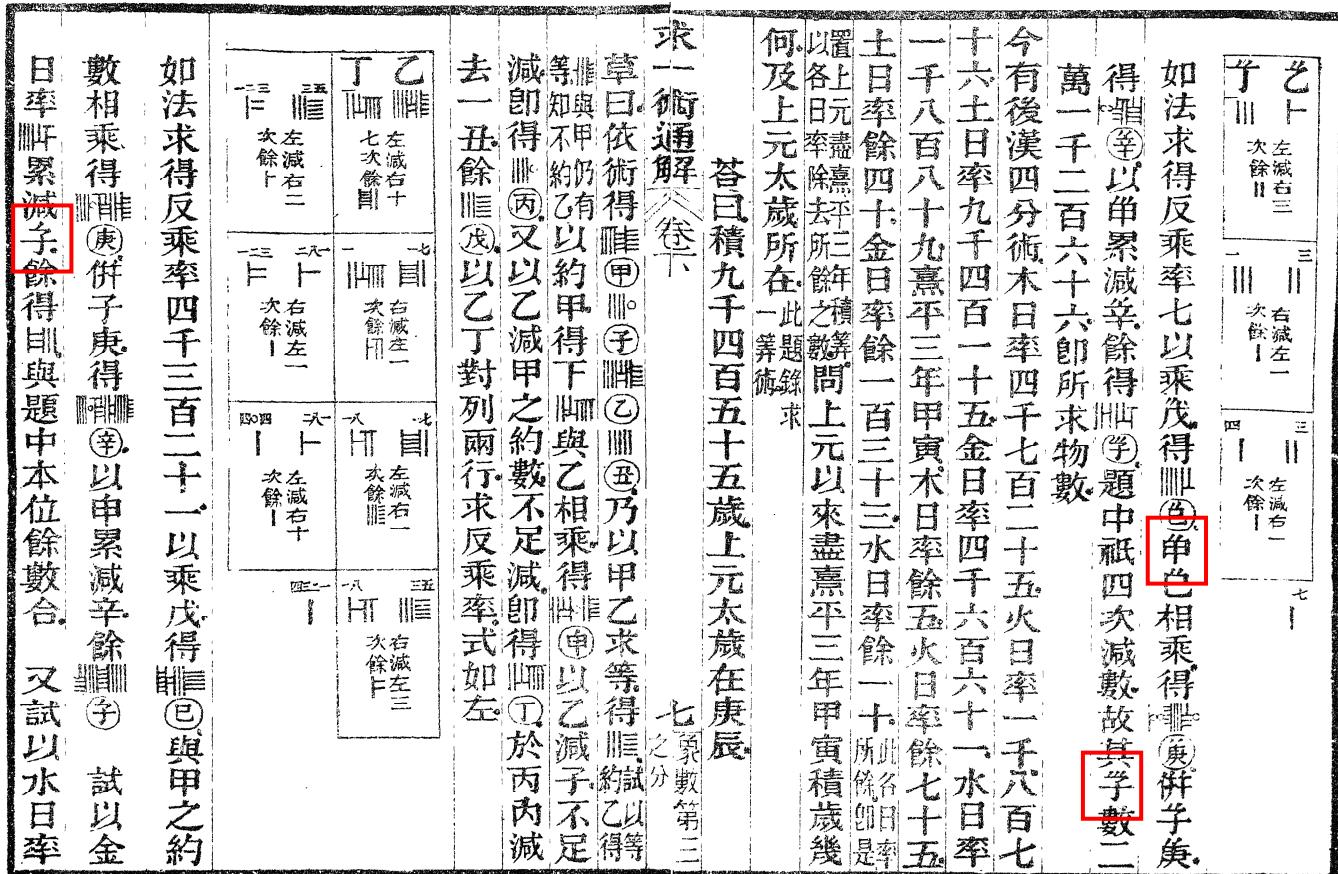
**Figure 1.** Example from Huang Zongxian's (黃宗憲) book *Qiuyishu Tongjie* (求一術通解) vol.2 p.7 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ȯ, ö and ö̈ in text.

者視原法數在實內有幾回也即用其幾回之
變法與暗數相呼加於實數之上逐位呼加加
歸除無異也

歸除式

式二有銀一百二十兩二人分之問各若干曰

先將法二於十內減之餘八即八為

數是為子丑兩暗數蓋子實一作一為

法二也丑實二內有一回原法二也

子暗數五曰五八得四十乃於子實

再以變法八呼丑暗數一曰一八如

上加八數已滿十曰八退二進一十

而於子位五進一為六逐位加畢視子位遞加

分數為每人各得六十兩也

甲云變八	丑云八	子云四五六

Figure 2. Example from Fang Zhongtong's (方中通) book *Zhusuan* (珠算) p.16 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ∮ in text.

得三萬三千五百四十三為同數消左得

三蔡方得九步為先開方數倍之得十八步為

九步自之得八十一步為從隅加從方得九十

又置先開方數減二步餘七步為後開方數自

九步加二步得五十一步為晼徑合問

積加面徑減圓周餘五十六步只云虛徑多如

面徑二步問三徑各幾何

答曰面徑四步 虛徑六步

通徑一十四步

曰立天元一為面徑如積求之得一百二十八

二為益方一十一為正隅 ⊠ 平方開之得面徑

士琳篆似字四步字前字似皆美文

Figure 3. Example from Zhu Shijie's (朱世傑) book *Siyuan Yujian* (四元玉鑑) vol.1.2 p.11 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ◎ in text.
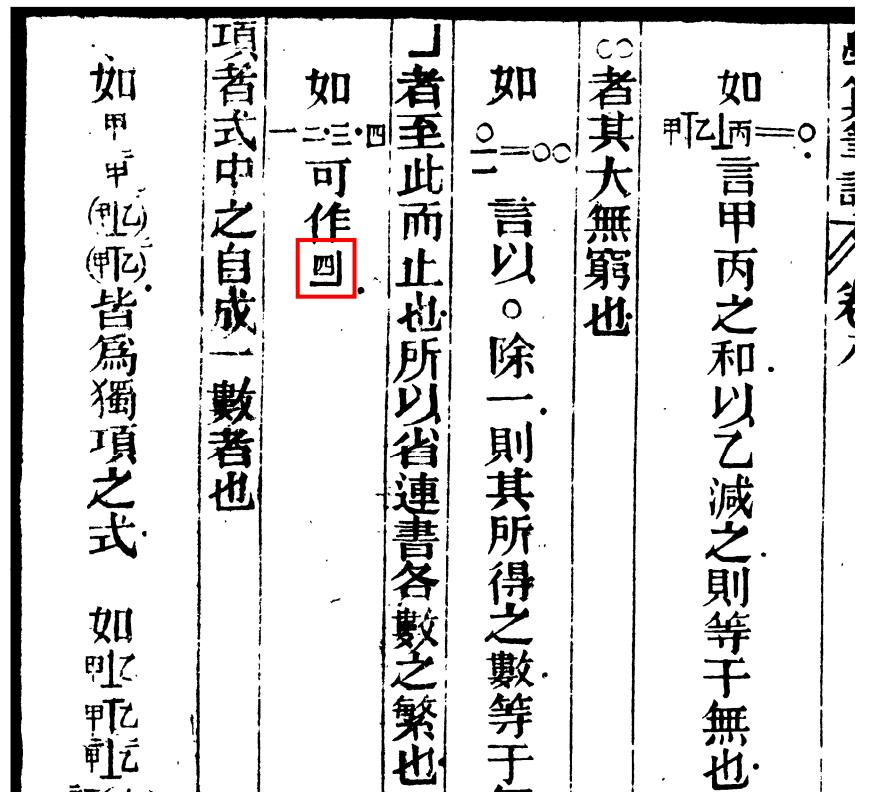
Figure 4. Example from Hua Hengfang's (華蘅芳) book *Xuesuan Bitan* (學算筆談) vol.8 p.4 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ◌⌋ in text.
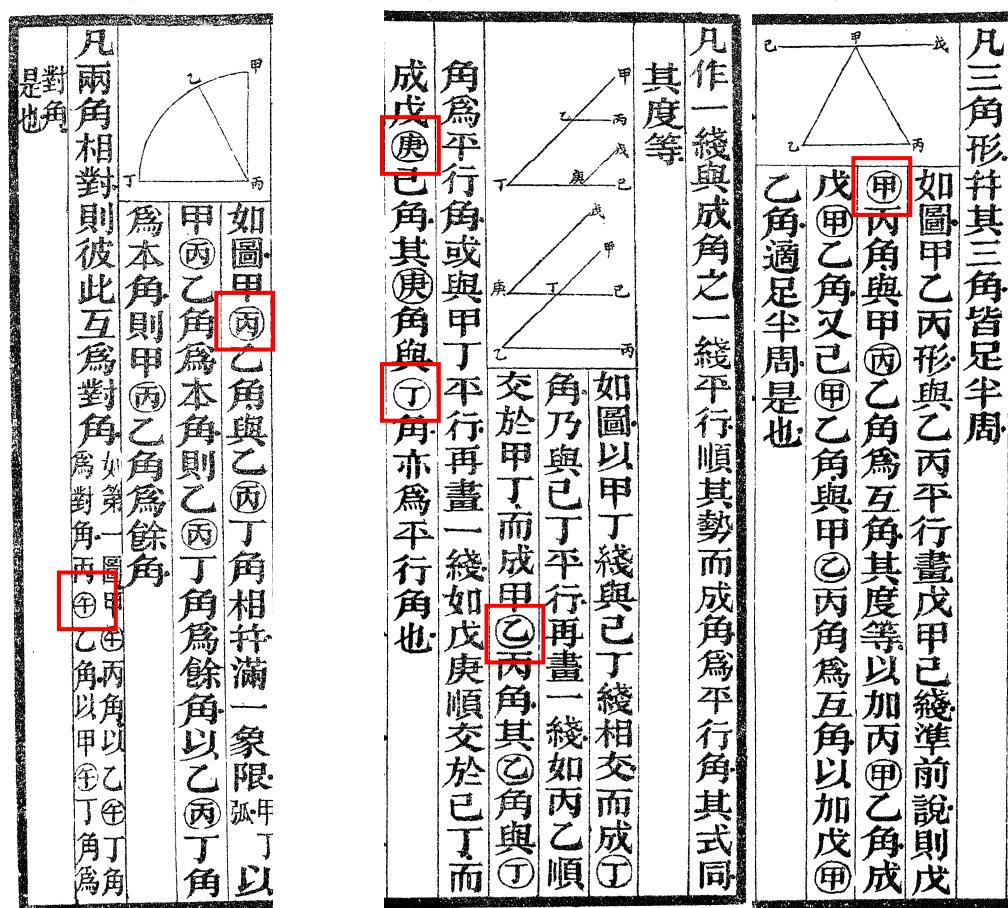
Figure 5. Example from Wu Jiashan's (吳嘉善) book *Pingsanjiao Bianjiao Huqiushu* (平三角邊角互求術) p.1 and p.2 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ⊕, ⊘, ⊛, ⊤, ⊕ and ⊕ in text.
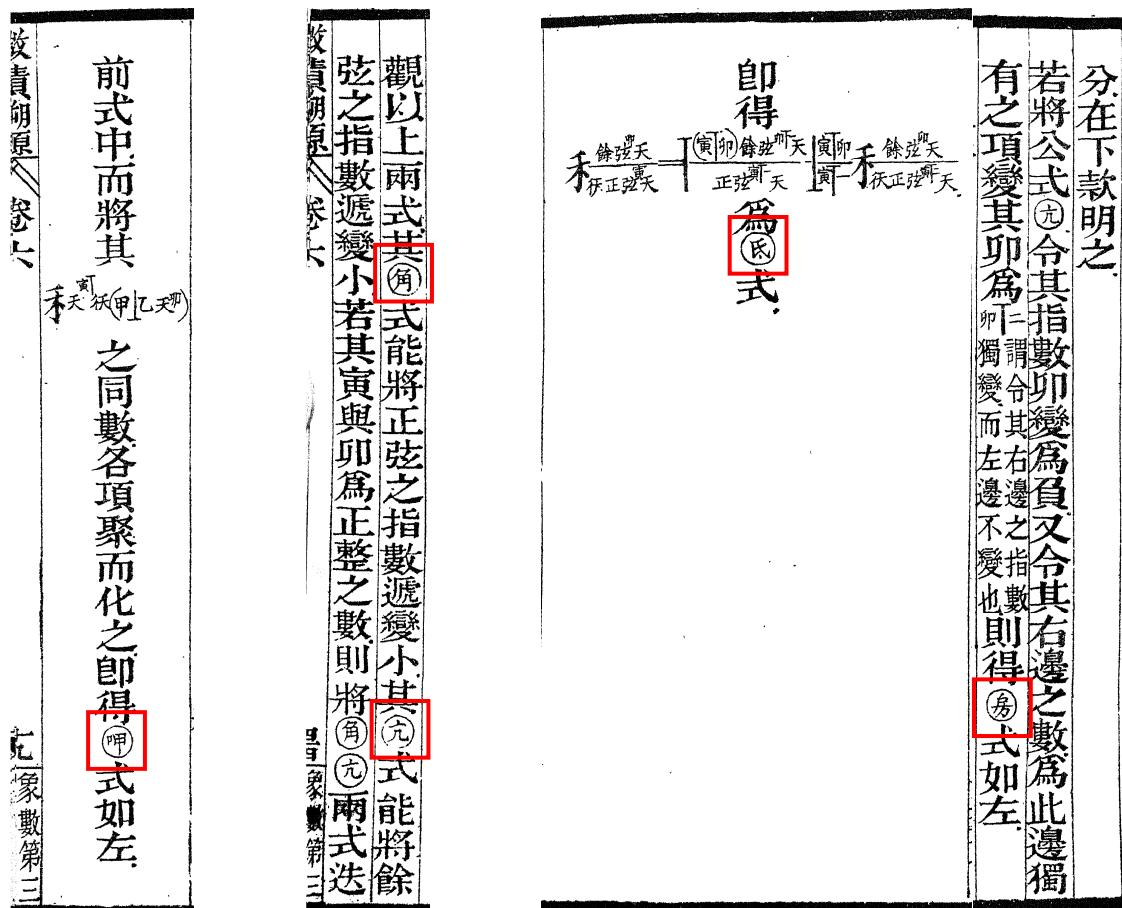
Figure 6. Example from Hua Hengfang's (華蘅芳) book *Weiji Suyuan* (微積溯源) vol.6 p.19, p.44 and p.45 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊙, ㊤, ㊨, ㊧ and ㊦ in text.
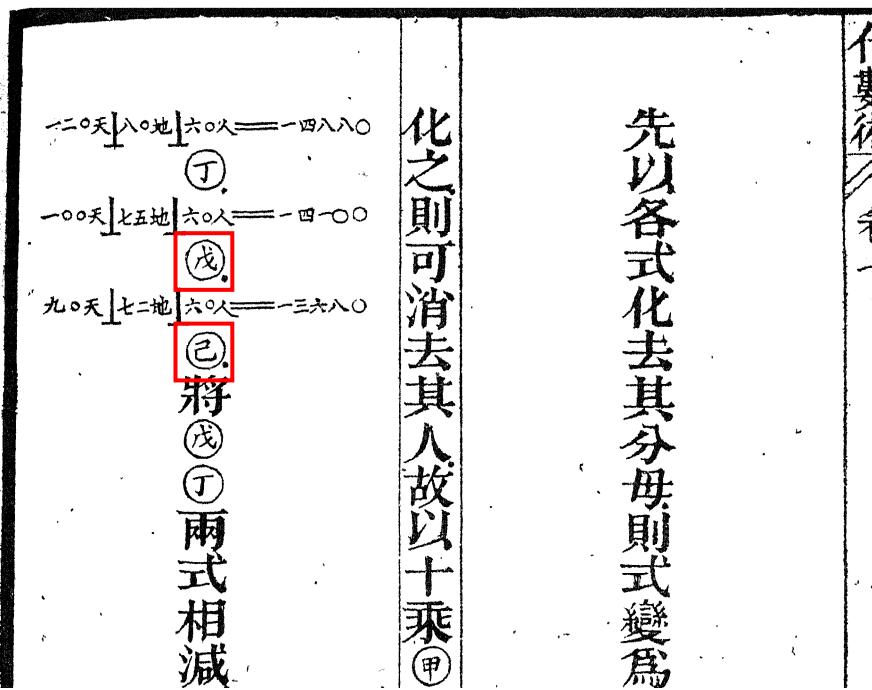
**Figure 7.** Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.7 p.7 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊥ and ㊩ in text.

七數之賸一十七以三十五數之賸二十一問物幾何

答曰二萬一千二百六十六

草曰依術得(甲)上(子)上(乙)上(丑)乃以甲乙求等無約等

乘得下(申)以乙減子不足減即得卜(丙)又以乙累減

(丁)於丙內減去一丑餘(戊)以乙丁對列兩行求反乘

左

丁	乙	
		左減右三 次餘
		右減左二 次餘
		左減右一 次餘

如法求得反乘率一十以乘戊得(巳)甲巳相乘得下

子庚得卜(辛)以申累減辛餘

又依術得(壬申)(子)(乙)乃以申乙求等不約等

得下(丙)(子)乃以申乙求等無約等申

又以乙累減子餘(丙)又以乙累減申餘卜(子)

Figure 8. Example from Huang Zongxian's (黃宗憲) book *Qiuyishu Tongjie* (求一術通解) vol.2 p.7 (Shanghai: Arithmetic Publishing House (算學書局), 1898), showing ㊖, ㊋, ㊏ and ㊚ in text.
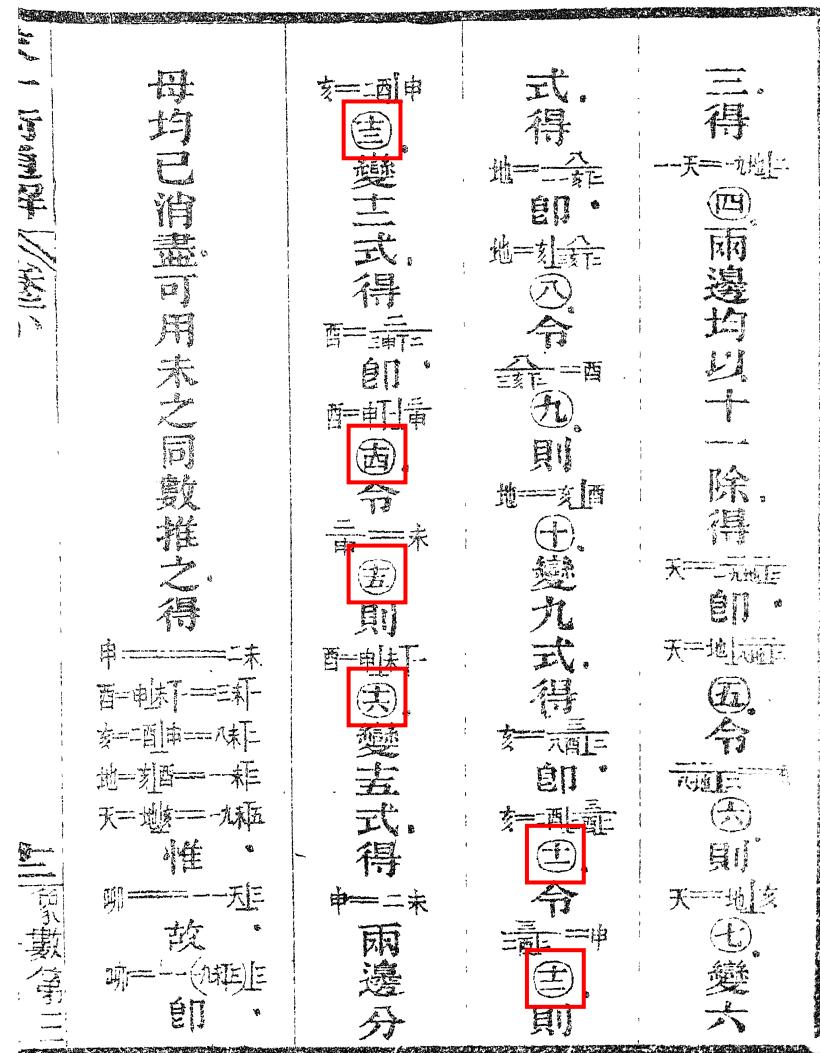
Figure 9. Example from Huang Zongxian's (黃宗憲) book *Qiuyishu Tongjie* (求一術通解) vol.2 p.12 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ⊕, ⊎, ⊜, ⊠, ⊞ and ⊗ in text.
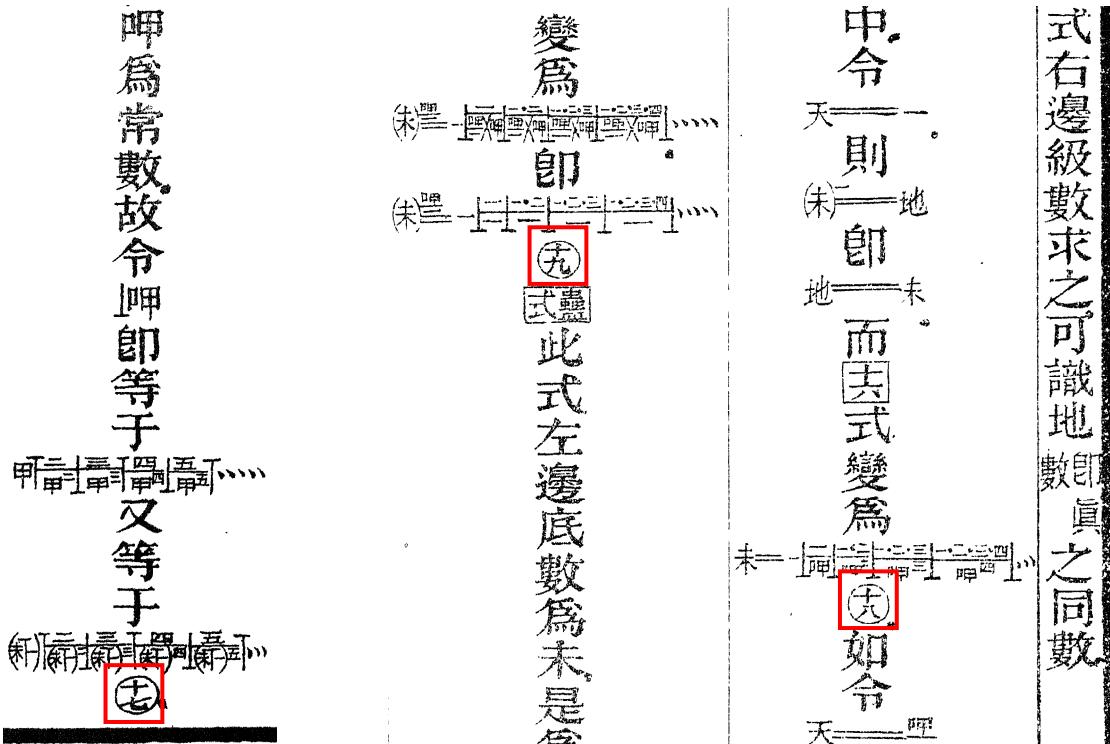
Figure 10. Example from Zeng Jihong's (曾紀鴻) book *Duishu Xiangjie* (對數詳解) vol.4 p.3 and p.4 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ⊞, ⊗ and ⊛ in text.
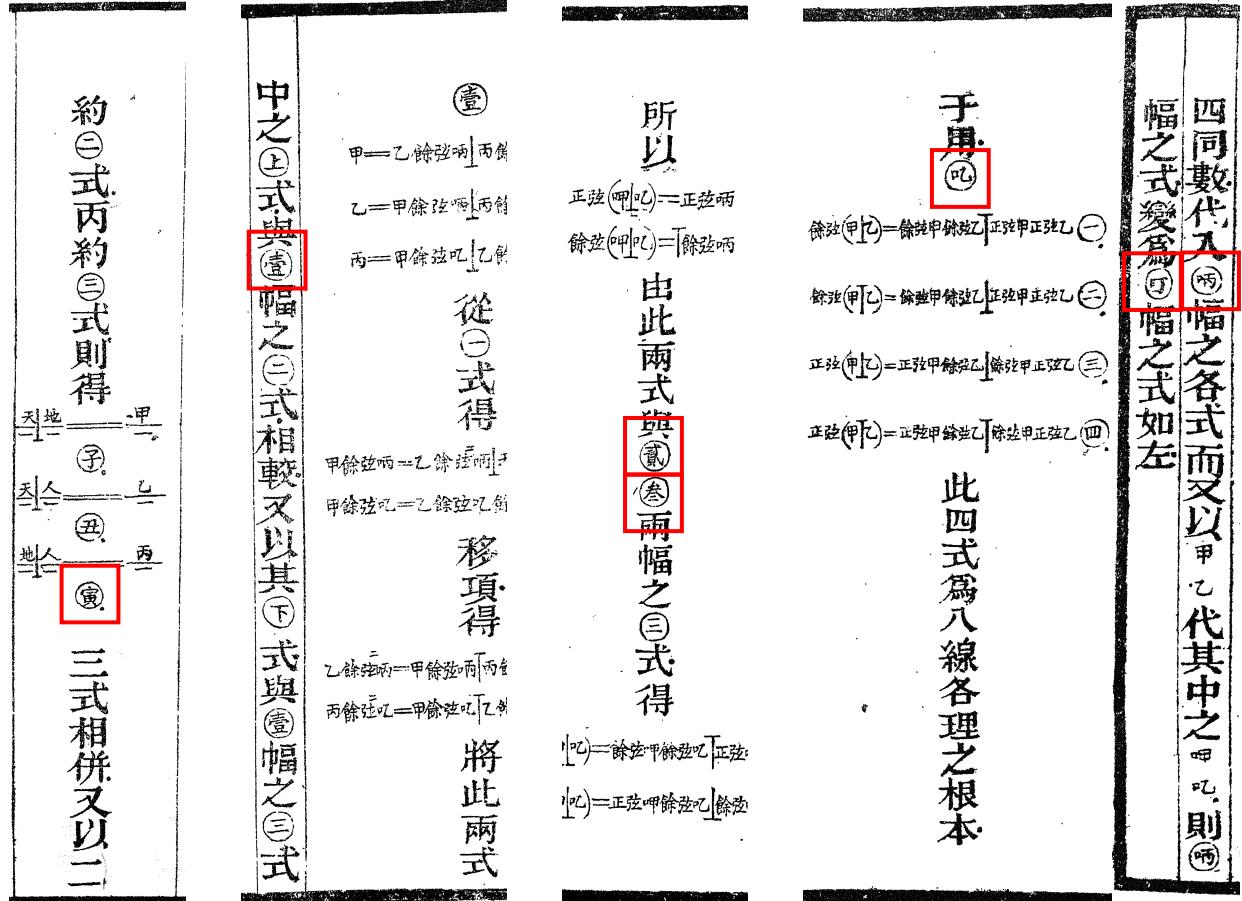
Figure 11. Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.8 p.10; vol.24 p.13, p.15, p.19 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 寅, 壹, 貳, 叄, 叺, 㖤 and 卯 in text.

Figure 12. Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.24 p.22, p.26 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 㖞 and 卯 in text.
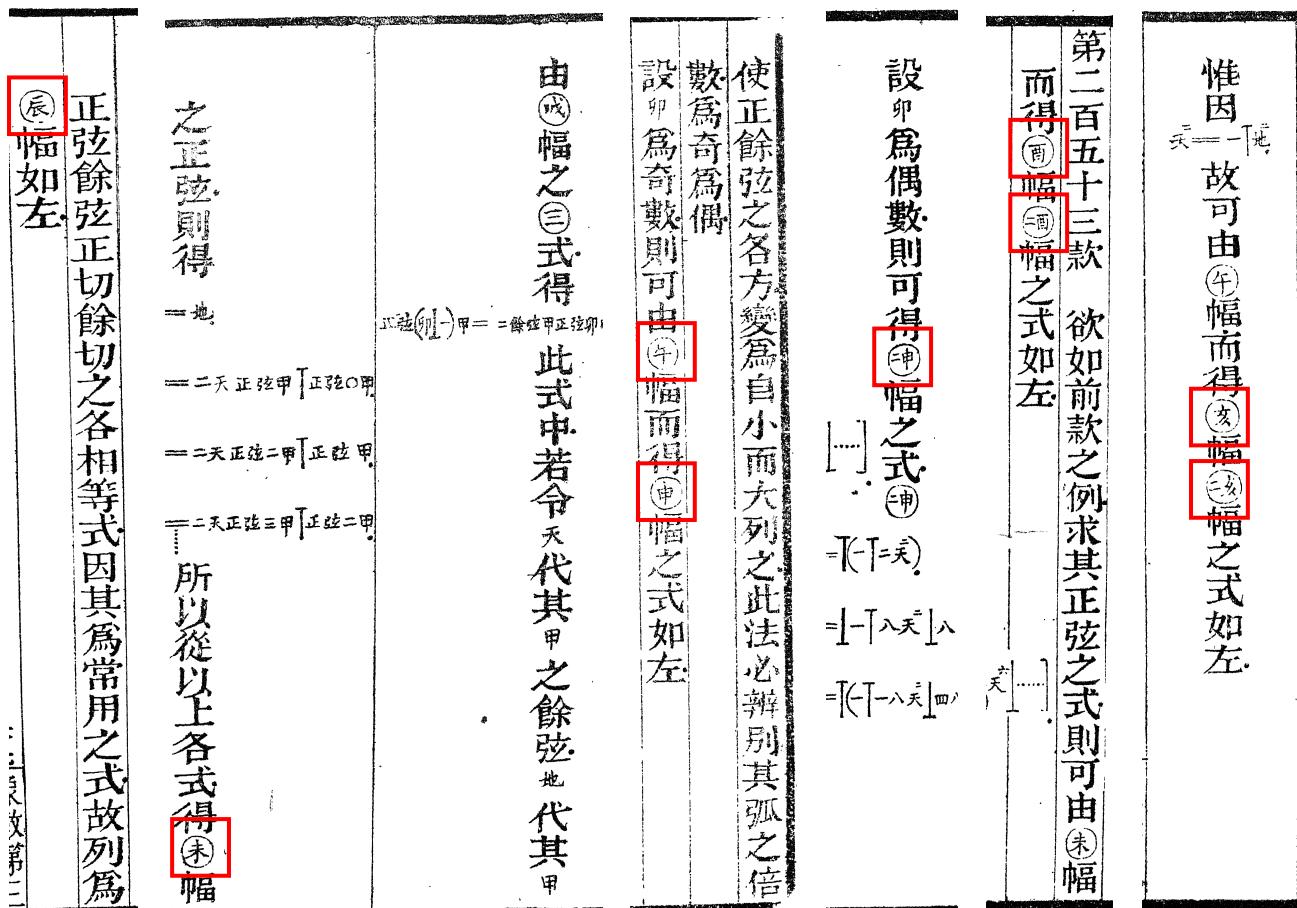
Figure 13. Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.24 p.27, p.29, p.31, p.32, p.33, p.34 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊐, ㊓, ㊌, ㊒, ㊒, ㊏, ㊏, ㊑ and ㊑ in text.
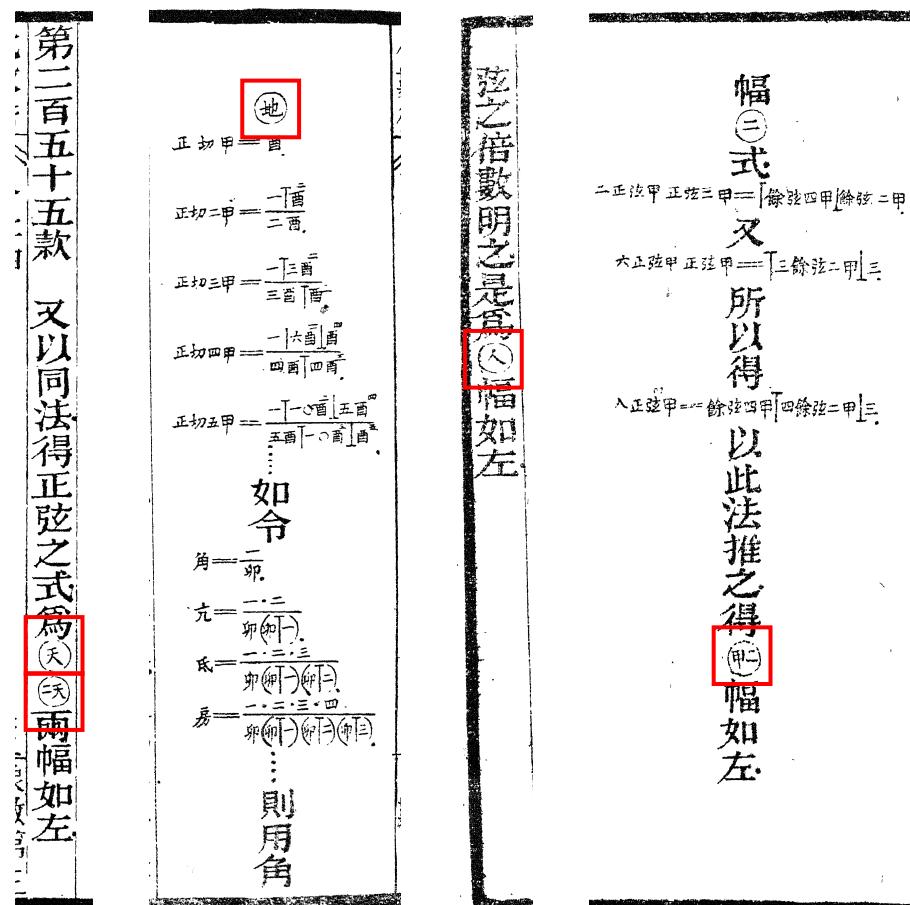
Figure 14. Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.24 p.35, p.37, p.39, p.40 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊍, ㊍, ㊔, ㊋ and ㊐ in text.
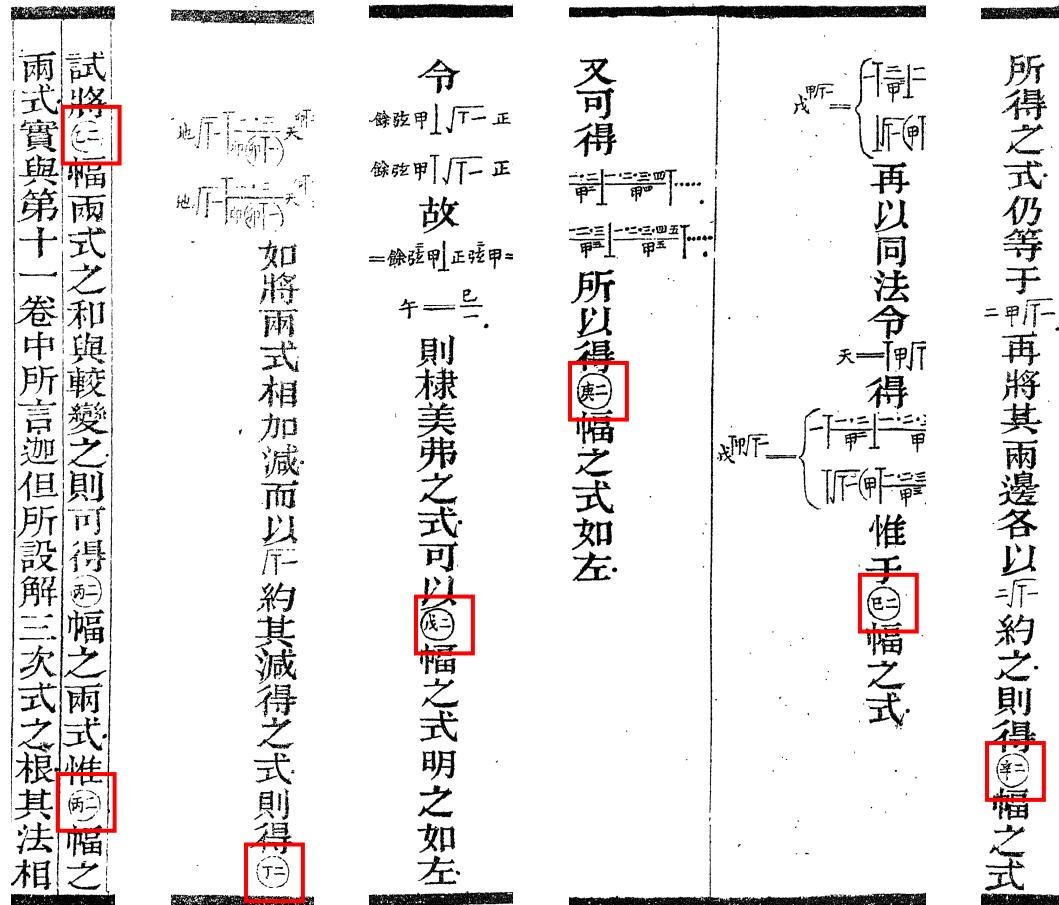
Figure 15. Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.25 p.6, p.7, p.8, p.17, p.19 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊋, ㊎, ㊉, ㊍, ㊌, ㊏ and ㊐ in text.
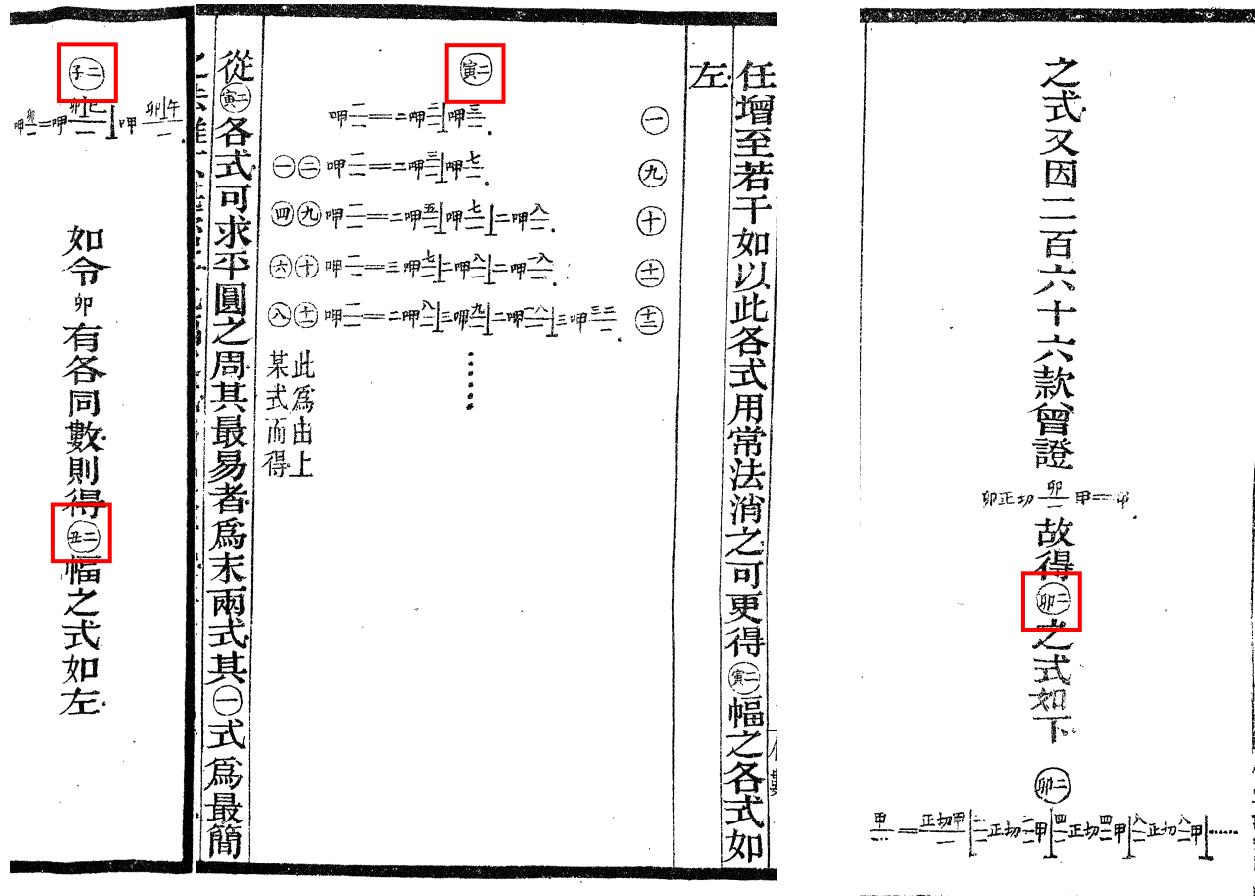
Figure 16. Example from Hua Hengfang's (華蘅芳) book *Daishushu* (代數術) vol.25 p.22, p.25 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊒, ㊓, ㊔ and ㊕ in text.

如乙法二乘寅實五得一十則一當在卯位也甲法一乘寅實五
得五五乃零數當在下位之下故亦在卯位上也蓋以寅為本位
之時則卯為下位之下也以丑為本位之時寅為下位
卯為下位之下也

因乘定位法

數㊉遞日以法首齊實首布列甲子同位乙丑同位從丑下一位
式三百六十五人每人一十二兩共得四三八問四為何數曰千
呼實首百為百矣向左推去丑為千位
四為千也但法未必單數乃可如今變後之首在丑即知
是也若一兩二錢或一百二十兩則不同矣總
以單數為率下則順推上則逆推可耳⊗而通

卯	寅	丑	子
變	五	六	三
八	後	四	甲一
	三	乙二㊉	

曰視得數之首在實之何位上今在實之十位上又視法有幾位

Figure 17. Example from Fang Zhongtong's (方中通) book *Zhusuan* (珠算) p.5
(Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ㊙, ⊗ and ㊉ in text.

Figure 18. Example from Zeng Jihong's (曾紀鴻) book *Yuanlü Kaozhen Tujie* (圓率攷眞圖解) p.13
(Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ⓪, 囸, 六 and 九 in text.
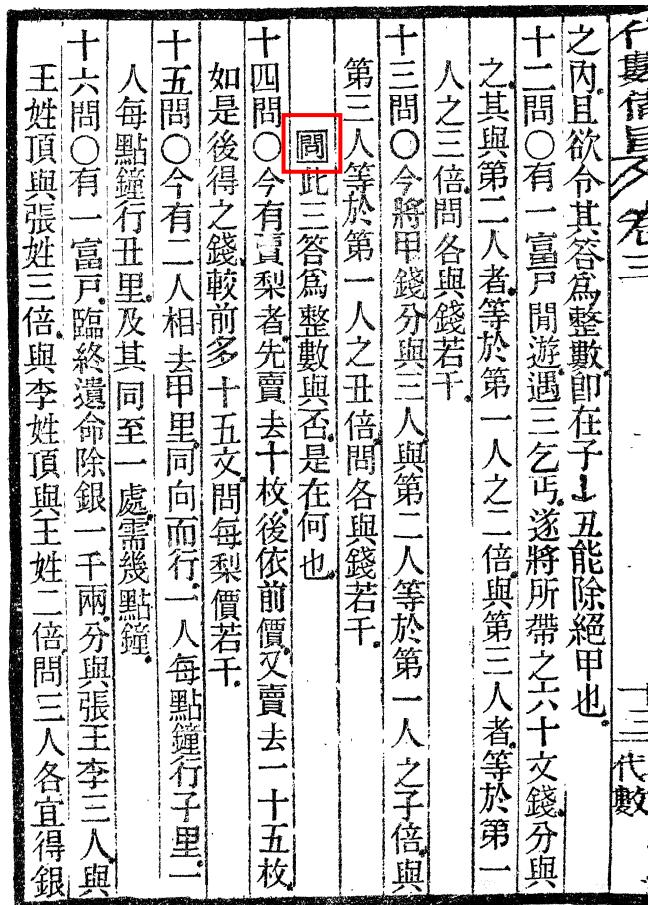
Figure 19. Example from Zou Liwen's (鄒立文) book *Daishu Beizhi* (代數備旨) vol.3 p.13 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 圖 in text.
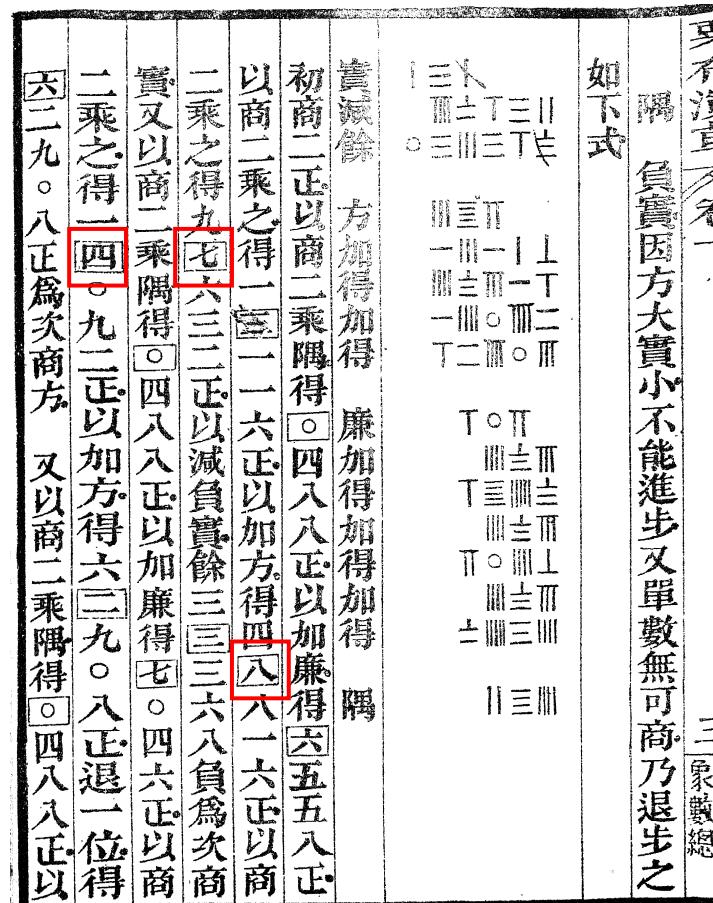
Figure 20. Example from Zeng Jihong's (曾紀鴻) book *Subu Yancao* (粟布演草) vol.1 p.3 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 四, 七 and 八 in text.
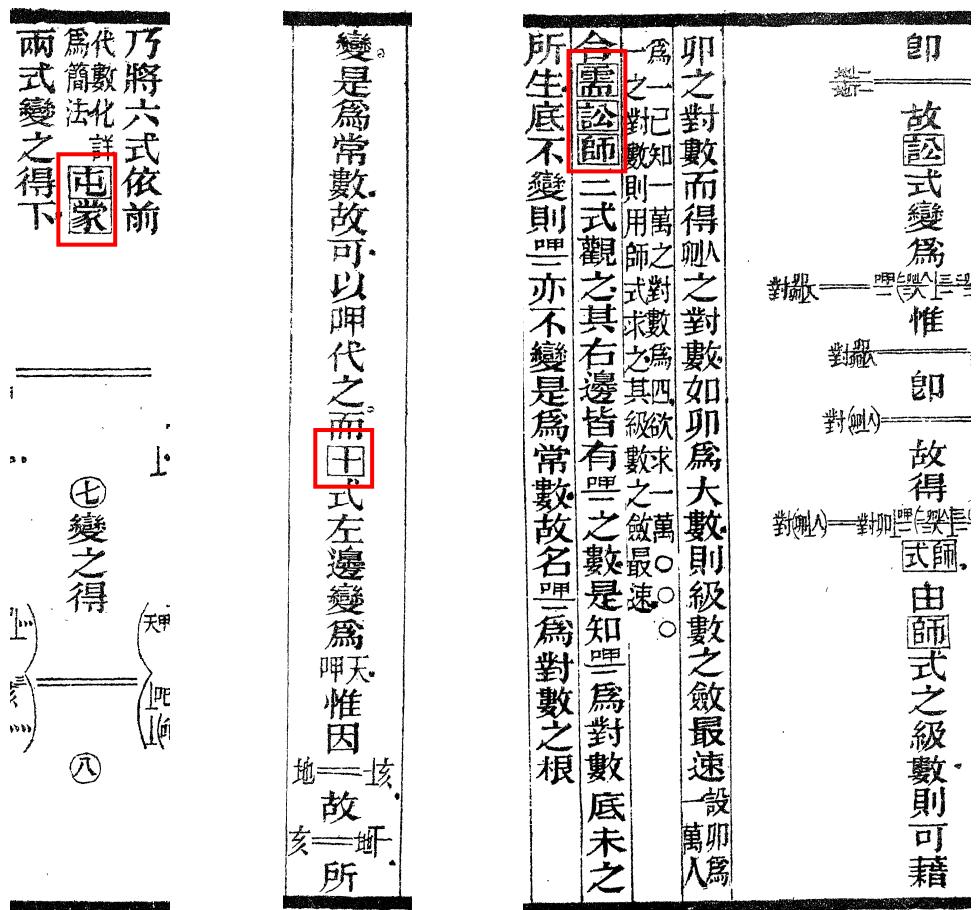
Figure 21. Example from Zeng Jihong's (曾紀鴻) book *Duishu Xiangjie* (對數詳解) vol.2 p.7, p.8 and p.10 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 屯, 蒙, 田, 需, 訟 and 師 in text.
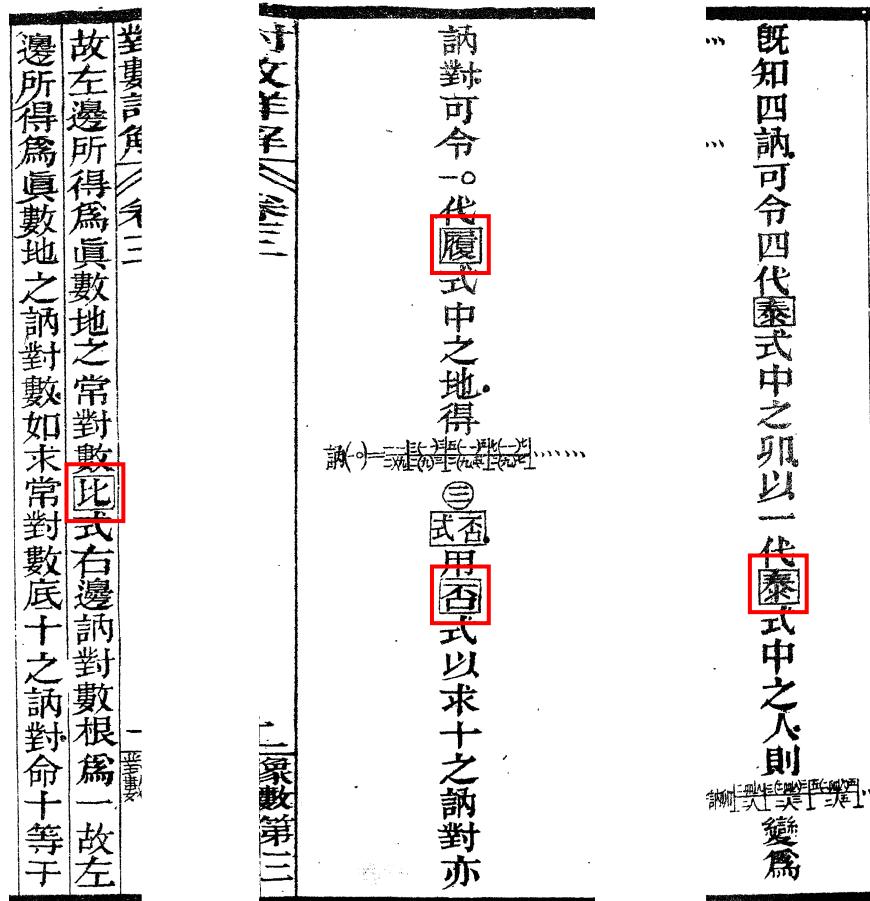
Figure 22. Example from Zeng Jihong's (曾紀鴻) book *Duishu Xiangjie* (對數詳解) vol.3 p.1, p.2 and p.3 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 比, 履, 否 and 泰 in text.
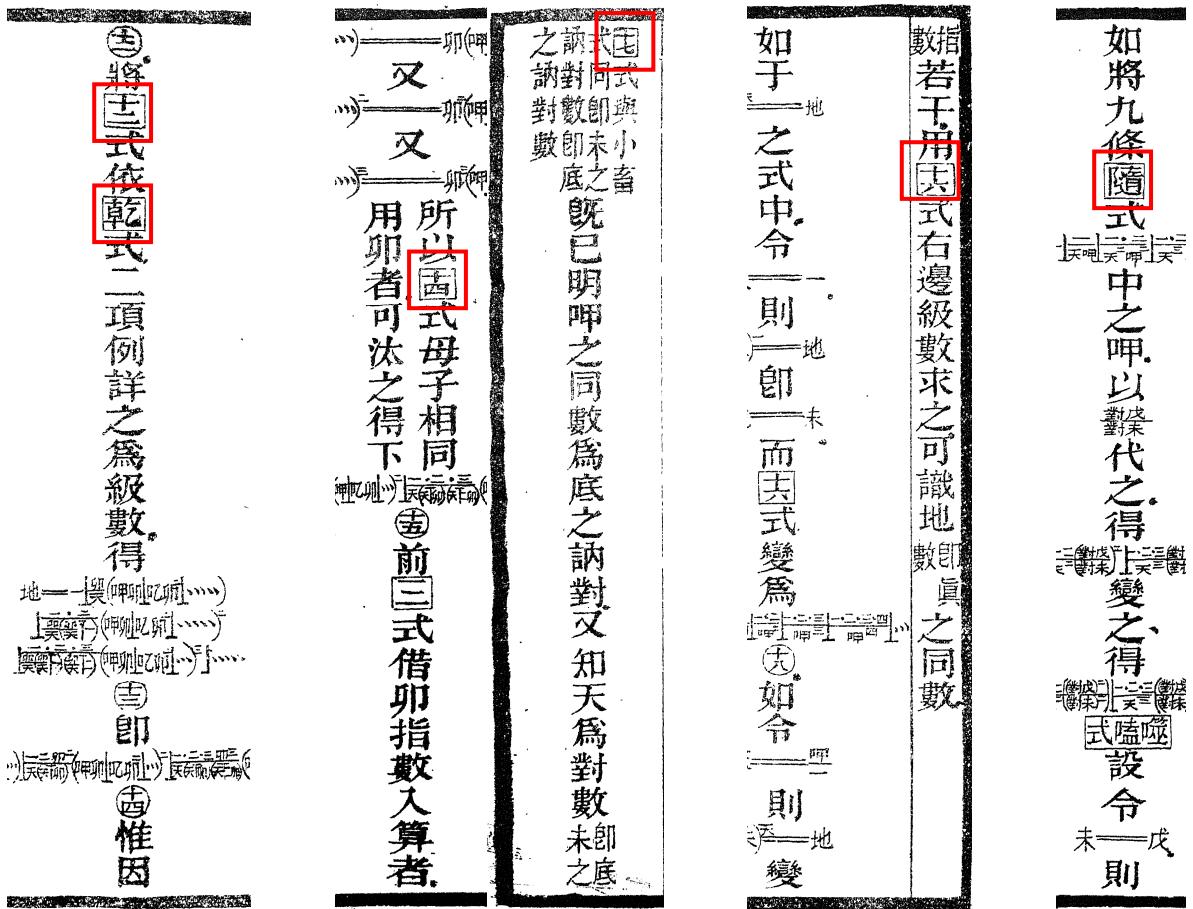
Figure 23. Example from Zeng Jihong's (曾紀鴻) book *Duishu Xiangjie* (對數詳解) vol.4 p.2, p.3, p.4 and p.6 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing 𡆼, 𡇙, 𡆵, 𡅞, 乾 and 𡇈 in text.

Figure 24. Example from Alexander Wylie and Li Shanlan's (李善蘭) book *Daiweiji Shiji Zhu* (代微積拾級注) vol.1 p.10 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ⌞, ⊤, and ╪ in text.
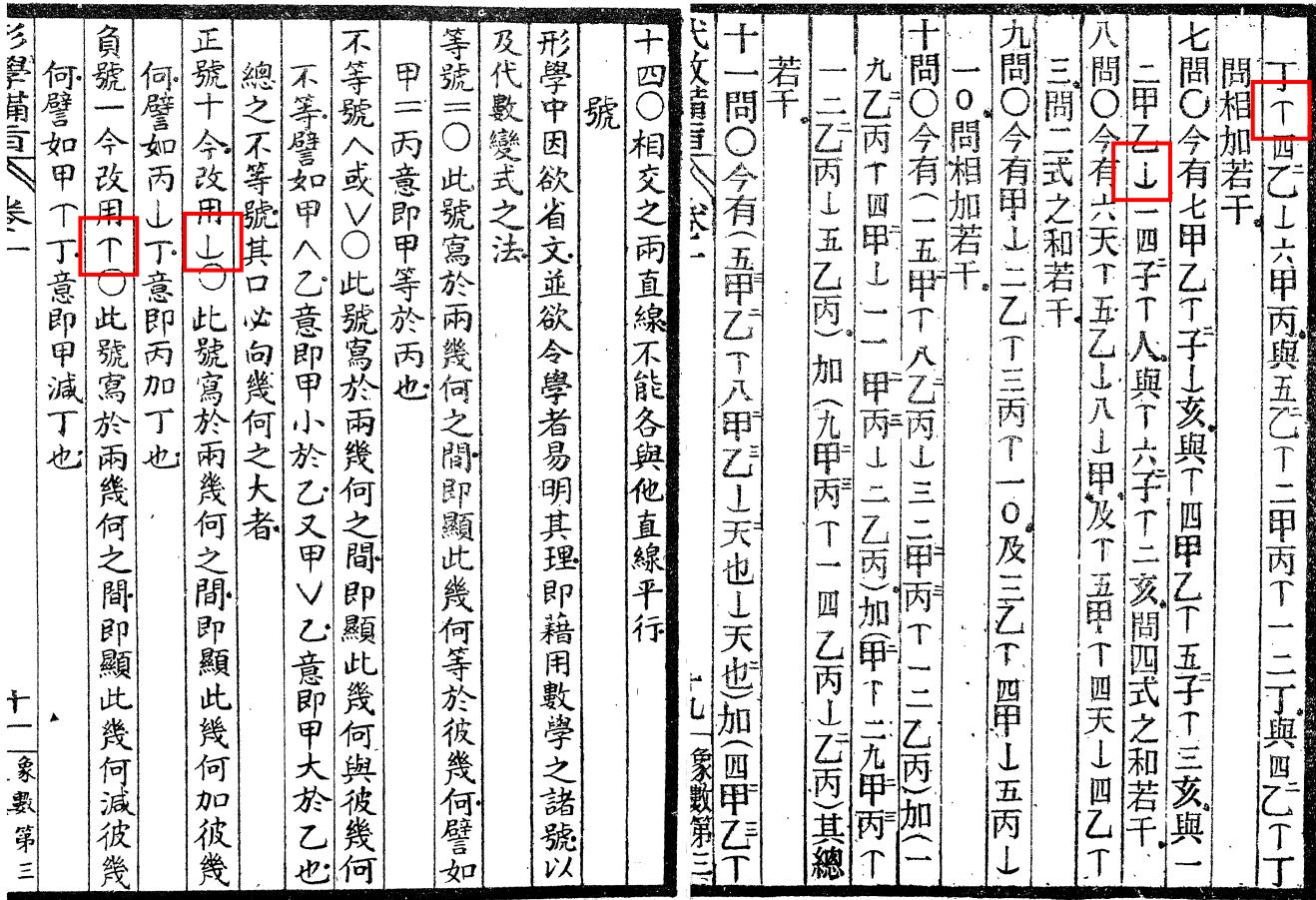
Figure 25. Example from Zou Liwen's (鄒立文) book *Xingxue Beizhi* (形學備旨) vol.1 p.11 and *Daishu Beizhi* (代數備旨) vol.1 p.19 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ↓ and ↑ in text.
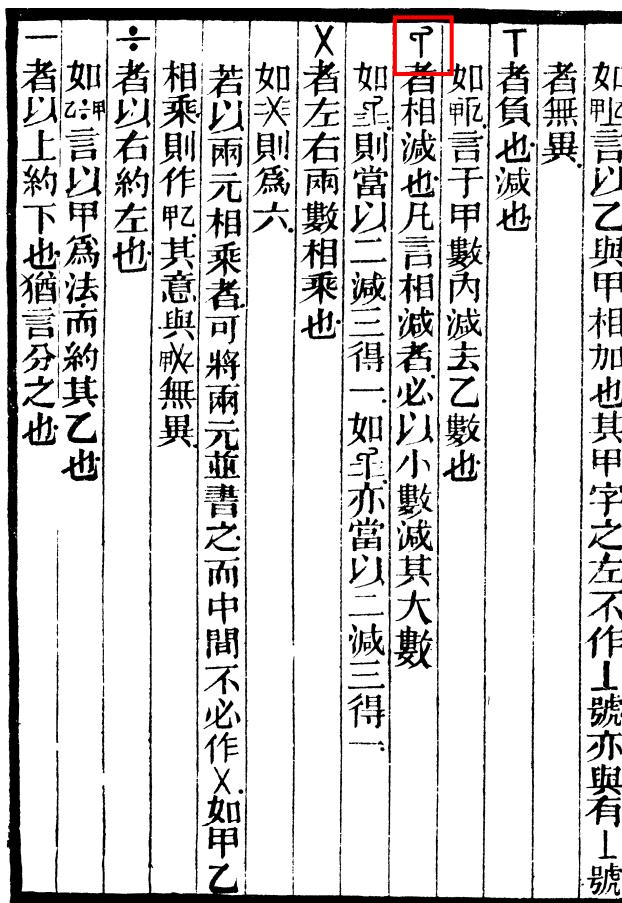
Figure 26. Example from Hua Hengfang's (華蘅芳) book *Xuesuan Bitan* (學算筆談) vol.8 p.1 (Shanghai: Arithmetic Publishing House (算学书局), 1898), showing ⼂ in text.
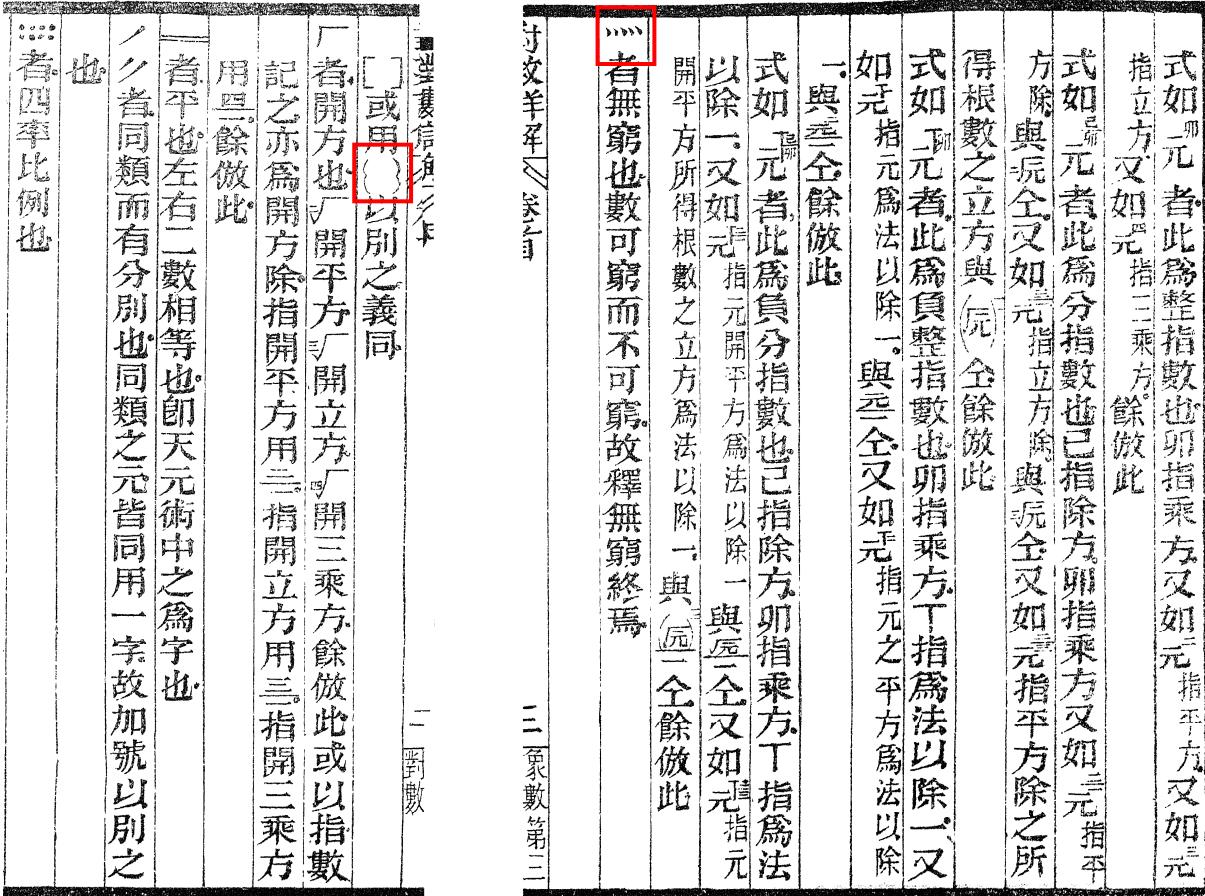
Figure 27. Example from Zeng Jihong's (曾紀鴻) book *Duishu Xiangjie* (對數詳解) vol.1 p.2 and p.3 (Shanghai: Arithmetic Publishing House (算學書局), 1898), showing ⸨, ⸩ and ⌢ in text.
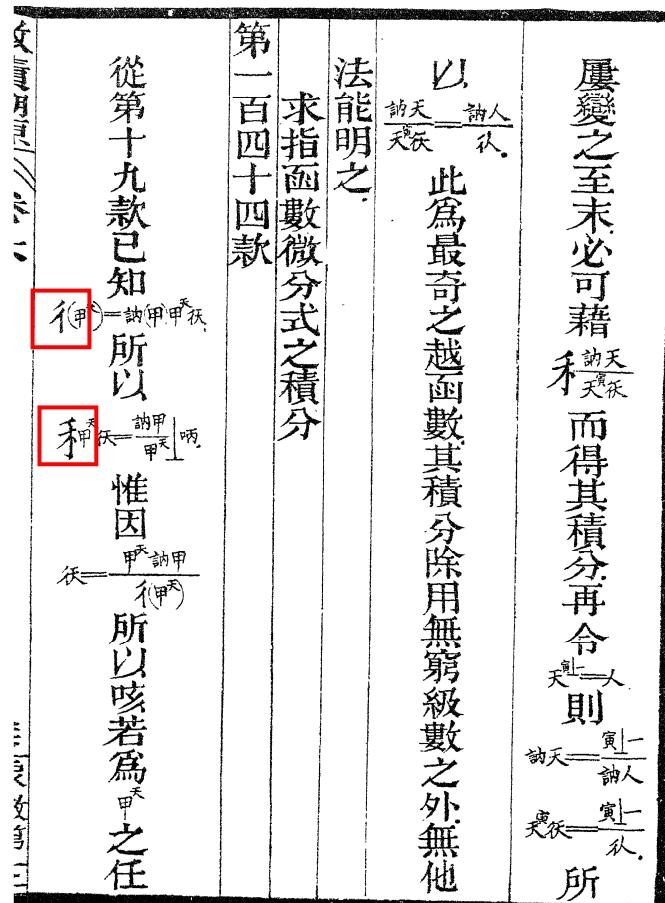

Figure 28. Example from Hua Hengfang's (華蘅芳) book *Weiji Suyuan* (微積溯源) vol.6 p.36 (Shanghai: Arithmetic Publishing House (算學書局), 1898), showing and in text.