of decently-dressed natives of both sexes regularly attend divine service" at the mission stations. These number five or six, and are supported by the United Presbyterian Church of Scotland, which began its labours here in 1846.

The predominant language, not only among the people of Calabar proper, but also of the various tribes on both sides of the Cross River, is Efik, which bids fair to be the common commercial speech of the whole district. It is really a modified Ibibio, and presents traces of what is known as alliterative concord, though this is by no means a universal characteristic. It has been reduced to writing by the missionaries, who have employed the ordinary English alphabet. Considerable progress has been made in the formation of an initiatory literature; no fewer than 65 volumes having proceeded from the mission press. Most important of these are the Efik translation of the New Testament by H. Goldie (1862), the translation of the Old Testament by Dr A. Robb (1868), and a Dictionary of the Efik by H. Goldie, published in 1862. Captain James Broom Walker of Duke Town, who has explored various parts of the country, presented several charts to the Royal Geographical Society, which are reproduced in the *United Presbyterian Missionary Record* for 1872 and 1875.

See Hope M. Waddell, *Twenty-nine Years in the West Indies and Central Africa*, 1866; "Details of Explorations of the Old Calabar River," by Captain Becroft in *Journ. Roy. Geogr. Soc.*, 1844; W. Nicholas Thomas in *Proceed. of Roy. Geogr. Soc.* on "The Oil Rivers of West Africa," 1873.

CALABAR BEAN, the seed of a leguminous plant, *Physostigma venenosum*, a native of tropical Africa. The plant has a climbing habit like the scarlet runner, and attains a height of about 50 feet, with a stem an inch or two in thickness. The seed pods, which contain two or three seeds or beans, are 6 or 7 inches in length; and the beans are about the size of an ordinary horse bean but much thicker, with a deep chocolate brown colour They constitute the E-ser-e or ordeal beans of the negroes of Old Calabar, being administered to persons accused of witchcraft or other crimes. In cases where the poisonous material did its deadly work it was held at once to indicate and rightly to punish guilt; but when it was rejected by the stomach of the accused, innocence was held to be satisfactorily established. A form of duelling with the seeds is also known among the natives, in which the two opponents divide a bean, each eating one-half; that quantity has been known to kill both adversaries. Although thus highly poisonous, the bean has nothing in external aspect, taste, or smell to distinguish it from any harmless leguminous seed, and very disastrous effects have resulted from its being incautiously left in the way of children. The beans were first introduced into England in the year 1840; but the plant was not accurately described till 1861, and its physiological effects were investigated in 1863 by Dr Thomas R. Fraser. In that year an alkaloid was isolated from the seeds to which the name physostigmine was applied; and under the name eserine another alkaloid was prepared from them; but it is not yet quite certain that the two substances are essentially different. Dr Fraser's investigations, which were conducted with an alcoholic extract of the seeds, showed that the active principles exerted a remarkable influence in contracting the pupil of the eye, and in counteracting the influence of atropine. The antagonism of physostigmine and atropine and its relations to many other alkaloids have subsequently been the subject of very numerous investigations. A committee of the British Medical Association under Professor Hughes Bennett found that the antagonism between sulphate of atropine and extract of Calabar bean exists only within narrow limits, so that for practical purposes atropine is useless as an antidote to Calabar bean. The investigation of the same committee into the relations of hydrate of chloral and Calabar bean, however, proves that they are mutually antagonistic, but as the toxic influence of the Calabar bean is very rapid, it is necessary to administer the chloral as soon as possible after the Calabar bean is taken. Calabar bean in the form of powder and extract is used in medical practice. It has been chiefly employed by ophthalmists to produce contraction of the pupil, but it is also used in tetanus, neuralgia, and rheumatic diseases.

CALABOZO, or CALABOSO, a town of Venezuela, formerly capital of the province of Caracas, but now of that of Guarico, is situated 120 miles S.S.W. of the city of Caracas on the left bank of the River Guarico. It lies so low that during the rainy season it is frequently surrounded by the floods; and in the summer it is exposed to extreme heat, the average temperature being 88° Fahr. It is well built, with streets running at right angles, and it has several fine churches, a college, and public schools. Its situation on the main road from Aragua to Apure makes it the seat of a considerable trade; and the surrounding country affords extensive pasture for cattle. There are thermal springs in the neighbourhood. Originally a small Indian village, Calabozo owes its existence as a town to the Compania Guipuzcoana, who made it the seat of one of their mercantile stations in the beginning of the 18th century. In 1820 it was the scene of a battle in which Bolivar and Paez beat the Spanish general Morales. Population in 1873, 5618.

CALABRIA, the name given by the Romans to the peninsula at the south-eastern extremity of Italy, and now given to the peninsula at the south-western extremity. The former district was called by the Greeks Iapygia and Messapia, though these terms were variously used, and sometimes also included all the south-east of Italy, from Lucania to the Garganian promontory. In the time of Augustus, Calabria was the district south and east of a line drawn from the neighbourhood of Tarentum to that of Brundisium, corresponding to the modern Terra d' Otranto. The principal cities were Tarentum (Taranto), Brundisium (Brindisi), and Hydruntum (Otranto), all of which are ports. The inhabitants were Sallentines and Calabrians or Messapians, both probably of Pre-Hellenic or Pelasgic race; Niebuhr, however, considered the Calabrians to be Oscan intruders distinct from the other tribes.

Ancient Calabria was a country of low hills with very gentle ascents, having a soil of Tertiary limestone formation, no rivers, and scarcely any small streams, and, during summer, a climate of intolerable heat, but exceedingly fertile, producing the olive and vine.

Owing to its position Calabria was long defended by the Greeks against the Goths, Lombards, and Saracens, and was the last portion of Italy lost by the Byzantine emperors. In the time of the Norman monarchy, in the 11th century, there took place a curious change in the application of the name, the cause and exact date of which are not known with any certainty. An explanation possessing some probability is, however, given. The Byzantines, it is likely, extended the name Calabria to all their possessions in Southern Italy; and when their possessions in the south-eastern peninsula became greatly inferior in importance to that in the south-western (Bruttium) they applied the name to the latter instead of the former. It was not, however, till after the Norman Conquest that the name was universally employed in this the modern sense.

In modern times Calabria, until the consolidation of the Italian kingdom, was the name of one of the four provinces into which the continental part of the kingdom of Naples, or of the Two Sicilies, was formerly divided; and it is now the name given to three out of the sixty-nine provinces of the present division of Italy. It is the most southern part of Italy, being bounded on the N. by the province of Basilicata, on the E. by the Gulf of Taranto, on the W. by the Tyrrhenian Sea, and on the S. by the Ionian. It extends from Cape Spartivento (37° 56′ N. lat.) to Monte Pollino on the southern border of Basilicata (40° 0′ N. lat.)

The territory is well watered, and exceedingly rugged and mountainous; but the summits of the hills are covered with extensive forests of oak, beech, elm, and pine, and towards the coast the branches of the Apennines open up into fertile valleys. Earthquakes and violent storms are very common; and there is extreme heat during the summer season, on the approach of which the wealthier inhabitants migrate annually to the lofty table-land of La Sila, where their flocks are fattened in the extensive pastures. The agriculture of Calabria is in a very rude and barbarous condition, a circumstance which is partly attributable to the extreme fertility of the soil. The principal productions are corn, wine, raw silk, olive oil of an inferior quality, cotton, rice, liquorice, and saffron. Manna, collected from the manna-ash (*Ornus rotundifolia*), was at one time a somewhat important article of commerce; but very little is now collected. Oranges, lemons, figs, mulberries, honey, and tobacco are also produced. The horses of Calabria are remarkable for their high spirit and compact form. There are considerable fisheries of the tunny, the swordfish, the anchovy, and mullet.

The three provinces into which Calabria is now divided are Calabria Citeriore, Calabria Ulteriore Seconda, and Calabria Ulteriore Prima.

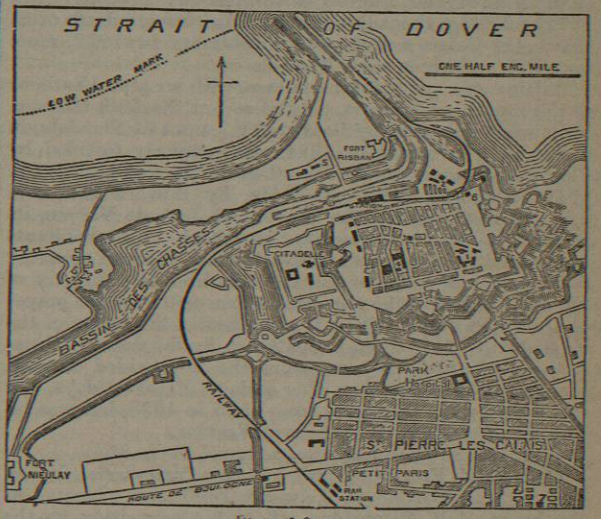
Calabria Citeriore, or Cosenza, is the most northern of the three provinces, and has an area of 2613 square miles, with a population in 1871 of 440,468. The southern and central districts are covered by the vast forests of La Sila, which furnished timber for the navies of antiquity. The principal rivers are the Crati, which after a course of 60 miles falls into the Gulf of Taranto, and the Neto, which rises in the heart of La Sila, and falls into the Adriatic. The principal towns are Cosenza, Rossano, Paola, and Castrovillari.

Calabria Ulteriore Seconda, or Catanzaro, on the south of Calabria Citra, having a coast line from the Punta dell' Alice to the Callipari on the east, and from the Savuto to the mouth of the Messina on the west, has an area of 2100 square miles. Population (1871) 412,226. At Catanzaro is a manufactory of silk; at Maida there are some seams of coal, antimony, and alabaster, which might be made available for exports. The principal towns are Catanzaro, Cotrone, Nicastro, and Monteleone.

Calabria Ulteriore Prima, or Reggio, the most southerly province of Italy, contains an area of 1250 square miles, with a population (1871) of 353,608. On the northern frontier are the mines of Lo Stilo, from which the iron is obtained for the Government foundries. The principal towns are Reggio, Gerace, and Palmi. A railway line now runs from Reggio to Taranto, along the coast of the Ionian Sea and the Gulf of Taranto.

CALAHORRA, the capital of the judicial district and diocese of the same name, in the province of Logroño, Spain, 24 miles S.E. of Logroño, in 42° 12′ N. lat., 2° 0′ W. long. It occupies an elevated site on the left bank of the River Cidacos, near its junction with the Ebro, and contains a cathedral in the mixed Gothic style, dating mainly from the 15th century, an episcopal palace, and several conventual and other schools. The climate is cold and damp, but the soil in the neighbourhood produces in abundance grain, pulse, flax, wine, and oil. Population in 1860, 7106. Calahorra is the ancient *Calagurris Nassica*, celebrated for its extraordinary fidelity to Sertorius in his war with Pompey and Metellus; and in the suburbs may still be traced the remains of an ancient Roman circus, an aqueduct, and a naumachia. Under the empire it was a municipium, and enjoyed the rights of Roman citizenship. It was the birthplace of Quintilian.

CALAIS, a town of France, capital of a canton of the same name, in the arrondissement of Boulogne and the department of Pas de Calais, 26 miles E.S.E. of Dover, and 185 miles by rail from Paris, in 50° 57′ 45″ N. lat., 1° 51′ E. long. Calais is a fortress of the first class, and was formerly a place of great strength, but it would now probably not be able to defend itself long against modern artillery. It is built in a rectangular form, having one of its longer sides towards the sea, while on the E. and S. it is surrounded by low and marshy ground which can be flooded to strengthen its defences. Overlooking the town on the W. is the citadel, erected in 1641 by Cardinal Richelieu. In the centre of the town is the great market-place, in which stands the Hôtel de Ville (rebuilt in 1740, restored in 1867), with busts of Eustache de St Pierre, the Duc de Guise, and Cardinal Richelieu. Near the Hôtel de Ville is the *Tour du guet*, or watch-tower, used as a lighthouse until 1848. The Church of Nôtre Dame was almost entirely rebuilt at the end of the 15th century, during the English occupancy of Calais; its lofty tower serves as a landmark for sailors. At the end of the Rue de la Prison is the Hôtel de Guise, built as a guildhall for the English woolstaplers. It was given to the Duc de Guise as a reward for the recapture of Calais, and hence its name. The building which was formerly the Hôtel Dessin, immortalized by Sterne in the *Sentimental Journey*, is now used as a museum. The harbour of Calais is shallow, admitting vessels of from 400 to 500 tons only at high water. The French Government contemplates the construction of a large harbour of refuge near Calais. There are two lighthouses at the entrance to the harbour, and a still larger one on the fortifications, with a revolving light visible 20 miles off. The principal institutions are the schools of design, hydrography, and artillery, a public library with 10,000 volumes, and public baths. The imports are chiefly from Great Britain, and consist of coal, iron, woollen and cotton fabrics, linen, skins, machinery, and colonial produce. Of late years the importation of timber



Plan of Calais

1. Church of Nôtre-Dame.
2. Church of the Courgain.
3. Hotel de Ville and Place de l'Armée.
4. Museum and Theatre.
5. Bathing establishment.
6. Lighthouse.
7. Hotel de Ville de St Pierre les Calais.

from Norway has greatly increased. The exports comprise corn, wine and spirits, eggs, silk, fruit, vegetables, glass, and sugar. The fisheries are much less important than those of Boulogne. The manufacture of *tulle* or bobbin-net was introduced from Nottingham by the English in 1818, and is one of the main sources of the prosperity of the town and suburbs. Calais communicates with Great Britain by submarine telegraph, laid down in 1851. Steamers carrying the mails cross twice a day to Dover and back. It is the principal landing-place for English travellers on the Continent. The number of passengers who crossed both ways was 208,432 in 1875, being an increase of 66 per cent. in the last ten years. The terminus of the proposed tunnel beneath the channel is near Sangatte, a village six miles west of Calais. The project has received the sanction of the French and English Governments. Population (in 1872) 12,843 ; the adjoining manufacturing suburb of St Pierre les Calais had 20,409 inhabitants in 1872, more than 1800 of whom were English.

Calais was a petty fishing-village, with a natural harbour at the mouth of a stream, till the end of the 10th century. It was first improved by Baldwin IV., count of Flanders, in 997, and afterwards, in 1224, was regularly fortified by Phillip of France, count of Boulogne. It was besieged in 1346, after the battle of Crécy, by Edward III., and held out resolutely by the bravery of Jean de Vienne, its governor, till famine forced it to surrender. Its inhabitants were saved from the cruel fate with which Edward menaced them by the devotion of Eustache de St Pierre and six of the chief citizens, who were themselves spared at the prayer of Queen Philippa. The city remained in the hands of the English till 1558, when it was taken by the duke of Guise at the head of 30,000 men, from the ill-provided English garrison only 800 strong, after a siege of seven days. It was held by the Spaniards from 1595 to 1598, but was restored to France by the treaty of Vervins.

CALAMIS. See Archæology, vol. ii. p. 354.

CALAMY, Edmund (1600–1666), a Presbyterian divine, was born at London in February 1600, and educated at Pembroke Hall, Cambridge, where his opposition to the Arminian party, then powerful in that society, excluded him from a fellowship. Dr Felton, bishop of Ely, however, made him his chaplain, and gave him a living which he held till 1626. He then removed to Bury St Edmunds, where he acted as lecturer for ten years. In 1636 he was appointed to the rectory of Rochford in Essex, which was so unhealthy that he had soon to leave it; and in 1639 he was chosen minister of St Mary Aldermanbury in London. Upon the opening of the Long Parliament he distinguished himself in defence of the Presbyterian cause, and had a principal share in writing the work commonly known under the appellation *Smectymnuus*, against Episcopacy. The initials of the names of the several contributors formed the name under which it was published, viz., S. Marshal, E. Calamy, T. Young, M. Newcomen, and W. Spurstow. Calamy was afterwards an active member in the assembly of divines, and a strenuous opposer of sectaries. In Cromwell's time he lived privately, but was assiduous in promoting the king's return; for this he was afterwards offered a bishopric, but declined it. He was, however, made one of Charles's chaplains. He was ejected for nonconformity in 1662, and was so affected by the sight of the devastation caused by the great fire of London, that he died shortly afterwards, October 29, 1666.

CALAMY, Edmund (1671–1732), grandson of the preceding, was born in London, April 5, 1671. He was educated at a private academy, and studied at the university of Utrecht. While there, he declined an offer of a professor's chair in the university of Edinburgh made to him by Principal Carstairs, who had gone over on purpose to find a person properly qualified for such an office. After his return to England in 1691 he began to study divinity; and having joined the Nonconformists, he was in 1692 unanimously chosen assistant to Matthew Sylvester at Blackfriars. In 1694 he was ordained at Annesley's meeting-house in Little St Helen's, and soon afterwards was invited to become assistant to Daniel Williams in Hand-Alley. In 1702 he was chosen one of the lecturers in Salters' Hall, and in 1703 he succeeded Vincent Alsop as pastor of a large congregation in Westminster. He drew up the table of contents to *Baxter's History of his Life and Times*, which was sent to the press in 1696 ; made some remarks on the work itself, and added to it an index ; and, reflecting on the usefulness of the book, he saw the expediency of continuing it, as Baxter's history came no farther than the year 1684. Accordingly, he composed an abridgment of it, with an account of many other ministers who were ejected after the restoration of Charles II. ; their apology, containing the grounds of their nonconformity and practice as to stated and occasional communion with the Church of England ; and a continuation of their history until the year 1691. This work was published in 1702. He afterwards published a moderate defence of nonconformity, in three tracts, in answer to some tracts of Dr Hoadly. In 1709 Calamy made a tour to Scotland, and had the degree of doctor of divinity conferred on him by the universities of Edinburgh, Aberdeen, and Glasgow. In 1713 he published a second edition of his *Abridgment of Baxter's History of his Life and Times*, in which, among various additions, there is a continuation of the history through the reigns of William and Anne, down to the passing of the Occasional Bill. At the end is subjoined the reformed liturgy, which was drawn up and presented to the bishops in 1661. In 1718 he wrote a vindication of his grandfather and several other persons against certain reflections cast upon them by Archdeacon Echard in his History of England ; and in 1728 appeared his continuation of the account of the ministers, lecturers, masters, and fellows of colleges, and schoolmasters, who were ejected, after the Restoration in 1660, by or before the Act of Uniformity. He died June 3, 1732. Besides the pieces already mentioned, he published many occasional sermons.

CALAS, Jean (1698–1762), a Protestant merchant at Toulouse, who was barbarously murdered under forms of law which were employed to shelter the sanguinary dictates of ignorant and fanatical zeal. He was born at La Caparède, in Languedoc, in 1698, and had lived forty years at Toulouse. His wife was an Englishwoman of French extraction. They had three sons and three daughters. His son Louis had embraced the Roman Catholic faith through the persuasions of a female domestic who had lived thirty years in the family. In October 1761 the family consisted of Calas, his wife, Marc-Antoine their son, who had been educated for the bar, Pierre their second son, and this domestic. Antoine being of a melancholy turn of mind, was continually dwelling on passages from authors on the subject of suicide, and one night in that month he hanged himself in his father's warehouse. The crowd, which collected on so shocking a discovery, took up the idea that he had been strangled by the family to prevent him from changing his religion, and that this was a common practice among Protestants. The officers of justice adopted the popular tale, and were supplied by the mob with what they accepted as conclusive evidence of the fact. The fraternity of White Penitents buried the body with great ceremony, and performed a solemn service for the deceased as a martyr; the Franciscans followed their example; and these formalities led to the popular belief in the guilt of the unhappy family.

Being all condemned to the rack in order to extort confession, they appealed to the parliament ; but this body, being as weak as the subordinate magistrates, sentenced the father to the torture, ordinary and extraordinary, to be broken alive upon the wheel, and then to be burnt to ashes ; which diabolical decree was carried into execution on the 9th of March 1762. Pierre Calas, the surviving son, was banished for life ; the rest were acquitted. The distracted widow, however, found some friends, and among them Voltaire, who laid her case before the council of state at Versailles ; and the parliament of Toulouse was ordered to transmit the proceedings. These the king and council unanimously agreed to annul ; the chief magistrate of Toulouse was degraded and fined ; old Calas was declared to have been innocent ; and every imputation of guilt was removed from the family. See *Causes Célèbres*, tom. iv.

CALASIO, Mario de (1550–1620), a Franciscan, and professor of the Hebrew language at Rome, was born in 1550 at a small town in Abruzzo, from which he took his name. His *Concordance of the Bible* (which occupied him forty years) was published at Rome in 1621, the year after his death. This work has been highly approved and commended both by Protestants and Roman Catholics, and is indeed an admirable work ; for, besides the Hebrew words of the Bible, which compose the body of the book, with the Latin version over against them, there are in the margin the differences between the Septuagint version and the Vulgate ; so that at one view may be seen wherein the three Bibles agree, and wherein they differ. At the beginning of every article there is a kind of dictionary, which gives the signification of each Hebrew word, affords an opportunity of comparing it with other Oriental languages (Syriac, Arabic, and Chaldee), and is extremely useful for determining more exactly the true meaning of the Hebrew words. It has been several times reprinted ; but the original edition is the best.

CALATAFIMI, a town of Sicily, in the province of Trapani and district of Alcamo, about 30 miles from Palermo. It lies between two hills in a fine corn country, and is celebrated for its cattle and its cheese. In one of its churches, Santa Croce, there is a fine altar of mosaic work ; and in the neighbourhood are the extensive and well-preserved ruins of Segesta. On the hill above the town stands the Saracenic castle of Kalat-al-Fimi, from which it derives its name, and about four miles distant is the battle-field on which Garibaldi won his first victory over the Neapolitans on May 15, 1860. Population, 9414.

CALATAYUD, a town of Spain, in the province of Saragossa in Aragon, 45 miles S.W. of the city of that name, in 41° 24′ N. lat., 1° 35′ W. long. It stands on the left bank of the River Jalon, near its confluence with the Jiloca, partly on the plain and partly on a rocky slope, which is covered with remains of ancient Moorish fortifications. It is generally spacious and well built, and contains several squares, the largest of which is used as the market-place, numerous convents, three hospitals, a fort, a provincial and municipal hall, an episcopal palace, a college, barracks, a theatre, and a bull-arena ; there are also two *collegiatas*, or collegiate churches, both of them handsome edifices, and eleven other parish churches. The principal articles of manufacture are coarse brown paper, leather, and woollen stuffs. The soil of the neighbourhood is fertile and well cultivated. Calatayud is a Moorish city, and receives its name (Job's Castle) from Job the nephew of Musa ; but it stands near the site of the ancient *Bilbilis*, the birthplace of the poet Martial, and was for the most part built out of its ruins. Population, 9830.

CALCAR, or Kalcker, John de (1499–1546), an eminent painter, born at Calcar, in the duchy of Clèves, in 1499. He was a disciple of Titian at Venice, and perfected himself by studying Raffaelle. He imitated those masters with such success as to deceive the most skilful critics. Among his various pieces is a Nativity, representing the angels around the infant Christ, which he arranged so that the light emanated wholly from the child. He died at Naples in 1546.

CALC-SPAR, or Calcareous Spar, is the popular name for certain of the crystalline forms of carbonate of lime or calcite ($CaCO_3$), containing in 100 parts 56 of lime and 44 of carbonic acid. The name includes only the varieties of calcite which belong to the rhombohedral or hexagonal order, to the exclusion of aragonite, which, having the same composition, belongs to the rhombic or right prismatic system, the two minerals forming a striking example of dimorphism. Calc-spar is also the same in chemical composition as marble, limestone, chalk, stalagmitic deposits, &c., which are among the most abundant ingredients in the rocky masses of the earth. The primary form of calc-spar is an obtuse rhombohedron, the faces of which are inclined to each other in the terminal edges at an angle of 105°·5, and all secondary crystals, however various they may be, tend to break or split up into that primary form. The variety of crystalline forms assumed by the mineral is exceedingly great, upwards of 800 being enumerated, of which 700 have been figured by Count Bournon in his treatise on carbonate of lime. The forms, although thus numerous, fall chiefly under the two heads of rhombohedrons, of which Iceland spar is a type, and scalenohedrons, which may be represented by the variety known as dog's-tooth spar. (See Mineralogy.) Pure calc-spar is a transparent, colourless mineral with a vitreous lustre ; its specific gravity is about 2·721 ; and in hardness it is intermediate between gypsum and fluor-spar, occupying the third place in the standard scale. It is frequently tinted in red, yellow, green, brown, and grey, from the presence of foreign matter. Pure, transparent rhombohedral crystals, obtained by cleavage or otherwise, are distinguished as Iceland spar, on account of the largest and finest crystals being found in that island, or as doubly-refracting spar (German, *Doppelspath*), from their exhibiting in the highest degree the double refraction of light. Before the blow-pipe it is reduced to caustic lime, and moistened with hydrochloric or other acid it displays a brisk effervescence. It occurs abundantly in almost all parts of the world,—Andreasberg in the Hartz and the Derbyshire lead mines being noted localities for large fine crystals. Magnificent cleavage rhombohedrons are obtained from Iceland, one having been noted which exceeded 6 yards long and 3 yards high. Professor Dana notices one nearly transparent crystal, weighing 165 ℔, now in the cabinet of Yale College, found in the Rossie Lead Mine, New York State, and he cites a large number of other localities in the United States where crystals occur. Iceland spar, on account of its high double refracting property, is very extensively employed in optical research. It is most conveniently used in the form of a Nicol's prism, which consists of a long rhomboidal crystal cut obliquely into two equal portions in a plane perpendicular to the plane of the longer diagonal of the base. The two halves are cemented together in their original position with Canada balsam; and in this condition the ordinary ray undergoes total reflection from the prism, whilst the extraordinary ray passes through.

CALCHAS, the most famous soothsayer among the Greeks at the time of the Trojan war, was the son of Thestor. He foretold to the Greeks the length of time they would be engaged in the siege of Troy, and when the fleet was detained by adverse winds, at Aulis, he explained the cause and demanded the sacrifice of Iphigenia. When the Greeks were visited with pestilence on account of Chryseis, he disclosed to them the reasons of Apollo's anger. After the return of the Greeks from Troy he is said to have retired to Colophon. According to the story, his death was due to chagrin at being surpassed in a trial of soothsaying skill by one Mopsus. It had long been predicted that he should die whenever he met his superior in divination.

CALCULATING MACHINES. Mathematicians and astronomers have felt in all ages the irksomeness of the labour of making necessary calculations, and this has led to the invention of various devices for shortening it. Some of these, such as the Abacus, Napier's Bones (invented by the father of logarithms), and the modern Sliding Rule, are rather aids to calculation than calculating machines. Pascal is believed to have been the original inventor of a calculating machine; its use was limited to addition, multiplication, &c., of sums of money, and as it required the constant intervention of a human operator the results were subject to the ordinary errors of manipulation. After him came the celebrated Leibnitz, Dr Saunderson, who, blind from his childhood, became professor of mathematics in Cambridge, and others. But all their machines were completely cast into the shade by the wonderful inventions of the late Charles Babbage. He knew well the immense value that absolutely correct tables possess for the astronomer and the navigator, and that a machine which could produce them with speed was a very great desideratum. The first calculating machine he invented he called a difference engine, because it was to calculate tables of numbers by the method of differences. By setting at the outset a few figures the attendant would obtain by a mechanical operation a long series of numbers absolutely correct. The difference engine was not intended to answer special questions, but to calculate and then print numerical tables, such as logarithm tables, tables for the *Nautical Almanac*, &c. An interesting account of some of the errors which are found in what are considered reliable tables is given in a paper by Babbage in the *Memoirs of the Astronomical Society*, 1827.

Every numerical table consists of a series of numbers which continuously increase or diminish. As an example take the squares of the natural numbers, 1, 4, 9, 16, 25, 36, &c. Designate this series by N. If we subtract each term from the one following it we get a new series, 3, 5, 7, 9, &c., which is called the series of first differences; designate this by Δ^1. If in the same way we subtract each term of this series from the succeeding term, we get what is called the series of second differences, every term of which is in this instance 2. Designate this series by Δ^2. As the different series were obtained by subtraction, it is quite evident that by reversing the process we shall obtain the original table. Suppose we are given the first terms of N, Δ^1, and Δ^2, *i.e.*, 1, 3, 2. If we add 3, the first term of Δ^1, to 1, the first term of N, we get 4, the second term of N; and if we add 2, the first term of Δ^2, to 3, the first term of Δ^1, we get 5, the second term of Δ^1; and this added to 4, the second term of N, gives us 9, the third term of N. Similarly we obtain 16 by adding 9, 5, and 2 together, and 25 by adding 16, 7, and 2. Hence, given 1, 3, 2, we can, by a process of additions, obtain the series of square numbers. All numerical tables can be calculated entirely by this method or by repetitions of it.

Table of Square Numbers, N	First Differences, Δ^1	Second Differences, Δ^2
1	3	2
4	5	2
9	7	2
16	9	
25		

The main characteristics of the difference engine, designed and partially constructed by Babbage, are these:—It consisted of several vertical columns of figure-wheels like large "draught men" one above another, to the number of six in each column. The natural numbers from 0 to 9 were cut on the rims of the figure wheels; hence each figure-wheel in a column could represent a digit. Thus the lowest wheel gave the units digit, the second wheel the tens digit. The number 5703 would be represented on the wheels of a column as in the margin. The different columns were to represent the successive series of differences above referred to, and were called the table column, the first difference column, &c.

$\boxed{5}$
$\boxed{7}$
$\boxed{0}$
$\boxed{3}$

"The mechanism was so contrived that whatever might be the numbers placed respectively on the figure wheels of each of the different columns, the following succession of operations took place as long as the handle was moved. Whatever number was found upon the column of first differences, would be added to the number found upon the table column. The same first difference remaining upon its own column, the number found upon the column of second differences would be added to that first difference." Similarly for all the other columns. For example, suppose we are calculating the cubes of the natural numbers. At a certain stage of the work we would find 125 shown by the wheels of the table column, 91 by those of the first difference column, 36 by those of the second difference column, and 6 on the lowest wheel of the third difference column. On making a turn of the handle the 91 would be added to the 125, which would then show 216; at the same time 36 would be added to the 91, so that the first difference column would then show 127; moreover 6 would be simultaneously added to the 36, which would thus become 42, and the 6 would remain unaltered. Another turn and we would get 343, 169, 48, 6 on the different columns. Had the engine been completed it would have had columns for six orders of differences, each of twenty places of figures, whilst the first three columns would each have had half a dozen additional figures.

	Table Column.	First Difference Column.	Second Difference Column.	Third Difference Column.
	1			
	2	9	3	
	5	1	6	6
After one Turn ...	2	1		
	1	2	4	
	6	7	2	6
After two Turns...	3	1		
	4	6	4	
	3	9	8	6

It was about 1822 that Babbage having constructed a small model of his engine sent an account of it to Sir Humphrey Davy, then president of the Royal Society of London. Government heard of the invention, and, having received from the Royal Society a favourable report on the merits and utility of the engine, advanced money towards its construction. Sums of money were at irregular intervals voted for this purpose; but so great were the difficulties to be overcome, so entirely new even were many of the tools necessary, so much time was occupied in testing the value of each proposed contrivance, that in 1834 only a portion was completed. The construction of the machine here stopped, although the Royal Society had again, in 1829, reported most favourably on the engine as regards its practicability, immense utility, and the progress it had made. The Government had already advanced £17,000 (over and above what Babbage had spent, besides giving his personal superintendence without any remuneration), and they saw no definite limit to the amount it would cost; and Babbage had a delicacy in pressing for the completion of the difference engine, as he had recently designed a new machine, the analytical engine, which, if completed, would entirely supersede it. The portion completed is in King's College, London.

It will be noticed that the use of the difference engine was limited to the working of such problems as can be solved by successive additions or subtractions. The analytical engine, on the other hand, was designed to *work out* any problem that the superintendent knew *how* to solve. It consists of two parts, each of a number of vertical columns of figure wheels, similar to those of the difference engine; on the one set called the "variables," which we shall designate by V_1, V_2, &c., the numbers of the special problem or formula are placed; the other set is called the "mill," and performs the required operations of multiplication, division, addition, or subtraction. Its working was directed by means of two sets of cards—"operation" cards, which instructed the mill whether to multiply, divide, add, or subtract, and "variable" cards, which indicated to the mill the particular columns, *i.e.*, numbers on which it was to perform this operation. An example will make this clear. Suppose we wish to solve the equations

$$\begin{aligned} ax + by &= c, \\ dx + fy &= g. \end{aligned}$$

On the wheels of V_1, the first column of the variables, the number a is placed, b on V_2, c on V_3, and so on. Six columns in all are required for this. It is evident that $x = \frac{fc - bg}{fa - bd}$. Hence, to get x, we require the products of f and c, b and g, &c. To get these the superintendent intimates to the mill by means of an "operation" card that a multiplication is to be performed, then points out by a "variable" card what are the two numbers, *i.e.*, the two columns to be multiplied, and on what column the result is to be placed. In the first case the columns indicated would be V_5, V_3, and V_7 respectively. By another operation card and another variable card, the mill would then be instructed to multiply the numbers on V_2 and V_6, and to place the result on V_8. Similarly ca and bd would be obtained on V_9 and V_{10}. The superintendent would then instruct the mill to subtract the number on V_8 from that on V_7, to place the result ($fc—bg$) on V_{11}, and similarly, $fa—bd$ would be placed on V_{12}. By a new operation card the mill would now be put into a "dividing" state, and a variable card would tell it that V_{11} was to be divided by V_{12}, and the result given on V_{13}. This would be the value of x. Similarly for y. The number of cards can be greatly diminished. Thus, for the four multiplications one card would suffice. The cards are of pasteboard (say) and have holes punched in them,—a "multiplication" card having a certain number of holes bored in it and arranged in a particular way, a "division" card a different arrangement of holes, &c. The cards are so placed in the machine that certain levers drop through these holes, while others are unaffected, and the machinery in connection with the levers is put out of gear or not as is desired. In this way the mill is put into a condition in which it multiplies (say) the numbers indicated to it. The variable cards act in a similar manner. When an operation card and a variable card are given to the engine, the numbers on the assigned columns are transferred to the mill, the operation is performed, and the numbers and the result are placed on the proper columns. The series of cards used for any one problem would enable the machine to solve any other similar problem. Babbage says of the engine, "The analytical engine is therefore a machine of the most general nature. Whatever formula it is required to develop, the law of its development must be communicated to it by two sets of cards. When these have been placed the engine is special for that particular formula. The numerical constants must then be put on the wheels, and on setting the engine in motion it will calculate and print the numerical results of that formula." In the construction of this engine he overcame one of the greatest difficulties in such an instrument, that of effecting the carrying of tens. The engine was designed so as to foresee these carriages, and act upon that foresight, and thus a great reduction of the time necessary to make a given calculation was at once obtained by effecting all carriages simultaneously instead of in succession. He says of it, "The analytical engine will contain—1°, apparatus for printing on paper, one, or if required, two copies of its results; 2°, means for producing a stereotype mould of the table or results it computes. The engine would compute all the tables it would itself require. It would have the power of expressing every number to fifty places of figures." It would multiply two numbers of fifty figures each, and print the result in one minute. Its construction was never begun, but Babbage left complete plans of every part of it.

In the *Edinburgh Review* for July 1834 appeared an account of the principles of Babbage's difference engine. Herr George Scheutz, a printer at Stockholm, read it, and shortly afterwards he and his son Edward set about constructing a calculating machine. By 1843 they produced one capable of calculating series with terms of five figures, with three orders of differences, also of five figures each, and of printing its results. Provided with a certificate to this effect from the Royal Swedish Academy of Sciences, they endeavoured unsuccessfully to get orders for their machine. In 1853, with the aid of grants from the Swedish Government, the Messrs Scheutz finished a second machine which was exhibited in England, and at the Paris exhibition of 1855. It eventually went to America. It was about the size of a small square pianoforte. It could calculate series with four orders of differences each of fifteen figures. It printed the results to eight figures, the last of which was capable of an automatic correction where necessary for those omitted. "It could calculate and stereotype without a chance of error two and a half pages of figures in the same time that a skilful compositor would take to set up the types for one single page."

A new machine by the Messrs Scheutz was constructed about 1860 by Messrs Donkin for the Registrar-General for the sum of £1200. It has been used in the calculation of some of the tables in the *English Life Table*, published in 1864. Dr Farr says of it, "The machine has been extensively tried, and it has upon the whole answered every expectation. But it is a delicate instrument, and requires considerable skill in the manipulation. It approaches infallibility in certain respects; but it is not infallible, except in very skilful hands. The weakest point is the printing apparatus, and that admits of evident improvement."

M. Staffel and M. Thomas (de Colmar) have invented machines which can perform addition, subtraction, multiplication, division, and extraction of the square root. M. Thomas's machine is extensively used.

Sir William Thomson has recently invented an instrument (no description of which has yet been printed) which is able to solve any linear differential equation with variable coefficients.

Professor Tait has also invented the principle of a machine, which, if constructed, will integrate any linear differential equation of the second order with variable coefficients.

See the article "Calculating Machines" in Walford's *Insurance Cyclopædia*, where many references will be found, and a translation of General Menambrea's article on Babbage's Analytical Engine in Taylor's *Scientific Memoirs*, vol. iii. (P. S. L.)