

# Reproduction of Prints, Drawings, and Paintings of Interest in the History of Science and Engineering

## 10. The First Hydrogen Balloon

By E. C. WATSON

**J**ACQUES ALEXANDRE CÉSAR CHARLES (1746-1823), the French physicist who discovered the gas law which bears his name and who was the first to fill and to ascend in a hydrogen balloon, was born on November 12, 1746. It is appropriate to commemorate this centennial by reproducing CHARLES' portrait together with several of the many interesting contemporary prints which celebrated the success of his pioneer experiments in aerostatics.

The first public ascent of a large scale balloon took place at Annonay, France, on June 5, 1783. The balloon used was of the hot air type invented and constructed by the MONTGOLFIER brothers. The demonstration was so successful that the Académie des

Sciences in Paris was stimulated to raise money for similar experiments and work with hydrogen was undertaken by CHARLES. The ascent of the first hydrogen balloon was described by BENJAMIN FRANKLIN in a letter to JOSEPH BANKS, President of the Royal Society in London, as follows:

Passy, Aug. 30, 1783

Sir,

On Wednesday the 27th instant, the new aerostatic experiment, invented by Messrs. Mongolfier of Annonay was repeated by Mr. Charles, Professor of Experimental Philosophy at Paris.

A hollow globe 12 feet diameter was formed of what is called in England oiled silk, here Taffetas gommée, the silk being impregnated with a solution of gum-elastic in lintseed oil, as is said. The parts were sewed together while wet with the gum, and some of it was afterwards passed over the seams, to render it as tight as possible.

It was afterwards filled with the inflammable air that is produced by pouring oil of vitriol upon filing of iron, when it was found to have a tendency upwards so strong as to be capable of lifting a weight of 39 pounds, exclusive of its own weight which was 25 lb. and the weight of the air contain'd.

It was brought early in the morning to the Champ de Mars<sup>1</sup>, a field in which reviews are sometimes made, lying between the Military School and the river. There it was held down by a cord, till 5 in the afternoon, when it was to be let loose. Care was taken before the hour to replace what portion had been lost of the inflammable air, or of its force, by injecting more.

It is supposed that not less than 50,000 people were assembled to see the experiment. The Champ de Mars being surrounded by multitudes, and vast numbers on the opposite side of the river.

At five o'clock notice was given to the spectators by the firing of two cannons, that the cord was about to be cut. And presently the globe was seen to rise, and that as fast as a body of 12 feet diameter with a force of only 39 pounds, could be suppos'd to move the resisting air out of its way. There was some wind, but not very strong.

A little rain had wet it, so that it shone, and made an agreeable appearance. It diminished in apparent magnitude as it rose, till it enter'd the clouds, when it seem'd to me scarce bigger than an orange, and soon after became invisible, the clouds concealing it.



Plate 1. Jacques Alexandre César Charles (1746-1823). (From a print published by Berthoud, Paris).

1. Where the Eiffel Tower now stands.

Plate 2. The landing of the first hydrogen balloon, August 27, 1783, in the village of Gonesse.  
(From a contemporary French print).

The multitude separated, all well satisfied & much delighted with the success of the experiment, and amusing one another with discourses of the various uses it may possibly be apply'd to, among which many were very extravagant. But possibly it may pave the way to some discoveries in natural philosophy of which at present we have no conception.

A note secur'd from the weather had been affixed to the globe, signifying the time & place of its departure, and praying those who might happen to find it, to send an account of its state to certain persons at Paris. No news was heard of it till the next day, when information was received that it fell a little after 6 o'clock at Gonesse, a place about 4 leagues distance; and that it was rent open, and some say had ice on it. It is suppos'd to have burst by the elasticity of the contain'd air when no longer compress'd by so heavy an atmosphere.

One of 38 feet diameter is preparing by M. Mongolfier himself at the expence of the Academy, which is to go up in a few days, I am told it is constructed of linen & paper, and is to be filled with a different air, not yet made public, but cheaper than that produc'd by the oil of vitriol of which 200 Paris pints were consum'd in filling the other.

It is said that for some days after its being fill'd, the ball was found to lose an eighth part of its force of levity in 24 hours: Whether this was from imperfection in the tightness of the ball, or a change in the nature of the air, experiments may easily discover.

I thought it my duty, Sir, to send an early account of this extraordinary fact, to the Society which does me the honour to reckon me among its members; and I will endeavor to make it more perfect, as I receive farther information.

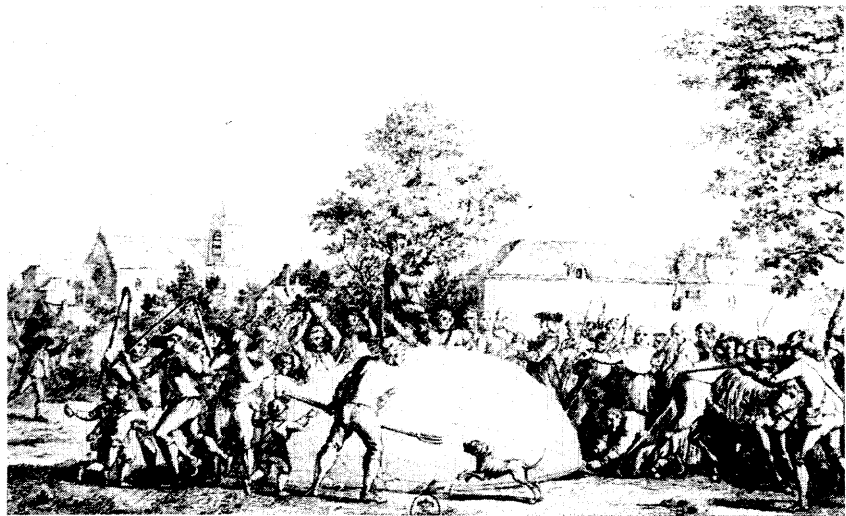
With great respect, I am, Sir

B. FRANKLIN

P.S.

I just now learn, that some observers say, the ball was 150 seconds in rising, from the cutting of the cord till hid in the clouds; that it's height was then about 500 toises<sup>2</sup>, but, mov'd out of the perpendicular by the wind, it had made a slant so as to form a triangle, whose base on the earth was about 200 toises. It is said the country people who saw it fall were frightened, conceiv'd from its bounding a little when it touch'd the ground, that there was some living animal in it, and attack'd it with stones and knives, so that it was much mangled; but it is now brought to town & will be repaired.

The great one of M. Mongolfier, is to go up as is said, from Versailles, in about 8 or 10 days. It is not a globe but of different form, more convenient for penetrating the air. It contains 50,000 cubic feet, and is supposed to have a force of levity equal to 1500 pounds weight. A



philosopher here, M. Pilatre de Rozier, has seriously apply'd to the Academy for leave to go up with it, in order to make some experiments. He was complimented on his zeal and courage for the promotion of science, but advis'd to wait till the management of these balls was made by experience more certain & safe. They say the filling of it in M. Mongolfier's way will not cost more than half a crown. One is talk'd of to be 110 feet diameter. Several gentlemen have ordered small ones to be made for their amusement; one has ordered four of 15 feet diameter each; I know not with what purpose, but such is the present enthusiasm for promoting & improving this discovery, that probably we shall soon make considerable progress in the art of constructing and using the machines:—

Among the pleasantries conversation produces on this subject, some suppose flying to be now invented, and that since men may be supported in the air, nothing is wanted but some light handy instruments to give and direct motion. Some think progressive motion on the earth may be advanc'd by it, and that a running footman or a horse slung and suspended under such a globe as to leave no more of weight pressing the earth with their feet, than perhaps 8 or 10 pounds, might with a fair wind run in a straight line across countries as fast as that wind, and over hedges, ditches, & even waters. It has been even fancied that in time people will keep such globes anchored in the air, to which by pullies they may draw up game to be preserved in the cook, & water to be frozen when ice is wanted. And that to get money, it will be contrived to give people an extensive view of the country, by running them upon an elbow chair a mile high for a guinea, etc., etc.<sup>3</sup>

The first human beings to ascend in a balloon were JEAN FRANCOIS PILATRE de ROZIER (1754-1785) and FRANCOIS LAURENT, MARQUIS D'ARLANDES (1742-1809)<sup>4</sup>. This ascent was made on November 21, 1783. Only 10 days later, on December 1, 1783, the second ascent and the first in a hydrogen filled balloon was made by CHARLES and one of the brothers ROBERT from the gardens of the Tuileries in Paris. The balloon, which was

3. This letter, which is preserved in the Library of the University of Pennsylvania, is reproduced in *The Ingenious Dr. Franklin*, by N. C. Goodman (Philadelphia, 1931).

4. See *Am. Jour. Phys.* 8 249 (1940).

2. About 3200 feet. A toise is 6.395 English feet.

Dear Sir:—

In mine of yesterday I promised to give you an account of Messrs. Charles & Robert's experiment, which was to have been made this day, and at which I intended to be present. Being a little indisposed, and the air cool, and the ground damp, I declined going into the garden of the Tuileries, where the balloon was placed, not knowing how long I might be obliged to wait there before it was ready to depart, and chose to stay in my carriage near the statue of Louis XV., from whence I could well see it rise, and have an extensive view of the region of air through which, as the wind sat, it was likely to pass. The morning was foggy, but about one o'clock the air became tolerably clear, to the great satisfaction of the spectators, who were infinite, notice having been given of the intended experiment several days before in the papers, so that all Paris was out, either about the Tuileries, on the quays and bridges, in the fields, the streets, at the windows, or on the tops of houses, besides the inhabitants of all the towns and villages of the environs. Never before was a philosophical experiment so magnificently attended. Some guns were fired to give notice that the departure of the balloon was near, and a small one was discharged, which went to an amazing height, there being but little wind to make it deviate from its perpendicular course, and at length the sight of it was lost. Means were used, I am told, to prevent the great balloon's rising so high as might endanger its bursting. Several bags of sand were taken on board before the cord that held it down was cut, and the whole weight being then too much to be lifted, such a quantity was discharged as to permit its rising slowly. Thus it would sooner arrive at that region where it would be in equilibrio with the surrounding air, and by discharging more sand afterwards, it might go higher if desired. Between one and two o'clock, all eyes were gratified with seeing it rise majestically from among the trees, and ascend gradually above the buildings, a most beautiful spectacle. When it was about two hundred feet high, the brave adventurers held out and waved a little white pennant, on both sides of their car, to salute the spectators, who returned loud claps of applause. The wind was very little, so that the object though moving to the northward, continued long in view; and it was a great while before the admiring people began to disperse. The persons embarked were Mr. Charles, professor of experimental philosophy, and a zealous promoter of that science; and one of the Messieurs Robert, the very ingenious constructors of the machine. When it arrived at its height, which I suppose might be three or four hundred toises, it appeared to have only horizontal motion. I had a pocket-glass, with which I followed it, till I lost sight first of the men, then of the car, and when I last saw the balloon, it appeared no bigger than a walnut. I write this at seven in the evening. What became of them is not yet known here. I hope they descended by daylight so as to see and avoid falling among trees or on houses, and that the experiment was completed without any mischievous accident, which the novelty of it and the want of

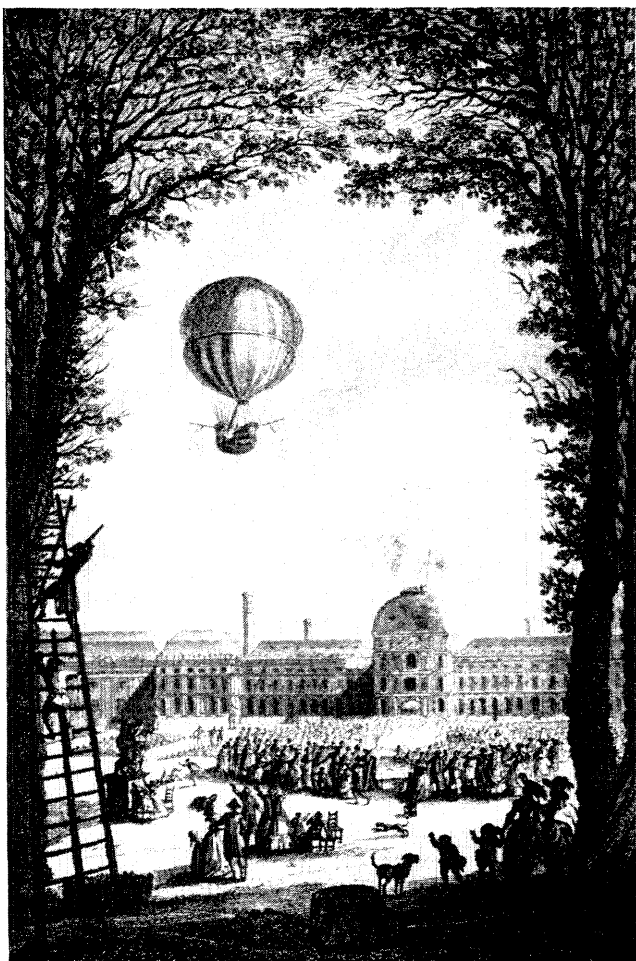


Plate 3. The ascent of Charles and Robert from the Tuileries, December 1, 1783.

(From an engraving by de Launay after de Lorimer, published by Vachez in Paris).

constructed by the brothers ROBERT, was made of lutestring coated with gum elastic and had a diameter of 27 feet. The car was suspended from a hoop surrounding the middle of the balloon and fastened to a net which covered the upper hemisphere. After ascending to a height of about 200 feet and covering a distance of 27 miles in about two hours, CHARLES and ROBERT descended near the small town of Nesle, where ROBERT left the car and CHARLES reascended alone for a journey lasting a further 35 minutes during which he reached a height estimated at 2 miles. "The pair carried thermometers, barometers, and other 'philosophical instruments' for the observation of as many new natural phenomena as might possibly be discovered in these hitherto uncharted regions. The voyage was completely successful and marked by no unexpected incidents . . . Despite the elaborate collection of instruments, Professor Charles noted no new phenomena beyond the clearly predicted decrease in barometric pressure with height. He specifically noted only that the atmospheric temperature decreased so rapidly that in 10 minutes he passed 'from the warmth of spring to the cold of winter'." It may be of interest to quote also BENJAMIN FRANKLIN'S report to JOSEPH BANKS upon this, the second aerial voyage made by man:

5. F. A. Magoun and E. Hodgins, *A History of Aircraft* (McGraw-Hill, 1931).

experience might well occasion. I am the more anxious for the event, because I am not well informed of the means provided for letting themselves down, and the loss of these very ingenious men would not only be a discouragement to the progress of the art, but be a sensible loss to science and society.

I shall enclose one of the tickets of admission, on which the globe was represented, as originally intended, but is altered by the pen to show its real state when it went off. When the tickets were engraved the car was to have hung to the neck of the globe as represented by a little drawing I have made in the corner.

I suppose it may have been an apprehension of danger in straining too much the balloon or tearing the silk, that induced the constructors to throw a net over it, fixed to a hoop which went around its middle, and to hang the car to that hoop.

Tuesday morning, December 2nd.—I am much relieved from my anxiety by hearing that the adventurers descended well near L'Isle Adam before sunset. This place is near seven leagues from Paris. Had the wind blown fresh they might have gone much farther.

If I receive any further particulars of importance, I shall communicate them hereafter.

With great esteem, I am, dear sir, your most obedient and most humble servant.

B. FRANKLIN.

P.S. Tuesday evening.—Since writing the above

I have received the printed paper and the manuscript containing some particulars of the experiment which I enclose. I hear further that the travellers had perfect command of their carriage, descending as they pleased by letting some of the inflammable air escape, and rising again by discharging some sand; that they descended over a field so low as to talk with the labourers in passing, and mounted again to pass a hill. The little balloon falling at Vincennes shows that mounting higher it met with a current of air in a contrary direction, an observation that may be of use to future aerial voyagers.<sup>6</sup>

Most of the features of modern balloons are due to CHARLES. Thus he was the first to use hydrogen successfully and he invented the valve at the top of the balloon as well as the method of suspending the car which are still generally used.

CHARLES attained great fame during his lifetime and many portraits of him exist. Plate 1 was made from a print published in Paris and reproduced by

6. This letter is also reproduced in *The Ingenious Dr. Franklin*, by N. G. Goodman (Philadelphia, 1931).

Plate 4. Charles re-ascending alone after landing at Nesle, December 1, 1783. (From an engraving by Denis after Desrais, published in Paris by Bassett).

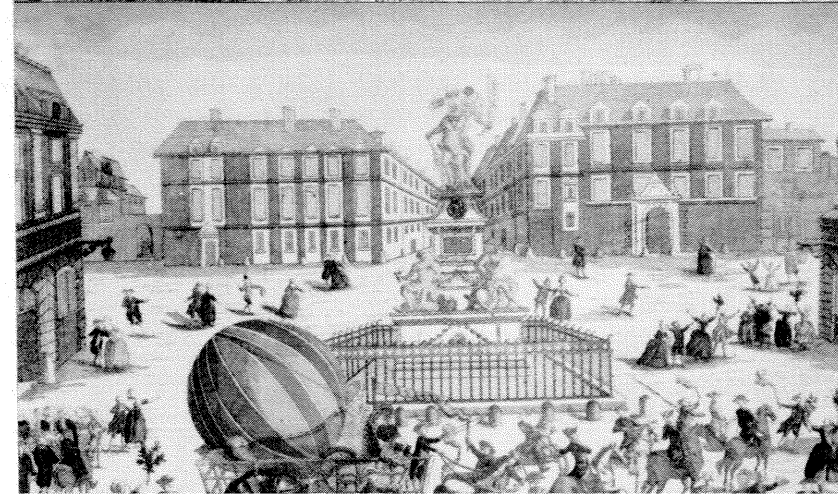
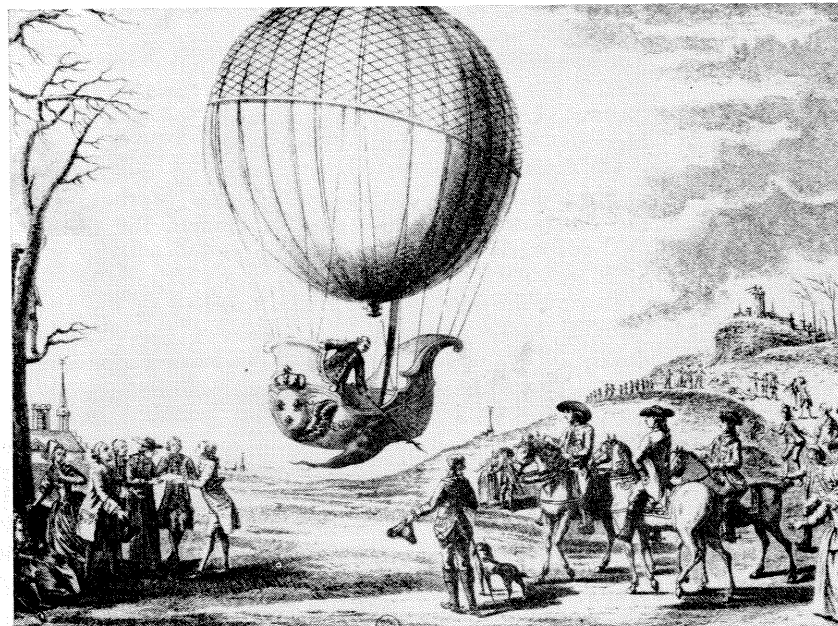
Plate 5. The return of the Charles and Robert balloon to Paris, December 2, 1783. (From a color print published in Paris by Bassett).

F. L. Bruel in his monumental *Histoire Aéronautique par les Monuments, Peints, Sculptés, Dessinés, et Gravés des Origines à 1830* (Paris, 1909). The vignette below the portrait-medallion depicts the enthusiastic scenes when CHARLES and ROBERT landed at Nesle, "where the procès verbal was signed by, among others, the Duc de Chartres and a 'Gentil-homme anglais,' Mr. Farrer, who rushed up to Charles on his arrival with the explanation, 'Moi, Charles, premier!' and was in such a state of excitement that he signed the procès verbal twice over in an almost illegible hand."

Plate 2 reproduces a contemporary print showing the frightened citizens of Gonesse attacking the first hydrogen balloon after its descent in the town. The scene and the reaction of the peasants is graphically described in the following quotation given in H. TURNOR'S *Astra Castra* (London, 1865):

For on first sight it is supposed by many to have come from another world; many fly; others, more sensible, think it a monstrous bird. After it has alighted, there is yet motion of it from the gas it still contains. A small crowd gains courage from numbers, and for an hour approaches by gradual steps, hoping meanwhile the monster will take flight. At length one bolder than the rest takes his gun, stalks carefully to within shot, fires, witnesses the monster shrink, gives a shout of

7. W. Lockwood Marsh, *Aeronautical Prints and Drawings* (London, 1924).



triumph and the crowd rushes in with flails and pitchforks. One tears what he thinks to be the skin, and causes a poisonous stench; again all retire. Shame, no doubt, now urges them on, and they tie the cause of alarm to a horse's tail, who gallops across the country, tearing it to shreds.

German and English copies of this print were published at Augsburg, Germany, and by John Wallis of Ludgate Street, London, and French copies in Paris.

The ascent of CHARLES and ROBERT from the Tuileries on December 1, 1783, produced a great profusion of prints.<sup>8</sup> Selected for reproduction here

8. The Katalog der Historischen Abteilung der Ersten Internationalen Luftschiffahrts-Asstellung (ILA) zu Frankfurt a.M. 1909, by L. Liebmann and G. Wahl (Frankfurt, 1912) lists more than 40 without exhausting the list.

(Plate 3) is one from the delightful series of de LAUNAY after de LORIMER, which was published by VACHEZ in both colored and uncolored states. These "are perhaps the best of all ballooning prints"<sup>9</sup> and several of them were used as illustration in FAUJAS de SAINT-FOND'S *description des experiences de la machine aerostatique* (Paris, 1783-4), which is "The chief contemporary authority for the details of the earlier ascents"<sup>9</sup>

Plate 4 shows CHARLES re-ascending alone after the signing of the *procès verbal* at Nesle and Plate 5 "is a highly imaginative picture of the triumphant return of the balloon to Paris the next day, showing it apparently still fully inflated with hydrogen and surrounded by flaming torches in dangerous proximity to the gas."<sup>9</sup>

9. W. Lockwood Marsh, *Aeronautical Prints and Drawings*, (London, 1924).

## C. I. T. NEWS

### LACEY OF CHEMICAL ENGINEERING NAMED DEAN OF GRADUATE SCHOOL

DR. William Noble Lacey, professor of chemical engineering was appointed Dean of the Graduate School in October. He succeeds Dr. Richard Chase Tolman, wartime vice-chairman of the N.D.R.C. Dr. Tolman resigned in order to devote more time to research and new duties as technical advisor to Bernard Baruch, United States representative on the United Nations Atomic Energy Commission.

Dr. Lacey has recently been designated as a recipient of the Anthony F. Lucas Gold Medal of the American Institute of Metallurgical Engineers for research on hydrocarbon behaviour. This award will be made in March 1947.

During the war Dr. Lacy was attached to the Eaton Canyon rocket project. He received his bachelor's degree at Stanford in 1911 and his master's and doctorate degrees at the University of California in 1913 and 1916. Before coming to the Institute in 1916, Dr. Lacey spent a year at M.I.T. as a research associate.

The graduate school deanship is not an honorary appointment. A great deal of work and responsibility will be added to Dr. Lacey's already crowded schedule. Recommendations for grants and other financial aids to graduate students are among the Dean's tasks. The great numerical expansion of the graduate school to 581 is instituting new problems.

A recently made curriculum change that Dr. Lacey must consider at close range is the addition last March of chemical engineering to the list of subjects in which the Ph.D. degree may be taken. Heretofore chemical engineering was offered as a minor subject in connection with the doctorate in chemistry or mechanical engineering.

The chemical engineering department is under the direction of Doctors Lacey and Sage. Chief research project now in progress is the American Petroleum Institute's hydrocarbon research now in its 20th year under Dr. Lacey's supervision. For the last nine

years, Dr. Sage has co-sponsored this research.

The behaviour of hydrocarbon mixtures under conditions found in underground petroleum and natural gas reservoirs is being studied. Temperatures as high as 400 degrees Fahrenheit and pressures up to 10,000 pounds per square inch are possible with the department equipment. Dr. Lacey describes this work as physical chemistry research done under engineering conditions. Also in progress at the chemical engineering department is research in engineering thermodynamics.

### BEAVER ELEVEN WINS TWO, LOSES TWO

OFF to a good start this season, beating La Verne College 40-0 in a non-league opener, and swamping Occidental 21-7, the Beavers have since slowed down, bowing to Whittier, currently heading the league, 19-7, and also to Redlands, second in league standings, 21-6.

The victory over Oxy, not wholly unexpected after the La Verne encounter, showed the Beavers in control at the Rose Bowl. After an early Occidental touchdown, the Techmen scored in the first, second, and fourth quarters.

The game with Whittier saw the Poets handing the Caltech team their first loss of the season. Looking good, but not quite good enough, the Beavers lost their first half lead of 7-6 early in the third quarter, when Whittier drove 70 yards down the field to their second and deciding touchdown. Whittier's other score came late in the game when a Poet guard fell on a Beaver fumble over the end zone.

Redlands, fresh from a 6-6 tie with Pomona which was reckoned the weakest team in the league, gave the home team a very rough time in the Rose Bowl. The Bulldogs' wide-open playing clicked too frequently and gave them a 14 point lead in the first half. A Beaver drive in the third quarter produced six points, but the game was never in doubt.

On the basis of this last game, the Beavers will start the Pomona game November 16, as underdogs. However, Coaches Mason Anderson and Pete Mehlinger will have the uninjured squad in shape to counter the Sagehens' standbys, the single wingback and short pass over the line with a passing attack, against which Pomona has produced only a weak defense this season.