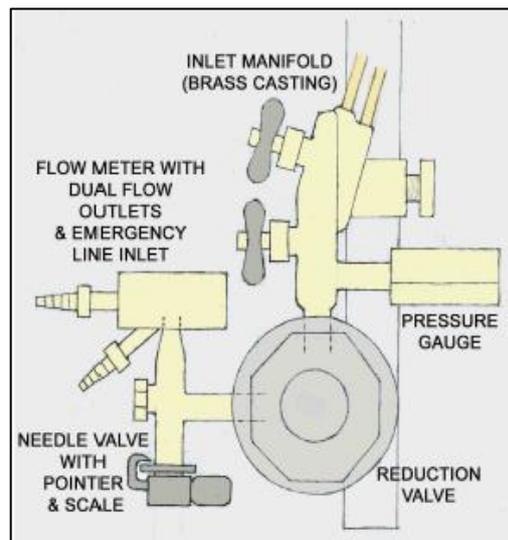
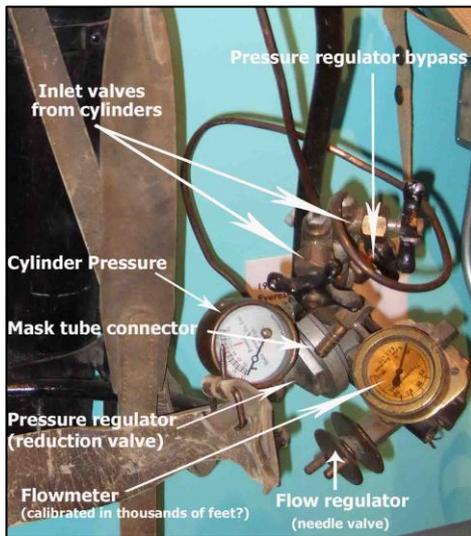


Mallory & Irvine: *Oxygen*

by Richard McQuet and Pete Poston

According to Noel Odell, the oxygen sets used during the 1924 Expedition were "nearly identical" to the 1922 oxygen sets used by George Finch & Geoffrey Bruce on their summit attempt. Unfortunately, no complete photographic record exists (to our knowledge) of the complete original sets, but an interesting glimpse can be found in an image in George Rodway's English-translated "Der Kampf um den Everest", improperly labelled "1922 oxygen apparatus". These images are subject to copyright, but can be found on p.65 of the book.

In these pictures we see the arm and instruments attached to a 6-cylinder carrier containing the 1922-type bottles. It appears that this was an early incarnation, built before the new racks and oxygen cylinders were available. The arm (with thumbscrews) and instrument layout matches perfectly the drawings and description in the 1924 oxygen manual. For comparison, the 1922 arrangement is shown below along with a representation of the component parts of the 1924 sets as per the manual's engineering drawings.



1922 instrumentation & representation of original 1924 drawings

Far from being complex, the sets were very simple in construction, and indeed the open-circuit apparatus used in the 1953 British Expedition used exactly the same principals and equipment as Finch's original 1922 sets, albeit with much lighter cylinders and instrumentation. Although Finch is credited with pioneering the use of oxygen at altitude, the engineering and parts were largely borrowed from work carried out for the air force during and after WW1.

Air force sets differed in that a constant *mass flow* could be delivered to the pilot by use of a sealed reduction valve generating a fixed *absolute* pressure, independent of atmospheric variations. The pressurised flow meter was upstream of the flow adjusting valve, so the density of oxygen at the measuring point was always constant - the flow meter always read correctly, but small adjustments of the flow would be required at different altitudes. This was important for aviation due to the extreme variations in altitude, but was considered unnecessary for the 23,000 to 29,000ft range for the 1924 climbers. Therefore, the climbing sets used a differential pressure regulator which gave around 1atm. above the atmospheric pressure. One positive side of this was that the differential pressure across the needle valve was constant - if the flow meter broke, the needle valve would continue to generate the same volumetric flow if left in the same position. The downside was that mass flow was variable with altitude, hence the requirement to calibrate the flow meters at a pressure equivalent to the altitude of the climbers.

Twin brass high pressure lines were used to attach the cylinders, with a coil to allow easier bending and stretching when changing bottles. Each line led to a stop valve (with brazed connection) incorporated into a brass casting. This also housed the pressure gauge at the end of a dead end branch. The first marking on the gauge was at 10 atm, but the bottles may not have necessarily been changed at this point. Although weigh scales were provided to test the cylinder contents (it was stated that weighing was preferable to attaching gauges, due to the easily damaged ebonite seats of the cylinder valves if opened/closed), six spare pressure gauges were sent out to allow testing of the bottles if required. The

casting was screwed to a reduction valve, with a fine adjusting valve (needle valve with pointer and scale) screwed into the reducing valve outlet (metal-to-metal seal). The outlet of the flow adjusting valve screwed directly into the flow meter base, jointed with a lead washer. From here, the oxygen travelled through rubber tubing to a mask based on Finch's 1922 design, where the climber bit down on a rubber tube when exhaling, then relaxed the tube when breathing in to get the full benefit of the gas.

It was advised to keep all rubber tubing and masks within the tent or sleeping bag to prevent it becoming brittle, and that spare tubes should be carried – does this have any bearing on what Odell saw within the tent at Camp VI? This mask/mouthpiece was held in place by two small buckles, although the mask need not have been worn at all if the climber gripped the tube between the teeth (as per Finch & Bruce in 1922). The usage of oxygen for Irvine, with his sunburnt face, would therefore not have caused any problems

The sprung vane-type flow meter used on the 1924 set was calibrated in a vacuum corresponding to 29,000ft, unlike the 1922 meters which were calibrated at atmospheric pressure (although at 0degC). Since gas density has a substantial effect on variable area flow indicators, the 1924 variants would have read much more accurately at higher altitudes than those of 1922, although at the height of the N.Col, oxygen consumption on Mallory and Irvine's sets would be markedly more than indicated (20% according to the manual).

On Mallory and Irvine's climb to the North Col, it is stated by Irvine that 1.5 l/min. was used - this would equate then to something like 1.7-1.8 l/min. of true flow, explaining their freshness at the top.

The carrying frames were capable of carrying three of the larger 535 litre oxygen cylinders, as opposed to four in 1922. Some capable of carrying four were apparently sent, and it is noted that "It will probably be found that the fourth receptacle is convenient for carrying a Thermos flask".

This, of course, tells us that Irvine carried his flask between cylinders in the empty slot, as seen in the last photo of them leaving the North Col. If 3 cylinders were chosen on June 8th, an alternative method of carriage may have been constructed; perhaps Irvine have used parts of spare frames to add a makeshift carrier- can this explain the work the on oxygen apparatus noted by Odell at Camp VI, and could the reduced carrying capacity and extra load of the 3rd cylinder be the reason the flares and lamps were left inside the tent ? Of course, he may have merely tied on a rucksack!

Another change was the removal of the emergency bypass valve contained in the 1922 sets that would allow a climber to still receive oxygen if the reducing valve failed or choked up. Instead, three other methods were employed.

- The flow meters had twin outlets (one normally capped) to allow sharing of sets between two climbers.
- Emergency tubes were provided (not fitted in normal use) that could be connected between the cylinders and the flow meter inlet. The manual notes that a spanner should be used to operate the emergency tube valves.
- Breaking the metal h.p. tubing and manually connecting the rubber hose leading to the face mask. A file was fitted to the spanners provided to the expedition for this purpose.

The twin outlet of the flow meter is a most interesting revelation. It means that any sleeping oxygen arrangement at Camp 6 would have been a straightforward operation, with no work on the sets required. It may also explain Odell's dissatisfaction with the apparatus taken from above the North Col if Irvine had loosened the cap on the second outlet to allow Norton & Sommervell to share the oxygen set taken to them on their return from their summit bid (I believe there's no doubt this was the same set Odell used).

The flow rates available to the 1924 climbers have been stated as being fixed 1.5 and 2.2 litres/min. in various works of literature, but this has never been properly referenced. Indeed, the 1924 manual is rather disparaging of the recommended flows provided by Dreyer to the 1922 expedition, stating instead that the oxygen flow should be adjusted to the minimum required to still allow an ascent rate of 600ft/h (which may explain Mallory's optimism in his last note to Noel). Irvine lets us know in his diary that *at least 3 litres/min.* was possible when describing a faulty flow meter as "...still sticky at 1.5 & 3, but works all right if hit every now and then", and the mechanics of the set itself (a needle valve for flow adjustment) point to an infinite range of flows from zero to (at least) the aforementioned 3 litres/min. This would make sense bearing in mind the twin outlets for emergency use, where a flow of 3l/min. or more would be advantageous for two climbers - if the maximum was 2.2, very little oxygen would be delivered to the two masks. Although the manual mentions a flow of 6l/min. through the reduction valve, this was probably only carried out in order to set the spring in the regulator to give 1atm above atmospheric at that flow. It would make little sense to supply a flow meter scaled to >6 litres/min. if the operating range was typically between zero and ~3.

The original design of the apparatus also contained a watch attached to the instrument arm so that a climber could tune his oxygen flow to his climbing rate, but this was later shelved. An extra unidentified instrument can be seen in the Finch photos previously mentioned that may very well be the watch. Instead, special Ingersoll watches with strong main springs and light oil were provided to the expedition due to the concern that normal wristwatches were prone to stopping at extreme low temperatures (with experiments apparently confirming this).

Does this have any bearing on Mallory's wristwatch being found in a pocket?

One other point of note in the 1924 Oxygen Manual is the description of "levelling-up" of cylinders, a method stated to have been applied by Finch during his summit bid. When down to the last full cylinder, the empty would not be discarded, but levelled in pressure by opening a path between it and the remaining full cylinder. This was designed to maintain a safety margin in case a problem arose with one of the lines or connections, so ensuring at least one standby source of oxygen. It would also obviously have benefits in weight distribution of the set, but increase the load carried whilst climbing. Obviously Finch felt that the safety margin and even balance outweighed the extra load.

One peculiarity is that M&I left the Col with two cylinders each for the short climb to Camp V, where one cylinder would be more than sufficient – or were they acting as porters in case some turned back?

Did Mallory and Irvine follow Finch's method, as outlined in the manual? An empty 1924 cylinder weighing on average 6 lbs (2.7 kg), but this method would have allowed Irvine to dispense with the heavy brass casting containing the inlet valves, using only the cylinder valves as a shut-off. If so, the single bottle found on the NE Ridge would of course point to at least one of the climbers using more than 2 bottles.