Title
PRESSURE REGULATION IN ACTIVITY ENCLOSURES

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ABSTRACT

Enclosure systems for maximum security of activity containment have minimum practical leakage and very low ventilation rates, and require some method to compensate for internal pressure changes resulting from leaks, vapor production, and physical volume changes.

This discussion considers the merits of pressure regulation, volume compensation, and the combination of both modes to handle surges and long-term changes. It further looks into the design, function, and successful use of one such system at Lawrence Radiation Laboratory, Berkeley, California.

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INTRODUCTION

The high degree of success with the "low-leak" concept of activity enclosures used at Lawrence Radiation Laboratory, Berkeley is documented elsewhere.[1] The trend now is to use this idea both on a broader scale and in smaller enclosures, since it offers a most effective means of controlling airborne radioactive contamination. There are two operational inconveniences, however, which limit the usefulness of this technique:

1. The system has been without provision to compensate for changes in system volume during the course of manipulation. As tongs move in, decreasing total volume, the internal pressure rises. In small-volume systems, these pressure excursions become dangerously large. Thus, manipulation must be sufficiently slow to permit displaced air to pass through the filter train out through the stack or pressure excursions exceed safe units. Further, rapid fluctuations in filter face velocity might reduce filter efficiency or produce filter unloading.

2. Controlling the negative pressure in the enclosure has been solely by exhaust-line dampler and by air bleed downstream from the final filter. As a practical matter, the relative negative pressure in the box must be limited to about 0.6 in. W. G. so that tong socks do not interfere with operations, or gloves inflate to stiffness.

MODES OF PRESSURE CONTROL

One promising solution to the pressure-excursion problem is to keep the total volume constant with something akin to a surge bellows such that whenever gloves or tongs move in, the bellows device moves out. Drawbacks to this method include net changes in volume due to leakage from atmosphere into the box, and gas or vapor production in the box resulting from evaporations and chemistry. Unless these "long-term" volume changes are carefully balanced by exhausting,the surge device reaches a mechanical limit and its usefulness is lost.

Another approach to the problem is the regulation of enclosure pressure with some device that exhausts air (or adds it) as required. Workers at Atomic Energy Research Establishment, Harwell developed such a device[2], and from their plans, a gloved box pressure regulator was built at Lawrence Radiation Laboratory, Berkeley. When we tried the regulator on a low-leak system, we found these drawbacks:

1. The control system was a "shorting" type, i. e., one of two valves opened before the other one closed. This means that over most of the operating range of the regulator, both valves were open, permitting through flow of air to increase the filter throughput. One advantage of the low-leak idea, very low filter flow, is lost in this manner.

2. The regulator apparently was designed to handle much higher input pressure and suction than we use; consequently, the valve capacity was much too low.

3. We felt that spring adjustment was not the ideal reference for pressure control for such small gradients, nor did we like the horizontal sliding members.

Even with a "nonshorting" valve system, such a control technique requires that air be exhausted through the filter train as fast as required for rapid volume compressions.

It would appear that combining the best features of these two modes, volume compensation and pressure control, we would have a satisfactory answer.

THE LAWRENCE RADIATION LABORATORY SURGE REGULATOR

Our design attempts just that combination. The system includes a surge bellows which, in addition to being able to compensate for full travel of one pair of gauntlets, also operates a control valve to control pressure in the system. If we plot valve vs port opening, we see the secret of success of this technique. Graph 1 shows such a function. As we can see, over 90% of the functioning range, valve ports open only a fraction of their capacity. This results in a corrective influence to compensate for the long-term volume changes in the low-leak system. All during manipulation, or even during inactive periods, the net tendency is for the regulator to seek the central position, thus leaving the bellows with adequate capacity to compensate in either direction. At the extreme displacement positions where the bellows can no longer correct further, the valve takes control with wide-open ports. The valve can handle a full 20 cfm at less than 2 in. W. G. differential.

FABRICATION

The bellows section, shown in Fig. 2, handles directly the same atmosphere as the interior of the activity enclosure. Therefore, the surge tank should be considered part of the enclosure and equally decontaminable or disposable. Hence the tank should be as inexpensive as possible commensurate with reliable function. We chose to make the bellows mechanism of sheet "Dural" painted with Bisonite 957 for corrosion protection. We expect the Teflon pin and Teflon bushings to give reliable service with minimum complexity. The counterweight is mounted in the interior of the chamber for two reasons: to minimize the external moving parts, and to remove the counterbalance load torque from the full length of the control shaft. The airtight bellows material is simply a polyethylene bag slipped over the top of the two vertical plates and taped to the edge of the tank at the bottom of the assembly. This bag is identical with the bags stocked for use in collecting rain samples. (Should leakage develop in the bag during service, it is a simple matter to slip a new bag over the old one and tape down the edges.)

The installed control valve is connected into the ventilation system downstream from the clean-up filters, and presumably see little activity. Therefore, the valve is considered re-usable, and we can afford more sophistication in design. As shown in Fig. 3, valve body is a fairly complex shape, so we planned that it should be made up of epon castings, two of which come from the same pattern. Our one operating model was machined out of Lucite as a pilot model.

OPERATIONAL EXPERIENCE

The bellows was designed to mount directly on the back of the activity enclosure, and to keep the 3-inch surge line as short as possible. On the installation with which we tried out this surge system, the bellows was placed off to one side, and the 3-inch surge line was approximately 7 ft long, with three elbows in the line and a short 2-in.-diam restriction at the back of the box. Naturally, with such a handicap as this, we expected the device to function somewhat sluggishly; but even so, the pressure inside the activity enclosure did not vary more than ±0.1 in. W. G.

Total operating experience is short; a longer time might show up some other characteristics. But what little we have seen has been a great improvement over past practice.

ACKNOWLEDGMENTS

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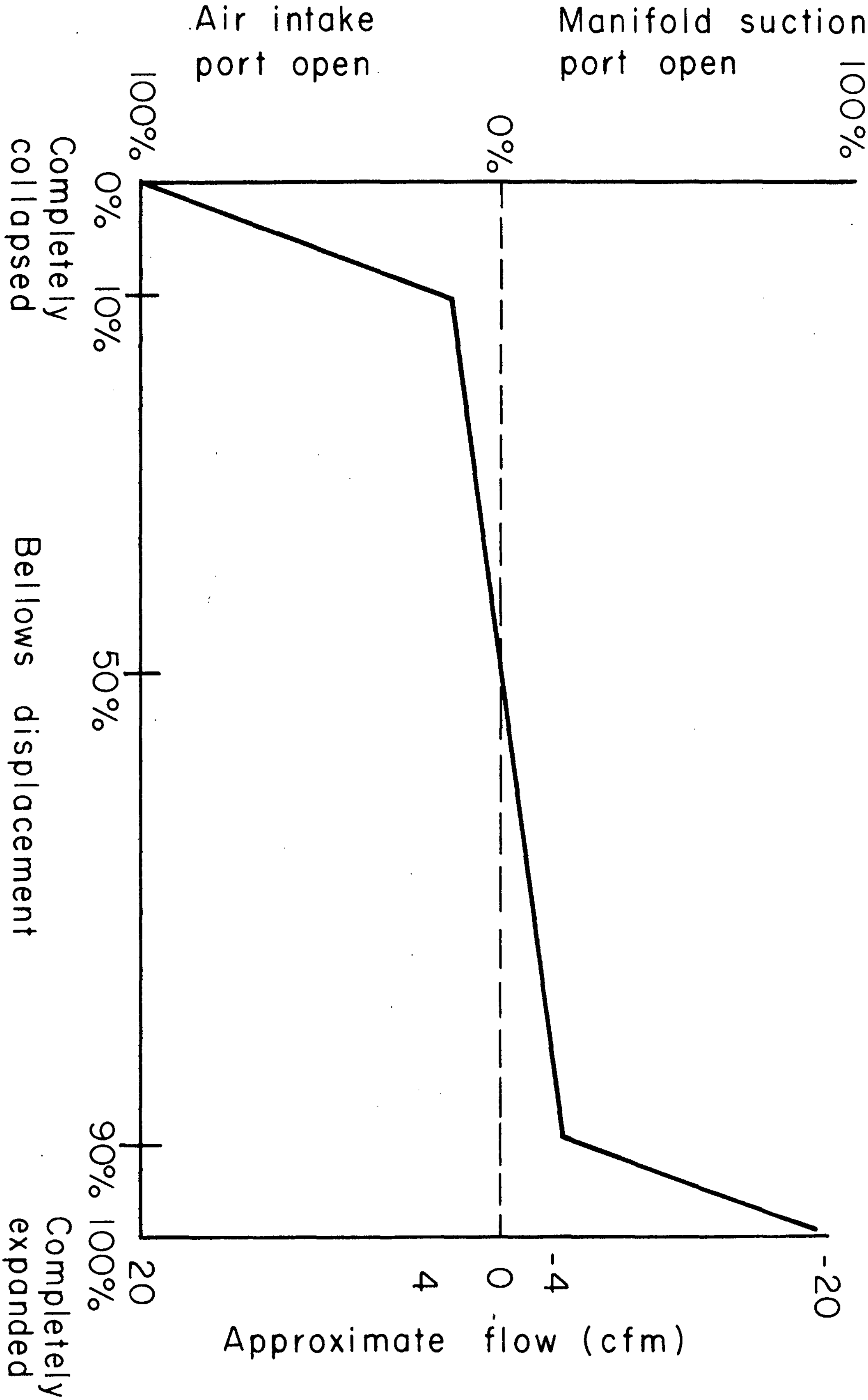
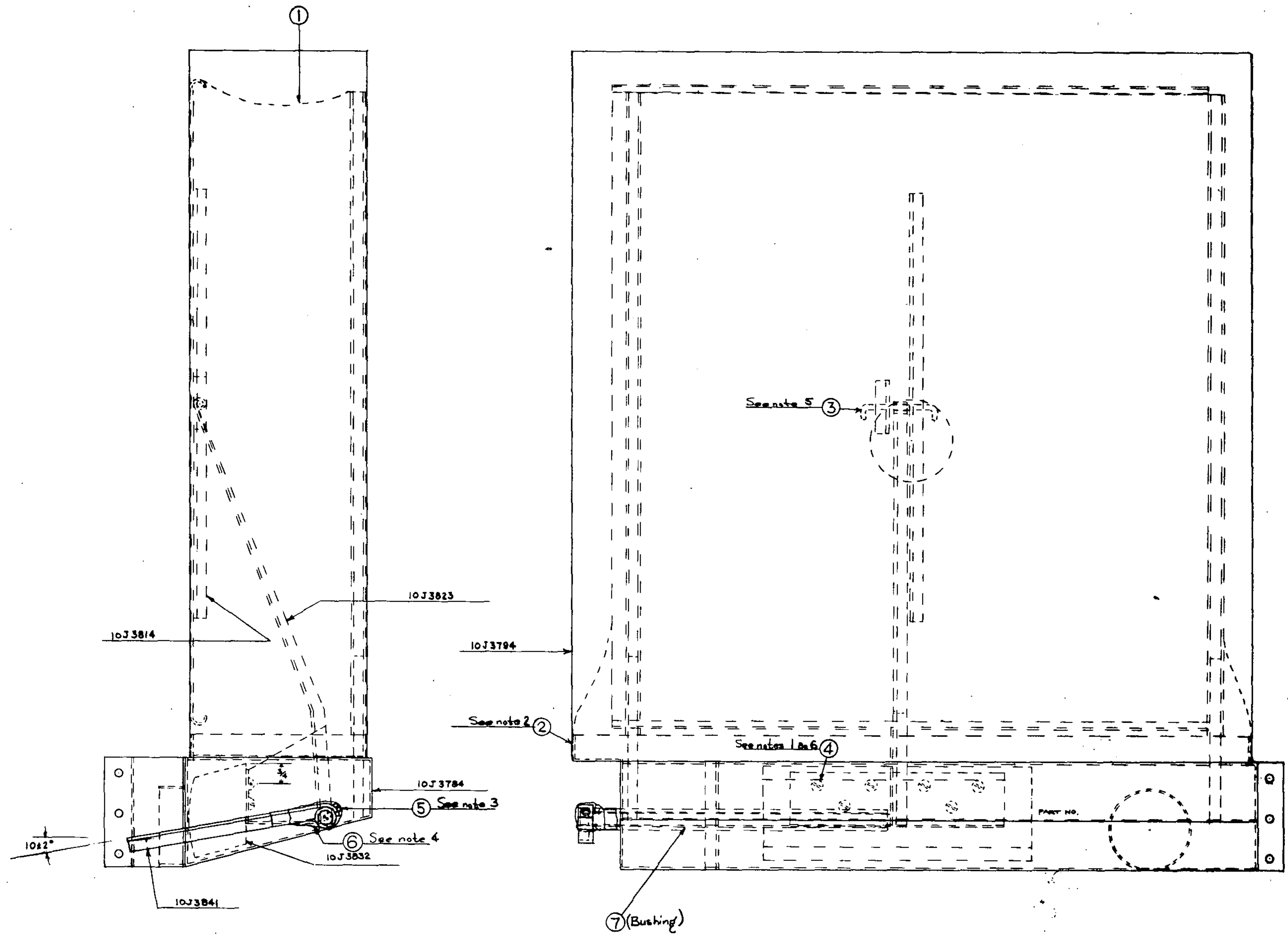
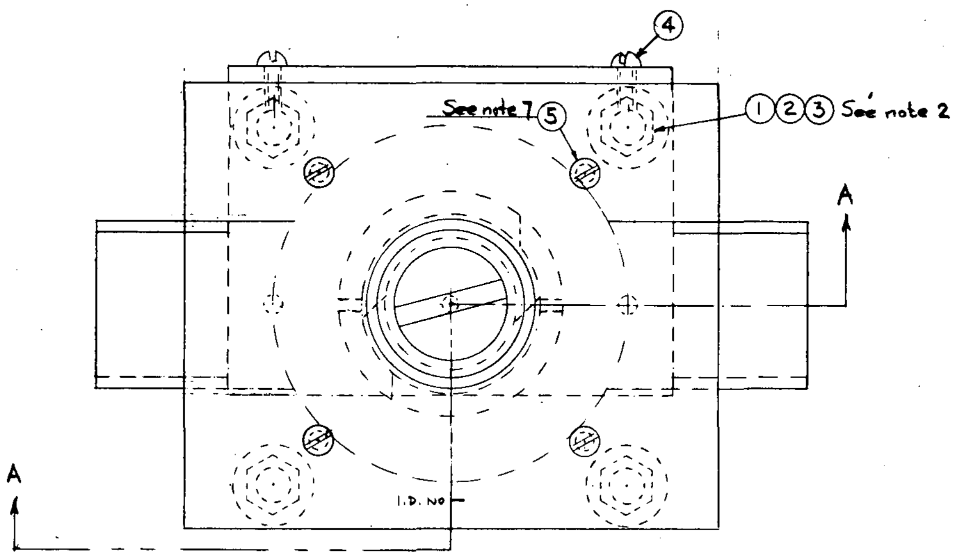
2. Drawing No. B220/256 et. seq., in J. M. North and J. Garstone, Glove Box Pressure Regulators, AERE-M/R-2417, Dec. 1957.



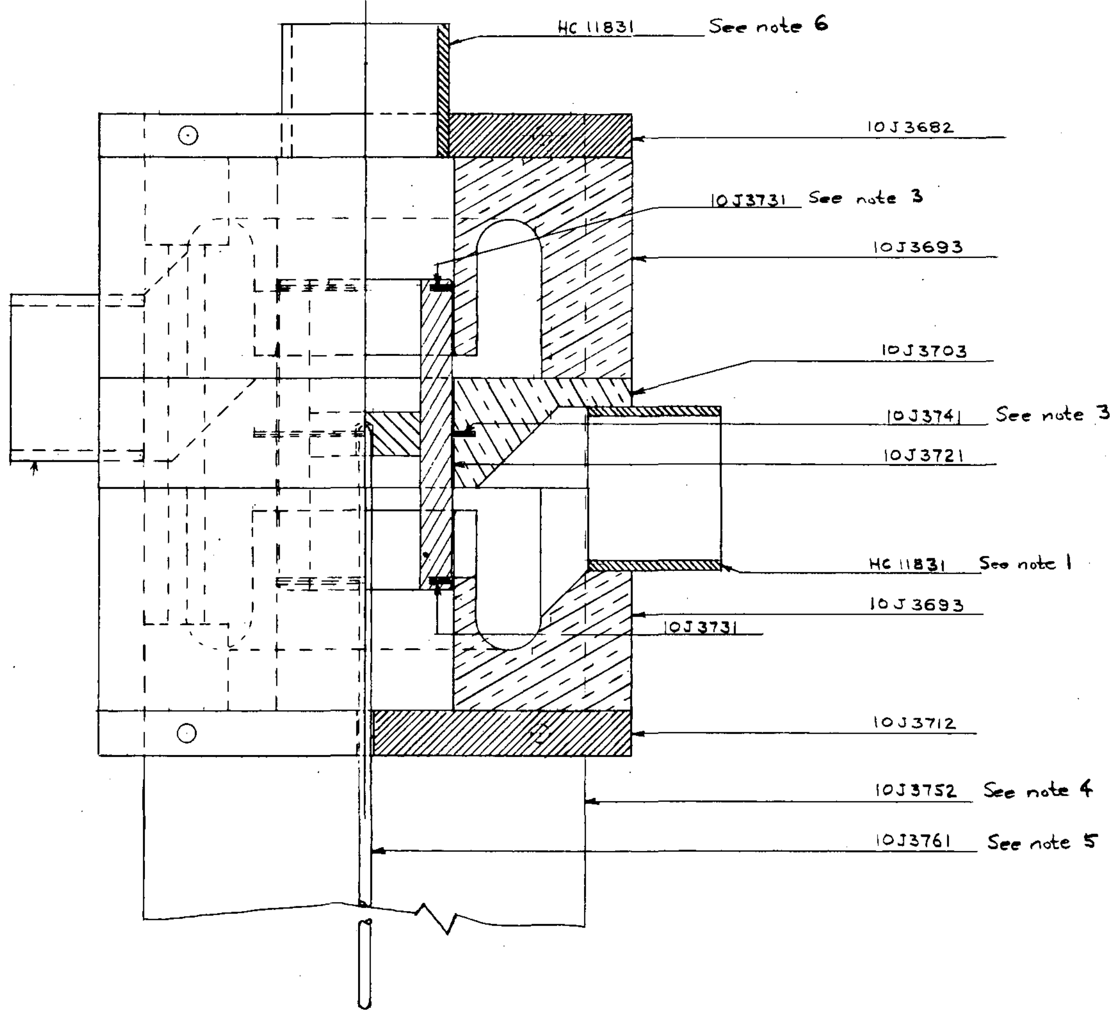
Air intake port open
Manifold suction port open
100%
0%
100%
Completely collapsed
0%
10%
50%
90%
100%
Completely expanded
Bellows displacement
20
4
0
-4
-20
Approximate flow (cfm)



1
10J3823
10J3814
10J3784
5 See note 3
6 See note 4
10J3832
10J3841
10±2°
3/4
See note 5
3
10J3794
See note 2
2
See notes 1 & 6
4
PART NO.
7 (Bushing)



4
See note 7
5
1 2 3 See note 2
A
A
I.D. No



HC 11831 See note 6
10J3682
10J3731 See note 3
10J3693
10J3703
10J3741 See note 3
10J3721
HC 11831 See note 1
10J3693
10J3731
10J3712
10J3752 See note 4
10J3761 See note 5

SECTION A-A