p0448r2 - A strstream replacement using span<charT> as buffer

Peter Sommerlad

2019-01-21

Document Number:	p0448r2 (N2065 done right?)
Date:	2019-01-21
Project:	Programming Language C++
Audience:	LEWG/LWG

1 History

Streams have been the oldest part of the C++ standard library and especially strstreams that can use pre-allocated buffers have been deprecated for a long time now, waiting for a replacement. p0407 and p0408 provide the efficient access to the underlying buffer for stringstreams that strstream provided solving half of the problem that strstreams provide a solution for. The other half is using a fixed size pre-allocated buffer, e.g., allocated on the stack, that is used as the stream buffers internal storage.

A combination of external-fixed and internal-growing buffer allocation that strstreambuf provides is IMHO a doomed approach and very hard to use right.

There had been a proposal for the pre-allocated external memory buffer streams in N2065 but that went nowhere. Today, with `span<T>` we actually have a library type representing such buffers views we can use for specifying (and implementing) such streams. They can be used in areas where dynamic (re-)allocation of stringstreams is not acceptable but the burden of caring for a pre-existing buffer during the lifetime of the stream is manageable.

1.1 Changes from p0448r1

There was email discussion (Alisdair, Marshall, Titus and library mailing list) on semantics of move, timing and wording of strstream removal. Therefore, this paper needs to be reconsidered with that design respect by LEWG. I also acquired an additional paper number for a paper to propose the strstream removal, so I drop it from here.

Marshall gave a list of review comments, I'd like to answer below:

— The synopsis shows these classes in std::experimental, while the class descriptions show std:: only. *fixed, copy relict.*

— The synopsis should probably #include and <string>, since that's where span and char_traits come from. *yes to not to <string> since the base class basic_streambuf already has a dependency to char_traits, so no gain from mentioning <string>, but including <streambuf> might be shown. Fixed. However, I found no precedence to such include directives for stream classes in n4791 (may be a more modern style of specification introduced with C++11. I guess mentioning a required identifier encourages implementors to make its definition available.*

— Why a separate <spanstream> header? why not just put it in one of the existing ones? (we're adding headers at a surprising - to me - rate) *First, because strstreams are also in their separate header. Second, LEWG blessed/asked for it. Third, the base class already has the dependency to char_traits.*

— 7.4.2/1 is really generic: "Move assigns the base and members of *this from the base and corresponding members of rhs." *These words are almost identical to basic_istringstream move assignment. Took the challenge and now use (more) code.*

— 7.4.2/2 is mixing prose and code ; I suspect it would be better just as code. "Effects Equivalent to: <two lines of code>" *almost identical to basic_istringstream::swap wording. see above.*

— Is the span that you pass to the constructors required to be non-empty? setbuf does have that requirement. *The latter is not really true: setbuf() is defined per streambuf subclass and we are free to define it any way. most subclasses say that setbuf(0,0) has no effect, filebuf makes I/O unbuffered and all say any other combination has implementation defined behavior. I do not require a non-empty span, the stream is then just not particularly useful, except to behave as a null object.*

Alisdair raised the question if the spanbuf move operations should actually disassociate the buffer-/stream from the original span, like (all?) other streambuf subclasses to when moved from.

> "I have a huge concern about the definition of move construction and move assignment for basic_spanbuf. The reason is that this is simply a copy operation, but we allowed move semantics on streams/buffers following the unique ownership principle. In other words, it would be very surprising that writing to the move-from stream would have any impact on the moved-to stream."

Titus had the counter argument that one should not spend cycles on cleaning up moved from objects.

The streambuf base class can only be copied. filebuf and stringbuf both disassociate the right hand side from its underlying data source that they both own. strstreambuf does neither support move or copy.

I am torn, so I made that implementation defined.

Now to what really changed...

— rebase to n4791

— removed superfluous experimental namespace from synopsis

— added header includes in header synopsis for <streambuf> and (even so no other iostream headers seem to do so).

— introduce an exposition-only member `span<charT> buf` representing the span. This will make wording, especially of move constructor more clear.

— make the wording of the move constructor more clear instead of hand waving about "locale and other state of rhs".

— make wording of spanbuf/streams's members more clear by code instead of weasel wording obtained from stringbuf/streams.

— TODO

1.2 Changes from p0448r0

— provide explanation why non-copy-ability, while technically feasible, is an OK thing.

— remove wrong Allocator template parameter (we never allocate anything).

— adhere to new section numbering of the standard.

— tried to clarify lifetime and threading issues.

2 Introduction

This paper proposes a class template `basic_spanbuf` and the corresponding stream class templates to enable the use of streams on externally provided memory buffers. No ownership or re-allocation support is given. For those features we have string-based streams.

3 Acknowledgements

— Thanks to those ISO C++ meeting members attending the Oulu meeting encouring me to write this proposal. I believe Neil and Pablo have been among them, but can't remember who else.

— Thanks go to Jonathan Wakely who pointed the problem of `strstream` out to me and to Neil Macintosh to provide the span library type specification.

— Thanks to Felix Morgner for proofreading.

— Thanks to Kona LEWG small group discussion suggesting some clarifications and Thomas Köppe for allowing me to use using type aliases instead of `typedef`.

4 Motivation

To finally get rid of the deprecated `strstream` in the C++ standard we need a replacement. p0407/p0408 provide one for one half of the needs for `strstream`. This paper provides one for the second half: fixed sized buffers.

[*Example*: reading input from a fixed pre-arranged character buffer:

```
char input[] = "10 20 30";
ispanstream is{span<char>{input}};
```

```
int i;
is >> i;
ASSERT_EQUAL(10,i);
is >> i ;
ASSERT_EQUAL(20,i);
is >> i;
ASSERT_EQUAL(30,i);
is >>i;
ASSERT(!is);
```

— *end example*] [*Example*: writing to a fixed pre-arranged character buffer:

```
char  output[30]{}; // zero-initialize array
ospanstream os{span<char>{output}};
os << 10 << 20 << 30 ;
auto const sp = os.span();
ASSERT_EQUAL(6,sp.size());
ASSERT_EQUAL("102030",std::string(sp.data(),sp.size()));
ASSERT_EQUAL(static_cast<void*>(output),sp.data()); // no copying of underlying data!
ASSERT_EQUAL("102030",output); // initialization guaranteed NUL termination
```

— *end example*]

5 Impact on the Standard

This is an extension to the standard library to enable deletion of the deprecated `strstream` classes by providing `basic_spanbuf`, `basic_spanstream`, `basic_ispanstream`, and `basic_ospanstream` class templates that take an object of type `span<charT>` which provides an external buffer to be used by the stream.

It also proposes to remove the deprecated strstreams [depr.str.strstreams] assuming p0407 is also included in the standard.

6 Design Decisions

6.1 General Principles

The design follows from the principles of the iostream library. If discussed a person knowledgable about iostream's implementation is favorable, because of its many legacy design decisions, that would no longer be taken by modern C++ class designers. The behavior presented is part of what "frozen" strstreams provide, namely relying on a pre-allocated buffer, without the idiosynchracy of (o)strstream that automatically (re-)allocates a new buffer on the C-heap, when the original buffer is insufficient for the output, which happens when such a buffer is not explicitly marked as "frozen". This broken design is the reason it has long been deprecated, but its use with pre-allocated buffers is one of the reasons it has not been banned completely, yet. Together with p0407 this paper gets rid of it.

As with all existing stream classes, using a stream object or a streambuf object from multiple threads can result in a data race. Only the pre-defined global stream objects cin/cout/cerr are exempt from

this.

6.2 Older Open Issues (to be) Discussed by LEWG / LWG

— Should arbitrary types as template arguments to `span` be allowed to provide the underlying buffer by using the `byte` sequence representation `span` provides. (I do not think so and some people in LEWG inofficially agree with it). You can always get a span of characters from the underlying byte sequence, so there is no need to put that functionality into spanbuf, it would break orthogonality and could lead to undefined behavior, because the streambuf would be aliasing with an arbitrary object.

— Should the `basic_spanbuf` be copy-able? It doesn't own any resources, so copying like with handles or `span` might be fine. Other concrete streambuf classes in the standard that own their buffer (`basic_stringbuf`, `basic_filebuf`) naturally prohibit copying, where the base class `basic_streambuf` provides a protected copy-ctor. I considered providing copyability for `basic_spanbuf`, because the implementation is `=default`. Note, none of the stream classes in the standard is copyable as are the stream classes provided here. Other streambuf subclasses are not copyable, mainly because they either represent an external resource (fstreambuf), or because one usually would not access it via its concrete type and only through its `basic_streambuf` abstraction, i.e., by using an associated stream's `rdbuf()` member function. I speculate that another reason, why basic_stringbuf is not copyable, is that copying its underlying string and re-establishing a new stream with it is possible and copying a streambuf felt not natural. Therefore, I stick with my decision to prohibit copying `basic_spanbuf`.

6.3 Current (r2) Open Issues (to be) Discussed by LEWG / LWG

— Should we keep a separate header <spanstream> ? Where to put it instead?

— Is adding a default constructor for basic_spanbuf OK?

7 Technical Specifications

Insert a new section 28.x in chapter 28 [input.output] after section 28.8 [string.streams]

7.1 28.x Span-based Streams [span.streams]

This section introduces a stream interface for user-provided fixed-size buffers.

7.1.1 28.x.1 Overview [span.streams.overview]

The header `<spanstream>` defines four class templates and eight types that associate stream buffers with objects of class `span` as described in [span]. [*Note*: A user of theses classes is responsible that the character sequence represented by the given span outlives the use of the sequence by objects of the classes in this chapter. Using multiple basic_spanbuf objects referring to overlapping underlying sequences from different threads, where at least one spanbuf is used for writing to the sequence results in a data race. — *end note*]

Header <spanstream> synopsis

```
#include <streambuf>
#include <span>

namespace std {
  template <class charT, class traits = char_traits<charT> >
    class basic_spanbuf;
  using spanbuf = basic_spanbuf<char>;
  using wspanbuf = basic_spanbuf<wchar_t>;
  template <class charT, class traits = char_traits<charT> >
    class basic_ispanstream;
  using ispanstream = basic_ispanstream<char>;
  using wispanstream = basic_ispanstream<wchar_t>;
  template <class charT, class traits = char_traits<charT> >
    class basic_ospanstream;
  using ospanstream = basic_ospanstream<char>;
  using wospanstream = basic_ospanstream<wchar_t>;
  template <class charT, class traits = char_traits<charT> >
    class basic_spanstream;
  using spanstream = basic_spanstream<char>;
  using wspanstream = basic_spanstream<wchar_t>;
}
```

7.2 28.x.2 Class template basic_spanbuf [spanbuf]

```
namespace std {
  template <class charT, class traits = char_traits<charT> >
  class basic_spanbuf
    : public basic_streambuf<charT, traits> {
  public:
    using char_type      = charT;
    using int_type       = typename traits::int_type;
    using pos_type       = typename traits::pos_type;
    using off_type       = typename traits::off_type;
    using traits_type    = traits;

    // [spanbuf.cons], constructors:
    basic_spanbuf() : basic_spanbuf(ios_base::in | ios_base::out) {}
    explicit basic_spanbuf(ios_base::openmode which)
      : basic_spanbuf(span<charT>(),which) {}
    template <ptrdiff_t Extent>
    explicit basic_spanbuf(
      span<charT, Extent> span,
      ios_base::openmode which = ios_base::in | ios_base::out);
    basic_spanbuf(const basic_spanbuf& rhs) = delete;
    basic_spanbuf(basic_spanbuf&& rhs) noexcept;

    // [spanbuf.assign], assign and swap:
    basic_spanbuf& operator=(const basic_spanbuf& rhs) = delete;
    basic_spanbuf& operator=(basic_spanbuf&& rhs) noexcept;
    void swap(basic_spanbuf& rhs) noexcept;
```

```
    // [spanbuf.members], get and set:
    span<charT> span() const noexcept;
    void span(span<charT> s) noexcept;

  protected:
    // [spanbuf.virtuals], overridden virtual functions:
    int_type underflow() override;
    int_type pbackfail(int_type c = traits::eof()) override;
    int_type overflow (int_type c = traits::eof()) override;
    basic_streambuf<charT, traits>* setbuf(charT*, streamsize) override;

    pos_type seekoff(off_type off, ios_base::seekdir way,
                     ios_base::openmode which
                      = ios_base::in | ios_base::out) override;
    pos_type seekpos(pos_type sp,
                     ios_base::openmode which
                      = ios_base::in | ios_base::out) override;

  private:
    ios_base::openmode mode;  // exposition only
    span<charT> buf; // exposition only
  };

  template <class charT, class traits>
    void swap(basic_spanbuf<charT, traits>& x,
              basic_spanbuf<charT, traits>& y) noexcept;
}
```

1 The class `basic_spanbuf` is derived from `basic_streambuf` to associate possibly the input sequence and possibly the output sequence with a sequence of arbitrary *characters*. The sequence is provided by an object of class `span<charT>`.

2 For the sake of exposition, the maintained data is presented here as:

(2.1) — `ios_base::openmode mode`, has `in` set if the input sequence can be read, and `out` set if the output sequence can be written.

(2.2) — `span<charT> buf` is the view to the underlying character sequence.

7.3 28.x.2.1 `basic_spanbuf` constructors [spanbuf.cons]

```
template <ptrdiff_t Extent>
explicit basic_spanbuf(
  basic_span<charT, Extent> s,
  ios_base::openmode which = ios_base::in | ios_base::out);
```

1 *Effects:* Constructs an object of class `basic_spanbuf`, initializing the base class with `basic_streambuf()` ([streambuf.cons]), initializing `mode` with `which`. Initializes the internal pointers as if calling `span(s)`.

```
basic_spanbuf(basic_spanbuf&& rhs) noexcept;
```

2 *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by copy constructing the

base class and initializing `mode` from `rhs.mode` and `buf` from `rhs.buf`. The sequence pointers in `*this` (`eback()`, `gptr()`, `egptr()`, `pbase()`, `pptr()`, `epptr()`) obtain the values which `rhs` had. It is implementation-defined wether `rhs.buf.empty()` returns true after the move.

3 *Ensures:* Let `rhs_p` refer to the state of `rhs` just prior to this construction.

(3.1) — `span() == rhs_p.span()`

(3.2) — `eback() == rhs_p.eback()`

(3.3) — `gptr() == rhs_p.gptr()`

(3.4) — `egptr() == rhs_p.egptr()`

(3.5) — `pbase() == rhs_p.pbase()`

(3.6) — `pptr() == rhs_p.pptr()`

(3.7) — `epptr() == rhs_p.epptr()`

(3.8) — `getloc() == rhs_p.getloc()`

7.3.1 28.x.2.2 Assign and swap [spanbuf.assign]

```
basic_spanbuf& operator=(basic_spanbuf&& rhs) noexcept;
```

1 *Effects:* After the move assignment `*this` has the observable state it would have had if it had been move constructed from `rhs` (see [spanbuf.cons]).

2 *Returns:* `*this`.

```
void swap(basic_spanbuf& rhs) noexcept;
```

3 *Effects:* `basic_streambuf<charT, traits>::swap(rhs); std::swap(mode,rhs.mode); std::swap(buf, rhs.buf)`.

```
template <class charT, class traits>
  void swap(basic_spanbuf<charT, traits>& x,
            basic_spanbuf<charT, traits>& y) noexcept;
```

4 *Effects:* As if by `x.swap(y)`.

7.3.2 28.x.2.3 Member functions [spanbuf.members]

```
span<charT> span() const;
```

1 *Returns:* If `mode == ios_base::out` is true, returns `span<charT>(pbase(),pptr())`, otherwise returns `buf`. [*Note*: In constrast to `basic_stringbuf` the underlying sequence can never grow and will not be owned. An owning copy can be obtained by converting the result to `basic_string<charT>`. — *end note*]

```
template<ptrdiff_t Extent>
void span(span<charT,Extent> s);
```

2 *Effects:* `buf = s;` Initializes the input and output sequences according to `mode`.

3 *Ensures:* If `mode & ios_base::out` is true, `pbase() == s.data()` and `epptr() == pbase() + s.size()` holds; in addition, if `mode & ios_base::ate` is true, `pptr() == pbase() +`

`s.size()` holds, otherwise `pptr() == pbase()` is true. If `mode & ios_base::in` is true, `eback() == s.data()`, and both `gptr() == eback()` and `egptr() == eback() + s.size()` hold.

[*Note*: Using append mode does not make sense for `span`-based streams. — *end note*]

7.3.3 28.x.2.4 Overridden virtual functions [spanbuf.virtuals]

1 [*Note*: Since the underlying buffer is of fixed size, neither `overflow`, `underflow` or `pbackfail` can provide useful behavior. — *end note*]

```
int_type underflow() override;
```

2 *Returns:* `traits::eof()`.

```
int_type pbackfail(int_type c = traits::eof()) override;
```

3 *Returns:* `traits::eof()`.

```
int_type overflow(int_type c = traits::eof()) override;
```

4 *Returns:* `traits::eof()`.

```
pos_type seekoff(off_type off, ios_base::seekdir way,
                 ios_base::openmode which
                   = ios_base::in | ios_base::out) override;
```

5 *Effects:* Alters the stream position within one of the controlled sequences, if possible, as indicated in Table 1[tab:spanbuf.seekoff.positioning].

Table 1 — `seekoff` positioning

Conditions	Result
`(which & ios_base::in) == ios_base::in`	positions the input sequence (xnext is `gptr()`, xbeg is `eback()`)
`(which & ios_base::out) == ios_base::out`	positions the output sequence (xnext is `pptr()`, xbeg is `pbase()`)
`(which & (ios_base::in | ios_base::out)) == (ios_base::in | ios_base::out)` and `way` == either `ios_base::beg` or `ios_base::end`	positions both the input and the output sequences
Otherwise	the positioning operation fails.

6 For a sequence to be positioned, if its next pointer xnext (either `gptr()` or `pptr()`) is a null pointer and the new offset `newoff` is nonzero, the positioning operation fails. Otherwise, the function determines `newoff` as indicated in Table 2[tab:spanbuf.newoff.values].

Table 2 — `newoff` values

Condition	`newoff` Value
`way == ios_base::beg`	0
`way == ios_base::cur`	`pptr()-pbase()` or `gptr()-eback()`.
`way == ios_base::end`	`(mode == ios_base::out)? pptr()-pbase() : buf.size()`

7 If `(newoff + off) < 0`, or if `(newoff + off) >= buf.size()`, the positioning operation fails. Otherwise, the function assigns `xbeg + newoff + off` to the next pointer `xnext`.

8 *Returns:* `pos_type(newoff)`, constructed from the resultant offset `newoff` (of type `off_type`), that stores the resultant stream position, if possible. If the positioning operation fails, or if the constructed object cannot represent the resultant stream position, the return value is `pos_type(off_type(-1))`.

```
pos_type seekpos(pos_type sp,
                 ios_base::openmode which
                   = ios_base::in | ios_base::out) override;
```

9 *Effects:* Equivalent to `seekoff(off_type(sp), ios_base::beg, which)`.

10 *Returns:* `sp` to indicate success, or `pos_type(off_type(-1))` to indicate failure.

```
basic_streambuf<charT, traits>* setbuf(charT* s, streamsize n);
```

11 *Effects:* If `s` and `n` denote a non-empty span `this->span(span<charT>(s,n));`

12 *Returns:* `this`.

7.4 28.x.3 Class template `basic_ispanstream` [ispanstream]

```
namespace std {
  template <class charT, class traits = char_traits<charT>>
  class basic_ispanstream
    : public basic_istream<charT, traits> {
  public:
    using char_type      = charT;
    using int_type       = typename traits::int_type;
    using pos_type       = typename traits::pos_type;
    using off_type       = typename traits::off_type;
    using traits_type    = traits;

    // [ispanstream.cons], constructors:
    template <ptrdiff_t Extent>
    explicit basic_ispanstream(
      span<charT, Extent> span,
      ios_base::openmode which = ios_base::in);
    basic_ispanstream(const basic_ispanstream& rhs) = delete;
```

```
    basic_ispanstream(basic_ispanstream&& rhs) noexcept;

    // [ispanstream.assign], assign and swap:
    basic_ispanstream& operator=(const basic_ispanstream& rhs) = delete;
    basic_ispanstream& operator=(basic_ispanstream&& rhs) noexcept;
    void swap(basic_ispanstream& rhs) noexcept;

    // [ispanstream.members], members:
    basic_spanbuf<charT, traits>* rdbuf() const noexcept;

    span<charT> span() const noexcept;
        template<ptrdiff_t Extent>
    void span(span<charT> s) noexcept;
  private:
    basic_spanbuf<charT, traits> sb; // exposition only
  };

  template <class charT, class traits>
    void swap(basic_ispanstream<charT, traits>& x,
              basic_ispanstream<charT, traits>& y) noexcept;
}
```

1 The class `basic_ispanstream<charT, traits>` supports reading objects of class `span<charT, traits>`. It uses a `basic_spanbuf<charT, traits>` object to control the associated span. For the sake of exposition, the maintained data is presented here as:

(1.1) — `sb`, the `spanbuf` object.

7.4.1 28.x.3.1 `basic_ispanstream` constructors [ispanstream.cons]

```
template <ptrdiff_t Extent>
explicit basic_ispanstream(
  span<charT, Extent> span,
  ios_base::openmode which = ios_base::in);
```

1 *Effects:* Constructs an object of class `basic_ispanstream<charT, traits>`, initializing the base class with `basic_istream(&sb)` and initializing `sb` with `basic_spanbuf<charT, traits>(span, which | ios_base::in)` ([spanbuf.cons]).

```
basic_ispanstream(basic_ispanstream&& rhs);
```

2 *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by initializing the base `basic_istream<charT, traits>` from `std::move(rhs)` and initializing `sb` from `std::move(rhs.sb)`. Next `basic_istream<charT, traits>::set_rdbuf(&sb)` is called to install the contained `basic_spanbuf`.

7.4.2 28.x.3.2 Assign and swap [ispanstream.assign]

```
basic_ispanstream& operator=(basic_ispanstream&& rhs);
```

1 *Effects:* `basic_istream<charT, traits>::swap(rhs); sb = std::move(rhs.sb)`.

2 *Returns:* `*this`.

```
void swap(basic_ispanstream& rhs);
```

3 *Effects:* `basic_istream<charT, traits>::swap(rhs);sb.swap(rhs.sb)`.

```
template <class charT, class traits>
  void swap(basic_ispanstream<charT, traits>& x,
            basic_ispanstream<charT, traits>& y);
```

4 *Effects:* `x.swap(y)`.

7.4.3 28.x.3.3 Member functions [ispanstream.members]

```
basic_spanbuf<charT>* rdbuf() const noexcept;
```

1 *Returns:* `const_cast<basic_spanbuf<charT>*>(&sb)`.

```
span<charT> span() const noexcept;
```

2 *Returns:* `rdbuf()->span()`.

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s) noexcept;
```

3 *Effects:* Calls `rdbuf()->span(s)`.

7.5 28.x.4 Class template `basic_ospanstream` [ospanstream]

```
namespace std {
  template <class charT, class traits = char_traits<charT>>
  class basic_ospanstream
    : public basic_ostream<charT, traits> {
  public:
    using char_type      = charT;
    using int_type       = typename traits::int_type;
    using pos_type       = typename traits::pos_type;
    using off_type       = typename traits::off_type;
    using traits_type    = traits;

    // [ospanstream.cons], constructors:
    template <ptrdiff_t Extent>
    explicit basic_ospanstream(
      span<charT, Extent> span,
      ios_base::openmode which = ios_base::out);
    basic_ospanstream(const basic_ospanstream& rhs) = delete;
    basic_ospanstream(basic_ospanstream&& rhs) noexcept;

    // [ospanstream.assign], assign and swap:
    basic_ospanstream& operator=(const basic_ospanstream& rhs) = delete;
    basic_ospanstream& operator=(basic_ospanstream&& rhs) noexcept;
    void swap(basic_ospanstream& rhs) noexcept;

    // [ospanstream.members], members:
    basic_spanbuf<charT, traits>* rdbuf() const noexcept;
```

```
    span<charT> span() const noexcept;
        template<ptrdiff_t Extent>
    void span(span<charT> s) noexcept;
  private:
    basic_spanbuf<charT, traits> sb; // exposition only
  };

  template <class charT, class traits>
    void swap(basic_ospanstream<charT, traits>& x,
              basic_ospanstream<charT, traits>& y) noexcept;
}
```

1 The class `basic_ospanstream<charT, traits>` supports writing to objects of class `span<charT, traits>`. It uses a `basic_spanbuf<charT, traits>` object to control the associated span. For the sake of exposition, the maintained data is presented here as:

(1.1) — `sb`, the `spanbuf` object.

7.5.1 28.x.4.1 `basic_ospanstream` constructors [ospanstream.cons]

```
template <ptrdiff_t Extent>
explicit basic_ospanstream(
  span<charT, Extent> span,
  ios_base::openmode which = ios_base::out);
```

1 *Effects:* Constructs an object of class `basic_ospanstream<charT, traits>`, initializing the base class with `basic_ostream(&sb)` and initializing `sb` with `basic_spanbuf<charT, traits>span, which | ios_base::out)` ([spanbuf.cons]).

```
basic_ospanstream(basic_ospanstream&& rhs) noexcept;
```

2 *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by initializing the base `basic_ostream<charT, traits>` from `std::move(rhs)` and initializing `sb` from `std::move(rhs.sb)`. Next `basic_istream<charT, traits>::set_rdbuf(&sb)` is called to install the contained `basic_spanbuf`.

7.5.2 28.x.4.2 Assign and swap [ospanstream.assign]

```
basic_ospanstream& operator=(basic_ospanstream&& rhs) noexcept;
```

1 *Effects:* `basic_ostream<charT, traits>::swap(rhs); sb = std::move(rhs.sb)`.

2 *Returns:* `*this`.

```
void swap(basic_ospanstream& rhs) noexcept;
```

3 *Effects:* `basic_ostream<charT, traits>::swap(rhs);sb.swap(rhs.sb)`.

```
template <class charT, class traits>
  void swap(basic_ospanstream<charT, traits>& x,
            basic_ospanstream<charT, traits>& y) noexcept;
```

4 *Effects:* As if by `x.swap(y)`.

7.5.3 28.x.4.3 Member functions [ospanstream.members]

```
basic_spanbuf<charT>* rdbuf() const noexcept;
```

1 *Returns:* `const_cast<basic_spanbuf<charT>*>(&sb)`.

```
span<charT> span() const noexcept;
```

2 *Returns:* `rdbuf()->span()`.

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s) noexcept;
```

3 *Effects:* Calls `rdbuf()->span(s)`.

7.6 28.x.5 Class template `basic_spanstream` [spanstream]

```
namespace std {
  template <class charT, class traits = char_traits<charT>>
  class basic_spanstream
    : public basic_iostream<charT, traits> {
  public:
    using char_type      = charT;
    using int_type       = typename traits::int_type;
    using pos_type       = typename traits::pos_type;
    using off_type       = typename traits::off_type;
    using traits_type    = traits;

    // [spanstream.cons], constructors:
    template <ptrdiff_t Extent>
    explicit basic_spanstream(
      span<charT, Extent> span,
      ios_base::openmode which = ios_base::out);
    basic_spanstream(const basic_spanstream& rhs) = delete;
    basic_spanstream(basic_spanstream&& rhs) noexcept;

    // [spanstream.assign], assign and swap:
    basic_spanstream& operator=(const basic_spanstream& rhs) = delete;
    basic_spanstream& operator=(basic_spanstream&& rhs) noexcept;
    void swap(basic_spanstream& rhs) noexcept;

    // [spanstream.members], members:
    basic_spanbuf<charT, traits>* rdbuf() const noexcept;

    span<charT> span() const noexcept;
        template<ptrdiff_t Extent>
    void span(span<charT> s) noexcept;
  private:
    basic_spanbuf<charT, traits> sb; // exposition only
  };

  template <class charT, class traits>
    void swap(basic_spanstream<charT, traits>& x,
```

```
                basic_spanstream<charT, traits>& y) noexcept;
}
```

1 The class `basic_spanstream<charT, traits>` supports reading from and writing to objects of class `span<charT, traits>`. It uses a `basic_spanbuf<charT, traits>` object to control the associated span. For the sake of exposition, the maintained data is presented here as:

(1.1) — `sb`, the `spanbuf` object.

7.6.1 28.x.5.1 `basic_spanstream` constructors [spanstream.cons]

```
template <ptrdiff_t Extent>
explicit basic_spanstream(
  span<charT, Extent> span,
  ios_base::openmode which = ios_base::out | ios_bas::in);
```

1 *Effects:* Constructs an object of class `basic_spanstream<charT, traits>`, initializing the base class with `basic_iostream(&sb)` and initializing `sb` with `basic_spanbuf<charT, traits>span, which)` ([spanbuf.cons]).

```
basic_spanstream(basic_spanstream&& rhs) noexcept;
```

2 *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by initializing the base `basic_iostream<charT, traits>` from `std::move(rhs)` and initializing `sb` from `std::move(rhs.sb)`. Next `basic_istream<charT, traits>::set_rdbuf(&sb)` is called to install the contained `basic_spanbuf`.

7.6.2 28.x.5.2 Assign and swap [spanstream.assign]

```
basic_spanstream& operator=(basic_spanstream&& rhs) noexcept;
```

1 *Effects:* `basic_iostream<charT, traits>::swap(rhs); sb = std::move(rhs.sb)`.

2 *Returns:* `*this`.

```
void swap(basic_spanstream& rhs) noexcept;
```

3 *Effects:* `basic_iostream<charT, traits>::swap(rhs);sb.swap(rhs.sb)`.

```
template <class charT, class traits>
  void swap(basic_spanstream<charT, traits>& x,
            basic_spanstream<charT, traits>& y) noexcept;
```

4 *Effects:* As if by `x.swap(y)`.

7.6.3 28.x.5.3 Member functions [spanstream.members]

```
basic_spanbuf<charT>* rdbuf() const noexcept;
```

1 *Returns:* `const_cast<basic_spanbuf<charT>*>(&sb)`.

```
span<charT> span() const noexcept;
```

2 *Returns:* `rdbuf()->span()`.

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s) noexcept;
```

3 *Effects:* Calls `rdbuf()->span(s)`.

8 Appendix: Example Implementations

An example implementation is available under the author's github account at: https://github.com/PeterSommerlad/SC22WG21_Papers/tree/master/workspace/p0448