

p0448r1 - A stringstream replacement using `span<charT>` as buffer

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1 History

Streams have been the oldest part of the C++ standard library and especially `stringstreams` 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 `stringstream` provided solving half of the problem that `stringstreams` 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 `stringstreambuf` 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 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 encouraging 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 `stringstream` 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 `stringstream` in the C++ standard we need a replacement. p0407/p0408 provide one for one half of the needs for `stringstream`. 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_istream`, and `basic_ostream` 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 knowledgeable 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 idiosyncrasy 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 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 unofficially 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`.

7 Technical Specifications

Remove section [depr.str.strstreams] from appendix D.

Insert a new section 30.x in chapter 30 [input.output] after section 30.8 [string.streams]

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

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

7.1.1 30.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 these 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

```
namespace std {
namespace experimental {
    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_ospstream;
    using ospstream = basic_ospstream<char>;
    using wospstream = basic_ospstream<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 30.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;

    // ??, constructors:
    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;

    // ??, assign and swap:
    basic_spanbuf& operator=(const basic_spanbuf& rhs) = delete;
    basic_spanbuf& operator=(basic_spanbuf&& rhs) noexcept;
    void swap(basic_spanbuf& rhs) noexcept;

    // ??, get and set:
    span<charT> span() const noexcept;
    void span(span<charT> s) noexcept;

protected:
    // ??, 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
};

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.

7.3 30.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()` (??), and 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`. Both `basic_spanbuf` objects share the same underlying `span`. The sequence pointers in `*this` (`eback()`, `gptr()`, `egptr()`, `pbase()`, `pptr()`, `epptr()`) obtain the values which `rhs` had. The `openmode`, `locale` and any other state of `rhs` is also copied.

- 3 *Postconditions:* 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()`

7.3.1 30.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 ??).

- 2 *Returns:* `*this`.

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

- 3 *Effects:* Exchanges the state of `*this` and `rhs`.

```
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 30.x.2.3 Member functions [spanbuf.members]

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

- 1 *Returns:* A `span` object representing the `basic_spanbuf` underlying character sequence. If the `basic_spanbuf` was created only in output mode, the resultant `span` represents the character sequence in the range `[pbase(), pptr())`, otherwise in the range `[eback(), egptr())`. [*Note:* In contrast 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:* Initializes the `basic_spanbuf` underlying character sequence with `s` and initializes the input and output sequences according to `mode`.
- 3 *Postconditions:* If `mode & ios_base::out` is true, `pbase()` points to the first underlying character 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()` points to the first underlying character, 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 30.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 ??.

- 6 For a sequence to be positioned, if its next pointer (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 ??.

- 7 If `(newoff + off) < 0`, or if `newoff + off` refers to an uninitialized character outside the span (as defined in ?? paragraph 1), 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 30.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;

        // 7.4.1, 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;

        // 7.4.2, assign and swap:
        basic_ispanstream& operator=(const basic_ispanstream& rhs) = delete;
        basic_ispanstream& operator=(basic_ispanstream&& rhs) noexcept;
        void swap(basic_ispanstream& rhs) noexcept;

        // 7.4.3, 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 30.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` (??).

```

basic_ispanstream(basic_ispanstream&& rhs);

```

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

7.4.2 30.x.3.2 Assign and swap [`ispanstream.assign`]

```

basic_ispanstream& operator=(basic_ispanstream&& rhs);

```

¹ *Effects:* Move assigns the base and members of `*this` from the base and corresponding members of `rhs`.

² *Returns:* `*this`.

```

void swap(basic_ispanstream& rhs);

```

³ *Effects:* Exchanges the state of `*this` and `rhs` by calling `basic_istream<charT, traits>::swap(rhs)` and `sb.swap(rhs.sb)`.

```

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

```

⁴ *Effects:* As if by `x.swap(y)`.

7.4.3 30.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 30.x.4 Class template `basic_ostream` [`ostream`]

```
namespace std {
    template <class charT, class traits = char_traits<charT>>
    class basic_ostream
    : 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;

        // 7.5.1, constructors:
        template <ptrdiff_t Extent>
        explicit basic_ostream(
            span<charT, Extent> span,
            ios_base::openmode which = ios_base::out);
        basic_ostream(const basic_ostream& rhs) = delete;
        basic_ostream(basic_ostream&& rhs) noexcept;

        // 7.5.2, assign and swap:
        basic_ostream& operator=(const basic_ostream& rhs) = delete;
        basic_ostream& operator=(basic_ostream&& rhs) noexcept;
        void swap(basic_ostream& rhs) noexcept;

        // 7.5.3, 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_ostream<charT, traits>& x,
              basic_ostream<charT, traits>& y) noexcept;
}
```

1 The class `basic_ostream<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 30.x.4.1 `basic_ostream` constructors [`ostream.cons`]

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

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

```
basic_ostream(basic_ostream&& rhs) noexcept;
```

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

7.5.2 30.x.4.2 Assign and swap [`ostream.assign`]

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

1 *Effects:* Move assigns the base and members of `*this` from the base and corresponding members of `rhs`.

2 *Returns:* `*this`.

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

3 *Effects:* Exchanges the state of `*this` and `rhs` by calling `basic_ostream<charT, traits>::swap(rhs)` and `sb.swap(rhs.sb)`.

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

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

7.5.3 30.x.4.3 Member functions [`ostream.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 30.x.5 Class template `basic_spanstream` [`spanstream`]

```

namespace std {
    template <class charT, class traits = char_traits<charT>>
    class basic_spanstream
    : 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;

        // 7.6.1, 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;

        // 7.6.2, assign and swap:
        basic_spanstream& operator=(const basic_spanstream& rhs) = delete;
        basic_spanstream& operator=(basic_spanstream&& rhs) noexcept;
        void swap(basic_spanstream& rhs) noexcept;

        // 7.6.3, 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 30.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_base::in);
```

- 1 *Effects:* Constructs an object of class `basic_spanstream<charT, traits>`, initializing the base class with `basic_istream(&sb)` and initializing `sb` with `basic_spanbuf<charT, traits>span, which` (??).

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

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

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

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

- 1 *Effects:* Move assigns the base and members of `*this` from the base and corresponding members of `rhs`.

- 2 *Returns:* `*this`.

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

- 3 *Effects:* Exchanges the state of `*this` and `rhs` by calling `basic_istream<charT, traits>::swap(rhs)` and `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 30.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